Techniques of Water-Resources Investigations of the United States Geological Survey

Chapter B4

REGRESSION MODELING OF GROUND-WATER FLOW

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Book 3
APPLICATIONS OF HYDRAULICS

no specified head parameters, $\underline{q}-\underline{\underline{D}}\underline{h}=\underline{0}$ can be written in the form

$$a_{i1}b_1+a_{i2}b_2+...+a_{ip}b_p-Q_i=0,\quad i=1,2,...,m \qquad (4.3\text{-}38)$$

where

a_{ij}=coefficient containing Δx, Δy, and head differences;
b_j=any parameter except a specified head parameter; and
Q_i=term not containing parameters in $\underline{b}$.

Define

$$\underline{J}_j=\frac{\partial \underline{q}}{\partial b_j}-\frac{\partial \underline{\underline{D}}}{\partial b_j}\underline{h}. \qquad (4.3\text{-}39)$$

Then, by carrying out the differentiations indicated in equation 4.3–39 and comparing the result with equation 4.3–38 it can be seen that

$$J_{ij}b_j=a_{ij}b_j \qquad (4.3\text{-}40)$$

so that

$$\sum_{j=1}^{p} J_{ij}b_j=\sum_{j=1}^{p} a_{ij}b_j=Q_i\ . \qquad (4.3\text{-}41)$$

If $\underline{b}$ contains all possible parameters (except specified head parameters) and there are no known fluxes, then $Q_i=0$ and

$$\sum_{j=1}^{p} J_{ij}b_j=0 \qquad (4.3\text{-}42)$$

or

$$\underline{\underline{J}}\underline{b}=\underline{0}\ . \qquad (4.3\text{-}43)$$

4.3.4 Documentation of Program for Nonlinear Regression Solution of Steady-State Ground-Water Flow Problems

Introduction.—This program is designed to obtain a nonlinear regression solution to the finite-difference model of steady-state ground-water flow given in section 4.3.1. Basic calculation methods are given in sections 4.1 and 4.3.2.

The program was developed using the Microsoft[1] Fortran Compiler, Version 3.3, with the DOS[1] 2.0 operating system on an IBM[1] PC/XT computer with the IBM[1] 8088 Math Coprocessor and 256 KB memory. Except for the OPEN statements near the beginning of the code, Fortran 66 was used throughout to make the code as machine independent as possible. The source code is contained in files INVFD.FOR and INVSUB.FOR in the 5¼ in. diskette accompanying this report. These two files must be linked or compiled together.

The computer program is composed of a main program and eight subroutines. The main program controls input-output and performs all computations that cannot be accomplished more effectively with subroutines. The eight subroutines (D4SOLV, COEF, LSTSQ, PRTOT, ORDER, ARRAY, ARRAYI, HOBS) perform the following specialized tasks:

D4SOLV Obtains an LDU factorization solution of the set of linear algebraic equations resulting from application of the finite difference methods, assuming the equations are ordered in an alternating diagonal fashion (Price and Coats, 1974).

COEF Computes coefficients necessary for the determination of sensitivities and heads.

LSTSQ Computes the coefficients of the normal equations and solves the system of equations to determine the vectors of parameter changes and parameters.

PRTOT Prints matrices or vectors in a column configuration.

ORDER Computes equation numbers at grid points corresponding to the alternating diagonal ordering scheme.

ARRAY Reads and (or) prints 1- and 2-dimensional real array variables.

ARRAYI Reads and (or) prints 1- and 2-dimensional integer array variables.

[1]Use of the trade names in this report is for identification purposes only and does not constitute endorsement by the U.S. Geological Survey.

HOBS Reads and prints observed heads and weighting values; computes coefficients for bilinear interpolation of computed heads and sensitivities at observation points.

The basic flow of the program can be described as follows:

A. Data are input and variables are initialized.

B. Using coefficients generated in COEF, an initial solution corresponding to the initial parameter estimates is computed by D4SOLV.

C. In an iterative fashion, the following four steps are taken until the regression technique converges or until the number of iterations exceeds the maximum allowed.

(1) Sensitivities are calculated using coefficients computed in COEF and in the main program.

(2) LSTSQ is employed to form and solve the normal equations.

(3) Parameters are updated in LSTSQ using the parameter change vector generated.

(4) Various coefficients involving the updated parameters are computed in COEF, and current estimates of head are computed using D4SOLV.

D. Various statistics associated with the regression analysis are computed.

Aquifer Property Zonation and Variable Definition.—Basic model geometry is defined by the finite difference grid that is constructed over the region to be modeled. Nodes, consisting of grid intersections, are numbered from the lower left-hand corner of the grid (columns from left to right and rows from bottom to top). Cells, consisting of intragrid areas bounded by four adjacent nodes, are numbered similarly (figure 4.3-7).

The finite difference grid is divided into aquifer property zones, which define zonal values for the aquifer properties T_{xx}, T_{yy}, R, and W. Each zonal value is constant within the zone. Variation of a property within a zone is accomplished by assigning cell values. The aquifer property at any particular cell is computed as the product of the zonal value and the cell value of the property. Thus, if all cell values for a property within a zone are given a value of unity, the zonal value becomes the value of the property for each cell within that zone.

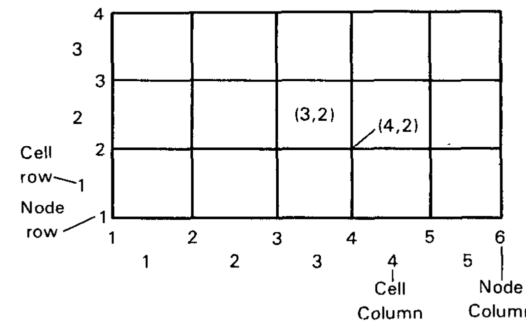

Figure 4.3-7

Zones are created by subdividing the grid into groups of cells having distinct combinations of zonal values. Cells belonging to these zones are accordingly assigned distinct zone numbers (IZN), reserving IZN=0 to indicate groups of cells outside of the model area.

All zonal values are either regarded as regression parameters to be determined by the procedure or are held constant and, thus, are not regarded as regression parameters to be determined, as specified in the input. From a conceptual viewpoint there is no difference between these two designations because zonal values that are held constant can be regarded as regression parameters having exact prior information. However, from a computational viewpoint it is most efficient to eliminate parameters being held constant from the calculations. Hence, these types of parameters do not appear in the normal equations or any of the vectors and matrices derived from them. To simplify nomenclature, in subsequent discussions the term regression parameter refers only to those regression parameters to be determined.

Cell values for an aquifer property are input using rectangular blocks of cells, which are defined for each property for convenience of input only. These blocks need not bear any relationship to the zones. Cell values may be constant or variable within each block. Cell values of a property are unaffected by the regression procedure.

Boundary Conditions and Boundary Parameters.—Two types of boundary conditions may be used: specified flow and (or) specified head. Nonzero specified-flow boundaries where the flow rate is known can be imposed by assigning the appropriate value of the specified flow rate to the nodal value of variable WELL. Because the no-flow boundary is the default condition, zeros do not have to be assigned to WELL to simulate this condition. Specified-head boundaries where the head is known can be imposed by assigning the value of the known head at the boundary nodes to variable HC, which also describes nodal values of computed head. A negative one must be assigned to variable IN corresponding to each node that is to be considered a specified head node. Segments of the boundary that will be considered as either flow or head regression parameters must not be entered into WELL or HC arrays.

Different variables are used if specified-flow or specified-head boundary conditions are to be considered as regression parameters. Variable QB is used to indicate the zonal value for discharge across groups of nodes that form a specified-flow segment (or zone). The specified volumetric flow per unit width for each cell boundary within a zone is the product of QB for that zone and a multiplier for the cell boundary. By restricting a flow-boundary zone to a single node, point recharge and discharge can be simulated. QB can be a regression parameter and, therefore, can be modified by the regression procedure; the multiplier is unaffected. If the variable IP that specifies the regression parameter number for the boundary zone is set to zero, then QB is held constant, and the segment is treated as a known-flow boundary, thus giving two possible ways (via WELL and via QB) to designate known-flow boundaries.

Specified-head boundary nodes that are to be considered regression parameters are defined by segments composed of a sequence of nodes (variables ILOC and JLOC) along portions of the boundary. The specified heads at the first and last nodes in the sequence can be either different regression parameters or a single regression parameter or held constant, depending on the nature of the problem. Adjustments to heads at these nodes computed by the regression procedure are apportioned to other nodes in the sequence. The proportion is the ratio of the distance (along the sequence of nodes) between the end node and the node of interest, to the distance between the two end nodes. These factors (PLA and PLB) are computed by the program for a given segment. As in the case with flow-boundary parameters, if the regression parameter number is set to zero, then that parameter is held constant. If the parameter numbers at both ends of the segment are set to zero, then the segment is treated as a known-head boundary, thus giving two possible ways to designate known-head boundaries. A negative one must be entered into IN for all nodes on the specified-head boundary, whether or not the boundary involves regression parameters.

The definition of some of the more important variables related to aquifer properties and boundary conditions in the computer program are given below.

Variable name	Definition
PAR(1), PAR(2), PAR(3), PAR(4)	Zonal value for transmissivity (T_{xx} and T_{yy}), hydraulic conductance (R), and distributed recharge (W), respectively.
IZN	An integer array that indicates the zone number of each cell.
CX, CY, VL, QR	Cell values for x-direction transmissivity, y-direction transmissivity, hydraulic conductance, and distributed recharge, respectively.
HR	Nodal values of head on the boundary of the confining bed opposite the aquifer.
WELL	Nodal (or point) values of known volumetric discharge (or recharge) from a well or other known-rate source-sink phenomena.
QBF	Cell-boundary multipliers for specified flow.
PLA, PLB	Arrays, which give the proportional distances from any point to either end of a segment where the specified heads at one (or both) end(s) of the segment is a (or are) regression parameter(s).

Numbering of Regression Parameters.—The three types of regression parameters (aquifer parameters, specified-flow parameters, and specified-head parameters) are numbered consecutively and in any order. Also, any of the zonal values for aquifer properties or specified-flows and segment-end values for specified head zones can be given a single regression parameter number. In this case the zonal or segment-end values sharing the same number must have identical regression parameter values. Any differences in property values must be specified by differences in multipliers. A common example is to use only one regression parameter for both the x- and y-direction zonal transmissivity values and to fix the degree of anisotropy for the zone by using the CX and CY arrays. As another example, if good estimates of the hydraulic gradient across cell boundaries forming a specified-flow boundary for an aquifer property zone were available, and if transmissivity were isotropic, then these gradient values could be used as multipliers so that the regression parameter QB for the specified-flow zone comprising the specified-flow boundary would be transmissivity. Thus, the x- and y-direction transmissivities for the aquifer property zone and QB for the specified-flow zone could all be the same regression parameter. A high degree of flexibility for distributing aquifer properties and boundary conditions while, at the same time, keeping the number of regression parameters to a minimum is achieved with these types of schemes.

Prior Information on Regression Parameters.—If estimates of the regression parameters and their (less than infinite) reliability are available from other sources (for example, aquifer tests), it is desirable to introduce this information into the regression analysis. For this case, initial values for the parameters are taken to be the prior information. The reliability of each estimate is represented by a standard deviation. Array WP is used to store these values for the regression parameters. However, only the standard deviations for the aquifer regression parameters are read directly into WP. The standard deviations for boundary regression parameters are read in through temporary variables (SDQB for specified-flow regression parameters, and SDHA and SDHB for specified-head regression parameters) and are only subsequently placed into the WP array.

The use of prior information of known reliability requires an estimate of the error variance of the heads (variable, EV) computed using ordinary least squares. If the estimate differs substantially from the value computed by the analysis using prior information, the problem should be resolved using the latter computed value as the estimate of error variance.

In some instances prior information of unknown reliability may be available. Use of this type of information is an advanced topic and is not covered in this report. The papers by Cooley (1982, 1983) cover the method in detail. Variables RP and BP are used to input the additional information needed for this method.

Solution-Only Mode.—To facilitate the calculation of certain statistical measures, the program is capable of bypassing the regression analysis and computing only head distributions for various combinations of parameter values. This is accomplished by specifying the solution-only option (variable ISO) and providing the various combinations of parameter values for which solutions are desired.

Using the Program.—The computer code has been designed to be as machine independent as possible. Also, to minimize confusion, all arrays have been dimensioned explicitly. The following list summarizes the minimum dimensions required for the program to operate properly for a specific problem. If

N_g is the number of node points ($N_x \times N_y$),
N_x is the number of node columns,
N_y is the number of node rows,
N_e is the number of active (nonspecified head) nodes in the grid,
N_o is the number of observed heads,
N_{oT} is the total number of observed heads plus the number of parameters on which there is prior information,
N_z is the number of aquifer property zones in the model grid,
N_p is the number of regression parameters associated with aquifer property zones,
N_n is the number of zonal aquifer properties that are not regression parameters,
N_{hs} is the number of specified-head zones (or segments),
N_{qp} is the total number of nodes on boundaries where flow is a regression parameter,
N_{hp} is the total number of nodes along boundaries where head is composed of one or more specified-head regression parameters,
N_{mh} is the maximum number of nodes in any specified-head zone, and
N_R is the total number of regression parameters;

then the array variables should be dimensioned as in table 4.3-1.

Table 4.3-1

Variable name	Dimension
WELL,HR,HC,XV,ILOC,JLOC,IN	N_g
CX,CY,VL,QR,CXS,CYS,VLS,QRS,IZN	$(N_x-1)(N_y-1)$
DX	N_x
DY,JPOS	N_y
HCI,BK,BL,BM,BN,HO,W,KOBS	N_o
PAR,XS,KN	4
IPRM	$4,N_z$
QBF,IBNA,IBNB	N_{qp}
PLA,PLB,IBHN	N_{hp} or N_{mh}, whichever is larger.
CXHR,CXHL,CYHT,CYHB	N_{hp}
IHSN	$2N_{hp}$
IBPA, IBPB	N_{hs}
IBZN	$N_{qp}+N_{hs}$
P,WP,NCBA,NCEA,NCBF,NCEF,NCBH,NCEH	N_R
X	N_R,N_o
S	N_R,N_{oT}
A	N_R,N_R
B	N_R+N_n
V	N_e or $3N_R$, whichever is larger.
AU,IC	$5,N_e/2$
AL	[1]$N_m,N_e/2$

[1]These dimensions are approximate. The exact sizes required are calculated and printed in subroutine ORDER. N_m is N_x+3 or N_y+3, whichever is smaller.

Note that array variables that have a single dimension (CX, CY, QBF, HO, etc.) and are passed to subroutines are dimensioned as unity within the subroutines (only the initial address of an array is actually passed to a subroutine). This unit dimension should not be changed in subroutines when the dimension of the variable is changed in the main program. A similar system is used for multidimensional arrays, and their dimensions within subroutines should not be changed either. To accompany any change in program dimensions, variable NVD must be set equal to the dimensions of A and the first dimension of X, and variable NAD must be set equal to the first dimension of AL. These variables are defined near the beginning of the main program.

Input Data.—The input is arranged into data sets, each data set being composed of one or more lines of logically related input data, such as cell-by-cell multipliers for x-direction transmissivity or zone-by-zone initial parameter values. Each input line in a data set is a maximum of 80 columns, or characters, long. The formats for the data applying for each line are given with the discussions of the data sets.

Data Set A.
Three title lines of user's choice (format, 20A4).
Data Set B.
Problem size information; one line (format, 16I5).

Line columns	Variable	Definition
1-5	ID	Number of node columns.
6-10	JD	Number of node rows.
11-15	NZNS	Number of aquifer property zones.
16-20	NOBS	Number of observations of head.
21-25	NPAR	Number of regression parameters associated with aquifer property zones.
26-30	NVAR	Total number of regression parameters.
31-35	NWELS	Number of known point flows.
36-40	NQBZ	Number of specified-flow boundary zones.
41-45	NHBZ	Number of specified-head boundary zones.
46-50	NUM	Maximum number of iterations allowed for the regression analysis.
51-55	IPRX	Additional print sensitivities and orthogonalize-sensitivities option. Code 1 to select the option.
56-60	IPO	Additional printout option. Code 1 to select the option.
61-65	ISO	Head-solutions only option. Code 1 to select the option.

Data Set C.
Special input parameters; one line (format, 8F10.0).

Line columns	Variable	Definition
1-10	DMX	Maximum fractional change, t_{mx}, allowed any regression parameter over any iteration.
11-20	CSA	Cosine, $\cos\theta_{mx}$, of the maximum angle allowed between the gradient direction and the search direction (normally set to 0.08).
21-30	RP	Ridge parameter for regression analysis using prior information of unknown reliability. Code 0.0 if not used.
31-40	BP	Bias parameter for regression using prior information of unknown reliability. Code 0.0 if not used.
41-50	EV	Estimated error variance for problems using prior information of known reliability. Code 0.0 if not used.

Data Sets D through K.

A number of variables are input into the code by first subdividing the grid into rectangular regions (blocks) and then reading the variables for each block. Blocking can be applied to either cells or nodes, depending upon the variable being input. Blocking allows considerable flexibility in the input of certain variables and, once understood, can speed the construction of a model. Block and zone boundaries do not necessarily have to coincide; blocking is basically a convenient way of assigning variable values to every node or cell in the grid.

Data sets D through K represent the real (floating-point) variables subject to blocking. These variables, in the order they must appear, are listed next.

Data Set	Variable	Type of Variable	Definition
D	DX	Cell array	Distance between node points in x or I direction.
E	DY	Cell array	Distance between node points in y or J direction.
F	CX	Cell array	Multiplier (cell value) for x-direction transmissivity.
G	CY	Cell array	Multiplier (cell value) for y-direction transmissivity.
H	VL	Cell array	Multiplier (cell value) for hydraulic conductance of confining bed.
I	HR	Nodal array ...	Head on boundary of confining bed opposite the aquifer.
J	QR	Cell array	Multiplier (cell value) for recharge rate per unit area.
K	HC	Nodal array ...	Initial head at active node or fixed head at specified-head node.

Each data set D through K consists of an initial line defining the number of blocks (NOBL) into which the grid has been subdivided, and then a subsequent line or set of lines that define the blocks and the value or values of the variable to be input. The initial line, read with a A4, lX, 2I5 format, has the following form:

Line columns	Variable	Definition
1-4	NME	Array name for the variable.
6-10	NOBL	Number of rectangular input blocks into which the variable has been subdivided.
11-15	IPRN	Print option for full array. Set to 0 for print. Set to 1 for no output.

The initial line directs the program to seek NOBL blocks of information for a particular variable. If the variable is uniform over the block, then a single line suffices to define the block location and the uniform value to be assigned to every node or cell. If the variable is nonuniform over the block, then by specifying a value of IVAR equal unity on this line the program can be directed to seek additional lines specifying values of the variable for each node or cell in the block. This information is input through the format 4I5, F10.0,I5 as follows:

Line columns	Variable	Definition
1-5	IB	Beginning column of the rectangular input block.
6-10	IE	Final column of the rectangular input block.
11-15	JB	Beginning row of the rectangular input block.
16-20	JE	Final row of the rectangular input block.
21-30	FACT	If the array set is uniform for the entire block, FACT is the cell or nodal value that is assigned to each element. If the array set is not uniform, each cell or nodal value on the subsequent data lines will be multiplied by FACT.
31-35	IVAR	Code 0 if the array set is uniform. Code 1 if it is not uniform.

If a value of IVAR equal to unity is specified, then the program will seek subsequent node or cell data sufficient to define the variable at every node or cell in the block. This information is input through the temporary variable A(I,J) with an 8F10.0 format in the following manner:

Line columns	Variable	Definition
1-10	A(IB,JB)	Temporary variable specifying nodal or cell values for the arrays in data sets D through K. Note that the information is read in row by row for the grid, each new row beginning a new line.
11-20	A(IB+1,JB)	
⋮	⋮	
	A(IE,JB)	
1-10	A(IB,JB+1)	
⋮	A(IB+1,JB+1)	
	⋮	
	A(IE,JB+1)	
	⋮	
	A(IE,JE)	

Any variable that is not defined by blocking over a particular part of the grid will be automatically set to zero on that part.

Data sets D and E, representing the internal spatial dimensions of the grid, are read in by blocking for convenience to the programmer. Because both the horizontal spacing DX and vertical spacing DY (as measured from the lower left corner of the grid) are, in reality, singly dimensioned arrays, it is necessary to set JB and JE equal to unity for both variables. The variable IE then equals ID-1 in the case of DX, and JD-1 in the case of DY (IB equals one, of course, in both cases). Variable grid spacing can be input by specifying a value of IVAR equal to unity and following this with the necessary array information in an 8F10.0 format.

Note that only cell values of x- and y-direction transmissivities, hydraulic conductance, and recharge (data sets F, G, H, and J) are read in through the blocking scheme. Data set P contains the zonal values by which these cell values are multiplied. A typical example of usage would be to form transmissivity as the product of hydraulic conductivity and thickness. Data sets F and G would contain the variable thickness of the aquifer, and the variable in data set P would represent the hydraulic conductivity zone by zone. Their product would be the transmissivity.

Data Set L.

Two integer variables also are input by blocking. Both are defined below, as read in by a 16I5 format, although only that variable associated with data set L is input at this location.

Data Set	Variable	Type of Variable	Definition
L	IZN	Cell array	Zone number of each cell. Each cell having a nonzero zone number must have CX or CY>0.
S	IN	Nodal array ...	Denotes specified head. Set to -1 at nodes where head is specified, including nodes in segments involving specified-head regression parameters, and leave as zero at all remaining nodes.

The initial line for these data is identical to that of the real variable case. The line defining blocks into which integer variables are divided is similar to that of the real variable case with the exception of the variable IFACT, as noted subsequently (format, 6I5):

Line columns	Variable	Definition
1-5	IB	Beginning column of the rectangular input block.
6-10	IE	Final column of the rectangular input block.
11-15	JB	Beginning row of the rectangular input block.
16-20	JE	Final row of the rectangular input block.
21-25	IFACT	If the array set is uniform for the entire block, IFACT is the cell or nodal value that is assigned to each grid point. If the array set is not uniform, each cell or nodal value on the subsequent data lines will not be multiplied by IFACT.
26-30	IVAR	Code 0 if the array set is uniform. Code 1 if it is not uniform.

The nonuniform integer input is identical to the real variable case, except that the temporary variable INT(I,J) input with format 16I5 is used in place of A(I,J).

Data set M.

Observed head data; set contains NOBS lines (format 3I5,4F10.0).

Line columns	Variable	Definitions
1-5	N	Observation number.
6-10	IL	Cell column in which observation lies.
11-15	JL	Cell row in which observation lies.
16-25	XL	x location of observation.
26-35	YL	y location of observation.
36-45	HO(N)	Observed value of head.
46-55	W(N)	Reliability weight, ω.

Observations are numbered from 1 through NOBS but may be read in any order. Observation N is assumed to lie in cell (IL,JL) at x and y location (XL,YL). If the observation lies on a node point, it may be assigned to any adjacent cell bounded by the node. The origin for x and y is assumed to be node (1,1). Omit this data set if NOBS=0.

Data Set N.

Aquifer regression parameter numbers; set contains NZNS lines (format, 16I5).

Line columns	Variable	Definition
1-5	I	Zone number.
6-10	IPRM(1,I)	Parameter number of x-transmissivity in zone I. Code 0 if it is not a regression parameter.
11-15	IPRM(2,I)	Parameter number of y-transmissivity in zone I. Code 0 if it is not a regression parameter.
16-20	IPRM(3,I)	Parameter number for hydraulic conductance in zone I. Code 0 if it is not a regression parameter.
21-25	IPRM(4,I)	Parameter number for distributed recharge in zone I. Code 0 if it is not a regression parameter.

Lines may appear in any order with respect to zone number, but there must be NZNS lines. Parameters may have any number from 1 through NVAR. Note that parameters of the same (or even different) property in different zones may have identical parameter numbers. Omit this data set if NPAR equals zero.

Data Set O.

Standard deviations for aquifer regression parameters; one value per line for a total of NPAR lines (format, I5,F10.0).

Line columns	Variable	Definition
1-5	K	Aquifer parameter number.
6-15	WP(K)	Standard deviation of each aquifer regression parameter. Code 0.0 if no prior information exists for the parameter.

Omit data set if NPAR equals zero.

Data Set P.

Zonal aquifer property values; set contains NZNS lines (format, I5,4F10.0).

Line columns	Variable	Definitions
1-5	I	Zone number.
6-15	PAR(1)	Zonal x-transmissivity value for zone I.
16-25	PAR(2)	Zonal y-transmissivity value for zone I.
26-35	PAR(3)	Zonal hydraulic conductance value for zone I.
36-45	PAR(4)	Zonal distributed recharge value for zone I. (PAR(4)*QR has units of volumetric rate per unit area.)

Lines may appear in any order with respect to zone number, but there must be NZNS lines.

Data Set Q.

Known point flow rates; set contains NWELS lines (format, 2I5,F10.0).

Line columns	Variable	Definition
1-5	I	Column location of point flow.
6-10	J	Row location of point flow.
11-20	WELL(I,J)	Total volumetric flow to or from node, negative for withdrawal.

If a point flow is located between node points, the total rate can be apportioned among the four adjacent nodes using bilinear or similar interpolation. The apportioned flow rates must be supplied by the user. Omit data set if NWELS equals zero.

Data Set R.

Specified boundary-flow zones and flow-zone parameters; set contains NQBZ lines, one line for each zone (format, 5I5,3F10.0).

Line columns	Variable	Definition
1-5	IA	Column location of the A end of the segment (zone).
6-10	JA	Row location of the A end of the segment (zone).
11-15	IB	Column location of the B end of segment (zone).
16-20	JB	Row location of the B end of segment (zone).
21-25	IP	Regression parameter number. Set equal to zero if QB is not a regression parameter.
26-35	QB	Zonal flow value.
36-45	SDQB ...	Standard deviation for regression parameter. Code as 0.0 if no prior information exists on the parameter.
46-55	QBM	Multiplier for zonal flow value.

Note that IA≤IB and JA≤JB, which define the A and B ends of the segment. If IA equals IB and JA equals JB, the flow is restricted to a single node. In this case, the product QB*QBM equals total volumetric flow into or out of the node. Otherwise, the product is a volumetric rate per unit cell width. When data set is used to model flow boundary conditions, zone must follow either a row or column. Regression parameters can have any numbers from 1 to NVAR. Note that by setting IP equal to zero, a fixed specified-flow condition is simulated. Omit data set when NQBZ equals zero.

Data Set S.

Specified-head boundary designation; see data set L. This data set, when used in conjunction with data set K or T (following), can be used to construct specified-head boundaries. In particular, nodes designated in this data set by -1 are forced to take on values specified in data set K or T. In addition to peripheral boundary conditions, this data set, in conjunction with data set K or T, can be used to model other constant head conditions such as bodies of open water.

Data Set T.

This data set defines specified-head boundary parameter zones. Each zone is associated with a subset of the T data and the number of subsets will equal NHBZ. The initial line in each subset contains size and descriptive information about the zone and appears as follows (format, 4I5,2F10.0).

Line columns	Variable	Definition
1-5	IZ	Segment or zone number.
6-10	NN	Number of nodes in the segment.
11-15	IBPA	Regression parameter number for A end of segment. Set equal to zero if head at the A end is not a regression parameter.
16-20	IBPB	Regression parameter number for B end of segment. Set equal to zero if head at the B end is not a regression parameter.
21-30	SDHA	Standard deviation of head at A end of segment. Code as 0.0 if no prior information exists on the parameter.
31-40	SDHB	Standard deviation of head at B end of segment. Code as 0.0 if no prior information exists on the parameter.

The A and B ends are arbitrary. Segments are numbered from 1 through NHBZ, and regression parameters may have any number from 1 through NVAR. A single head change can be found for all the intermediate specified head nodes by allowing IBPA to equal IBPB.

After reading the initial line, the program then seeks NN subsequent lines in each subset that define the heads along the boundary segment (format, 2I5,F10.0).

Line columns	Variable	Definition
1-5	ILOC	Column location of node.
6-10	JLOC	Row location of node.
11-20	V	Estimated head at node ILOC, JLOC.

Note that any shape of head surface can be input along a boundary segment. Because heads at the segment ends are the only regression parameters in each segment, their influence is distributed to the intermediate nodes by linear interpolation. The linear interpolation is based upon distance from the parameter in question, with a weight of one assigned at the end node occupied by the parameter and zero at the node of the opposite end of the segment. If zeros are assigned to the head variables V at intermediate nodes in a boundary segment, then the program automatically assumes that the head surface along the segment is simply a straight line between the heads specified at the end nodes. Omit the entire data set if NHBZ equals zero.

The following data sets are required only if the solution-only option (ISO, data set B) is specified. In the following description input variables are loosely termed parameters for convenience, but it must be realized that they are not actually regression parameters because no regression is performed. Also, data set V requires that the parameters being varied have nonzero numbers corresponding to regression parameter numbers defined for the initial solution. Hence, the input for the initial solution must be coded as if it were to be a regression for these parameters although no regression will actually be performed.

Data Set U.
Additional solution specification, one line (format, I5).

Line columns	Variable	Definition
1-5	N	Number of solutions required using alternative parameter sets. Code 0 if a solution is desired only for the initial set of parameters.

Data Set V.
New set of parameters; the set contains NVAR lines (format I5,F10.0).

Line columns	Variable	Definition
1-5	I	Parameter number.
6-15	B(I)	Parameter value.

Parameters are numbered in the same order as used for the initial solution. This data set is repeated N times, and the program will compute and print the solution corresponding to each set of parameters.

Output.—The following discussion gives the content and order of the output obtained from the program. It should be noted that some of the output is only obtained under certain specified conditions. All output is clearly labeled. However, order numbers in the following discussion do not appear in the output; they are for convenience in listing the order of output only. The statistical measures cited below are described in section 5.

1. Three title lines (data set A).
2. Problem size information (data set B).
3. Special input parameters (data set C).
4. Array sets (data sets D through L). For each variable, input information (variable name, block number, IB, IE, JB, JE, and value of FACT or IFACT) for each block is listed block by block. If specified, this information is then followed by the values of all entries in the array.
5. Observed head data (data set M).
6. Aquifer regression parameter numbers (data set N). This input is printed only if NPAR is greater than zero.
7. Coefficients of variation for aquifer regression parameters (data set O). This input is printed only if NPAR is greater than zero.
8. Zonal aquifer properties (data set P).
9. Known point-flow rates (data set Q). This input is printed only if NWELS is greater than zero.
10. Specified boundary-flow information (data set R). This input is printed only if NQBZ is greater than zero.
11. Specified boundary-head distribution (data set S). This input is printed in the same manner as indicated under 4.
12. Specified boundary-head information (data set T). For each segment, input information (segment number, number of nodes in the segment, IBPA, IBPB, SDHA, and SDHB) is printed followed by a listing of node locations and input values of specified heads. This input is printed only if NHBZ is greater than zero.
13. Error message. If IZN >0, CX≤0, and CY≤0 occur at the same cell, then the following error message is printed: "AT CELL (*i,j*), IZN >0, CX=0, AND CY=0."
14. Error message. If the error in 13 happens at one or more cells, then the following message is printed: "PROGRAM ABORTED BECAUSE OF CONFLICT BETWEEN IZN, CX, AND CY." Execution then terminates.
15. Error message. If an active node is isolated from other active nodes, then the following message is printed: AC-TIVE NODE (*i,j*) CANNOT BE ISOLATED." Execution then terminates.
16. Information on matrix solution procedure used to compute heads. Message that solution is by LDU factorization is followed by the computed minimum required dimensions of arrays used in the solution.
17. Initial solution for heads.
18. Program branch. If the solution-only option is specified, then output skips to 35.
19. Number of parameters having prior information.
20. Sensitivity matrix $\underline{X}$. This is printed only if optional print-out was selected.
21. Error message. If any diagonal term of the coefficient matrix $\underline{\underline{S}}_s^T\underline{\underline{V}}_s^{-1}\underline{\underline{S}}_s+\underline{\underline{S}}_p^T\underline{\underline{U}}^{-1}\cdot\underline{\underline{S}}_p s^2$ of the normal equations is smaller than 10^{-10}, then the following message is printed: "SENSITIVITIES FOR PARAMETER *i* EFFECTIVELY ZERO." If this error occurs, the current weighted residuals $\hat{\underline{u}}$ (section 5.5.1) are then printed. If the sensitivity print and orthogonalization option was selected, the sensitivities and orthogonalized sensitivities are also printed in the forms given in 33 and 34. Execution then terminates.
22. Coefficient matrix $\underline{\underline{S}}_s^T\underline{\underline{V}}_s^{-1}\underline{\underline{S}}_s+\underline{\underline{S}}_p^T\underline{\underline{U}}^{-1}\underline{\underline{S}}_p s^2+\mu\underline{\underline{I}}$ and the gradient vector $\underline{\underline{S}}_s^T\underline{\underline{V}}_s^{-1}(\underline{Y}_s-\underline{f}_s(\underline{\underline{\xi}},\underline{b}))+\underline{\underline{S}}_p^T\underline{\underline{U}}^{-1}s^2(\underline{Y}_p-\underline{f}_p(\underline{\underline{\xi}},\underline{b}))$. This output is printed only if the optional print-out was selected. (Note: If prior information of unknown reliability was used, then the matrix and vector will be modified to include this information.)
23. Error message. If, during solution of the normal equations, it becomes evident

that the problem is singular, then the following message is printed: "LEAST SQUARES COEFFICIENT MATRIX SINGULAR; SOLUTION FOR PARAMETERS NOT UNIQUE." The course of action is then the same as that given under 21.

24. Iteration number, current sum of weighted, squared deviations of computed from observed heads, determinant of the current least squares coefficient matrix defined in 22 above, current value of μ, current value of ρ, followed by the current parameter vector $\underline{b}_{r+1}$ defined by equation 3.3-19.
25. Error message. If a parameter is more than one thousand times smaller in magnitude than initially specified, then, the message "PARAMETER *i* EFFECTIVELY ZERO" is printed. If this problem occurs, then further iterations are aborted, the current solution is taken as the final one, and the course of action given in 21 is taken.
26. Solution converged message and final number of iterations. If the solution did not converge in the allotted number of iterations, then a message to this effect is written instead, and output skips to 32.
27. Error message. If the coefficient matrix of the normal equations (see 22) is singular when μ=0, and this status has not been detected because μ>0 has been computed and used by the program, then the message given in 23 is printed. In this case the subsequent course of action is the same as in 21.
28. Error variance (s^2) (section 5.4.1), final total sum of squares (sum of weighted, squared deviations of computed from observed heads plus sum of weighted, squared deviations of computed from prior estimates of parameters), and correlation coefficient (R_y) (section 5.4.2).
29. Final parameter estimates and their estimated standard errors (section 5.4.3).
30. Estimated variance-covariance matrix, $(\underline{X}_s^T \underline{V}_s^{-1} \underline{X}_s + \underline{X}_p^T \underline{U}^{-1} \underline{X}_p s^2)^{-1} s^2$ (section 5.4.3). The ordering of rows and columns matches that for $\underline{b}$ in 24.
31. Correlation matrix for parameters, $\{r_{ij}\} = \{\mathrm{Cov}(b_i,b_j)/(\mathrm{Var}(b_i)\cdot\mathrm{Var}(b_j))^{1/2}\}$ (section 5.4.4). Again, the ordering matches that for $\underline{b}$.
32. Computed and observed heads, and weighted residuals, $\hat{\underline{u}}$ (section 5.5.1).
33. Nodal sensitivities printed parameter by parameter. These are printed only if the sensitivity print and orthogonalization option was selected or if the solution did not converge.
34. Orthogonalized, scaled sensitivities, $\underline{\underline{Q}}$, with the sensitivities for the prior information forming the last n_p rows. These are printed only if the sensitivities in 33 above are printed. This completes the output for regression solutions.
35. New parameters (data set V), all in sequential order; the solution number, and the solution for heads. These are printed for all solutions when the solution-only option is invoked.

Example Problem.—The following example problem illustrates use of most of the program options. As illustrated in figure 4.3-8, the modeled area consists of three aquifer zones bounded by three specified boundary-flow zones containing three boundary-flow regression parameters, a no-flow boundary, and two specified boundary-head segments containing three boundary-head regression parameters. Initial values for the regression parameters are:

q_{B1}=8	T_3=1,000
q_{B2}=0.8	W_1=0.0001
q_{B3}=1	W_2=0.0005
h_{B1}=40	W_3=-0.0001
h_{B2}=10	R_1=0.001
h_{B3}=16	R_2=0.0007
T_1=4,000	R_3=0.0015.
T_2=400	

Parameter q_{B1} has prior information with a standard deviation of 0.8 on it. Because all aquifer properties and boundary flows are constant within their respective zones, multipliers for these parameters may be assigned values of unity. Assume that the estimated error variance

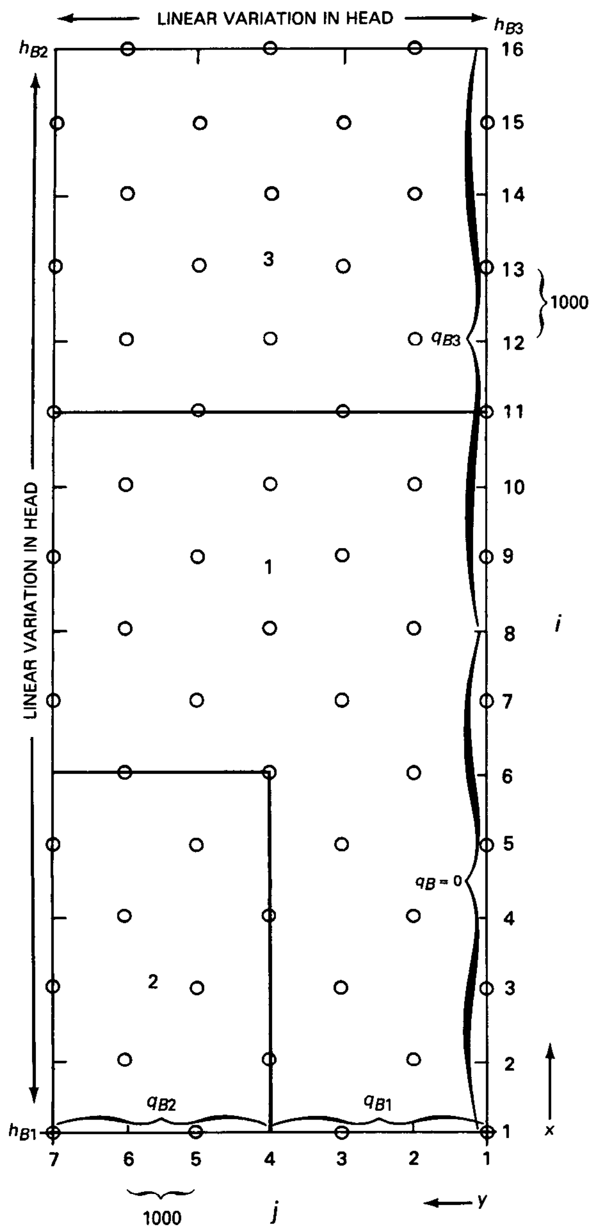

Figure 4.3-8

for use with the prior information has a value of unity, t_{mx}=1.5, and cosΘ_{mx}=0.08.

Locations of observed heads are indicated by the small open circles on figure 4.3-8. Values corresponding to these locations are given in table 4.3-2. All observations have a weight ω_{ii} of unity.

Table 4.3-2

Node	Value	Node	Value
(1,1)	29.51	(10,4)	22.46
(3,1)	26.38	(12,4)	17.16
(5,1)	25.16	(14,4)	15.74
(7,1)	26.81	(16,4)	14.69
(9,1)	23.82	(1,5)	36.05
(11,1)	23.59	(3,5)	31.64
(13,1)	16.68	(5,5)	32.91
(15,1)	15.31	(7,5)	25.05
(2,2)	28.27	(9,5)	25.47
(4,2)	25.17	(11,5)	20.39
(6,2)	26.94	(13,5)	14.40
(8,2)	23.59	(15,5)	14.37
(10,2)	22.53	(2,6)	38.66
(12,2)	17.89	(4,6)	34.51
(14,2)	15.87	(6,6)	27.81
(16,2)	15.98	(8,6)	25.98
(1,3)	31.25	(10,6)	22.16
(3,3)	27.50	(12,6)	15.73
(5,3)	26.22	(14,6)	14.79
(7,3)	25.65	(16,6)	10.48
(9,3)	24.35	(1,7)	41.28
(11,3)	22.48	(3,7)	34.82
(13,3)	15.85	(5,7)	32.00
(15,3)	15.71	(7,7)	26.97
(2,4)	29.36	(9,7)	25.67
(4,4)	27.76	(11,7)	18.12
(6,4)	25.51	(13,7)	18.40
(8,4)	24.43	(15,7)	11.90

Heads H on the distal side of the aquitard are computed by first assigning constant values to all cells in an aquifer property zone, then computing nodal values as the average of all adjacent cell values. Cell values are 25 for zone 1, 35 for zone 2, and 15 for zone 3.

Input data for the example problem are coded on figure 4.3-9 and are contained in file EXPROB.DAT in the diskette accompanying this report. These data should be compared with the data input instructions given above.

Output is given in figure 4.3-10. Statistical measures listed are described in section 5.

EXAMPLE PROBLEM FOR DATA INPUT

```
   16    7    3   56    9   15     0     3     2    20     1     1     0
        1.5        .08         0           0           1
DX       1    0
    1   15    1    1       1000
DY       1    0
    1    6    1    1       1000
CX       1    0
    1   15    1    6          1
CY       1    0
    1   15    1    6          1
VL       1    0
    1   15    1    6          1
HR       8    0
    1    6    1    3         25
    7   10    1    7         25
    1    5    4    4         30
    6    6    4    4       27.5
    6    6    5    7         30
    1    5    5    7         35
   11   11    1    7         20
   12   16    1    7         15
QR       1    0
    1   15    1    6          1
HC       1    0
    1   16    1    7         10
IZN      4    0
    1    5    1    3    1
    6   10    1    6    1
    1    5    4    6    2
   11   15    1    6    3
    1    1    1         0          0     29.51          1
    2    3    1      2000          0     26.38          1
    3    5    1      4000          0     25.16          1
    4    7    1      6000          0     26.81          1
    5    9    1      8000          0     23.82          1
    6   11    1     10000          0     23.59          1
    7   13    1     12000          0     16.68          1
    8   15    1     14000          0     15.31          1
    9    2    2      1000       1000     28.27          1
   10    4    2      3000       1000     25.17          1
   11    6    2      5000       1000     26.94          1
   12    8    2      7000       1000     23.59          1
   13   10    2      9000       1000     22.53          1
   14   12    2     11000       1000     17.89          1
   15   14    2     13000       1000     15.87          1
   16   15    2     15000       1000     15.98          1
   17    1    3         0       2000     31.25          1
   18    3    3      2000       2000     27.50          1
   19    5    3      4000       2000     26.22          1
   20    7    3      6000       2000     25.65          1
```

Figure 4.3-9

```
21   9   3    8000    2000   24.35     1
22  11   3   10000    2000   22.48     1
23  13   3   12000    2000   15.85     1
24  15   3   14000    2000   15.71     1
25   2   4    1000    3000   29.36     1
26   4   4    3000    3000   27.76     1
27   6   4    5000    3000   25.51     1
28   8   4    7000    3000   24.43     1
29  10   4    9000    3000   22.46     1
30  12   4   11000    3000   17.16     1
31  14   4   13000    3000   15.74     1
32  15   4   15000    3000   14.69     1
33   1   5       0    4000   36.05     1
34   3   5    2000    4000   31.64     1
35   5   5    4000    4000   32.91     1
36   7   5    6000    4000   25.05     1
37   9   5    8000    4000   25.47     1
38  11   5   10000    4000   20.39     1
39  13   5   12000    4000   14.40     1
40  15   5   14000    4000   14.37     1
41   2   6    1000    5000   38.66     1
42   4   6    3000    5000   34.51     1
43   6   6    5000    5000   27.81     1
44   8   6    7000    5000   25.98     1
45  10   6    9000    5000   22.16     1
46  12   6   11000    5000   15.73     1
47  14   6   13000    5000   14.79     1
48  15   6   15000    5000   10.48     1
49   1   6       0    6000   41.28     1
50   3   6    2000    6000   34.82     1
51   5   6    4000    6000   32.00     1
52   7   6    6000    6000   26.97     1
53   9   6    8000    6000   25.67     1
54  11   6   10000    6000   18.12     1
55  13   6   12000    6000   18.40     1
56  15   6   14000    6000   11.90     1
 1   1   1   4   7
 2   2   2   5   8
 3   3   3   6   9
 1       0
 2       0
 3       0
 4       0
 5       0
 6       0
 7       0
 8       0
 9       0
 1    4000    4000    .001    .0001
 2     400     400   .0007    .0005
 3    1000    1000   .0015   -.0001
 1   1   1   4  10       8       .8     1
 1   4   1   7  11      .8        0     1
```

Figure 4.3-9—Continued

```
    8    1   16    1   12         1         0         1
IN       2    0
   16   16    1    7   -1
    1   15    7    7   -1
    1   16   13   14         0         0
    1    7        40
    2    7
    3    7
    4    7
    5    7
    6    7
    7    7
    8    7
    9    7
   10    7
   11    7
   12    7
   13    7
   14    7
   15    7
   16    7        10
    2    7   14   15         0         0
   16    7        10
   16    6
   16    5
   16    4
   16    3
   16    2
   16    1        16
```

Figure 4.3-9—Continued

```
EXAMPLE PROBLEM FOR DATA INPUT

NUMBER OF COLUMNS (ID) ------------------------------ =   16
NUMBER OF ROWS (JD) --------------------------------- =    7
NUMBER OF AQUIFER ZONES (NZNS) ---------------------- =    3
NUMBER OF OBSERVATIONS (NOBS) ----------------------- =   56
NUMBER OF AQUIFER PARAMETERS (NPAR) ----------------- =    9
TOTAL NUMBER OF PARAMETERS (NVAR) ------------------- =   15
NUMBER OF KNOWN POINT FLOWS (NWELS) ----------------- =    0
NUMBER OF SPECIFIED FLOW ZONES (NQBZ) --------------- =    3
NUMBER OF SPECIFIED HEAD ZONES (NHBZ) --------------- =    2
MAXIMUM NUMBER OF ITERATIONS (NUM) ------------------ =   20
SENSITIVITY PRINT AND ORTHOGONALIZATION OPTION (IPRX) =    1
ADDITIONAL PRINTOUT OPTION (IPO) -------------------- =    1
SOLUTION ONLY OPTION (ISO) -------------------------- =    0
MAXIMUM ALLOWABLE PARAMETER CORRECTION (DMX) - =  1.5000
SEARCH DIRECTION ADJUSTMENT PARAMETER (CSA) -- =  .80000E-01
RIDGE PARAMETER FOR REGRESSION (RP) ---------- =  .00000
BIAS PARAMETER FOR REGRESSION (BP) ----------- =  .00000
ESTIMATED ERROR VARIANCE (EV) ---------------- =  1.0000

DX
 1  IB =    1  IE =   15  JB =    1  JE =    1  FACT =  1000.0

DX  ARRAY

          1         2         3         4         5         6         7         8         9        10

 1   1000.0    1000.0    1000.0    1000.0    1000.0    1000.0    1000.0    1000.0    1000.0    1000.0

         11        12        13        14        15

 1   1000.0    1000.0    1000.0    1000.0    1000.0

DY
 1  IB =    1  IE =    6  JB =    1  JE =    1  FACT =  1000.0

DY  ARRAY

          1         2         3         4         5         6

 1   1000.0    1000.0    1000.0    1000.0    1000.0    1000.0

CX
 1  IB =    1  IE =   15  JB =    1  JE =    6  FACT =  1.0000
```

CX ARRAY

	1	2	3	4	5	6	7	8	9	10
6	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
5	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
4	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
3	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

	11	12	13	14	15
6	1.0000	1.0000	1.0000	1.0000	1.0000
5	1.0000	1.0000	1.0000	1.0000	1.0000
4	1.0000	1.0000	1.0000	1.0000	1.0000
3	1.0000	1.0000	1.0000	1.0000	1.0000
2	1.0000	1.0000	1.0000	1.0000	1.0000
1	1.0000	1.0000	1.0000	1.0000	1.0000

CY
1 IB = 1 IE = 15 JB = 1 JE = 6 FACT = 1.0000

CY ARRAY

	1	2	3	4	5	6	7	8	9	10
6	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
5	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
4	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
3	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

	11	12	13	14	15
6	1.0000	1.0000	1.0000	1.0000	1.0000
5	1.0000	1.0000	1.0000	1.0000	1.0000
4	1.0000	1.0000	1.0000	1.0000	1.0000
3	1.0000	1.0000	1.0000	1.0000	1.0000
2	1.0000	1.0000	1.0000	1.0000	1.0000
1	1.0000	1.0000	1.0000	1.0000	1.0000

VL
1 IB = 1 IE = 15 JB = 1 JE = 6 FACT = 1.0000

Figure 4.3–10

```
VL    ARRAY

          1        2        3        4        5        6        7        8        9       10

  6  1.0000   1.0000   1.0000   1.0000   1.0000   1.0000   1.0000   1.0000   1.0000   1.0000
  5  1.0000   1.0000   1.0000   1.0000   1.0000   1.0000   1.0000   1.0000   1.0000   1.0000
  4  1.0000   1.0000   1.0000   1.0000   1.0000   1.0000   1.0000   1.0000   1.0000   1.0000
  3  1.0000   1.0000   1.0000   1.0000   1.0000   1.0000   1.0000   1.0000   1.0000   1.0000
  2  1.0000   1.0000   1.0000   1.0000   1.0000   1.0000   1.0000   1.0000   1.0000   1.0000
  1  1.0000   1.0000   1.0000   1.0000   1.0000   1.0000   1.0000   1.0000   1.0000   1.0000

         11       12       13       14       15

  6  1.0000   1.0000   1.0000   1.0000   1.0000
  5  1.0000   1.0000   1.0000   1.0000   1.0000
  4  1.0000   1.0000   1.0000   1.0000   1.0000
  3  1.0000   1.0000   1.0000   1.0000   1.0000
  2  1.0000   1.0000   1.0000   1.0000   1.0000
  1  1.0000   1.0000   1.0000   1.0000   1.0000

HR
  1  IB =     1  IE =     6  JB =     1  JE =     3  FACT =  25.000
  2  IB =     7  IE =    10  JB =     1  JE =     7  FACT =  25.000
  3  IB =     1  IE =     5  JB =     4  JE =     4  FACT =  30.000
  4  IB =     6  IE =     6  JB =     4  JE =     4  FACT =  27.500
  5  IB =     6  IE =     6  JB =     5  JE =     7  FACT =  30.000
  6  IB =     1  IE =     5  JB =     5  JE =     7  FACT =  35.000
  7  IB =    11  IE =    11  JB =     1  JE =     7  FACT =  20.000
  8  IB =    12  IE =    16  JB =     1  JE =     7  FACT =  15.000
```

HR ARRAY

HR	1	2	3	4	5	6	7	8	9	10
7	35.000	35.000	35.000	35.000	35.000	30.000	25.000	25.000	25.000	25.000
6	35.000	35.000	35.000	35.000	35.000	30.000	25.000	25.000	25.000	25.000
5	35.000	35.000	35.000	35.000	35.000	30.000	25.000	25.000	25.000	25.000
4	30.000	30.000	30.000	30.000	30.000	27.500	25.000	25.000	25.000	25.000
3	25.000	25.000	25.000	25.000	25.000	25.000	25.000	25.000	25.000	25.000
2	25.000	25.000	25.000	25.000	25.000	25.000	25.000	25.000	25.000	25.000
1	25.000	25.000	25.000	25.000	25.000	25.000	25.000	25.000	25.000	25.000

HR	11	12	13	14	15	16
7	20.000	15.000	15.000	15.000	15.000	15.000
6	20.000	15.000	15.000	15.000	15.000	15.000
5	20.000	15.000	15.000	15.000	15.000	15.000
4	20.000	15.000	15.000	15.000	15.000	15.000
3	20.000	15.000	15.000	15.000	15.000	15.000
2	20.000	15.000	15.000	15.000	15.000	15.000
1	20.000	15.000	15.000	15.000	15.000	15.000

Figure 4.3-10—Continued

QR
1 IB = 1 IE = 15 JB = 1 JE = 6 FACT = 1.0000

QR ARRAY

	1	2	3	4	5	6	7	8	9	10
6	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
5	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
4	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
3	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

	11	12	13	14	15
6	1.0000	1.0000	1.0000	1.0000	1.0000
5	1.0000	1.0000	1.0000	1.0000	1.0000
4	1.0000	1.0000	1.0000	1.0000	1.0000
3	1.0000	1.0000	1.0000	1.0000	1.0000
2	1.0000	1.0000	1.0000	1.0000	1.0000
1	1.0000	1.0000	1.0000	1.0000	1.0000

HC
1 IB = 1 IE = 16 JB = 1 JE = 7 FACT = 10.000

HC ARRAY

	1	2	3	4	5	6	7	8	9	10
7	10.000	10.000	10.000	10.000	10.000	10.000	10.000	10.000	10.000	10.000
6	10.000	10.000	10.000	10.000	10.000	10.000	10.000	10.000	10.000	10.000
5	10.000	10.000	10.000	10.000	10.000	10.000	10.000	10.000	10.000	10.000
4	10.000	10.000	10.000	10.000	10.000	10.000	10.000	10.000	10.000	10.000
3	10.000	10.000	10.000	10.000	10.000	10.000	10.000	10.000	10.000	10.000
2	10.000	10.000	10.000	10.000	10.000	10.000	10.000	10.000	10.000	10.000
1	10.000	10.000	10.000	10.000	10.000	10.000	10.000	10.000	10.000	10.000

	11	12	13	14	15	16
7	10.000	10.000	10.000	10.000	10.000	10.000
6	10.000	10.000	10.000	10.000	10.000	10.000
5	10.000	10.000	10.000	10.000	10.000	10.000
4	10.000	10.000	10.000	10.000	10.000	10.000
3	10.000	10.000	10.000	10.000	10.000	10.000
2	10.000	10.000	10.000	10.000	10.000	10.000
1	10.000	10.000	10.000	10.000	10.000	10.000

IZN

1	IB =	1	IE =	5	JB =	1	JE =	3	IFACT =	1
2	IB =	6	IE =	10	JB =	1	JE =	6	IFACT =	1
3	IB =	1	IE =	5	JB =	4	JE =	6	IFACT =	2
4	IB =	11	IE =	15	JB =	1	JE =	6	IFACT =	3

IZN ARRAY

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
6	2	2	2	2	2	1	1	1	1	1	3	3	3	3	3
5	2	2	2	2	2	1	1	1	1	1	3	3	3	3	3
4	2	2	2	2	2	1	1	1	1	1	3	3	3	3	3
3	1	1	1	1	1	1	1	1	1	1	3	3	3	3	3
2	1	1	1	1	1	1	1	1	1	1	3	3	3	3	3
1	1	1	1	1	1	1	1	1	1	1	3	3	3	3	3

OBSERVED HEAD DATA

OBS. NO.	CELL LOC. I	J	X LOC.	Y LOC.	OBS. HEAD	WEIGHT
1	1	1	.00000	.00000	29.510	1.0000
2	3	1	2000.0	.00000	26.380	1.0000
3	5	1	4000.0	.00000	25.160	1.0000
4	7	1	6000.0	.00000	26.810	1.0000
5	9	1	8000.0	.00000	23.820	1.0000
6	11	1	10000.	.00000	23.590	1.0000
7	13	1	12000.	.00000	16.680	1.0000
8	15	1	14000.	.00000	15.310	1.0000
9	2	2	1000.0	1000.0	28.270	1.0000
10	4	2	3000.0	1000.0	25.170	1.0000
11	6	2	5000.0	1000.0	26.940	1.0000
12	8	2	7000.0	1000.0	23.590	1.0000
13	10	2	9000.0	1000.0	22.530	1.0000
14	12	2	11000.	1000.0	17.890	1.0000
15	14	2	13000.	1000.0	15.870	1.0000
16	15	2	15000.	1000.0	15.980	1.0000
17	1	3	.00000	2000.0	31.250	1.0000
18	3	3	2000.0	2000.0	27.500	1.0000
19	5	3	4000.0	2000.0	26.220	1.0000
20	7	3	6000.0	2000.0	25.650	1.0000
21	9	3	8000.0	2000.0	24.350	1.0000
22	11	3	10000.	2000.0	22.480	1.0000
23	13	3	12000.	2000.0	15.850	1.0000
24	15	3	14000.	2000.0	15.710	1.0000
25	2	4	1000.0	3000.0	29.360	1.0000
26	4	4	3000.0	3000.0	27.760	1.0000

Figure 4.3-10—Continued

27	6	4	5000.0	3000.0	25.510	1.0000
28	8	4	7000.0	3000.0	24.430	1.0000
29	10	4	9000.0	3000.0	22.460	1.0000
30	12	4	11000.	3000.0	17.160	1.0000
31	14	4	13000.	3000.0	15.740	1.0000
32	15	4	15000.	3000.0	14.690	1.0000
33	1	5	.00000	4000.0	36.050	1.0000
34	3	5	2000.0	4000.0	31.640	1.0000
35	5	5	4000.0	4000.0	32.910	1.0000
36	7	5	6000.0	4000.0	25.050	1.0000
37	9	5	8000.0	4000.0	25.470	1.0000
38	11	5	10000.	4000.0	20.390	1.0000
39	13	5	12000.	4000.0	14.400	1.0000
40	15	5	14000.	4000.0	14.370	1.0000
41	2	6	1000.0	5000.0	38.660	1.0000
42	4	6	3000.0	5000.0	34.510	1.0000
43	6	6	5000.0	5000.0	27.810	1.0000
44	8	6	7000.0	5000.0	25.980	1.0000
45	10	6	9000.0	5000.0	22.160	1.0000
46	12	6	11000.	5000.0	15.730	1.0000
47	14	6	13000.	5000.0	14.790	1.0000
48	15	6	15000.	5000.0	10.480	1.0000
49	1	6	.00000	6000.0	41.280	1.0000
50	3	6	2000.0	6000.0	34.820	1.0000
51	5	6	4000.0	6000.0	32.000	1.0000
52	7	6	6000.0	6000.0	26.970	1.0000
53	9	6	8000.0	6000.0	25.670	1.0000
54	11	6	10000.	6000.0	18.120	1.0000
55	13	6	12000.	6000.0	18.400	1.0000
56	15	6	14000.	6000.0	11.900	1.0000

AQUIFER PARAMETER NUMBERS

ZONE	TRANX	TRANY	VLEAK	QDIST
1	1	1	4	7
2	2	2	5	8
3	3	3	6	9

STANDARD DEVIATIONS
FOR AQUIFER PARAMETERS

PAR. NO.	STD. DEV.
1	.00000
2	.00000
3	.00000
4	.00000
5	.00000
6	.00000
7	.00000
8	.00000
9	.00000

```
          INITIAL AQUIFER PARAMETERS BY ZONE
ZONE     TRANX         TRANY        VLEAK        QDIST
 1      4000.0        4000.0      .10000E-02   .10000E-03
 2      400.00        400.00      .70000E-03   .50000E-03
 3      1000.0        1000.0      .15000E-02  -.10000E-03

                    INITIAL SPECIFIED FLOW DATA
       NODE NO.S            PAR.     FLOW          STD.
 IA    JA    IB    JB       NO.    PARAMETER       DEV.       MULTIPLIER
  1     1     1     4       10      8.0000        .80000        1.0000
  1     4     1     7       11       .80000       .00000        1.0000
  8     1    16     1       12      1.0000        .00000        1.0000

IN
 1  IB =    16  IE =    16  JB =     1  JE =     7  IFACT =    -1
 2  IB =     1  IE =    15  JB =     7  JE =     7  IFACT =    -1

IN   ARRAY

     1   2   3   4   5   6   7   8   9  10  11  12  13  14  15  16

 7  -1  -1  -1  -1  -1  -1  -1  -1  -1  -1  -1  -1  -1  -1  -1  -1
 6   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0  -1
 5   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0  -1
 4   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0  -1
 3   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0  -1
 2   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0  -1
 1   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0  -1

                INITIAL SPECIFIED HEAD DATA

NO. OF NODES IN ZONE   1 =  16
PAR. NO. HEAD A =  13              PAR. NO. HEAD B =  14
STD. DEV. HEAD A =  .00000         STD. DEV. HEAD B =  .00000
                    INITIAL VALUES OF HEAD
                     I      J       HEAD
                     1      7      40.000
                     2      7      .00000
                     3      7      .00000
                     4      7      .00000
                     5      7      .00000
                     6      7      .00000
                     7      7      .00000
                     8      7      .00000
                     9      7      .00000
                    10      7      .00000
                    11      7      .00000
                    12      7      .00000
                    13      7      .00000
                    14      7      .00000
                    15      7      .00000
                    16      7      10.000
```

Figure 4.3-10—Continued

```
NO. OF NODES IN ZONE   2 =    7
PAR. NO. HEAD A =  14              PAR. NO. HEAD B =  15
STD. DEV. HEAD A =  .00000         STD. DEV. HEAD B =  .00000
                    INITIAL VALUES OF HEAD
                     I     J        HEAD
                    16     7      10.000
                    16     6      .00000
                    16     5      .00000
                    16     4      .00000
                    16     3      .00000
                    16     2      .00000
                    16     1      16.000

SOLUTION BY LDU FACTORIZATION ASSUMING D4 ORDERING
MINIMUM DIMENSIONS FOR ARRAYS USED BY THIS METHOD ARE AS FOLLOWS
 AU:     5 BY    45
 AL:     9 BY    45
 IC:     5 BY    45
  V:    90

 INITIAL SOLUTION
```

	1	2	3	4	5	6	7	8	9	10
7	40.000	38.000	36.000	34.000	32.000	30.000	28.000	26.000	24.000	22.000
6	37.229	36.064	35.263	34.409	32.890	28.278	26.913	25.554	24.162	22.673
5	35.441	34.373	33.789	33.201	31.928	27.398	26.273	25.255	24.188	22.940
4	31.311	29.853	28.947	28.280	27.600	26.598	25.818	25.043	24.168	23.046
3	30.504	28.992	28.034	27.353	26.759	26.128	25.538	24.917	24.161	23.113
2	30.074	28.548	27.576	26.905	26.369	25.875	25.397	24.882	24.212	23.216
1	29.940	28.411	27.438	26.771	26.255	25.800	25.368	24.947	24.366	23.409

	11	12	13	14	15	16
7	20.000	18.000	16.000	14.000	12.000	10.000
6	20.982	17.072	15.556	14.585	13.453	11.000
5	21.315	16.957	15.500	14.807	14.007	12.000
4	21.447	16.977	15.532	14.946	14.378	13.000
3	21.534	17.036	15.605	15.088	14.724	14.000
2	21.660	17.180	15.772	15.308	15.118	15.000
1	21.916	17.623	16.251	15.816	15.719	16.000

```
NO. OF PARAMETERS HAVING PRIOR INFORMATION =     1

   OBSERVATION NUMBER AND SENSITIVITIES FOR EACH PARAMETER
    1 -.38228E-03  .50620E-03 -.10080E-04 -2586.5      83.948      -4.3781      887.72
       131.42      2.7446      .45909      .47201E-01  .63299E-02  .10367E-01  .57848E-02
       .15307E-04
    2  .60319E-04  .48072E-03 -.16301E-04 -1946.1      111.72      -7.0915      885.92
       122.18      4.4396      .15965      .30392E-01  .10512E-01  .13276E-01  .85986E-02
       .24853E-04
```

3	.84556E-04	.35640E-03	-.42379E-04	-1104.0	124.56	-18.535	877.71
	91.807	11.550	.54188E-01	.12744E-01	.29967E-01	.22834E-01	.17803E-01
	.65461E-04						
4	.20950E-04	.19118E-03	-.11934E-03	-377.48	78.699	-52.851	851.92
	49.653	32.568	.17697E-01	.44771E-02	.10882	.33990E-01	.30295E-01
	.18996E-03						
5	-.44029E-04	.83352E-04	-.34274E-03	195.90	36.560	-155.50	774.03
	21.594	93.554	.58100E-02	.15130E-02	.37073	.34274E-01	.35670E-01
	.57555E-03						
6	.26304E-03	.36640E-04	-.98740E-03	64.792	16.440	-468.15	542.22
	9.4671	265.38	.22527E-02	.59308E-03	.49558	.23666E-01	.27636E-01
	.17904E-02						
7	.28057E-04	.35984E-05	.30068E-03	7.7542	1.6281	-698.55	52.278
	.92848	605.89	.21021E-03	.55570E-04	.67776	.30985E-02	.94553E-02
	.25686E-01						
8	.25379E-05	.31618E-06	-.12566E-03	.74317	.14383	-249.14	4.5450
	.81492E-01	453.52	.17832E-04	.47267E-05	.53296	.40054E-03	.24008E-01
	.29071						
9	-.83160E-04	.57567E-03	-.11317E-04	-2294.8	99.794	-4.9144	873.71
	147.71	3.0815	.26739	.48691E-01	.70743E-02	.11698E-01	.65538E-02
	.17175E-04						
10	.74473E-04	.49706E-03	-.25302E-04	-1475.1	149.77	-11.007	869.67
	126.28	6.8912	.91556E-01	.21604E-01	.16239E-01	.18505E-01	.13061E-01
	.38574E-04						
11	.47626E-04	.30114E-03	-.69809E-04	-697.32	120.92	-30.536	855.15
	78.330	19.029	.30075E-01	.76372E-02	.47836E-01	.33684E-01	.27683E-01
	.10790E-03						
12	-.78560E-05	.13518E-03	-.19833E-03	-50.049	58.932	-87.936	812.07
	35.078	54.179	.96800E-02	.25227E-02	.14360	.41772E-01	.40022E-01
	.31695E-03						
13	.66592E-04	.54863E-04	-.56959E-03	331.28	24.679	-258.98	679.82
	14.175	156.44	.33205E-02	.87589E-03	.23450	.34954E-01	.39677E-01
	.96774E-03						
14	.93956E-04	.11523E-04	.78272E-03	26.881	5.2279	-919.11	166.18
	2.9720	533.15	.66123E-03	.17509E-03	.21476	.99077E-02	.14989E-01
	.71191E-02						
15	.90142E-05	.11049E-05	.25398E-03	2.7048	.50386	-286.38	15.800
	.28467	587.43	.61321E-04	.16276E-04	.19256	.14460E-02	.23067E-01
	.78345E-01						
16	.00000	.00000	.00000	.00000	.00000	.00000	.00000
	.00000	.00000	.00000	.00000	.00000	.00000	.16667
	.83333						
17	-.45126E-03	.77585E-03	-.93026E-05	-2315.3	79.365	-4.0344	829.78
	211.03	2.5325	.43630	.10673	.56983E-02	.12821E-01	.58605E-02
	.14073E-04						
18	-.30579E-04	.80329E-03	-.15146E-04	-1711.6	182.15	-6.5629	828.39
	199.47	4.1228	.14804	.43134E-01	.91359E-02	.16340E-01	.94350E-02
	.22863E-04						
19	.28901E-05	.57360E-03	-.39933E-04	-925.31	239.20	-17.263	821.58
	150.39	10.867	.49074E-01	.13689E-01	.22888E-01	.32544E-01	.24242E-01
	.59929E-04						

Figure 4.3-10—Continued

20	.74527E-05	.25177E-03	-.11028E-03	-317.08	113.08	-47.651	798.48
	65.606	30.027	.14925E-01	.40309E-02	.56894E-01	.59526E-01	.50865E-01
	.16546E-03						
21	.97692E-06	.92081E-04	-.32071E-03	231.85	42.275	-139.00	730.34
	23.765	87.594	.48754E-02	.13058E-02	.11083	.58707E-01	.62438E-01
	.48724E-03						
22	.31325E-03	.37011E-04	-.93635E-03	105.13	17.063	-407.58	513.48
	9.5215	258.23	.19044E-02	.50911E-03	.11689	.40150E-01	.50880E-01
	.14719E-02						
23	.29513E-04	.34962E-05	.55627E-03	9.8336	1.6132	-466.70	48.803
	.89858	601.69	.17858E-03	.47720E-04	.66737E-01	.59267E-02	.22167E-01
	.19946E-01						
24	.25224E-05	.29879E-06	-.48766E-04	.83892	.13791	29.768	4.1862
	.76760E-01	451.40	.15211E-04	.40639E-05	.37527E-01	.10161E-02	.10958
	.20807						
25	-.30166E-03	.13148E-02	-.95542E-05	-1554.3	139.64	-4.1385	743.34
	327.31	2.6005	.22761	.11082	.57427E-02	.16999E-01	.66367E-02
	.14409E-04						
26	-.18475E-03	.11880E-02	-.21865E-04	-861.49	420.38	-9.4268	741.46
	295.75	5.9472	.76582E-01	.25953E-01	.12207E-01	.26347E-01	.16217E-01
	.32589E-04						
27	-.87979E-04	.55544E-03	-.64379E-04	-282.46	259.77	-27.335	726.82
	146.91	17.470	.19856E-01	.57530E-02	.27894E-01	.81928E-01	.62115E-01
	.92238E-04						
28	-.91868E-05	.17295E-03	-.16514E-03	-11.250	82.965	-69.148	700.61
	44.467	44.753	.64338E-02	.17865E-02	.48881E-01	.10402	.96892E-01
	.22814E-03						
29	.71576E-04	.55001E-04	-.51144E-03	364.06	26.031	-210.11	594.94
	14.070	138.63	.22930E-02	.62403E-03	.64502E-01	.83153E-01	.10344
	.67123E-03						
30	.92326E-04	.10587E-04	.76168E-03	34.853	4.9790	-781.62	143.17
	2.7081	517.97	.46383E-03	.12548E-03	.31186E-01	.25569E-01	.47757E-01
	.46455E-02						
31	.83915E-05	.95788E-06	.84438E-04	3.0762	.44848	-55.665	13.157
	.24514	574.43	.43482E-04	.11721E-04	.17367E-01	.57210E-02	.70359E-01
	.48951E-01						
32	.00000	.00000	.00000	.00000	.00000	.00000	.00000
	.00000	.00000	.00000	.00000	.00000	.00000	.50000
	.50000						
33	-.13585E-03	-.25598E-02	-.26627E-05	-477.25	-301.31	-1.1524	213.74
	1002.5	.72464	.95183E-01	1.2178	.15875E-02	.78076E-01	.53671E-02
	.40076E-05						
34	-.66372E-04	-.22910E-02	-.46499E-05	-345.96	901.99	-1.9997	216.49
	990.80	1.2640	.40683E-01	.73922E-01	.25531E-02	.73485E-01	.14555E-01
	.68844E-05						
35	-.79757E-04	-.36705E-02	-.18796E-04	-139.57	2002.1	-7.8992	282.90
	808.93	5.0881	.13808E-01	.71506E-02	.75221E-02	.94268E-01	.48924E-01
	.26192E-04						
36	-.37833E-04	.35423E-03	-.75545E-04	-169.17	184.86	-31.070	572.98
	89.202	20.368	.61410E-02	.18139E-02	.21123E-01	.18904	.14489
	.99179E-04						

37	-.65253E-05	.86770E-04	-.23158E-03	219.88	42.569	-91.671	547.07
	21.894	61.963	.24664E-02	.69171E-03	.31053E-01	.16382	.18057
	.27081E-03						
38	.27163E-03	.28872E-04	-.81642E-03	112.84	13.856	-307.78	389.90
	7.3247	216.36	.10252E-02	.28178E-03	.28030E-01	.11166	.16798
	.78789E-03						
39	.23516E-04	.25208E-05	.43777E-03	9.3753	1.1989	-333.52	34.509
	.64136	552.79	.98203E-04	.26781E-04	.79262E-02	.26022E-01	.99611E-01
	.10225E-01						
40	.18717E-05	.20407E-06	-.36846E-03	.72193	.96428E-01	279.22	2.8109
	.52032E-01	421.64	.84765E-05	.22995E-05	.30619E-02	.70276E-02	.25312
	.10455						
41	-.25042E-04	-.45069E-03	-.94596E-06	-112.33	-613.46	-.40719	57.617
	931.86	.25718	.17418E-01	.26527	.52938E-03	.26812	.21579E-01
	.14039E-05						
42	-.21672E-04	-.22841E-02	-.33126E-05	-63.908	782.39	-1.3912	70.690
	893.31	.89634	.68573E-02	.15118E-01	.13611E-02	.23864	.64002E-01
	.46073E-05						
43	-.14945E-03	.67722E-03	-.29884E-04	23.624	298.22	-12.191	327.26
	153.08	8.0378	.31654E-02	.11004E-02	.80304E-02	.34417	.20931
	.38360E-04						
44	-.28535E-05	.11684E-03	-.71883E-04	-35.333	56.396	-28.215	358.20
	28.327	19.149	.18309E-02	.53855E-03	.11594E-01	.31371	.27945
	.82432E-04						
45	.19335E-04	.27719E-04	-.27348E-03	275.39	13.427	-98.168	314.97
	6.9334	70.983	.76354E-03	.21377E-03	.13371E-01	.23796	.33550
	.23516E-03						
46	.52326E-04	.48415E-05	.67366E-03	21.772	2.3279	-589.79	70.055
	1.2223	374.84	.16018E-03	.44215E-04	.49386E-02	.10476	.26050
	.15742E-02						
47	.40914E-05	.41281E-06	-.12829E-03	1.6529	.19695	99.608	5.7928
	.10474	418.28	.15304E-04	.41870E-05	.16250E-02	.43177E-01	.30714
	.16394E-01						
48	.00000	.00000	.00000	.00000	.00000	.00000	.00000
	.00000	.00000	.00000	.00000	.00000	.00000	.83333
	.16667						
49	.00000	.00000	.00000	.00000	.00000	.00000	.00000
	.00000	.00000	.00000	.00000	.00000	1.0000	.00000
	.00000						
50	.00000	.00000	.00000	.00000	.00000	.00000	.00000
	.00000	.00000	.00000	.00000	.00000	.86667	.13333
	.00000						
51	.00000	.00000	.00000	.00000	.00000	.00000	.00000
	.00000	.00000	.00000	.00000	.00000	.73333	.26667
	.00000						
52	.00000	.00000	.00000	.00000	.00000	.00000	.00000
	.00000	.00000	.00000	.00000	.00000	.60000	.40000
	.00000						

Figure 4.3-10—Continued

53	.00000	.00000	.00000	.00000	.00000	.00000	.00000
	.00000	.00000	.00000	.00000	.00000	.46667	.53333
	.00000						
54	.00000	.00000	.00000	.00000	.00000	.00000	.00000
	.00000	.00000	.00000	.00000	.00000	.33333	.66667
	.00000						
55	.00000	.00000	.00000	.00000	.00000	.00000	.00000
	.00000	.00000	.00000	.00000	.00000	.20000	.80000
	.00000						
56	.00000	.00000	.00000	.00000	.00000	.00000	.00000
	.00000	.00000	.00000	.00000	.00000	.66667E-01	.93333
	.00000						

SCALED LEAST SQUARES MATRIX

	1	2	3	4	5	6	7	8	9	10
1	1.0000	-.69544E-01	-.26635	.53102	-.17273	-.34007	-.17912	-.31368	.23649	-.35370
2	-.69544E-01	1.0000	-.30813E-01	-.25996	-.53051	-.20677E-01	.23497	-.63216	.13554E-01	.11366
3	-.26635	-.30813E-01	1.0000	-.25211E-01	-.44226E-01	-.20498	-.34146	-.31616E-01	.16613	-.13671E-01
4	.53102	-.25996	-.25211E-01	1.0000	-.20068	-.23735E-01	-.67194	-.33069	.16667E-01	-.48758
5	-.17273	-.53051	-.44226E-01	-.20068	1.0000	-.28414E-01	.30415	.50312	.18664E-01	.76453E-01
6	-.34007	-.20677E-01	-.20498	-.23735E-01	-.28414E-01	1.0000	-.26777	-.20134E-01	-.73701	-.84692E-02
7	-.17912	.23497	-.34146	-.67194	.30415	-.26777	1.0000	.33113	.17797	.31876
8	-.31368	-.63216	-.31616E-01	-.33069	.50312	-.20134E-01	.33113	1.0000	.13167E-01	.16830
9	.23649	.13554E-01	.16613	.16667E-01	.18664E-01	-.73701	.17797	.13167E-01	1.0000	.54464E-02
10	-.35370	.11366	-.13671E-01	-.48758	.76453E-01	-.84692E-02	.31876	.16830	.54464E-02	1.0000
11	-.24478	-.39631	-.52388E-02	-.20846	-.11478	-.31911E-02	.14497	.60353	.20517E-02	.13317
12	.20587	.32808E-01	-.21300	-.34027E-02	.43106E-01	-.63606	.33531	.32631E-01	.58178	.17099E-01
13	-.27537E-01	-.66174E-01	-.73124E-01	-.29440E-01	.10554	-.78825E-01	.17203	.20337	.63744E-01	.20165E-01
14	.27664E-01	.45383E-02	-.77518E-01	-.33928E-02	.65180E-01	-.10046	.14428	.55433E-01	.18631	.90366E-02
15	.67823E-02	.21096E-03	-.14278E-01	.37787E-03	.26532E-03	-.52616E-01	.35636E-02	.18356E-03	.20016	.71068E-04

	11	12	13	14	15
1	-.24478	.20587	-.27537E-01	.27664E-01	.67823E-02
2	-.39631	.32808E-01	-.66174E-01	.45383E-02	.21096E-03
3	-.52388E-02	-.21300	-.73124E-01	-.77518E-01	-.14278E-01
4	-.20846	-.34027E-02	-.29440E-01	-.33928E-02	.37787E-03
5	-.11478	.43106E-01	.10554	.65180E-01	.26532E-03
6	-.31911E-02	-.63606	-.78825E-01	-.10046	-.52616E-01
7	.14497	.33531	.17203	.14428	.35636E-02
8	.60353	.32631E-01	.20337	.55433E-01	.18356E-03
9	.20517E-02	.58178	.63744E-01	.18631	.20016
10	.13317	.17099E-01	.20165E-01	.90366E-02	.71068E-04
11	1.0000	.64661E-02	.77897E-01	.82024E-02	.25505E-04
12	.64661E-02	1.0000	.47384E-01	.59304E-01	.16373
13	.77897E-01	.47384E-01	1.0000	.43839	.17691E-02
14	.82024E-02	.59304E-01	.43839	1.0000	.27922
15	.25505E-04	.16373	.17691E-02	.27922	1.0000

```
SCALED GRADIENT VECTOR
.51601     -.99079     -.45346     1.2969     -1.2398     -.22907     -1.3453     .30868
.67924     -.37087      .90839      .69633      .16964      .49968      1.6963

ITERATION NO.   1
YSQ =  62.212      DET(C) =  .31948E-03  AMP =  .00000     AP =  .46254
REGRESSION PARAMETERS
3400.8       220.54      701.64      .98853E-03  .14786E-03  .12781E-02  -.50000E-04  .68114E-03
.20223E-04   8.0000      .40847      1.0376      40.039      10.019      16.657
                                   * * * * * * * *
```

Output for iterations 2 through 6 is analogous to output for iteration 1, and, thus, is omitted. The scaled least squares matrix and gradient vector following is for iteration 6.

* * * * * * * *

SCALED LEAST SQUARES MATRIX

	1	2	3	4	5	6	7	8	9	10
1	1.0000	.17180	-.17219	.58498	.82455E-02	-.22676	-.19756	-.25747	.15229	-.45891
2	.17180	1.0000	.19293E-03	.43378E-01	-.17720	-.38005E-03	-.83920E-01	-.95324	.24789E-03	-.56820E-01
3	-.17219	.19293E-03	1.0000	-.51165E-01	-.11965E-01	-.38104	-.25862	-.91209E-02	.30206	-.72582E-02
4	.58498	.43378E-01	-.51165E-01	1.0000	.86505E-02	-.34320E-01	-.55596	-.18514	.22358E-01	-.57010
5	.82455E-02	-.17720	-.11965E-01	.86505E-02	1.0000	-.72451E-02	.12575	.45636E-01	.45959E-02	-.10614E-01
6	-.22676	-.38005E-03	-.38104	-.34320E-01	-.72451E-02	1.0000	-.20760	-.54336E-02	-.80292	-.44164E-02
7	-.19756	-.83920E-01	-.25862	-.55596	.12575	-.20760	1.0000	.22633	.13295	.35646
8	-.25747	-.95324	-.91209E-02	-.18514	.45636E-01	-.54336E-02	.22633	1.0000	.34231E-02	.13920
9	.15229	.24789E-03	.30206	.22358E-01	.45959E-02	-.80292	.13295	.34231E-02	1.0000	.27229E-02
10	-.45891	-.56820E-01	-.72582E-02	-.57010	-.10614E-01	-.44164E-02	.35646	.13920	.27229E-02	1.0000
11	-.26481	-.63943	-.18290E-02	-.17598	-.46230	-.10535E-02	.12938	.64480	.65011E-03	.14295
12	.12516	.34937E-03	-.11514	.29284E-01	.11169E-01	-.67278	.25625	.93450E-02	.54316	.98485E-02
13	-.38769E-01	-.22608	-.41526E-01	-.97069E-02	-.52273E-02	-.53213E-01	.16347	.26989	.43188E-01	.28550E-01
14	.18259E-01	-.40783E-01	-.44719E-01	.18788E-01	.36389E-01	-.84249E-01	.12543	.53228E-01	.14376	.77942E-02
15	.20587E-02	.63503E-05	-.58981E-02	.14509E-03	.25097E-04	-.88041E-01	.12579E-02	.17694E-04	.16090	.14932E-04

Figure 4.3-10—Continued

	11	12	13	14	15
1	-.26481	.12516	-.38769E-01	.18259E-01	.20587E-02
2	-.63943	.34937E-03	-.22608	-.40783E-01	.63503E-05
3	-.18290E-02	-.11514	-.41526E-01	-.44719E-01	-.58981E-02
4	-.17598	.29284E-01	-.97069E-02	.18788E-01	.14509E-03
5	-.46230	.11169E-01	-.52273E-02	.36389E-01	.25097E-04
6	-.10535E-02	-.67278	-.53213E-01	-.84249E-01	-.88041E-01
7	.12938	.25625	.16347	.12543	.12579E-02
8	.64480	.93450E-02	.26989	.53228E-01	.17694E-04
9	.65011E-03	.54316	.43188E-01	.14376	.16090
10	.14295	.98485E-02	.28550E-01	.77942E-02	.14932E-04
11	1.0000	.23673E-02	.13444	.12050E-01	.29220E-05
12	.23673E-02	1.0000	.25953E-01	.33840E-01	.14324
13	.13444	.25953E-01	1.0000	.42776	.70059E-03
14	.12050E-01	.33840E-01	.42776	1.0000	.27776
15	.29220E-05	.14324	.70059E-03	.27776	1.0000

SCALED GRADIENT VECTOR

-.51657E-03	.11084E-03	-.20590E-03	-.28675E-03	-.93586E-03	.11319E-02	.11511E-03	.50789E-03
-.47620E-03	.19812E-03	-.25707E-03	-.15761E-02	-.30471E-03	.33699E-03	.27447E-03	

ITERATION NO. 6

YSQ = 51.970 DET(C) = .45800E-04 AMP = .00000 AP = 1.0000

REGRESSION PARAMETERS

2865.3	117.67	497.85	.99782E-03	.96559E-04	.10785E-02	-.17358E-03	.33062E-03
.14220E-03	8.0000	.22321	.89599	40.109	10.042	17.454	

SOLUTION CONVERGED IN 6 ITERATIONS

ERROR VARIANCE = 1.2374
ESTIMATED SUM OF SQUARED ERRORS = 51.970
CORRELATION COEFFICIENT = .99033

ESTIMATED PARAMETER DATA

PAR. NO.	PAR.	STD. DEV.
1	2865.3	1293.6
2	117.67	266.83
3	497.85	426.73
4	.99782E-03	.34440E-03
5	.96559E-04	.22643E-03
6	.10785E-02	.99504E-03
7	-.17358E-03	.50163E-03
8	.33062E-03	.73586E-03
9	.14220E-03	.71033E-03

10	8.0000	.88990
11	.22321	.59676
12	.89599	1.1288
13	40.109	.68267
14	10.042	.66620
15	17.454	1.1536

VARIANCE-COVARIANCE MATRIX

	1	2	3	4	5	6	7	8	9	10
1	.16734E+07	92126.	.19755E+06	-.12629	.81201E-01	.47075	-.10060	.25244	.54361E-01	283.68
2	92126.	71196.	-12931.	.18984E-01	.52827E-01	-.17544E-01	-.84450E-01	.19080	-.55455E-02	11.633
3	.19755E+06	-12931.	.18210E+06	.17659E-01	-.10515E-01	.27608	.88590E-01	-.35979E-01	.22092E-01	49.298
4	-.12629	.18984E-01	.17659E-01	.11861E-06	.10370E-07	.20261E-07	.47110E-07	.51140E-07	.75899E-08	.98759E-04
5	.81201E-01	.52827E-01	-.10515E-01	.10370E-07	.51269E-07	-.13461E-07	-.69361E-07	.13232E-06	-.42375E-08	.95671E-05
6	.47075	-.17544E-01	.27608	.20261E-07	-.13461E-07	.99011E-06	.14834E-06	-.49792E-07	.41018E-06	.10675E-03
7	-.10060	-.84450E-01	.88590E-01	.47110E-07	-.69361E-07	.14834E-06	.25163E-06	-.22998E-06	.34130E-07	-.17185E-04
8	.25244	.19080	-.35979E-01	.51140E-07	.13232E-06	-.49792E-07	-.22998E-06	.54149E-06	-.16027E-07	.32659E-04
9	.54361E-01	-.55455E-02	.22092E-01	.75899E-08	-.42375E-08	.41018E-06	.34130E-07	-.16027E-07	.50456E-06	.14038E-04
10	283.68	11.633	49.298	.98759E-04	.95671E-05	.10675E-03	-.17185E-04	.32659E-04	.14038E-04	.79192
11	235.55	129.38	-15.206	.29647E-04	.12079E-03	-.11589E-04	-.15827E-03	.30324E-03	-.73381E-05	.22128E-01
12	437.83	9.4207	274.15	-.12778E-04	.88531E-05	.72802E-03	.25834E-04	.24921E-04	.24132E-04	.88817E-01
13	22.301	-5.5050	1.1342	-.19591E-04	.36933E-05	.19509E-04	-.17699E-04	-.43658E-04	.18016E-04	-.50764E-16
14	26.987	1.8507	16.104	-.12935E-04	-.16303E-05	.10117E-04	-.21829E-04	.13911E-04	-.49939E-04	.52352E-16
15	-23.100	-5.3819	-10.743	.12131E-04	-.29205E-05	-.99534E-04	.28963E-04	-.19299E-04	-.89174E-04	-.19250E-15

	11	12	13	14	15
1	235.55	437.83	22.301	26.987	-23.100
2	129.38	9.4207	-5.5050	1.8507	-5.3819
3	-15.206	274.15	1.1342	16.104	-10.743
4	.29647E-04	-.12778E-04	-.19591E-04	-.12935E-04	.12131E-04
5	.12079E-03	.88531E-05	.36933E-05	-.16303E-05	-.29205E-05
6	-.11589E-04	.72802E-03	.19509E-04	.10117E-04	-.99534E-04
7	-.15827E-03	.25834E-04	-.17699E-04	-.21829E-04	.28963E-04
8	.30324E-03	.24921E-04	-.43658E-04	.13911E-04	-.19299E-04
9	-.73381E-05	.24132E-04	.18016E-04	-.49939E-04	-.89174E-04
10	.22128E-01	.88817E-01	-.50764E-16	.52352E-16	-.19250E-15
11	.35613	.35953E-01	.12982E-01	-.20156E-02	-.74691E-02
12	.35953E-01	1.2742	.59038E-02	.80067E-01	-.16715
13	.12982E-01	.59038E-02	.46604	-.19602	.99711E-01
14	-.20156E-02	.80067E-01	-.19602	.44382	-.23097
15	-.74691E-02	-.16715	.99711E-01	-.23097	1.3307

Figure 4.3-10—Continued

CORRELATION MATRIX

	1	2	3	4	5	6	7	8	9	10
1	1.0000	.26690	.35786	-.28346	.27722	.36572	-.15503	.26519	.59160E-01	.24642
2	.26690	1.0000	-.11357	.20659	.87438	-.66079E-01	-.63094	.97176	-.29259E-01	.48992E-01
3	.35786	-.11357	1.0000	.12016	-.10882	.65018	.41385	-.11458	.72883E-01	.12982
4	-.28346	.20659	.12016	1.0000	.13298	.59123E-01	.27269	.20179	.31026E-01	.32224
5	.27722	.87438	-.10882	.13298	1.0000	-.59744E-01	-.61067	.79416	-.26347E-01	.47480E-01
6	.36572	-.66079E-01	.65018	.59123E-01	-.59744E-01	1.0000	.29720	-.68002E-01	.58033	.12056
7	-.15503	-.63094	.41385	.27269	-.61067	.29720	1.0000	-.62304	.95784E-01	-.38497E-01
8	.26519	.97176	-.11458	.20179	.79416	-.68002E-01	-.62304	1.0000	-.30661E-01	.49873E-01
9	.59160E-01	-.29259E-01	.72883E-01	.31026E-01	-.26347E-01	.58033	.95784E-01	-.30661E-01	1.0000	.22208E-01
10	.24642	.48992E-01	.12982	.32224	.47480E-01	.12056	-.38497E-01	.49873E-01	.22208E-01	1.0000
11	.30513	.81254	-.59713E-01	.14425	.89391	-.19516E-01	-.52871	.69054	-.17311E-01	.41668E-01
12	.29984	.31278E-01	.56915	-.32869E-01	.34638E-01	.64818	.45625E-01	.30003E-01	.30096E-01	.88418E-01
13	.25253E-01	-.30222E-01	.38934E-02	-.83327E-01	.23894E-01	.28720E-01	-.51685E-01	-.86908E-01	.37153E-01	-.83562E-16
14	.31315E-01	.10412E-01	.56647E-01	-.56376E-01	-.10808E-01	.15261E-01	-.65321E-01	.28376E-01	-.10553	.88305E-16
15	-.15480E-01	-.17485E-01	-.21823E-01	.30535E-01	-.11181E-01	-.86713E-01	.50051E-01	-.22735E-01	-.10883	-.18752E-15

	11	12	13	14	15
1	.30513	.29984	.25253E-01	.31315E-01	-.15480E-01
2	.81254	.31278E-01	-.30222E-01	.10412E-01	-.17485E-01
3	-.59713E-01	.56915	.38934E-02	.56647E-01	-.21823E-01
4	.14425	-.32869E-01	-.83327E-01	-.56376E-01	.30535E-01
5	.89391	.34638E-01	.23894E-01	-.10808E-01	-.11181E-01
6	-.19516E-01	.64818	.28720E-01	.15261E-01	-.86713E-01
7	-.52871	.45625E-01	-.51685E-01	-.65321E-01	.50051E-01
8	.69054	.30003E-01	-.86908E-01	.28376E-01	-.22735E-01
9	-.17311E-01	.30096E-01	.37153E-01	-.10553	-.10883
10	.41668E-01	.88418E-01	-.83562E-16	.88305E-16	-.18752E-15
11	1.0000	.53372E-01	.31867E-01	-.50698E-02	-.10850E-01
12	.53372E-01	1.0000	.76614E-02	.10647	-.12836
13	.31867E-01	.76614E-02	1.0000	-.43102	.12662
14	-.50698E-02	.10647	-.43102	1.0000	-.30054
15	-.10850E-01	-.12836	.12662	-.30054	1.0000

HEAD RESIDUALS

OBS. NO.	PREDICTED VALUE	OBSERVED VALUE	WEIGHTED RESIDUAL
1	29.988	29.510	.47777
2	26.826	26.380	.44644
3	25.687	25.160	.52684
4	25.055	26.810	-1.7551
5	24.409	23.820	.58942
6	22.257	23.590	-1.3331
7	16.544	16.680	-.13645
8	16.426	15.310	1.1157
9	28.095	28.270	-.17495

10	26.249	25.170	1.0794
11	25.409	26.940	-1.5305
12	24.720	23.590	1.1296
13	23.386	22.530	.85609
14	17.048	17.890	-.84160
15	15.527	15.870	-.34305
16	16.218	15.980	.23841
17	30.499	31.250	-.75148
18	27.340	27.500	-.15980
19	26.114	26.220	-.10621
20	25.199	25.650	-.45050
21	24.155	24.350	-.19520
22	21.790	22.480	-.69007
23	15.618	15.850	-.23236
24	15.152	15.710	-.55827
25	29.315	29.360	-.45113E-01
26	27.443	27.760	-.31699
27	26.121	25.510	.61129
28	24.861	24.430	.43100
29	23.194	22.460	.73447
30	16.819	17.160	-.34134
31	15.154	15.740	-.58562
32	13.748	14.690	-.94206
33	36.304	36.050	.25364
34	33.923	31.640	2.2829
35	31.303	32.910	-1.6070
36	25.933	25.050	.88337
37	24.185	25.470	-1.2851
38	21.558	20.390	1.1678
39	15.529	14.400	1.1286
40	14.428	14.370	.57542E-01
41	37.152	38.660	-1.5078
42	34.692	34.510	.18165
43	27.906	27.810	.96020E-01
44	25.453	25.980	-.52672
45	22.809	22.160	.64860
46	16.934	15.730	1.2037
47	14.804	14.790	.14347E-01
48	11.277	10.480	.79746
49	40.109	41.280	-1.1707
50	36.100	34.820	1.2804
51	32.091	32.000	.91448E-01
52	28.082	26.970	1.1125
53	24.074	25.670	-1.5965
54	20.065	18.120	1.9446
55	16.056	18.400	-2.3444
56	12.047	11.900	.14670

Figure 4.3-10—Continued

```
FINAL COMPUTED NODAL HEAD ARRAY

         1        2        3        4        5        6        7        8        9        10

 7    40.109   38.105   36.100   34.096   32.091   30.087   28.082   26.078   24.074   22.069
 6    38.593   37.152   35.970   34.092   32.677   27.906   26.682   25.453   24.186   22.809
 5    36.304   34.897   33.923   32.961   31.303   26.879   25.933   25.086   24.185   23.088
 4    31.294   29.315   28.170   27.443   26.852   26.121   25.473   24.861   24.157   23.194
 3    30.499   28.493   27.340   26.630   26.114   25.640   25.199   24.741   24.155   23.267
 2    30.105   28.095   26.943   26.249   25.782   25.409   25.074   24.720   24.220   23.386
 1    29.988   27.977   26.826   26.139   25.687   25.345   25.055   24.806   24.409   23.621

        11       12       13       14       15       16

 7    20.065   18.060   16.056   14.051   12.047   10.042
 6    21.189   16.934   15.585   14.804   13.839   11.277
 5    21.558   16.804   15.529   15.033   14.428   12.513
 4    21.698   16.819   15.552   15.154   14.800   13.748
 3    21.790   16.875   15.618   15.282   15.152   14.983
 2    21.935   17.048   15.814   15.527   15.585   16.218
 1    22.257   17.722   16.544   16.282   16.426   17.454

NODAL SENSITIVITY ARRAYS

PARAMETER NUMBER     1

           1             2             3             4             5             6             7             8             9             10

 7     .00000        .00000        .00000        .00000        .00000        .00000        .00000        .00000        .00000        .00000
 6  -.88137E-04   -.66179E-04   -.45801E-04   -.39830E-04   -.55354E-04   -.12696E-03    .28778E-04    .23754E-04   -.13650E-04    .49991E-05
 5  -.29267E-03   -.18520E-03   -.11486E-03   -.90919E-04   -.10016E-03   -.17191E-03    .28266E-05    .11947E-04   -.10330E-04    .42481E-04
 4  -.95285E-03   -.41941E-03   -.23200E-03   -.18360E-03   -.16481E-03   -.78069E-04    .89593E-05    .41699E-05   -.77975E-05    .64948E-04
 3  -.74906E-03   -.18793E-03    .80211E-05    .52822E-04    .47692E-04    .42387E-04    .31497E-04    .77544E-06   -.11412E-04    .69590E-04
 2  -.66908E-03   -.10218E-03    .96560E-04    .13846E-03    .12054E-03    .84288E-04    .39456E-04   -.10571E-04   -.30645E-04    .51074E-04
 1  -.64887E-03   -.80986E-04    .11830E-03    .15921E-03    .13755E-03    .93228E-04    .36182E-04   -.42638E-04   -.88759E-04   -.12934E-04

          11            12            13            14            15            16

 7     .00000        .00000        .00000        .00000        .00000        .00000
 6    .23800E-03    .53870E-04    .12424E-04    .28988E-05    .64893E-06    .00000
 5    .33628E-03    .81713E-04    .19828E-04    .47999E-05    .11021E-05    .00000
 4    .37635E-03    .93820E-04    .23314E-04    .57642E-05    .13465E-05    .00000
 3    .38737E-03    .97069E-04    .24326E-04    .60791E-05    .14352E-05    .00000
 2    .37098E-03    .92960E-04    .23522E-04    .59547E-05    .14231E-05    .00000
 1    .29523E-03    .81573E-04    .21784E-04    .56894E-05    .13844E-05    .00000
```

PARAMETER NUMBER 2

	1	2	3	4	5	6	7	8	9	10
7	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
6	-.14387E-01	-.10074E-01	-.11709E-01	-.14373E-01	-.14515E-01	.92843E-03	.34211E-03	.13590E-03	.58013E-04	.27361E-04
5	-.18117E-01	-.13644E-01	-.14908E-01	-.17039E-01	-.16410E-01	.95459E-03	.42323E-03	.19079E-03	.88987E-04	.44680E-04
4	.14446E-02	.19155E-02	.19316E-02	.16777E-02	.12208E-02	.66243E-03	.35277E-03	.18145E-03	.93448E-04	.50526E-04
3	.97440E-03	.10626E-02	.10513E-02	.92156E-03	.70059E-03	.44828E-03	.26676E-03	.15198E-03	.85361E-04	.49435E-04
2	.66706E-03	.67908E-03	.65545E-03	.57752E-03	.45560E-03	.31938E-03	.20690E-03	.12724E-03	.76302E-04	.46532E-04
1	.56792E-03	.56764E-03	.54208E-03	.47852E-03	.38354E-03	.27795E-03	.18624E-03	.11806E-03	.72642E-04	.45190E-04

	11	12	13	14	15	16
7	.00000	.00000	.00000	.00000	.00000	.00000
6	.16279E-04	.38632E-05	.92257E-06	.22088E-06	.50347E-07	.00000
5	.27398E-04	.66173E-05	.16039E-05	.38889E-06	.89535E-07	.00000
4	.32134E-04	.79335E-05	.19603E-05	.48333E-06	.11279E-06	.00000
3	.32529E-04	.82024E-05	.20656E-05	.51793E-06	.12253E-06	.00000
2	.31401E-04	.80433E-05	.20547E-05	.52184E-06	.12476E-06	.00000
1	.30787E-04	.79331E-05	.20376E-05	.52000E-06	.12481E-06	.00000

PARAMETER NUMBER 3

	1	2	3	4	5	6	7	8	9	10
7	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
6	-.15078E-05	-.18450E-05	-.30940E-05	-.62466E-05	-.14283E-04	-.35985E-04	-.48512E-04	-.88405E-04	-.18033E-03	-.39214E-03
5	-.35813E-05	-.42956E-05	-.68287E-05	-.12747E-04	-.26645E-04	-.62814E-04	-.86546E-04	-.15556E-03	-.30354E-03	-.60987E-03
4	-.71714E-05	-.84601E-05	-.12794E-04	-.21753E-04	-.38648E-04	-.69937E-04	-.10943E-03	-.19791E-03	-.37406E-03	-.71454E-03
3	-.73464E-05	-.86613E-05	-.13074E-04	-.22145E-04	-.39026E-04	-.69289E-04	-.12142E-03	-.22150E-03	-.41048E-03	-.76120E-03
2	-.74492E-05	-.87801E-05	-.13247E-04	-.22436E-04	-.39611E-04	-.70893E-04	-.12773E-03	-.23331E-03	-.42806E-03	-.78264E-03
1	-.74834E-05	-.88203E-05	-.13308E-04	-.22552E-04	-.39879E-04	-.71624E-04	-.12977E-03	-.23716E-03	-.43483E-03	-.79741E-03

	11	12	13	14	15	16
7	.00000	.00000	.00000	.00000	.00000	.00000
6	-.91488E-03	.14872E-02	.63461E-03	-.31842E-03	-.10832E-02	.00000
5	-.12416E-02	.16125E-02	.77206E-03	-.90615E-04	-.73796E-03	.00000
4	-.13618E-02	.16511E-02	.87756E-03	.15751E-03	-.31308E-03	.00000
3	-.14022E-02	.17147E-02	.10011E-02	.39898E-03	.92917E-04	.00000
2	-.14164E-02	.17411E-02	.10674E-02	.55652E-03	.40007E-03	.00000
1	-.14671E-02	.10314E-02	.31150E-03	-.15526E-03	-.15560E-03	.00000

Figure 4.3-10—Continued

PARAMETER NUMBER 4

	1	2	3	4	5	6	7	8	9	10
7	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
6	-215.11	-188.73	-131.28	-60.679	28.425	190.68	-87.083	20.249	224.47	344.43
5	-659.90	-563.73	-383.68	-189.76	7.0766	295.72	-2.5536	108.84	327.25	435.34
4	-1839.7	-1486.2	-965.48	-477.82	-100.25	58.649	-2.9031	158.15	369.78	454.73
3	-2381.7	-2014.5	-1475.8	-969.80	-559.28	-265.57	-62.017	163.44	373.52	442.85
2	-2568.6	-2196.9	-1650.5	-1135.3	-707.56	-368.73	-95.016	150.65	353.11	411.00
1	-2611.5	-2238.8	-1690.3	-1172.7	-740.48	-392.23	-107.12	135.69	328.13	378.88

	11	12	13	14	15	16
7	.00000	.00000	.00000	.00000	.00000	.00000
6	73.063	16.265	3.6788	.84037	.18435	.00000
5	99.174	23.537	5.5765	1.3181	.29626	.00000
4	99.187	24.104	5.8472	1.4138	.32409	.00000
3	81.573	20.043	4.9562	1.2274	.28812	.00000
2	49.088	12.940	3.4397	.90946	.22489	.00000
1	16.186	7.2124	2.4016	.71519	.18895	.00000

PARAMETER NUMBER 5

	1	2	3	4	5	6	7	8	9	10
7	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
6	-10145.	-6628.8	-1888.6	3026.2	6864.6	566.80	227.02	94.150	40.969	19.439
5	-5092.0	-1632.6	2740.1	6990.7	9748.2	796.11	326.18	141.39	64.549	31.984
4	-45.157	223.72	574.68	847.68	907.44	468.64	253.76	129.89	66.328	35.590
3	98.952	180.21	316.85	422.38	428.36	290.68	178.68	103.29	58.378	33.893
2	115.00	144.04	200.46	243.68	242.05	188.26	129.19	82.183	50.321	31.085
1	112.99	130.65	167.03	194.69	192.14	156.68	112.60	74.543	47.156	29.857

	11	12	13	14	15	16
7	.00000	.00000	.00000	.00000	.00000	.00000
6	11.572	2.7438	.65424	.15633	.35567E-01	.00000
5	19.493	4.6912	1.1335	.27406	.62952E-01	.00000
4	22.546	5.5529	1.3691	.33692	.78502E-01	.00000
3	22.320	5.6298	1.4180	.35558	.84129E-01	.00000
2	21.092	5.4194	1.3881	.35330	.84608E-01	.00000
1	20.494	5.3038	1.3673	.35003	.84219E-01	.00000

PARAMETER NUMBER 6

	1	2	3	4	5	6	7	8	9	10
7	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
6	-.56423	-.68739	-1.1401	-2.2681	-5.1014	-12.653	-16.846	-29.872	-58.764	-121.97
5	-1.3462	-1.6105	-2.5426	-4.6962	-9.6800	-22.485	-30.726	-54.278	-103.67	-203.50
4	-2.7065	-3.1904	-4.8147	-8.1564	-14.398	-25.743	-39.990	-71.738	-134.24	-253.57
3	-2.7752	-3.2709	-4.9332	-8.3460	-14.685	-26.034	-45.675	-83.418	-154.71	-286.92
2	-2.8186	-3.3234	-5.0189	-8.5148	-15.074	-27.098	-49.159	-90.592	-168.12	-312.00
1	-2.8337	-3.3421	-5.0515	-8.5846	-15.246	-27.559	-50.386	-93.209	-173.72	-325.89

	11	12	13	14	15	16
7	.00000	.00000	.00000	.00000	.00000	.00000
6	-268.07	-914.35	-415.10	52.738	427.32	.00000
5	-405.64	-1071.0	-523.05	-80.647	249.85	.00000
4	-477.90	-1137.6	-596.95	-212.15	43.367	.00000
3	-527.28	-1215.7	-699.11	-364.37	-172.51	.00000
2	-575.68	-1366.5	-893.16	-597.67	-438.41	.00000
1	-619.29	-1626.4	-1207.6	-930.66	-757.77	.00000

PARAMETER NUMBER 7

	1	2	3	4	5	6	7	8	9	10
7	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
6	134.36	135.15	139.27	155.18	213.78	423.78	430.34	425.60	411.17	380.06
5	377.63	378.13	381.27	395.29	451.98	671.75	672.85	660.10	633.20	580.30
4	930.45	929.45	925.93	917.84	898.80	846.13	814.48	789.59	752.72	686.06
3	957.35	956.35	952.96	945.73	931.75	907.47	883.96	857.00	815.12	740.83
2	970.56	969.64	966.62	960.66	950.44	935.00	915.68	888.75	844.74	766.78
1	974.52	973.65	970.80	965.33	956.30	942.95	924.83	898.02	853.43	774.40

	11	12	13	14	15	16
7	.00000	.00000	.00000	.00000	.00000	.00000
6	312.13	72.205	16.967	4.0234	.91257	.00000
5	474.93	116.08	28.379	6.9270	1.6030	.00000
4	560.30	140.16	34.999	8.7025	2.0437	.00000
3	604.32	152.75	38.551	9.6850	2.2947	.00000
2	625.13	158.73	40.256	10.164	2.4192	.00000
1	631.24	160.48	40.760	10.306	2.4564	.00000

Figure 4.3-10—Continued

PARAMETER NUMBER 8

	1	2	3	4	5	6	7	8	9	10
7	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
6	4732.5	4716.7	4642.4	4379.9	3464.1	252.34	97.684	40.087	17.476	8.3539
5	4879.2	4861.7	4781.4	4505.7	3563.7	306.14	132.31	59.145	27.548	13.847
4	564.00	558.38	538.54	493.77	400.12	214.34	112.34	57.222	29.313	15.808
3	326.10	321.44	305.87	274.50	220.26	142.40	84.596	48.013	26.879	15.531
2	211.05	207.33	195.47	173.67	140.69	99.968	65.085	40.069	24.018	14.635
1	176.90	173.55	163.05	144.48	117.83	86.505	58.366	37.109	22.851	14.213

	11	12	13	14	15	16
7	.00000	.00000	.00000	.00000	.00000	.00000
6	5.0002	1.1905	.28503	.68379E-01	.15610E-01	.00000
5	8.5005	2.0548	.49846	.12095	.27865E-01	.00000
4	10.045	2.4792	.61250	.15101	.35241E-01	.00000
3	10.210	2.5731	.64770	.16235	.38401E-01	.00000
2	9.8706	2.5275	.64543	.16387	.39165E-01	.00000
1	9.6806	2.4939	.64036	.16338	.39203E-01	.00000

PARAMETER NUMBER 9

	1	2	3	4	5	6	7	8	9	10
7	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
6	.32358	.39574	.66278	1.3357	3.0478	7.6628	10.311	18.707	37.918	81.735
5	.76895	.92207	1.4647	2.7309	5.6992	13.413	18.463	33.114	64.432	129.04
4	1.5405	1.8172	2.7476	4.6701	8.2923	14.988	23.441	42.381	80.082	152.97
3	1.5782	1.8606	2.8084	4.7565	8.3819	14.882	26.092	47.641	88.419	164.39
2	1.6005	1.8865	2.8464	4.8218	8.5150	15.246	27.487	50.256	92.352	169.39
1	1.6080	1.8953	2.8600	4.8477	8.5749	15.407	27.925	51.041	93.496	170.79

	11	12	13	14	15	16
7	.00000	.00000	.00000	.00000	.00000	.00000
6	188.43	579.24	657.93	650.43	537.26	.00000
5	261.96	716.90	818.77	807.03	654.01	.00000
4	291.64	752.02	858.23	844.50	679.98	.00000
3	303.99	761.79	868.07	853.47	685.86	.00000
2	308.99	764.70	870.57	855.62	687.20	.00000
1	310.34	765.36	871.07	856.02	687.45	.00000

PARAMETER NUMBER 10

	1	2	3	4	5	6	7	8	9	10
7	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
6	.53074E-01	.41784E-01	.27227E-01	.16052E-01	.84549E-02	.29026E-02	.22072E-02	.14298E-02	.86627E-03	.52587E-03
5	.17238	.12120	.73462E-01	.41729E-01	.21818E-01	.77685E-02	.52650E-02	.31434E-02	.18110E-02	.10671E-02
4	.53580	.29685	.16411	.89902E-01	.47263E-01	.19187E-01	.97739E-02	.51620E-02	.27977E-02	.15951E-02
3	.55281	.30544	.16869	.92611E-01	.49752E-01	.25101E-01	.12884E-01	.67301E-02	.35968E-02	.20262E-02
2	.55909	.30976	.17133	.94342E-01	.51351E-01	.27318E-01	.14418E-01	.76205E-02	.40852E-02	.22995E-02
1	.56074	.31104	.17217	.94920E-01	.51870E-01	.27914E-01	.14869E-01	.79014E-02	.42464E-02	.23920E-02

	11	12	13	14	15	16
7	.00000	.00000	.00000	.00000	.00000	.00000
6	.35319E-03	.90109E-04	.22920E-04	.57962E-05	.13805E-05	.00000
5	.70802E-03	.17946E-03	.45409E-04	.11435E-04	.27152E-05	.00000
4	.10445E-02	.26290E-03	.66152E-04	.16585E-04	.39246E-05	.00000
3	.13190E-02	.33078E-03	.82964E-04	.20741E-04	.48968E-05	.00000
2	.14952E-02	.37456E-03	.93835E-04	.23431E-04	.55261E-05	.00000
1	.15554E-02	.38960E-03	.97581E-04	.24359E-04	.57435E-05	.00000

PARAMETER NUMBER 11

	1	2	3	4	5	6	7	8	9	10
7	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
6	5.2629	1.5043	.43378	.12627	.35285E-01	.21657E-02	.12477E-02	.70540E-03	.39528E-03	.22865E-03
5	5.3522	1.5578	.46126	.13987	.41723E-01	.42803E-02	.25542E-02	.14242E-02	.78468E-03	.44855E-03
4	.41301	.19460	.92953E-01	.45246E-01	.21772E-01	.83311E-02	.41539E-02	.21481E-02	.11439E-02	.64351E-03
3	.16773	.11507	.67522E-01	.37391E-01	.19890E-01	.98661E-02	.50281E-02	.26184E-02	.13976E-02	.78690E-03
2	.86163E-01	.70502E-01	.48177E-01	.29924E-01	.17453E-01	.96505E-02	.52243E-02	.28116E-02	.15276E-02	.86830E-03
1	.65914E-01	.57139E-01	.41532E-01	.27093E-01	.16425E-01	.94182E-02	.52256E-02	.28549E-02	.15648E-02	.89380E-03

	11	12	13	14	15	16
7	.00000	.00000	.00000	.00000	.00000	.00000
6	.15038E-03	.37906E-04	.95429E-05	.23921E-05	.56579E-06	.00000
5	.29351E-03	.73788E-04	.18538E-04	.46398E-05	.10963E-05	.00000
4	.41870E-03	.10498E-03	.26325E-04	.65802E-05	.15534E-05	.00000
3	.51215E-03	.12843E-03	.32210E-04	.80521E-05	.19010E-05	.00000
2	.56718E-03	.14248E-03	.35782E-04	.89538E-05	.21153E-05	.00000
1	.58495E-03	.14709E-03	.36966E-04	.92548E-05	.21873E-05	.00000

Figure 4.3-10—Continued

PARAMETER NUMBER 12

	1	2	3	4	5	6	7	8	9	10
7	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
6	.76330E-03	.88767E-03	.13018E-02	.21588E-02	.38679E-02	.75714E-02	.85541E-02	.10375E-01	.12020E-01	.12432E-01
5	.19056E-02	.22156E-02	.32313E-02	.52410E-02	.89224E-02	.16324E-01	.19248E-01	.24539E-01	.29456E-01	.31222E-01
4	.39952E-02	.46600E-02	.68241E-02	.10962E-01	.17595E-01	.26030E-01	.34276E-01	.47619E-01	.60297E-01	.66227E-01
3	.41516E-02	.48696E-02	.72470E-02	.11991E-01	.20371E-01	.34243E-01	.56139E-01	.87944E-01	.11888	.13594
2	.43173E-02	.51151E-02	.78265E-02	.13558E-01	.24748E-01	.46355E-01	.87636E-01	.15976	.23271	.27533
1	.43904E-02	.52278E-02	.81107E-02	.14386E-01	.27324E-01	.54928E-01	.11880	.28637	.45789	.54126

	11	12	13	14	15	16
7	.00000	.00000	.00000	.00000	.00000	.00000
6	.10815E-01	.37378E-02	.17059E-02	.10118E-02	.54211E-03	.00000
5	.27643E-01	.10525E-01	.57682E-02	.39903E-02	.23306E-02	.00000
4	.60505E-01	.27741E-01	.19343E-01	.15492E-01	.98366E-02	.00000
3	.13066	.80666E-01	.70257E-01	.62343E-01	.42825E-01	.00000
2	.28726	.26868	.27081	.25580	.19186	.00000
1	.64700	1.0178	1.0750	1.0521	.88426	.00000

PARAMETER NUMBER 13

	1	2	3	4	5	6	7	8	9	10
7	1.0000	.93333	.86667	.80000	.73333	.66667	.60000	.53333	.46667	.40000
6	.39285	.37685	.35397	.33205	.31917	.33899	.32197	.29224	.25767	.22049
5	.14081	.13716	.13142	.12816	.13480	.16994	.16873	.15773	.14100	.12079
4	.11845E-01	.12381E-01	.14471E-01	.19753E-01	.32807E-01	.68297E-01	.84042E-01	.83858E-01	.76883E-01	.66329E-01
3	.82604E-02	.88185E-02	.10777E-01	.15034E-01	.23211E-01	.36528E-01	.44537E-01	.45972E-01	.43113E-01	.37559E-01
2	.64353E-02	.69259E-02	.85357E-02	.11629E-01	.16555E-01	.22785E-01	.27109E-01	.28385E-01	.27049E-01	.23781E-01
1	.58695E-02	.63253E-02	.77821E-02	.10441E-01	.14358E-01	.18881E-01	.22168E-01	.23290E-01	.22332E-01	.19716E-01

	11	12	13	14	15	16
7	.33333	.26667	.20000	.13333	.66667E-01	.00000
6	.18025	.87171E-01	.55050E-01	.34922E-01	.17220E-01	.00000
5	.97407E-01	.35487E-01	.17317E-01	.97065E-02	.45785E-02	.00000
4	.53174E-01	.16900E-01	.65239E-02	.30275E-02	.13025E-02	.00000
3	.30087E-01	.90087E-02	.29788E-02	.11334E-02	.42423E-03	.00000
2	.19080E-01	.55774E-02	.16997E-02	.55725E-03	.17977E-03	.00000
1	.15836E-01	.45992E-02	.13659E-02	.42289E-03	.12691E-03	.00000

PARAMETER NUMBER 14

	1	2	3	4	5	6	7	8	9	10
7	.00000	.66667E-01	.13333	.20000	.26667	.33333	.40000	.46667	.53333	.60000
6	.15372E-01	.32033E-01	.57705E-01	.88387E-01	.12946	.20556	.22813	.25909	.28951	.31132
5	.10066E-01	.14731E-01	.24523E-01	.39070E-01	.63709E-01	.11582	.12728	.14225	.15507	.15964
4	.37082E-02	.44186E-02	.67529E-02	.11795E-01	.22878E-01	.50658E-01	.67216E-01	.77109E-01	.82863E-01	.82525E-01
3	.34160E-02	.39940E-02	.59039E-02	.97854E-02	.16880E-01	.28298E-01	.37221E-01	.42946E-01	.45599E-01	.44328E-01
2	.31570E-02	.36280E-02	.51388E-02	.79695E-02	.12434E-01	.18283E-01	.23385E-01	.26804E-01	.28133E-01	.26878E-01
1	.30552E-02	.34851E-02	.48427E-02	.72941E-02	.10934E-01	.15379E-01	.19372E-01	.22085E-01	.23046E-01	.21857E-01

	11	12	13	14	15	16
7	.66667	.73333	.80000	.86667	.93333	1.0000
6	.30453	.21532	.21569	.24872	.35986	.83333
5	.14521	.74009E-01	.65795E-01	.91276E-01	.20329	.66667
4	.72001E-01	.29976E-01	.24680E-01	.44954E-01	.13558	.50000
3	.37743E-01	.14128E-01	.11438E-01	.25624E-01	.87696E-01	.33333
2	.22552E-01	.79464E-02	.60884E-02	.13898E-01	.46144E-01	.16667
1	.18234E-01	.62253E-02	.42550E-02	.78324E-02	.16239E-01	.00000

PARAMETER NUMBER 15

	1	2	3	4	5	6	7	8	9	10
7	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
6	.45762E-06	.55363E-06	.90191E-06	.17496E-05	.38206E-05	.91972E-05	.11942E-04	.19965E-04	.36036E-04	.66041E-04
5	.10996E-05	.13103E-05	.20462E-05	.37146E-05	.74778E-05	.16918E-04	.22763E-04	.38833E-04	.70682E-04	.13024E-03
4	.22244E-05	.26194E-05	.39408E-05	.66398E-05	.11607E-04	.20362E-04	.31282E-04	.55442E-04	.10223E-03	.18999E-03
3	.22841E-05	.26909E-05	.40539E-05	.68467E-05	.12022E-04	.21278E-04	.37452E-04	.68727E-04	.12839E-03	.24109E-03
2	.23253E-05	.27432E-05	.41486E-05	.70553E-05	.12539E-04	.22685E-04	.41559E-04	.77546E-04	.14622E-03	.27719E-03
1	.23404E-05	.27628E-05	.41863E-05	.71427E-05	.12760E-04	.23263E-04	.43019E-04	.80673E-04	.15267E-03	.29070E-03

	11	12	13	14	15	16
7	.00000	.00000	.00000	.00000	.00000	.00000
6	.12088E-03	.69575E-03	.27812E-02	.10897E-01	.42624E-01	.16667
5	.23958E-03	.13876E-02	.55542E-02	.21781E-01	.85235E-01	.33333
4	.35253E-03	.20657E-02	.82948E-02	.32603E-01	.12777	.50000
3	.45274E-03	.27011E-02	.10918E-01	.43167E-01	.16994	.66667
2	.52725E-03	.32166E-02	.13153E-01	.52679E-01	.21017	.83333
1	.55694E-03	.34503E-02	.14283E-01	.58303E-01	.23983	1.0000

Figure 4.3-10—Continued

SCALED AND ORTHOGONALIZED SENSITIVITY MATRIX
OBSERVATION NUMBER AND VALUES FOR EACH PARAMETER

OBS. NO.	PARAMETER NOS. 1	2	3	4	5	6	7	8
1	-.48486	.10012	-.88313E-01	-.19353	.28397E-01	-.11681	-.71251E-01	-.30847E-01
2	.88399E-01	.86688E-03	.12077E-01	-.36799	.81978E-02	.92902E-01	.37863E-01	-.10784E-01
3	.10279	-.62999E-02	.85497E-02	-.19925	.10257E-01	.59571E-01	.13319	-.11047E-01
4	.27036E-01	.87074E-03	-.25771E-01	-.34406E-01	.77748E-02	-.16027E-01	.17937	-.18262E-01
5	-.66324E-01	.13546E-01	-.11370	.10690	.69793E-02	-.14516	.16006	-.18556E-01
6	.22061	-.36989E-01	-.30457	-.11209	-.98094E-02	-.27365	-.87243E-01	.38504E-02
7	.16278E-01	-.27362E-02	.75860E-01	-.13250E-01	-.27104E-03	-.37791	-.12464	.92882E-02
8	.10345E-02	-.17403E-03	-.36267E-01	.13396E-02	-.21064E-03	-.27755	-.12024	.90602E-02
9	-.76352E-01	.33228E-01	-.16223E-01	-.36282	.13719E-01	.41578E-01	-.19559E-01	-.10764E-01
10	.10347	-.67224E-03	.12581E-01	-.27327	.14384E-01	.77535E-01	.93922E-01	-.28296E-02
11	.62983E-01	-.13619E-02	-.57208E-02	-.10549	.12057E-01	.22372E-01	.16289	-.11724E-01
12	-.78991E-02	.51252E-02	-.56173E-01	.36031E-01	.71357E-02	-.64501E-01	.18224	-.18494E-01
13	.38164E-01	-.51786E-02	-.17661	.63478E-01	.72899E-03	-.18764	.96243E-01	-.98763E-02
14	.69463E-01	-.11696E-01	.42019	-.61148E-01	-.73223E-03	-.26174	.30864E-01	-.25158E-02
15	.44496E-02	-.74899E-03	.13116	-.94200E-02	.44404E-03	-.14667	-.22347E-01	.16658E-02
16	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
17	-.55973	.12502	-.10194	-.10463	.33366E-01	-.15744	-.51240E-01	-.41809E-02
18	.59936E-02	.30105E-01	-.29543E-02	-.27720	.26133E-01	.49428E-01	.54632E-01	.19606E-01
19	.35638E-01	.14626E-01	-.34547E-02	-.12426	.32773E-01	.24332E-01	.14430	.11134E-01
20	.23535E-01	.38568E-02	-.24510E-01	-.23826E-01	.13341E-01	-.16764E-01	.17587	-.11128E-01
21	-.85274E-02	.39930E-02	-.97751E-01	.80158E-01	.53928E-02	-.11314	.16245	-.14950E-01
22	.28946	-.48766E-01	-.27714	-.14230	-.12564E-01	-.20817	-.65493E-01	.56575E-02
23	.18178E-01	-.30618E-02	.23775	-.22473E-01	.41211E-03	-.12972	.16959E-01	-.12634E-02
24	.10724E-02	-.18062E-03	.21957E-01	-.17465E-02	.61644E-04	-.49475E-01	-.13621E-01	.10264E-02
25	-.31340	.11057	-.59339E-01	-.84594E-01	.38305E-01	-.86424E-01	.44078E-01	.60891E-01
26	-.13719	.73254E-01	-.30966E-01	-.30343E-02	.76989E-01	-.49781E-01	.14654	.66978E-01
27	-.58336E-01	.29640E-01	-.27338E-01	.48271E-01	.40859E-01	-.44313E-01	.18463	.15586E-01
28	.31159E-02	.48384E-02	-.45976E-01	.30433E-01	.10511E-01	-.49994E-01	.16651	-.11471E-01
29	.48532E-01	-.68414E-02	-.15882	.64542E-01	.77344E-03	-.15751	.97825E-01	-.73610E-02
30	.70106E-01	-.11809E-01	.39923	-.58337E-01	-.83040E-03	-.19214	.50137E-01	-.34587E-02
31	.43072E-02	-.72567E-03	.37663E-01	-.42920E-02	.10301E-04	-.55111E-01	-.10748E-01	.82561E-03
32	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
33	-.21870	-.49895	-.23188E-01	-.23453E-01	-.46622	-.35522E-01	.35154E-01	-.10854
34	-.85831E-01	-.42675	-.32858E-02	-.46393E-01	.12394	.38490E-02	.39904E-02	.60535E-01
35	-.74841E-01	-.47312	-.46130E-02	.17499E-01	.63320	-.72934E-02	-.21677E-02	-.28154E-01
36	.21121E-02	.12171E-01	-.20284E-01	.77644E-04	.26193E-01	-.19469E-01	.13814	.63711E-02
37	-.77194E-02	.39616E-02	-.72558E-01	.69708E-01	.58646E-02	-.82403E-01	.13392	-.10142E-01
38	.25128	-.42359E-01	-.24629	-.11793	-.10878E-01	-.16625	-.60479E-01	.64329E-02
39	.14816E-01	-.24980E-02	.18349	-.17486E-01	.28823E-03	-.94202E-01	.15200E-01	-.10613E-02
40	.82357E-03	-.13884E-03	-.17273	.87086E-02	-.84439E-03	.98069E-02	-.41607E-01	.31532E-02
41	-.49452E-01	-.28984	-.54730E-04	-.23377E-01	-.54244	.48665E-02	.55888E-01	.10402
42	-.29762E-01	-.42055	.63147E-02	-.19010E-01	.14605	.15402E-01	-.13436E-01	.50639E-01
43	-.94867E-01	.43794E-01	-.26109E-01	.95067E-01	.51478E-01	-.56935E-01	.10631	.42213E-01
44	.17750E-01	.97528E-03	-.17684E-01	-.56082E-02	.68348E-02	-.12966E-01	.85974E-01	-.42625E-02
45	.37355E-02	.16855E-03	-.91226E-01	.66980E-01	.16181E-02	-.93569E-01	.66688E-01	-.42298E-02
46	.40254E-01	-.68013E-02	.35554	-.39731E-01	.85119E-04	-.14449	.47001E-01	-.32339E-02
47	.21661E-02	-.36559E-03	-.74211E-01	.27965E-02	-.43380E-03	-.14051E-01	-.24688E-01	.18819E-02

48	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
49	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
50	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
51	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
52	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
53	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
54	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
55	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
56	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
57	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000

OBS. NO.	PARAMETER NOS. 9	10	11	12	13	14	15
1	-.18116E-01	.18461E-01	-.10261	-.76670E-01	.15602E-01	-.10705E-02	.26210E-02
2	.15398E-01	-.63714E-02	-.10520E-01	.60021E-01	.21545E-01	.88367E-02	-.23863E-02
3	.19270E-01	-.59081E-02	-.13502E-01	.58394E-01	-.31557E-02	-.19161E-02	.43963E-02
4	.13865E-01	-.39926E-02	-.40248E-01	.62201E-01	-.17986E-01	-.80041E-02	.29120E-02
5	-.64447E-02	-.13709E-01	-.54199E-01	.15221	-.22743E-01	-.26276E-02	-.26176E-01
6	-.63039E-01	-.82059E-02	.13557E-01	.57499E-01	-.49339E-02	-.38820E-02	-.35640E-01
7	-.28073E-01	-.34999E-01	.11925E-01	.27877	.19645E-01	.15303E-01	-.88377E-01
8	.28890E-01	-.31691E-01	.11163E-01	.25216	.19334E-01	.12377E-01	.13325
9	.42650E-02	-.89289E-03	-.22234E-01	.23578E-01	.25553E-01	.96000E-02	-.40331E-02
10	.17661E-01	-.79392E-02	.70300E-02	.60078E-01	.49967E-02	.29181E-02	.85570E-03
11	.17141E-01	-.40038E-02	-.20132E-01	.47596E-01	-.11892E-01	-.62497E-02	.64073E-02
12	.76332E-02	-.17338E-02	-.45887E-01	.47766E-01	-.23701E-01	-.10628E-01	.23060E-02
13	-.19936E-01	.49384E-02	-.28424E-01	-.19798E-01	-.33736E-01	-.19195E-01	.18410E-03
14	-.89682E-01	.64821E-02	-.17682E-02	-.51953E-01	-.13593E-01	-.21140E-03	.70513E-02
15	.14885	-.35952E-02	-.44827E-03	.29859E-01	-.36843E-02	-.31528E-01	.11362E-02
16	.00000	.00000	.00000	.00000	.00000	.84057E-01	.77757
17	-.23283E-01	.15133E-01	-.42296E-01	-.93402E-01	-.39154E-02	-.50069E-02	.19005E-02
18	.93527E-02	-.94857E-02	.50630E-01	.40927E-01	.14658E-02	.49220E-02	-.33358E-02
19	.14382E-01	-.76122E-02	.32460E-01	.38813E-01	-.14822E-01	-.47574E-02	.42417E-02
20	.13359E-01	-.11690E-02	-.23750E-01	.26954E-01	-.11451E-01	-.73606E-02	.76480E-02
21	-.74947E-04	.63984E-02	-.40223E-01	-.23171E-01	-.26848E-01	-.14388E-01	.96146E-02
22	-.33999E-01	.20836E-01	.25131E-01	-.18951	-.19809E-01	-.26975E-01	.16407E-01
23	.13087	.67467E-02	-.38542E-02	-.52603E-01	-.11616E-01	-.37463E-01	-.12748E-01
24	.20500	.18080E-02	-.12905E-02	-.13909E-01	-.60042E-02	-.59968E-02	.11174
25	-.11093E-01	-.64651E-02	.11763	-.32837E-01	-.33475E-01	-.37928E-02	-.35805E-02
26	.16055E-02	-.13031E-01	.14458	.14100E-02	-.48216E-01	-.10543E-01	.12397E-02
27	.90939E-02	-.33097E-02	.31903E-01	.38786E-02	-.15396E-01	-.87702E-02	.77372E-02
28	.89084E-02	.31763E-02	-.27959E-01	-.56644E-02	.30900E-02	-.11232E-02	.75317E-02
29	-.88583E-02	.15650E-01	-.20747E-01	-.11340	-.18460E-01	-.10425E-01	.13955E-01
30	-.28167E-01	.15862E-01	-.26993E-02	-.12832	-.14381E-01	-.93444E-02	.16983E-01
31	.25336	.41461E-02	-.20409E-02	-.32566E-01	-.77660E-02	-.41361E-01	-.18186E-01
32	.00000	.00000	.00000	.00000	.00000	.25217	.39943
33	.62420E-02	-.13050E-01	.14321	.25669E-02	.17396E-02	.13249E-02	-.41588E-03
34	-.34508E-02	.36447E-02	-.38942E-01	-.14874E-02	-.69499E-01	.13692E-01	-.53401E-02
35	.91670E-03	-.23169E-02	.29096E-01	-.22257E-02	.10733E-01	-.86787E-02	.30763E-02
36	.90702E-02	-.22451E-02	.16153E-01	.66404E-02	.53810E-01	.12316E-01	.12429E-03
37	.34392E-02	.82785E-02	-.27664E-01	-.47790E-01	.30662E-01	.21147E-01	.18821E-02
38	-.16103E-01	.22265E-01	.25521E-01	-.20154	.17508E-01	.11819E-01	.65712E-02

Figure 4.3-10—Continued

39	.16117	.78650E-02	-.36457E-02	-.61941E-01	-.41596E-02	-.18909E-01	-.26062E-01
40	.30681	.62477E-04	.14940E-02	-.16047E-02	-.15188E-02	.32843E-01	-.63188E-02
41	-.20001E-02	.76411E-02	-.88409E-01	.18257E-02	.14546E-01	-.79979E-02	.33027E-02
42	-.28171E-02	.69553E-02	-.77255E-01	-.69040E-03	.48823E-01	-.47372E-03	.17000E-03
43	-.83165E-03	-.62057E-02	.89476E-01	-.14396E-01	.13127	.15071E-01	-.57999E-02
44	.64958E-02	.10056E-02	-.87212E-02	-.18886E-02	.13289	.55158E-01	-.14467E-01
45	-.12977E-02	.10628E-01	-.14025E-01	-.77051E-01	.80307E-01	.83613E-01	-.20443E-01
46	-.31529E-01	.12352E-01	-.35402E-02	-.98877E-01	.28424E-01	.76494E-01	-.11890E-01
47	.25299	.18326E-02	-.45556E-04	-.15020E-01	.12539E-01	.58409E-01	-.72207E-01
48	.00000	.00000	.00000	.00000	.00000	.42028	.21297E-01
49	.00000	.00000	.00000	.00000	.52187	-.22325	.72429E-01
50	.00000	.00000	.00000	.00000	.45229	-.12624	.40402E-01
51	.00000	.00000	.00000	.00000	.38271	-.29228E-01	.83755E-02
52	.00000	.00000	.00000	.00000	.31312	.67784E-01	-.23651E-01
53	.00000	.00000	.00000	.00000	.24354	.16480	-.55678E-01
54	.00000	.00000	.00000	.00000	.17396	.26181	-.87705E-01
55	.00000	.00000	.00000	.00000	.10437	.35882	-.11973
56	.00000	.00000	.00000	.00000	.34791E-01	.45583	-.15176
57	.00000	.79278	.12415E-01	.52711E-01	.41851E-16	.18357E-16	-.61881E-16

Figure 4.3-10—Continued

Program Listing

```
C       FINITE DIFFERENCE PROGRAM FOR NONLINEAR REGRESSION SOLUTION
C       OF TWO-DIMENSIONAL, STEADY-STATE, GROUND-WATER FLOW PROBLEMS
C       BY R. L. COOLEY, USGS, DENVER, COLO.
      IMPLICIT DOUBLE PRECISION (A-H,O-Z)
      DIMENSION TITLE(20),DX(30),DY(30),CX(500),CY(500),VL(500)
     1,QR(500),WELL(500),HR(500),HC(500),HCI(70),BK(70),BL(70)
     2,BM(70),BN(70),HO(70),W(70),PAR(4),QBF(50),PLA(50),PLB(50)
     3,CXHR(50),CXHL(50),CYHT(50),CYHB(50),AU(5,250),AL(20,250)
     4,V(500),X(20,70),S(20,90),XV(500),XS(4),P(20),WP(20)
     5,A(20,20),B(50)
      DIMENSION JPOS(30),IZN(500),IBZN(50),IPRM(4,20),IBNA(50)
     1,IBNB(50),IBPA(10),IBPB(10),IBHN(50),IHSN(100),KOBS(70)
     2,LN(4),NCBA(20),NCEA(20),NCBF(20),NCEF(20),NCBH(20)
     3,NCEH(20),ILOC(500),JLOC(500),IN(500),IC(5,250)
      COMMON/INT/NIJ,NEQ,ICR,ICR1,IB1,LH1,ID,JD,IM,JM,NOBS,NQSD,NBH
     1,NVAR,NVX2,KOUNT,INDT,IPO
      COMMON/LOC/ILOC,JLOC
      COMMON/TNME/IIN,IOUT
      COMMON/FLT/CX,CY,VL,QR,WELL,HR,HC,BK,BL,BM,BN,HO,W
      COMMON/SOLV/AU,AL
      COMMON/REG/DMX,ADMX,AP,CSA,AMP,RP,BP,YSQ
      EQUIVALENCE (TITLE(1),A(1,1),S(1,1),AU(1,1)),(HC(1),XV(1))
     1,(CX(1),HCI(1)),(ILOC(1),IC(1,1))
      OPEN (5,FILE='INVFD.DAT',STATUS='OLD',ACCESS='SEQUENTIAL'
     1,FORM='FORMATTED')
      OPEN (6,FILE='INVFD.OUT',STATUS='NEW',ACCESS='SEQUENTIAL'
     1,FORM='FORMATTED')
      OPEN (7,STATUS='NEW',ACCESS='SEQUENTIAL',FORM='UNFORMATTED')
C**DEFINE INPUT FILE, OUTPUT FILE, SCRATCH FILE, AND ARRAY DIMENSIONS
      IIN=5
      IOUT=6
      ITA=7
      NVD=20
      NAD=20
C**READ THREE TITLE LINES
      WRITE(IOUT,804)
      DO 5 I=1,3
      READ(IIN,801) (TITLE(J),J=1,20)                                 SET A
    5 WRITE(IOUT,803) (TITLE(J),J=1,20)
C**READ JOB SPECIFICATION DATA
      READ(IIN,800) ID,JD,NZNS,NOBS,NPAR,NVAR,NWELS,NQBZ,NHBZ,NUM,IPRX
     1,IPO,ISO                                                        SET B
      WRITE(IOUT,802) ID,JD,NZNS,NOBS,NPAR,NVAR,NWELS,NQBZ,NHBZ,NUM
     1,IPRX,IPO,ISO
      READ(IIN,820) DMX,CSA,RP,BP,EV                                  SET C
      WRITE(IOUT,806) DMX,CSA,RP,BP,EV
C**READ INITIAL ARRAY DATA
      IM=ID-1
      JM=JD-1
      CALL ARRAY(DX,IM,1,0)                                           SET D
```

Program Listing—Continued

```
      CALL ARRAY(DY,JM,1,0)                                            SET E
      CALL ARRAY(CX,IM,JM,0)                                           SET F
      CALL ARRAY(CY,IM,JM,0)                                           SET G
      CALL ARRAY(VL,IM,JM,0)                                           SET H
      CALL ARRAY(HR,ID,JD,0)                                           SET I
      CALL ARRAY(QR,IM,JM,0)                                           SET J
      CALL ARRAY(HC,ID,JD,0)                                           SET K
C**READ GRID ZONATION
      CALL ARRAYI(IZN,IM,JM,0)                                         SET L
C**READ OBSERVED HEAD DATA
      IF(NOBS.LT.1) GO TO 15
      CALL HOBS(DX,DY,V(1),V(ID+1),BK,BL,BM,BN,HO,W,KOBS)              SET M
C**INITIALIZE PARAMETER NUMBERS AND STANDARD DEVIATIONS TO ZERO
   15 DO 25 I=1,NZNS
      DO 20 K=1,4
   20 IPRM(K,I)=0
   25 CONTINUE
      DO 27 I=1,NVAR
   27 WP(I)=0.
C**READ AQUIFER PARAMETER NUMBERS
      IF(NPAR.LT.1) GO TO 35
      WRITE(IOUT,816)
      DO 30 J=1,NZNS
      READ(IIN,800) I,(IPRM(K,I),K=1,4)                                SET N
      WRITE(IOUT,818) I,(IPRM(K,I),K=1,4)
   30 CONTINUE
C**READ AQUIFER PARAMETER STANDARD DEVIATIONS
      WRITE(IOUT,822)
      DO 32 J=1,NPAR
      READ(IIN,812) K,WP(K)                                            SET O
   32 WRITE(IOUT,823) K,WP(K)
C**READ INITIAL AQUIFER PARAMETERS BY ZONE, AND LOAD THEM INTO THE
C  PARAMETER VECTOR
   35 WRITE(IOUT,810)
      M=NVAR
      DO 45 J=1,NZNS
      READ(IIN,812) I,PAR(1),PAR(2),PAR(3),PAR(4)                      SET P
      WRITE(IOUT,814) I,PAR(1),PAR(2),PAR(3),PAR(4)
      DO 40 K=1,4
      L=IPRM(K,I)
      IF(L.GT.0) GO TO 40
      M=M+1
      L=M
      IPRM(K,I)=L
   40 B(L)=PAR(K)
   45 CONTINUE
C**DEFINE JPOS ARRAY SUCH THAT COLUMN+JPOS(ROW)=NODE NUMBER
      JPOS(1)=0
      DO 50 J=2,JD
   50 JPOS(J)=JPOS(J-1)+ID
C**READ POINT FLOW DATA
      NIJ=ID*JD
```

Program Listing—Continued

```
      DO 55 N=1,NIJ
   55 WELL(N)=0.
      IF(NWELS.LT.1) GO TO 61
      WRITE(IOUT,824)
      DO 60 K=1,NWELS
      READ(IIN,826) I,J,TMP                                    SET Q
      WRITE(IOUT,828) I,J,TMP
      L=I+JPOS(J)
   60 WELL(L)=TMP
C**READ AND FORM ARRAYS FOR SPECIFIED POINT OR LINE FLOWS
   61 NQSD=0
      IF(NQBZ.LT.1) GO TO 85
      WRITE(IOUT,830)
      N=0
      DO 80 J=1,NQBZ
      READ(IIN,832) IA,JA,IB,JB,IP,QB,SDQB,QBM                 SET R
      WRITE(IOUT,831) IA,JA,IB,JB,IP,QB,SDQB,QBM
      M=1
      K=IA-1
      IF(JA.EQ.JB) GO TO 62
      M=ID
      K=JA-1
   62 MA=IA+JPOS(JA)
      MB=IB+JPOS(JB)-M
      IF(MB.GE.MA) GO TO 64
      IF(IP.LT.1) GO TO 63
      N=N+1
      IBNA(N)=MA
      IBNB(N)=MA
      QBF(N)=.5*QBM
      IBZN(N)=IP
      GO TO 68
   63 WELL(MA)=QB*QBM
      GO TO 80
   64 QBM=.5*QBM
      IF(IP.LT.1) GO TO 70
      DO 66 L=MA,MB,M
      N=N+1
      IBNA(N)=L
      IBNB(N)=L+M
      K=K+1
      TEMP=DX(K)
      IF(M.EQ.ID) TEMP=DY(K)
      QBF(N)=QBM*TEMP
   66 IBZN(N)=IP
   68 B(IP)=QB
      WP(IP)=SDQB
      GO TO 80
   70 TMP=QB*QBM
      DO 75 L=MA,MB,M
      K=K+1
      TEMP=DX(K)
```

Program Listing—Continued

```
      IF(M.EQ.ID) TEMP=DY(K)
      TEMP=TMP*TEMP
      WELL(L)=WELL(L)+TEMP
   75 WELL(L+M)=WELL(L+M)+TEMP
   80 CONTINUE
      NQSD=N
C**READ SPECIFIED BOUNDARY HEAD POSITIONS AS -1'S
   85 CALL ARRAYI(IN,ID,JD,0)                                       SET S
C**READ DATA AND FORM ARRAYS FOR SPECIFIED HEADS AND PARAMETERS
      IF(NHBZ.LT.1) GO TO 110
      WRITE(IOUT,833)
      NBH=0
      DO 108 KK=1,NHBZ
      READ(IIN,834) IZ,NN,M,N,SDHA,SDHB                             SET T
      WRITE(IOUT,836) IZ,NN,M,N,SDHA,SDHB
      DO 95 J=1,NN
      READ(IIN,826) ILOC(J),JLOC(J),V(J)                            SET T
   95 WRITE(IOUT,840) ILOC(J),JLOC(J),V(J)
      IBPA(IZ)=M
      IBPB(IZ)=N
      IF(M.LT.1) GO TO 97
      B(M)=V(1)
      WP(M)=SDHA
   97 IF(N.LT.1) GO TO 98
      B(N)=V(NN)
      WP(N)=SDHB
   98 J=JLOC(1)
      K=ILOC(1)+JPOS(J)
      M=M+N
      NBHS=NBH
      IF(IN(K).LT.-1) GO TO 100
      NBH=NBH+1
      IF(M.GT.0) IN(K)=-NBH-1
      IBZN(NBH+NQSD)=IZ
      IBHN(NBH)=K
      PLA(NBH)=1.
      PLB(NBH)=0.
  100 IF(NN.LT.2) GO TO 107
      DIST=0.
      DO 102 KNT=2,NN
      J=JLOC(KNT)
      L=ILOC(KNT)+JPOS(J)
      NBH=NBH+1
      IF(M.GT.0) IN(L)=-NBH-1
      IBZN(NBH+NQSD)=IZ
      IBHN(NBH)=L
      JM1=JLOC(KNT-1)
      IF(J.EQ.JM1) GO TO 101
      J=MIN0(J,JM1)
      DIST=DIST+DY(J)
      GO TO 102
  101 I=MIN0(ILOC(KNT),ILOC(KNT-1))
```

Program Listing—Continued

```
      DIST=DIST+DX(I)
  102 PLB(NBH)=DIST
      N=NBH-NN+1
      DO 106 KNT=2,NN
      J=JLOC(KNT)
      L=ILOC(KNT)+JPOS(J)
      N=N+1
      TMPA=PLB(N)/DIST
      TMPB=1.-TMPA
      TMPC=TMPA*V(NN)+TMPB*V(1)
      IF(DABS(V(KNT)).LE.0.) GO TO 104
      TMP=V(KNT)/TMPC
      TMPA=TMPA*TMP
      TMPB=TMPB*TMP
      TMPC=V(KNT)
  104 PLA(N)=TMPB
      PLB(N)=TMPA
  106 HC(L)=TMPC
  107 IF(M.LT.1) NBH=NBHS
  108 HC(K)=V(1)
C**COMPARE CX AND CY WITH IZN FOR CONFLICT
  110 IER=0
      N=0
      DO 115 J=1,JM
      DO 115 I=1,IM
      N=N+1
      IF(IZN(N).LT.1) GO TO 115
      IF(CX(N).GT.0..OR.CY(N).GT.0.) GO TO 115
      IER=1
      WRITE(IOUT,842) I,J
  115 CONTINUE
      IF(IER.LT.1) GO TO 120
      WRITE(IOUT,844)
      STOP
C**TRANSFER DOMAIN GEOMETRY TO IN(M) AND COMPUTE CELL FLOW-COEFFICIENTS
  120 N=0
      DO 122 J=1,JM
      DYN=.5*DY(J)
      DO 122 I=1,IM
      N=N+1
      IF(IZN(N).LT.1) GO TO 122
      M=N+J
      IF(IN(M).GT.-1) IN(M)=1
      IF(IN(M-1).GT.-1) IN(M-1)=1
      IF(IN(M+ID-1).GT.-1) IN(M+ID-1)=1
      IF(IN(M+ID).GT.-1) IN(M+ID)=1
      CX(N)=CX(N)*DYN/DX(I)
      DXN=.5*DX(I)
      CY(N)=CY(N)*DXN/DY(J)
      AREA=DXN*DYN
      VL(N)=VL(N)*AREA
      QR(N)=QR(N)*AREA
```

Program Listing—Continued

```
  122 CONTINUE
C**SET UP D4 ORDERING
      CALL ORDER(JPOS,IN,IC)
C**COMPUTE INITIAL SOLUTION
      CALL COEF(WELL,HR,HC,CX,CY,VL,QR,CXHR,CXHL,CYHT,CYHB,QBF,B,AU,AL
     1,V,IZN,IBZN,IPRM,IBNA,IBNB,IN,IC,NAD)
      CALL D4SOLV(HC,AU,AL,V,IN,IC,NAD)
      WRITE(IOUT,846)
      CALL ARRAY(HC,ID,JD,1)
      IF(ISO.EQ.1) GO TO 640
C**COMPUTE AND COUNT PRIOR INFORMATION DATA
      NPRIR=0
      DO 137 I=1,NVAR
      P(I)=B(I)
      IF(WP(I).LE.0.) GO TO 137
      WP(I)=EV/(WP(I)*WP(I))
      NPRIR=NPRIR+1
  137 CONTINUE
      WRITE(IOUT,848) NPRIR
C**INITIALIZE BEGINNING AND END POINT ARRAYS
      DO 148 I=1,NVAR
      NCBA(I)=0
      NCEA(I)=0
      NCBF(I)=0
      NCEF(I)=0
      NCBH(I)=0
  148 NCEH(I)=0
C**DEFINE BEGINNING AND END POINT ARRAYS FOR AQUIFER PARAMETERS
      IF(NPAR.LT.1) GO TO 154
      N=0
      DO 152 J=1,JM
      DO 152 I=1,IM
      N=N+1
      L=IZN(N)
      IF(L.LT.1) GO TO 152
      DO 150 M=1,4
      K=IPRM(M,L)
      IF(K.GT.NVAR) GO TO 150
      NCEA(K)=N
      IF(NCBA(K).LT.1) NCBA(K)=N
  150 CONTINUE
  152 CONTINUE
C**ORDER IBZN AND CORRESPONDING ARRAYS FOR LINE FLOW PARAMETERS
C  FROM SMALLEST TO LARGEST
  154 IF(NQSD.LT.1) GO TO 162
      DO 158 I=1,NQSD
      DO 156 J=I,NQSD
      IF(IBZN(J).GE.IBZN(I)) GO TO 156
      ITMP=IBZN(I)
      IBZN(I)=IBZN(J)
      IBZN(J)=ITMP
      ITMP=IBNA(I)
```

Program Listing—Continued

```
      IBNA(I)=IBNA(J)
      IBNA(J)=ITMP
      ITMP=IBNB(I)
      IBNB(I)=IBNB(J)
      IBNB(J)=ITMP
      TMP=QBF(I)
      QBF(I)=QBF(J)
      QBF(J)=TMP
  156 CONTINUE
  158 CONTINUE
C**DEFINE BEGINNING AND END POINT ARRAYS FOR LINE FLOW PARAMETERS
      DO 160 I=1,NQSD
      K=IBZN(I)
      NCEF(K)=I
      IF(NCBF(K).LT.1) NCBF(K)=I
  160 CONTINUE
C**DEFINE SEQUENCE NUMBERS, AND BEGINNING AND END POINT ARRAYS
C  FOR SPECIFIED HEAD PARAMETERS
  162 IF(NBH.LT.1) GO TO 174
      DO 164 I=1,NBH
      J=IBZN(I+NQSD)
      K=IBPA(J)
      IF(K.EQ.0) GO TO 163
      NCEH(K)=I
      IF(NCBH(K).LT.1) NCBH(K)=I
  163 K=IBPB(J)
      IF(K.EQ.0) GO TO 164
      NCEH(K)=I
      IF(NCBH(K).LT.1) NCBH(K)=I
  164 CONTINUE
      L=0
      DO 172 K=1,NVAR
      IF(NCBH(K).LT.1) GO TO 172
      JB=NCBH(K)
      JE=NCEH(K)
      NCBH(K)=L+1
      DO 170 J=JB,JE
      I=IBZN(J+NQSD)
      IF(IBPA(I).EQ.K.OR.IBPB(I).EQ.K) GO TO 168
      GO TO 170
  168 L=L+1
      IHSN(L)=J
  170 CONTINUE
      NCEH(K)=L
  172 CONTINUE
C**BEGIN ITERATIONS
  174 INDT=0
      ER=.01
      ERP=.001
      AMP=0.
      NVX2=NVAR+NVAR
      KOUNT=0
```

Program Listing—Continued

```
  176 KOUNT=KOUNT+1
      REWIND ITA
C**SOLVE FOR SENSITIVITIES:
      DO 260 N=1,NVAR
      DO 178 I=1,NEQ
  178 V(I)=0.
      IF(NCBA(N).LT.1) GO TO 208
C**ASSEMBLE R.H.S. FOR AQUIFER PARAMETERS
      LB=NCBA(N)
      LE=NCEA(N)
      DO 200 L=LB,LE
      J=IZN(L)
      IF(J.LT.1) GO TO 200
      NA=L+(L-1)/IM
      NB=NA+1
      NC=NB+ID
      ND=NA+ID
      INA=IN(NA)
      INB=IN(NB)
      INC=IN(NC)
      IND=IN(ND)
      IF(IPRM(1,J).NE.N) GO TO 180
      IF(INA.GT.0) V(INA)=V(INA)+CX(L)*(HC(NB)-HC(NA))
      IF(INB.GT.0) V(INB)=V(INB)+CX(L)*(HC(NA)-HC(NB))
      IF(INC.GT.0) V(INC)=V(INC)+CX(L)*(HC(ND)-HC(NC))
      IF(IND.GT.0) V(IND)=V(IND)+CX(L)*(HC(NC)-HC(ND))
  180 IF(IPRM(2,J).NE.N) GO TO 185
      IF(INA.GT.0) V(INA)=V(INA)+CY(L)*(HC(ND)-HC(NA))
      IF(INB.GT.0) V(INB)=V(INB)+CY(L)*(HC(NC)-HC(NB))
      IF(INC.GT.0) V(INC)=V(INC)+CY(L)*(HC(NB)-HC(NC))
      IF(IND.GT.0) V(IND)=V(IND)+CY(L)*(HC(NA)-HC(ND))
  185 IF(IPRM(3,J).NE.N) GO TO 190
      IF(INA.GT.0) V(INA)=V(INA)+VL(L)*(HR(NA)-HC(NA))
      IF(INB.GT.0) V(INB)=V(INB)+VL(L)*(HR(NB)-HC(NB))
      IF(INC.GT.0) V(INC)=V(INC)+VL(L)*(HR(NC)-HC(NC))
      IF(IND.GT.0) V(IND)=V(IND)+VL(L)*(HR(ND)-HC(ND))
  190 IF(IPRM(4,J).NE.N) GO TO 200
      IF(INA.GT.0) V(INA)=V(INA)+QR(L)
      IF(INB.GT.0) V(INB)=V(INB)+QR(L)
      IF(INC.GT.0) V(INC)=V(INC)+QR(L)
      IF(IND.GT.0) V(IND)=V(IND)+QR(L)
  200 CONTINUE
C**ASSEMBLE R.H.S. FOR SPECIFIED LINE FLOW PARAMETERS
  208 IF(NCBF(N).LT.1) GO TO 212
      LB=NCBF(N)
      LE=NCEF(N)
      DO 210 L=LB,LE
      I=IBNA(L)
      J=IN(I)
      IF(J.GT.0) V(J)=V(J)+QBF(L)
      I=IBNB(L)
      J=IN(I)
```

Program Listing—Continued

```
      IF(J.GT.0) V(J)=V(J)+QBF(L)
  210 CONTINUE
C**ASSEMBLE R.H.S. FOR SPECIFIED HEAD PARAMETERS
  212 IF(NCBH(N).LT.1) GO TO 216
      LB=NCBH(N)
      LE=NCEH(N)
      DO 214 L=LB,LE
      K=IHSN(L)
      I=IBZN(K+NQSD)
      TMP=0.
      IF(IBPA(I).EQ.N) TMP=PLA(K)
      IF(IBPB(I).EQ.N) TMP=TMP+PLB(K)
      I=IBHN(K)+1
      IF(I.LE.NIJ) J=IN(I)
      IF(J.GT.0) V(J)=V(J)+CXHR(K)*TMP
      I=IBHN(K)-1
      IF(I.GT.0) J=IN(I)
      IF(J.GT.0) V(J)=V(J)+CXHL(K)*TMP
      I=IBHN(K)+ID
      IF(I.LE.NIJ) J=IN(I)
      IF(J.GT.0) V(J)=V(J)+CYHT(K)*TMP
      I=IBHN(K)-ID
      IF(I.GT.0) J=IN(I)
      IF(J.GT.0) V(J)=V(J)+CYHB(K)*TMP
  214 CONTINUE
C**MODIFY R.H.S.--UPPER HALF
  216 DO 220 J=1,ICR1
      II=IC(1,J)
      DO 218 I=2,II
      LR=IC(I,J)
      V(LR)=V(LR)-AU(I,J)*V(J)
  218 CONTINUE
  220 V(J)=V(J)/AU(1,J)
C**MODIFY R.H.S.--LOWER HALF
      JJ=NEQ-ICR
      DO 224 J=1,JJ
      JR=J+ICR1
      LR=JR
      DO 222 I=2,IB1
      LR=LR+1
      IF(AL(I,J).NE.0.) V(LR)=V(LR)-AL(I,J)*V(JR)
  222 CONTINUE
  224 V(JR)=V(JR)/AL(1,J)
C**BACK SOLVE--LOWER HALF
      V(NEQ)=V(NEQ)/AL(1,NEQ-ICR1)
      DO 230 J=1,JJ
      KK=NEQ-J
      KL=KK-ICR1
      L=KK
      DO 226 I=2,IB1
      L=L+1
      IF(AL(I,KL).NE.0.) V(KK)=V(KK)-AL(I,KL)*V(L)
```

Program Listing—Continued

```
  226 CONTINUE
  230 CONTINUE
C**BACK SOLVE--UPPER HALF
      DO 250 J=1,ICR1
      KK=ICR-J
      II=IC(1,KK)
      DO 240 I=2,II
      L=IC(I,KK)
      V(KK)=V(KK)-AU(I,KK)*V(L)
  240 CONTINUE
  250 CONTINUE
      WRITE(ITA) (V(I),I=1,NEQ)
C**COMPUTE SENSITIVITIES AT OBSERVATION POINTS
      DO 255 I=1,NOBS
      K=KOBS(I)
      LN(1)=IN(K)
      LN(2)=IN(K+1)
      LN(3)=IN(K+ID)
      LN(4)=IN(K+ID+1)
      DO 253 J=1,4
      L=LN(J)
      IF(L.GT.0) GO TO 252
      XS(J)=0.
      IF(L.GT.-2) GO TO 253
      L=-L-1
      IZ=IBZN(L+NQSD)
      TMP=0.
      IF(IBPA(IZ).EQ.N) TMP=PLA(L)
      IF(IBPB(IZ).EQ.N) TMP=TMP+PLB(L)
      XS(J)=TMP
      GO TO 253
  252 XS(J)=V(L)
  253 CONTINUE
  255 X(N,I)=BK(I)*XS(1)+BL(I)*XS(2)+BM(I)*XS(3)+BN(I)*XS(4)
  260 CONTINUE
      IF(IPO.NE.1) GO TO 270
      WRITE(IOUT,850)
      DO 265 N=1,NOBS
      WRITE(IOUT,852) N,(X(K,N),K=1,NVAR)
  265 CONTINUE
C**CALL LEAST SQUARES
  270 CALL LSTSQ(HC,BK,BL,BM,BN,HO,W,P,WP,X,A,B,V,KOBS,IN,NVD)
      IF(INDT.GT.0) GO TO 515
C**COMPUTE NEW SPECIFIED HEADS
      IF(NBH.LT.1) GO TO 310
      DO 300 N=1,NBH
      M=IBZN(N+NQSD)
      K=IBPA(M)
      TMPA=0.
      IF(K.GT.0) TMPA=PLA(N)*V(K)
      L=IBPB(M)
      TMPB=0.
```

Program Listing—Continued

```
      IF(L.GT.0) TMPB=PLB(N)*V(L)
      J=IBHN(N)
      HC(J)=HC(J)+TMPA+TMPB
  300 CONTINUE
C**CHECK FOR CONVERGENCE
  310 IF(ADMX.LT.ER) GO TO 350
C**CHECK FOR PARAMETERS GOING TO ZERO
      IND=0
      DO 335 I=1,NVAR
      IF(DABS(B(I)).GT.DABS(ERP*P(I))) GO TO 335
      WRITE(IOUT,858) I
      IND=1
  335 CONTINUE
      IF(IND.GT.0) GO TO 515
      IF(KOUNT.EQ.NUM) GO TO 340
C**COMPUTE NEW HEADS AT GRID POINTS
      CALL COEF(WELL,HR,HC,CX,CY,VL,QR,CXHR,CXHL,CYHT,CYHB,QBF,B,AU,AL
     1,V,IZN,IBZN,IPRM,IBNA,IBNB,IN,IC,NAD)
      CALL D4SOLV(HC,AU,AL,V,IN,IC,NAD)
      GO TO 176
  340 WRITE(IOUT,860) NUM
      GO TO 515
  350 WRITE(IOUT,862) KOUNT
C**COMPUTE FINAL ESTIMATES OF HEAD
      REWIND ITA
      DO 366 K=1,NVAR
      READ(ITA) (CX(I),I=1,NEQ)
      DO 364 J=1,NIJ
      L=IN(J)
      IF(L.GT.0) HC(J)=HC(J)+CX(L)*V(K)
  364 CONTINUE
  366 CONTINUE
C**CORRECT A FOR MARQUARDT PARAMETER
      IF(NVAR.EQ.1) GO TO 420
      IF(AMP.LE.0.) GO TO 385
      DO 380 I=1,NVAR
      A(I,I)=1.+RP
      DO 375 J=I,NVAR
  375 A(J,I)=A(I,J)
  380 CONTINUE
      AMP=-1.
      CALL LSTSQ(HC,BK,BL,BM,BN,HO,W,P,WP,X,A,B,V,KOBS,IN,NVD)
      IF(INDT.GT.0) GO TO 515
C**COMPUTE A-INVERSE
  385 A(NVAR,NVAR)=1./A(NVAR,NVAR)
      NM1=NVAR-1
      DO 410 K=1,NM1
      KP1=K+1
      DO 395 I=KP1,NVAR
      SUM=0.
      IM1=I-1
      DO 390 J=K,IM1
```

Program Listing—Continued

```
  390 SUM=SUM+A(I,J)*A(J,K)
      A(K,I)=-SUM
  395 A(I,K)=-SUM*A(I,I)
      DO 405 I=1,K
      SUM=A(K,I)
      DO 400 J=KP1,NVAR
  400 SUM=SUM+A(J,K)*A(I,J)
      A(K,I)=SUM
  405 A(I,K)=A(K,I)
  410 CONTINUE
      DO 415 J=1,NVAR
  415 A(J,NVAR)=A(NVAR,J)
      GO TO 425
  420 A(1,1)=1./(1.+RP)
C**COMPUTE TR((A-INVERSE)**2) AND A-INVERSE - RP*(A-INVERSE)**2
  425 TRACE=0.
      IF(RP.LE.0.) GO TO 448
      DO 445 N=1,NVAR
      DO 430 J=1,NVAR
  430 V(J)=A(J,N)
      SUMA=0.
      DO 440 J=N,NVAR
      SUM=0.
      DO 435 I=1,NVAR
  435 SUM=SUM+V(I)*A(I,J)
      V(J+NVAR)=SUM
  440 A(J,N)=A(J,N)-RP*SUM
  445 TRACE=TRACE+V(N+NVAR)
C**COMPUTE SUM OF SQUARED ERRORS
  448 YSQ=0.
      DO 450 N=1,NOBS
      K=KOBS(N)
      HCI(N)=BK(N)*HC(K)+BL(N)*HC(K+1)+BM(N)*HC(K+ID)+BN(N)*HC(K+ID+1)
  450 YSQ=YSQ+(HO(N)-HCI(N))*W(N)*(HO(N)-HCI(N))
      DO 455 I=1,NVAR
  455 YSQ=YSQ+(P(I)-B(I))*WP(I)*(P(I)-B(I))
C**COMPUTE ERROR VARIANCE
      TEMP=NPRIR-NVAR
      OBS=NOBS
      VAR=YSQ/(OBS+TEMP+RP*RP*TRACE)
C**COMPUTE CORRELATION COEFFICIENT
      SUMA=0.
      SUMB=0.
      SUMC=0.
      SUMD=0.
      SUM=0.
      DO 460 N=1,NOBS
      TMP=W(N)**.5
      W(N)=TMP
      TEMP=TMP*HO(N)
      TMP=TMP*HCI(N)
      SUMA=SUMA+TEMP
```

Program Listing—Continued

```
      SUMB=SUMB+TMP
      SUMC=SUMC+TEMP*TEMP
      SUMD=SUMD+TMP*TMP
      SUM=SUM+TEMP*TMP
  460 CONTINUE
      R=(OBS*SUM-SUMA*SUMB)/((OBS*SUMC-SUMA*SUMA)*(OBS*SUMD-SUMB*SUMB))
     1**.5
C**PRINT ERROR VARIANCE, ESTIMATED SUM OF SQUARED ERRORS, AND
C  CORRELATION COEFFICIENT
      WRITE(IOUT,864) VAR,YSQ,R
C**COMPUTE VARIANCE-COVARIANCE MATRIX
      DO 463 J=1,NVAR
      TEMP=V(J+NVX2)
      DO 462 I=J,NVAR
      A(I,J)=VAR*A(I,J)/(V(I+NVX2)*TEMP)
  462 A(J,I)=A(I,J)
  463 V(J)=A(J,J)**.5
C**PRINT PARAMETERS AND STANDARD ERRORS
      WRITE(IOUT,870)
      DO 480 J=1,NVAR
  480 WRITE(IOUT,856) J,B(J),V(J)
C**PRINT VARIANCE-COVARIANCE MATRIX
  490 WRITE(IOUT,874)
      CALL PRTOT(A,NVAR,NVD,0)
C**COMPUTE AND PRINT CORRELATION MATRIX
      DO 510 J=1,NVAR
      TEMP=V(J)
      DO 500 I=J,NVAR
      A(I,J)=A(I,J)/(V(I)*TEMP)
  500 A(J,I)=A(I,J)
  510 CONTINUE
      WRITE(IOUT,876)
      CALL PRTOT(A,NVAR,NVD,0)
C**PRINT COMPUTED AND OBSERVED HEADS, AND COMPUTE AND PRINT RESIDUALS
      GO TO 518
  515 DO 516 N=1,NOBS
      K=KOBS(N)
      HCI(N)=BK(N)*HC(K)+BL(N)*HC(K+1)+BM(N)*HC(K+ID)+BN(N)*HC(K+ID+1)
  516 W(N)=W(N)**.5
  518 WRITE(IOUT,878)
      DO 520 N=1,NOBS
      RES=W(N)*(HCI(N)-HO(N))
      WRITE(IOUT,880) N,HCI(N),HO(N),RES
  520 CONTINUE
C**PRINT HYDRAULIC HEADS FOR EACH NODE
      WRITE(IOUT,881)
      CALL ARRAY(HC,ID,JD,1)
C**PRINT SENSITIVITIES FOR EACH NODE
      IF(IPRX.LT.1.AND.KOUNT.LT.NUM) STOP
      WRITE(IOUT,882)
      REWIND ITA
      DO 530 KK=1,NVAR
```

Program Listing—Continued

```
      READ(ITA) (CX(I),I=1,NEQ)
      WRITE(IOUT,884) KK
      DO 525 N=1,NIJ
      L=IN(N)
      IF(L.GT.0) GO TO 523
      XV(N)=0.
      IF(L.GT.-2) GO TO 525
      L=-L-1
      IZ=IBZN(L+NQSD)
      TMP=0.
      IF(IBPA(IZ).EQ.KK) TMP=PLA(L)
      IF(IBPB(IZ).EQ.KK) TMP=TMP+PLB(L)
      XV(N)=TMP
      GO TO 525
  523 XV(N)=CX(L)
  525 CONTINUE
  530 CALL ARRAY(XV,ID,JD,1)
      IF(NVAR.LT.2) STOP
C**SCALE AND ORTHOGONALIZE COLUMNS OF SENSITIVITY MATRIX, X:
C**SCALE X AND AUGMENT X TO INCLUDE PRIOR
      DO 535 N=1,NOBS
      DO 535 K=1,NVAR
  535 S(K,N)=X(K,N)*W(N)/V(K+NVX2)
      IF(NPRIR.LT.1) GO TO 539
      N=NOBS
      DO 538 I=1,NVAR
      IF(WP(I).LT.1.E-10) GO TO 538
      N=N+1
      DO 537 J=1,NVAR
  537 S(J,N)=0.
      S(I,N)=WP(I)**.5/V(I+NVX2)
  538 CONTINUE
C**ORTHOGONALIZE S
  539 NTMP=NOBS+NPRIR
      DO 540 I=1,NTMP
  540 CY(I)=S(1,I)
      DO 600 N=2,NVAR
      NM1=N-1
      SUM=0.
      DO 550 I=1,NTMP
      SUM=SUM+CY(I)*CY(I)
      S(NM1,I)=CY(I)
  550 CONTINUE
      IF(SUM.LT.1.E-20) GO TO 610
      V(NM1)=1./SUM
      DO 570 J=1,NM1
      SUM=0.
      DO 560 K=1,NTMP
  560 SUM=SUM+V(J)*S(J,K)*S(N,K)
  570 CX(J)=SUM
      DO 590 K=1,NTMP
      SUM=0.
```

Program Listing—Continued

```
      DO 580 I=1,NM1
  580 SUM=SUM+S(I,K)*CX(I)
  590 CY(K)=S(N,K)-SUM
  600 CONTINUE
C**PRINT ORTHOGONALIZED S
  610 WRITE(IOUT,886)
      K=1
      L=8
      DO 630 M=1,NVAR,8
      IF(L.GT.NVAR) L=NVAR
      WRITE(IOUT,888) (I,I=K,L)
      DO 620 J=1,NTMP
      S(NVAR,J)=CY(J)
      WRITE(IOUT,890) J,(S(I,J),I=K,L)
  620 CONTINUE
      WRITE(IOUT,890)
      K=K+8
      L=L+8
  630 CONTINUE
      STOP
C**READ, PRINT, AND EXECUTE FOR ALTERNATE SOLUTIONS
  640 READ(IIN,800) N                                              SET U
      IF(N.LT.1) STOP
      DO 690 KNT=1,N
      WRITE(IOUT,891) KNT
      DO 670 L=1,NVAR
      READ(IIN,812) I,PR                                           SET V
      V(I)=PR-B(I)
  670 B(I)=PR
      WRITE(IOUT,892)
      CALL PRTOT(B,NVAR,0,1)
      IF(NBH.LT.1) GO TO 685
      DO 680 N=1,NBH
      M=IBZN(N+NQSD)
      K=IBPA(M)
      TMPA=0.
      IF(K.GT.0) TMPA=PLA(N)*V(K)
      L=IBPB(M)
      TMPB=0.
      IF(L.GT.0) TMPB=PLB(N)*V(L)
      J=IBHN(N)
  680 HC(J)=HC(J)+TMPA+TMPB
  685 CALL COEF(WELL,HR,HC,CX,CY,VL,QR,CXHR,CXHL,CYHT,CYHB,QBF,B,AU,AL
     1,V,IZN,IBZN,IPRM,IBNA,IBNB,IN,IC,NAD)
      CALL D4SOLV(HC,AU,AL,V,IN,IC,NAD)
      WRITE(IOUT,898)
      CALL ARRAY(HC,ID,JD,1)
  690 CONTINUE
      STOP
C
  800 FORMAT (16I5)
  801 FORMAT (20A4)
```

Program Listing—Continued

```
802 FORMAT (56H0NUMBER OF COLUMNS (ID) ----------------------------
   $=,I5
   $/56H NUMBER OF ROWS (JD) --------------------------------- =,I5
   $/56H NUMBER OF AQUIFER ZONES (NZNS) ---------------------- =,I5
   $/56H NUMBER OF OBSERVATIONS (NOBS) ----------------------- =,I5
   $/56H NUMBER OF AQUIFER PARAMETERS (NPAR) ----------------- =,I5
   $/56H TOTAL NUMBER OF PARAMETERS (NVAR) ------------------- =,I5
   $/56H NUMBER OF KNOWN POINT FLOWS (NWELS) ----------------- =,I5
   $/56H NUMBER OF SPECIFIED FLOW ZONES (NQBZ) --------------- =,I5
   $/56H NUMBER OF SPECIFIED HEAD ZONES (NHBZ) --------------- =,I5
   $/56H MAXIMUM NUMBER OF ITERATIONS (NUM) ------------------ =,I5
   $/56H SENSITIVITY PRINT AND ORTHOGONALIZATION OPTION (IPRX) =,I5
   $/56H ADDITIONAL PRINTOUT OPTION (IPO) -------------------- =,I5
   $/56H SOLUTION ONLY OPTION (ISO) -------------------------- =,I5)
803 FORMAT (1H ,20A4)
804 FORMAT (1H1)
806 FORMAT (50H MAXIMUM ALLOWABLE PARAMETER CORRECTION (DMX) - =
   $,G11.5
   $/50H SEARCH DIRECTION ADJUSTMENT PARAMETER (CSA) -- = ,G11.5
   $/50H RIDGE PARAMETER FOR REGRESSION (RP) ---------- = ,G11.5
   $/50H BIAS PARAMETER FOR REGRESSION (BP) ----------- = ,G11.5
   $/50H ESTIMATED ERROR VARIANCE (EV) ---------------- = ,G11.5)
810 FORMAT (1H0,12X,34HINITIAL AQUIFER PARAMETERS BY ZONE/6H  ZONE
   1,5X,5HTRANX,8X,5HTRANY,8X,5HVLEAK,8X,5HQDIST)
812 FORMAT (I5,4F10.0)
814 FORMAT (1H ,I4,2X,4(2X,G11.5))
816 FORMAT (1H0,11X,25HAQUIFER PARAMETER NUMBERS/1H ,5X,4HZONE,4X
   1,5HTRANX,3X,5HTRANY,3X,5HVLEAK,3X,5HQDIST)
818 FORMAT (1H ,8I8)
820 FORMAT (8F10.0)
822 FORMAT (1H0,4X,19HSTANDARD DEVIATIONS/1H ,3X,22HFOR AQUIFER PARAME
   1TERS/1H ,6X,4HPAR.,6X,4HSTD./1H ,7X,3HNO.,6X,4HDEV.)
823 FORMAT (1H ,5X,I4,4X,G11.5)
824 FORMAT (1H0,12X,11HPOINT FLOWS/1H ,7X,1HI,7X,1HJ,4X,9HVOL. RATE)
826 FORMAT (2I5,F10.0)
828 FORMAT (1H ,2I8,4X,G11.5)
830 FORMAT (1H0,22X,27HINITIAL SPECIFIED FLOW DATA/1H ,6X,9HNODE NO.S
   1,7X,4HPAR.,6X,4HFLOW,10X,4HSTD./1H ,19H  IA   JA   IB   JB,4X
   2,3HNO.,4X,9HPARAMETER,7X,4HDEV.,5X,10HMULTIPLIER)
831 FORMAT (1H ,4(1X,I3,1X),2X,I3,3X,3(2X,G11.5))
832 FORMAT (5I5,3F10.0)
833 FORMAT (1H0,18X,27HINITIAL SPECIFIED HEAD DATA)
834 FORMAT (4I5,2F10.0)
836 FORMAT (1H0,22H  NO. OF NODES IN ZONE,I4,3H = ,I3/1H
   1,20H  PAR. NO. HEAD A = ,I3,12X,18HPAR. NO. HEAD B = ,I3/1H
   2,21H  STD. DEV. HEAD A = ,G11.5,22H   STD. DEV. HEAD B = ,G11.5
   3/1H ,20X,22HINITIAL VALUES OF HEAD/1H ,21X,1HI,5X,1HJ,8X,4HHEAD)
840 FORMAT (1H ,19X,2(I3,3X),2X,G11.5)
842 FORMAT (9H0AT CELL ,1H(,I3,1H,,I3,1H),23H, IZN>0, CX=0, AND CY=0)
844 FORMAT (60H0PROGRAM ABORTED BECAUSE OF CONFLICT BETWEEN IZN, CX, A
   1ND CY)
846 FORMAT (18H0 INITIAL SOLUTION)
```

Program Listing—Continued

```
848 FORMAT (46HONO. OF PARAMETERS HAVING PRIOR INFORMATION = ,I4)
850 FORMAT (1H0,3X,55HOBSERVATION NUMBER AND SENSITIVITIES FOR EACH PA
   1RAMETER)
852 FORMAT (1H ,1X,I4,7(1X,G11.5)/(1H ,(5X,7(1X,G11.5))))
856 FORMAT (1H ,1X,I4,3X,4(G11.5,4X))
858 FORMAT (11HOPARAMETER ,I3,17H EFFECTIVELY ZERO)
860 FORMAT (//32HOSOLUTION FAILED TO CONVERGE IN ,I3,11H ITERATIONS)
862 FORMAT (//23HOSOLUTION CONVERGED IN ,I3,11H ITERATIONS)
864 FORMAT (18HOERROR VARIANCE = ,G11.5/35H ESTIMATED SUM OF SQUARED E
   1RRORS = ,G11.5/27H CORRELATION COEFFICIENT = ,G11.5)
870 FORMAT (1H0,5X,24HESTIMATED PARAMETER DATA/1H ,6H  PAR.
   1/1H ,6H   NO.,5X,4HPAR.,9X,9HSTD. DEV.)
874 FORMAT (28H0 VARIANCE-COVARIANCE MATRIX)
876 FORMAT (20H0 CORRELATION MATRIX)
878 FORMAT (1H0,21X,14HHEAD RESIDUALS/1H ,7H   OBS.,5X,9HPREDICTED
   1,7X,8HOBSERVED,8X,8HWEIGHTED/1H ,4X,3HNO.,7X,5HVALUE,10X
   2,5HVALUE,10X,8HRESIDUAL)
880 FORMAT (1H ,2X,I4,1X,3(5X,G11.5))
881 FORMAT (33H0 FINAL COMPUTED NODAL HEAD ARRAY)
882 FORMAT (26H0 NODAL SENSITIVITY ARRAYS)
884 FORMAT (19H0 PARAMETER NUMBER ,I5)
886 FORMAT (1H0,3X,44HSCALED AND ORTHOGONALIZED SENSITIVITY MATRIX
   1/1H ,49H OBSERVATION NUMBER AND VALUES FOR EACH PARAMETER)
888 FORMAT (7H   OBS.,13X,14HPARAMETER NOS./1H ,3X,3HNO.,4X,8(I3,9X))
890 FORMAT (1H ,1X,I4,8(1X,G11.5))
891 FORMAT (24H0ADDITIONAL SOLUTION NO.,I5)
892 FORMAT (1H0,30X,14HNEW PARAMETERS/1H ,3(4X,3HNO.,8X,5HVALUE,4X))
898 FORMAT (16H0 COMPUTED HEADS)
    END
```

Program Listing—Continued

```
      SUBROUTINE ARRAY(A,IND,JND,IT)
      IMPLICIT DOUBLE PRECISION (A-H,O-Z)
      DIMENSION A(IND,JND)
      COMMON/TNME/IIN,IOUT
C**IF IT=0, LOAD 1 AND 2 DIMENSIONAL ARRAYS
C**IF IT=1, PRINT 2 DIMENSIONAL ARRAYS
      IF(IT.EQ.1) GO TO 55
      DO 5 J=1,JND
      DO 5 I=1,IND
    5 A(I,J)=0.
      READ(IIN,65) NME,NOBL,IPRN
      WRITE(IOUT,75) NME
      DO 50 K=1,NOBL
      READ(IIN,70) IB,IE,JB,JE,FACT,IVAR
      WRITE(IOUT,80) K,IB,IE,JB,JE,FACT
      IF(IVAR.GT.0) GO TO 20
      DO 10 J=JB,JE
      DO 10 I=IB,IE
   10 A(I,J)=FACT
      GO TO 50
   20 DO 40 J=JB,JE
      READ(IIN,90) (A(I,J),I=IB,IE)
      DO 40 I=IB,IE
   40 A(I,J)=A(I,J)*FACT
   50 CONTINUE
      IF(IPRN.GT.0) RETURN
      WRITE(IOUT,100) NME
   55 DO 60 K=1,IND,10
      I10=K+9
      IF(I10.GT.IND) I10=IND
      WRITE(IOUT,110) (I,I=K,I10)
      WRITE(IOUT,105)
      DO 60 J=1,JND
      JR=JND-J+1
   60 WRITE(IOUT,120) JR,(A(I,JR),I=K,I10)
      RETURN
C
   65 FORMAT (A4,1X,2I5)
   70 FORMAT (4I5,F10.0,3I5)
   75 FORMAT (1H0,A4)
   80 FORMAT (1H ,I3,2X,5HIB = ,I5,2X,5HIE = ,I5,2X,5HJB = ,I5,2X
     1,5HJE = ,I5,2X,7HFACT = ,G11.5)
   90 FORMAT (8F10.0)
  100 FORMAT (1H0,1X,A4,6H ARRAY)
  105 FORMAT (1H )
  110 FORMAT (1H0,10(9X,I3))
  120 FORMAT (1H ,I3,1X,10(1X,G11.5))
      END
      SUBROUTINE ARRAYI(INT,IND,JND,IT)
      DIMENSION INT(IND,JND)
      COMMON/TNME/IIN,IOUT
C**IF IT=0, LOAD 1 AND 2 DIMENSIONAL INTEGER ARRAYS
C**IF IT=1, PRINT 2 DIMENSIONAL INTEGER ARRAYS
```

Program Listing—Continued

```
      IF(IT.EQ.1) GO TO 45
      DO 5 J=1,JND
      DO 5 I=1,IND
    5 INT(I,J)=0
      READ(IIN,55) NME,NOBL,IPRN
      WRITE(IOUT,65) NME
      DO 40 K=1,NOBL
      READ(IIN,60) IB,IE,JB,JE,IFACT,IVAR
      WRITE(IOUT,70) K,IB,IE,JB,JE,IFACT
      IF(IVAR.GT.0) GO TO 20
      DO 10 J=JB,JE
      DO 10 I=IB,IE
   10 INT(I,J)=IFACT
      GO TO 40
   20 DO 30 J=JB,JE
      READ(IIN,60) (INT(I,J),I=IB,IE)
   30 CONTINUE
   40 CONTINUE
      IF(IPRN.GT.0) RETURN
      WRITE(IOUT,80) NME
   45 DO 50 K=1,IND,30
      I30=K+29
      IF(I30.GT.IND) I30=IND
      WRITE(IOUT,90) (I,I=K,I30)
      WRITE(IOUT,100)
      DO 50 J=1,JND
      JR=JND-J+1
   50 WRITE(IOUT,110) JR,(INT(I,JR),I=K,I30)
      RETURN
C
   55 FORMAT (A4,1X,2I5)
   60 FORMAT (16I5)
   65 FORMAT (1H0,A4)
   70 FORMAT (1H ,I3,2X,5HIB = ,I5,2X,5HIE = ,I5,2X,5HJB = ,I5,2X
     1,5HJE = ,I5,2X,8HIFACT = ,I5)
   80 FORMAT (1H0,1X,A4,6H ARRAY)
   90 FORMAT (1H0,3X,30(1X,I3))
  100 FORMAT (1H )
  110 FORMAT (1H ,31(I3,1X))
      END
      SUBROUTINE ORDER(JPOS,IN,IC)
      DIMENSION JPOS(1),IN(1),IC(5,1)
      COMMON/INT/NIJ,NEQ,ICR,ICR1,IB1,LH1,ID,JD,IM,JM,NOBS,NQSD,NBH
     1,NVAR,NVX2,KOUNT,INDT,IPO
      COMMON/TNME/IIN,IOUT
C**COMPUTE EQUATION NUMBERS FOR D4 ORDERING:
      NXP=ID+JD-1
      K=0
C**ORDER--LEFT TO RIGHT, BOTTOM TO TOP
      DO 20 I=1,NXP,2
      DO 20 J=1,JD
      IK=I-J+1
      IF(IK.LT.1.OR.IK.GT.ID) GO TO 20
```

Program Listing—Continued

```
      N=IK+JPOS(J)
      IF(IN(N).LT.1) GO TO 20
      K=K+1
      IN(N)=K
   20 CONTINUE
      ICR=K+1
      DO 30 I=2,NXP,2
      DO 30 J=1,JD
      IK=I-J+1
      IF(IK.LT.1.OR.IK.GT.ID) GO TO 30
      N=IK+JPOS(J)
      IF(IN(N).LT.1) GO TO 30
      K=K+1
      IN(N)=K
   30 CONTINUE
C**COMPUTE BAND WIDTH AND DETERMINE CONNECTING EQUATION NUMBERS:
      MNO=9999
      MXO=0
      N=0
      IND=0
      DO 80 J=1,JD
      DO 80 I=1,ID
      N=N+1
      JR=IN(N)
      IF(JR.LT.1.OR.JR.GE.ICR) GO TO 80
      IU=1
C**BELOW
      IF((J-1).LT.1.OR.IN(N-ID).LT.1) GO TO 40
      IU=IU+1
      IC(IU,JR)=IN(N-ID)
      MM=IN(N-ID)-JR
      MXO=MAX0(MM,MXO)
      MNO=MIN0(MM,MNO)
C**LEFT
   40 IF((I-1).LT.1.OR.IN(N-1).LT.1) GO TO 50
      IU=IU+1
      IC(IU,JR)=IN(N-1)
      MM=IN(N-1)-JR
      MNO=MIN0(MM,MNO)
      MXO=MAX0(MM,MXO)
C**RIGHT
   50 IF((I+1).GT.ID.OR.IN(N+1).LT.1) GO TO 60
      IU=IU+1
      IC(IU,JR)=IN(N+1)
      MM=IN(N+1)-JR
      MXO=MAX0(MM,MXO)
      MNO=MIN0(MM,MNO)
C**ABOVE
   60 IF((J+1).GT.JD.OR.IN(N+ID).LT.1) GO TO 70
      IU=IU+1
      IC(IU,JR)=IN(N+ID)
      MM=IN(N+ID)-JR
      MXO=MAX0(MM,MXO)
```

Program Listing—Continued

```
      MNO=MIN0(MM,MNO)
   70 IC(1,JR)=IU
      IF(IU.GT.1) GO TO 80
      WRITE(IOUT,110) I,J
      IND=1
   80 CONTINUE
      IF(IND.GT.0) STOP
      NEQ=K
      ICR1=ICR-1
      IB1=MXO-MNO+1
      LH1=NEQ-ICR1
      WRITE(IOUT,90)
      WRITE(IOUT,100) ICR1,IB1,LH1,ICR1,NEQ
      RETURN
C
   90 FORMAT (51H0SOLUTION BY LDU FACTORIZATION ASSUMING D4 ORDERING)
  100 FORMAT (65H MINIMUM DIMENSIONS FOR ARRAYS USED BY THIS METHOD ARE
     1AS FOLLOWS/1H ,12H AU:    5 BY,I5/1H ,4H AL:,I5,3H BY,I5/1H
     2,12H IC:    5 BY,I5/1H ,4H  V:,I5)
  110 FORMAT (1H0,13HACTIVE NODE (,I3,1H,,I3,20H) CANNOT BE ISOLATED)
      END
      SUBROUTINE COEF(WELL,HR,HC,CX,CY,VL,QR,CXHR,CXHL,CYHT,CYHB,QBF
     1,B,AU,AL,V,IZN,IBZN,IPRM,IBNA,IBNB,IN,IC,NAD)
      IMPLICIT DOUBLE PRECISION (A-H,O-Z)
      DIMENSION WELL(1),HR(1),HC(1),CX(1),CY(1),VL(1),QR(1),CXHR(1)
     1,CXHL(1),CYHT(1),CYHB(1),QBF(1),B(1),AU(5,1),AL(NAD,1),V(1)
      DIMENSION IZN(1),IBZN(1),IPRM(4,1),IBNA(1),IBNB(1),IN(1),IC(5,1)
      COMMON/INT/NIJ,NEQ,ICR,ICR1,IB1,LH1,ID,JD,IM,JM,NOBS,NQSD,NBH
     1,NVAR,NVX2,KOUNT,INDT,IPO
C**INITIALIZE ARRAYS
      DO 10 J=1,ICR1
      DO 10 I=1,5
   10 AU(I,J)=0.
      DO 20 J=1,LH1
      DO 20 I=1,IB1
   20 AL(I,J)=0.
      DO 40 I=1,NIJ
      N=IN(I)
      IF(N.GT.0) V(N)=WELL(I)
   40 CONTINUE
      IF(NBH.LT.1) GO TO 45
      DO 42 I=1,NBH
      CXHR(I)=0.
      CXHL(I)=0.
      CYHT(I)=0.
   42 CYHB(I)=0.
C**CALCULATE V FOR SPECIFIED FLOW PARAMETERS
   45 IF(NQSD.LT.1) GO TO 52
      DO 50 I=1,NQSD
      IZ=IBZN(I)
      TMP=B(IZ)*QBF(I)
      INA=IBNA(I)
      L=IN(INA)
```

Program Listing—Continued

```
      IF(L.GT.0) V(L)=V(L)+TMP
      INB=IBNB(I)
      L=IN(INB)
      IF(L.GT.0) V(L)=V(L)+TMP
   50 CONTINUE
C**BEGIN MAIN LOOP
   52 N=0
      DO 150 J=1,JM
      DO 150 I=1,IM
      N=N+1
      M=IZN(N)
      IF(M.LT.1) GO TO 150
      LTX=IPRM(1,M)
      LTY=IPRM(2,M)
      LVL=IPRM(3,M)
      LQD=IPRM(4,M)
      NB=N+J
      NA=NB-1
      NC=NB+ID
      ND=NA+ID
      INA=IN(NA)
      INB=IN(NB)
      INC=IN(NC)
      IND=IN(ND)
      CXT=B(LTX)*CX(N)
      CYT=B(LTY)*CY(N)
      VLT=B(LVL)*VL(N)
      QRT=B(LQD)*QR(N)
      E=CXT+CYT+VLT
C**CALCULATE AU, AL, V, AND COEFFICIENT ARRAYS FOR SPECIFIED HEAD
C  PARAMETERS
      K=-INA-1
      IF(K) 60,75,53
   53 CXHR(K)=CXHR(K)+CXT
      CYHT(K)=CYHT(K)+CYT
      GO TO 75
   60 IF(INA.GE.ICR) GO TO 65
      AU(1,INA)=AU(1,INA)+E
      AU(4,INA)=AU(4,INA)-CXT
      AU(5,INA)=AU(5,INA)-CYT
      GO TO 70
   65 AL(1,INA-ICR1)=AL(1,INA-ICR1)+E
   70 V(INA)=V(INA)+QRT+VLT*(HR(NA)-HC(NA))+CXT*(HC(NB)-HC(NA))
     1+CYT*(HC(ND)-HC(NA))
   75 K=-INB-1
      IF(K) 85,100,77
   77 CXHL(K)=CXHL(K)+CXT
      CYHT(K)=CYHT(K)+CYT
      GO TO 100
   85 IF(INB.GE.ICR) GO TO 90
      AU(1,INB)=AU(1,INB)+E
      AU(3,INB)=AU(3,INB)-CXT
      AU(5,INB)=AU(5,INB)-CYT
```

Program Listing—Continued

```
      GO TO 95
   90 AL(1,INB-ICR1)=AL(1,INB-ICR1)+E
   95 V(INB)=V(INB)+QRT+VLT*(HR(NB)-HC(NB))+CXT*(HC(NA)-HC(NB))
     1+CYT*(HC(NC)-HC(NB))
  100 K=-INC-1
      IF(K) 110,125,102
  102 CXHL(K)=CXHL(K)+CXT
      CYHB(K)=CYHB(K)+CYT
      GO TO 125
  110 IF(INC.GE.ICR) GO TO 115
      AU(1,INC)=AU(1,INC)+E
      AU(2,INC)=AU(2,INC)-CYT
      AU(3,INC)=AU(3,INC)-CXT
      GO TO 120
  115 AL(1,INC-ICR1)=AL(1,INC-ICR1)+E
  120 V(INC)=V(INC)+QRT+VLT*(HR(NC)-HC(NC))+CXT*(HC(ND)-HC(NC))
     1+CYT*(HC(NB)-HC(NC))
  125 K=-IND-1
      IF(K) 135,150,127
  127 CXHR(K)=CXHR(K)+CXT
      CYHB(K)=CYHB(K)+CYT
      GO TO 150
  135 IF(IND.GE.ICR) GO TO 140
      AU(1,IND)=AU(1,IND)+E
      AU(2,IND)=AU(2,IND)-CYT
      AU(4,IND)=AU(4,IND)-CXT
      GO TO 145
  140 AL(1,IND-ICR1)=AL(1,IND-ICR1)+E
  145 V(IND)=V(IND)+QRT+VLT*(HR(ND)-HC(ND))+CXT*(HC(NC)-HC(ND))
     1+CYT*(HC(NA)-HC(ND))
  150 CONTINUE
C**COMPRESS AU
      N=0
      DO 190 J=1,JD
      DO 190 I=1,ID
      N=N+1
      K=IN(N)
      IF(K.LT.1.OR.K.GT.ICR1.OR.IC(1,K).EQ.5) GO TO 190
      IU=1
      IF((J-1).LT.1.OR.IN(N-ID).LT.1) GO TO 160
      IU=IU+1
      AU(IU,K)=AU(2,K)
  160 IF((I-1).LT.1.OR.IN(N-1).LT.1) GO TO 170
      IU=IU+1
      AU(IU,K)=AU(3,K)
  170 IF((I+1).GT.ID.OR.IN(N+1).LT.1) GO TO 180
      IU=IU+1
      AU(IU,K)=AU(4,K)
  180 IF((J+1).GT.JD.OR.IN(N+ID).LT.1) GO TO 190
      IU=IU+1
      AU(IU,K)=AU(5,K)
  190 CONTINUE
      RETURN
```

Program Listing—Continued

```
      END
      SUBROUTINE D4SOLV(HC,AU,AL,V,IN,IC,NAD)
      IMPLICIT DOUBLE PRECISION (A-H,O-Z)
      DIMENSION HC(1),AU(5,1),AL(NAD,1),V(1)
      DIMENSION IN(1),IC(5,1)
      COMMON/INT/NIJ,NEQ,ICR,ICR1,IB1,LH1,ID,JD,IM,JM,NOBS,NQSD,NBH
     1,NVAR,NVX2,KOUNT,INDT,IPO
C**DECOMPOSE TO FILL AL
      DO 280 J=1,ICR1
      II=IC(1,J)
      DO 270 I=2,II
      LR=IC(I,J)
      L=LR-ICR1
      C=AU(I,J)/AU(1,J)
      DO 260 K=I,II
      KL=IC(K,J)-LR+1
      AL(KL,L)=AL(KL,L)-C*AU(K,J)
  260 CONTINUE
      AU(I,J)=C
      V(LR)=V(LR)-C*V(J)
  270 CONTINUE
  280 V(J)=V(J)/AU(1,J)
C**DECOMPOSE AL
      JJ=NEQ-ICR
      DO 310 J=1,JJ
      JR=J+ICR1
      L=J
      DO 300 I=2,IB1
      L=L+1
      IF(AL(I,J).EQ.0.) GO TO 300
      LR=L+ICR1
      C=AL(I,J)/AL(1,J)
      KL=0
      DO 290 K=I,IB1
      KL=KL+1
      IF(AL(K,J).NE.0.) AL(KL,L)=AL(KL,L)-C*AL(K,J)
  290 CONTINUE
      AL(I,J)=C
      V(LR)=V(LR)-C*V(JR)
  300 CONTINUE
  310 V(JR)=V(JR)/AL(1,J)
C**BACK SOLVE--LOWER HALF
      V(NEQ)=V(NEQ)/AL(1,NEQ-ICR1)
      DO 330 J=1,JJ
      K=NEQ-J
      KL=K-ICR1
      L=K
      DO 320 I=2,IB1
      L=L+1
      IF(AL(I,KL).NE.0.) V(K)=V(K)-AL(I,KL)*V(L)
  320 CONTINUE
  330 CONTINUE
C**BACK SOLVE--UPPER HALF
```

Program Listing—Continued

```
      DO 350 J=1,ICR1
      K=ICR-J
      II=IC(1,K)
      DO 340 I=2,II
      L=IC(I,K)
      V(K)=V(K)-AU(I,K)*V(L)
  340 CONTINUE
  350 CONTINUE
C**COMPUTE HC+DELTHC
      DO 360 N=1,NIJ
      L=IN(N)
      IF(L.LT.1) GO TO 360
      HC(N)=HC(N)+V(L)
  360 CONTINUE
      RETURN
      END
      SUBROUTINE LSTSQ(HC,BK,BL,BM,BN,HO,W,P,WP,X,C,B,V,KOBS,IN,NVD)
      IMPLICIT DOUBLE PRECISION (A-H,O-Z)
      DIMENSION HC(1),BK(1),BL(1),BM(1),BN(1),HO(1),W(1),P(1),WP(1)
     1,X(NVD,1),C(NVD,1),B(1),V(3)
      DIMENSION KOBS(1),IN(1)
      COMMON/INT/NIJ,NEQ,ICR,ICR1,IB1,LH1,ID,JD,IM,JM,NOBS,NQSD,NBH
     1,NVAR,NVX2,KOUNT,INDT,IPO
      COMMON/TNME/IIN,IOUT
      COMMON/REG/DMX,ADMX,AP,CSA,AMP,RP,BP,YSQ
C**CHECK FOR NONZERO MARQUARDT PARAMETER
      NM1=NVAR-1
      IF(AMP.LT.-.5) GO TO 105
C**INITIALIZE
      DO 20 J=1,NVAR
      DO 10 I=1,NVAR
   10 C(I,J)=0.
   20 V(J)=0.
      YSQ=0.
C**FORM COEFFICIENT MATRIX AND R.H.S. VECTOR
      DO 70 N=1,NOBS
      K=KOBS(N)
      TEMP=HO(N)-BK(N)*HC(K)-BL(N)*HC(K+1)-BM(N)*HC(K+ID)-BN(N)
     1*HC(K+ID+1)
      DO 60 J=1,NVAR
      TMP=W(N)*X(J,N)
      DO 50 I=J,NVAR
   50 C(I,J)=X(I,N)*TMP+C(I,J)
   60 V(J)=TMP*TEMP+V(J)
      YSQ=YSQ+TEMP*W(N)*TEMP
   70 CONTINUE
      IF(NVAR.EQ.1) GO TO 190
      DO 80 I=1,NVAR
      TEMP=C(I,I)+WP(I)
      IF(TEMP.GT.1.E-10) GO TO 78
      WRITE(IOUT,260) I
      INDT=1
      GO TO 80
```

Program Listing—Continued

```
   78 C(I,I)=TEMP**.5
   80 CONTINUE
      IF(INDT.GT.0) RETURN
      DO 100 J=1,NM1
      TEMP=C(J,J)
      JP1=J+1
      DO 90 I=JP1,NVAR
      C(I,J)=C(I,J)/(C(I,I)*TEMP)
   90 C(J,I)=C(I,J)
      V(J)=(V(J)+WP(J)*(P(J)-B(J)))/TEMP+RP*TEMP*(BP*P(J)-B(J))
      V(J+NVAR)=V(J)
      V(J+NVX2)=TEMP
  100 C(J,J)=1.+RP+AMP
      TEMP=C(NVAR,NVAR)
      V(NVAR)=(V(NVAR)+WP(NVAR)*(P(NVAR)-B(NVAR)))/TEMP
     1+RP*TEMP*(BP*P(NVAR)-B(NVAR))
      V(NVX2)=V(NVAR)
      V(NVAR+NVX2)=TEMP
      C(NVAR,NVAR)=1.+RP+AMP
      IF(IPO.NE.1) GO TO 105
      WRITE(IOUT,250)
      CALL PRTOT(C,NVAR,NVD,0)
      WRITE(IOUT,255)
      WRITE(IOUT,230) (V(I),I=1,NVAR)
C**SOLVE FOR V USING LDU FACTORIZATION:
C**DECOMPOSITION AND FORWARD SUBSTITUTION
  105 DET=1.
      DO 140 K=1,NM1
      PIV=C(K,K)
      DET=DET*PIV
      IF(DABS(PIV).GT.1.E-10) GO TO 110
      WRITE(IOUT,210)
      INDT=1
      RETURN
  110 PIV=1./PIV
      KP1=K+1
      DO 130 J=KP1,NVAR
      TMP=C(J,K)*PIV
      DO 120 I=J,NVAR
  120 C(I,J)=C(I,J)-TMP*C(I,K)
  130 V(J)=V(J)-TMP*V(K)
      C(K,K)=PIV
  140 CONTINUE
      DET=DET*C(NVAR,NVAR)
      IF(DABS(C(NVAR,NVAR)).GT.1.E-10) GO TO 150
      WRITE(IOUT,210)
      INDT=1
      RETURN
  150 IF(AMP.LT.-.5) RETURN
C**BACK SUBSTITUTION
      V(NVAR)=V(NVAR)/C(NVAR,NVAR)
      I=NVAR
  160 I=I-1
```

Program Listing—Continued

```
      IF(I.LT.1) GO TO 175
      IP1=I+1
      SUM=0.
      DO 170 J=IP1,NVAR
  170 SUM=SUM+C(J,I)*V(J)
      V(I)=(V(I)-SUM)*C(I,I)
      GO TO 160
C**CHECK SOLUTION AND ADD MARQUARDT PARAMETER IF NEEDED
  175 TMPA=0.
      TMPB=0.
      TMPC=0.
      DO 176 I=1,NVAR
      TMPA=TMPA+V(I)*V(I)
      TMPB=TMPB+V(I+NVAR)*V(I+NVAR)
  176 TMPC=TMPC+V(I)*V(I+NVAR)
      IF(TMPC.GT.CSA*DSQRT(TMPA*TMPB)) GO TO 200
      AMP=1.5*AMP+.001
      IF(AMP.GT.1.) GO TO 200
      DO 180 I=1,NVAR
      V(I)=V(I+NVAR)
      C(I,I)=1.+RP+AMP
      DO 178 J=I,NVAR
  178 C(J,I)=C(I,J)
  180 CONTINUE
      GO TO 105
C**SOLUTION WHEN NVAR=1
  190 TEMP=C(1,1)+WP(1)
      IF(TEMP.GT.1.E-10) GO TO 195
      I=1
      WRITE(IOUT,260) I
      INDT=1
      RETURN
  195 V(3)=TEMP**.5
      V(2)=(V(1)+WP(1)*(P(1)-B(1)))/V(3)+RP*V(3)*(BP*P(1)-B(1))
      C(1,1)=1.+RP
      DET=C(1,1)
      V(1)=V(2)/DET
      IF(IPO.NE.1) GO TO 200
      WRITE(IOUT,250)
      CALL PRTOT(C,1,NVD,0)
      WRITE(IOUT,255)
      WRITE(IOUT,230) V(1)
C**COMPUTE AND PRINT PARAMETERS
  200 ADMX=0.
      DO 203 J=1,NVAR
      V(J)=V(J)/V(J+NVX2)
      TMPA=1.
      IF(B(J)) 201,202,201
  201 TMPA=B(J)
  202 TMP=DABS(V(J)/TMPA)
      IF(TMP.GT.ADMX) ADMX=TMP
  203 CONTINUE
      AP=1.
```

Program Listing—Continued

```
      IF(ADMX.GT.DMX) AP=DMX/ADMX
      DO 204 J=1,NVAR
      V(J)=AP*V(J)
  204 B(J)=V(J)+B(J)
      WRITE(IOUT,220) KOUNT,YSQ,DET,AMP,AP
      WRITE(IOUT,230) (B(J),J=1,NVAR)
      RETURN
C
  210 FORMAT (42H0LEAST SQUARES COEFFICIENT MATRIX SINGULAR
     1/35H SOLUTION FOR PARAMETERS NOT UNIQUE)
  220 FORMAT (1H0,14HITERATION NO. ,I3/1H ,6HYSQ = ,G11.5,2X
     1,9HDET(C) = ,G11.5,2X,6HAMP = ,G11.5,2X,5HAP = ,G11.5
     2/1H ,21HREGRESSION PARAMETERS)
  230 FORMAT ((1H ,8(G11.5,2X)))
  250 FORMAT (29H0 SCALED LEAST SQUARES MATRIX)
  255 FORMAT (24H0 SCALED GRADIENT VECTOR)
  260 FORMAT (29H0SENSITIVITIES FOR PARAMETER ,I4,17H EFFECTIVELY ZERO)
      END
      SUBROUTINE PRTOT(C,NO,NOD,IT)
      IMPLICIT DOUBLE PRECISION (A-H,O-Z)
      DIMENSION C(1)
      COMMON/TNME/IIN,IOUT
C**IF IT=0, PRINT SYMMETRIC MATRIX DIVIDED VERTICALLY INTO TEN-COLUMN
C  BLOCKS
C**IF IT=1, PRINT VECTOR IN THREE COLUMNS
      IF(IT.EQ.1) GO TO 25
      DO 20 L=1,NO,10
      J10=L+9
      IF(J10.GT.NO) J10=NO
      WRITE(IOUT,30) (J,J=L,J10)
      WRITE(IOUT,50)
      K=-NOD
      DO 10 I=1,NO
      K=K+NOD
   10 WRITE (IOUT,40) I,(C(J+K),J=L,J10)
      WRITE(IOUT,60)
   20 CONTINUE
      RETURN
   25 NR=NO/3
      IF((3*NR).NE.NO) NR=NR+1
      DO 26 K=1,NR
   26 WRITE(IOUT,80) (L,C(L),L=K,NO,NR)
      RETURN
C
   30 FORMAT (1H0,8X,I3,9(9X,I3))
   40 FORMAT (1H ,I3,10(1X,G11.5)
   50 FORMAT (1H )
   60 FORMAT (1H0)
   80 FORMAT (1H ,3X,3(I3,7X,G11.5,3X))
      END
```

Program Listing—Continued

```
      SUBROUTINE HOBS(DX,DY,X,Y,BK,BL,BM,BN,HO,W,KOBS)
      IMPLICIT DOUBLE PRECISION (A-H,O-Z)
      DIMENSION DX(1),DY(1),X(1),Y(1),BK(1),BL(1),BM(1),BN(1),HO(1)
     1,W(1)
      DIMENSION KOBS(1)
      COMMON/INT/NIJ,NEQ,ICR,ICR1,IB1,LH1,ID,JD,IM,JM,NOBS,NQSD,NBH
     1,NVAR,NVX2,KOUNT,INDT,IPO
      COMMON/TNME/IIN,IOUT
C**COMPUTE X-LOCATIONS OF NODE POINTS
      X(1)=0.
      DO 10 I=2,ID
   10 X(I)=X(I-1)+DX(I-1)
C**COMPUTE Y-LOCATIONS OF NODE POINTS
      Y(1)=0.
      DO 20 J=2,JD
   20 Y(J)=Y(J-1)+DY(J-1)
      WRITE(IOUT,40)
      DO 30 I=1,NOBS
C**READ OBSERVED HEAD DATA
      READ(IIN,50) N,IL,JL,XL,YL,HO(N),W(N)
      WRITE(IOUT,60) N,IL,JL,XL,YL,HO(N),W(N)
C**COMPUTE LOCATION OF FIRST NODE IN CELL (IL,JL)
      K=IL+IM*(JL-1)
      KOBS(N)=K+(K-1)/IM
C**COMPUTE WEIGHTS FOR BILINEAR INTERPOLATION
      AREA=DX(IL)*DY(JL)
      BK(N)=(X(IL+1)-XL)*(Y(JL+1)-YL)/AREA
      BL(N)=(XL-X(IL))*(Y(JL+1)-YL)/AREA
      BM(N)=(X(IL+1)-XL)*(YL-Y(JL))/AREA
   30 BN(N)=(XL-X(IL))*(YL-Y(JL))/AREA
C
   40 FORMAT (1H0,25X,18HOBSERVED HEAD DATA/1H ,6H  OBS.,2X,9HCELL LOC.
     1,3X,6HX LOC.,7X,6HY LOC.,8X,4HOBS.,8X,6HWEIGHT/1H ,6H   NO.,4X
     2,1HI,5X,1HJ,30X,4HHEAD)
   50 FORMAT (3I5,4F10.0)
   60 FORMAT (1H ,1X,3(I4,2X),4(G11.5,2X))
      RETURN
      END
```

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