



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

Chapter A1

**A MODULAR THREE-DIMENSIONAL
FINITE-DIFFERENCE GROUND-WATER
FLOW MODEL**

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Book 6

MODELING TECHNIQUES

APPENDIX B

SPACE REQUIREMENTS IN THE X ARRAY

The outline below gives the X-array space requirements for each package. The formulas can be used to calculate the exact size of the X array for a given problem. However, it is generally easier to simply run the model program and let it calculate the size. The total space required is printed as part of the model printout even if the X array is dimensioned too small. As a rough estimate, the X array is approximately 10 to 15 times the number of nodes in the model depending on the options selected. In the outline below, NODES is defined as $NCOL * NROW * NLAY$, the number of nodes in the model.

I. BAS Package

- A. $8 * NODES + (NLAY - 1) * NCOL * NROW + NROW + NCOL + 4 * NLAY$
- B. Additionally, add NODES if start head is saved (ISTRT is not 0), and add NODES if BUFF is separate from RHS (IAPART is not 0)

II. BCF Package

- A. NLAY
- B. If a transient simulation (ISS is 0), add NODES
- C. For each layer where LAYCON is one or three, add $2 * NCOL * NROW$
- D. For each layer where LAYCON is two or three, add $NCOL * NROW$
- E. If a transient simulation (ISS is 0), for each layer where LAYCON is two or three, add $NCOL * NROW$

III. WEL Package -- $4 * MXWELL$

IV. DRN Package -- $5 * MXDRAN$

V. RIV Package -- $6 * MXRIVR$

VI. EVT Package

A. Option 1 -- $3 * NCOL * NROW$

B. Option 2 -- $4 * NCOL * NROW$

VII. GHB Package -- $5 * MXBND$

VIII. RCH Package

A. Options 1 and 3 -- $NCOL * NROW$

B. Option 2 -- $2 * NCOL * NROW$

IX. SIP Package -- $4 * NODES + 4 * MXITER + NPARM$

X. SOR Package -- $(NLAY + 4) * NCOL * NLAY + 4 * MXITER$

Generally, it is advisable to have the X-array dimension relatively close to the amount of space needed for a specific problem. On the other hand, it is inconvenient to redimension the X array every time a new option is selected. Several load modules with the size of the X array differing by a factor of two should be adequate.

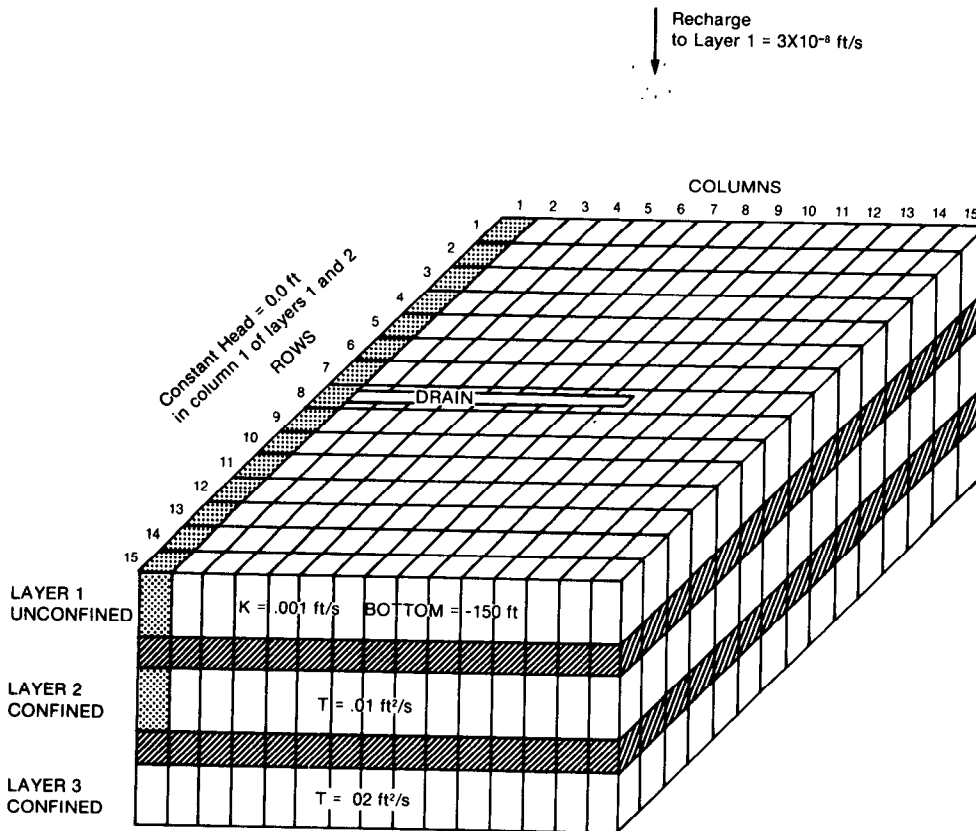
APPENDIX C
CONTINUATION OF A PREVIOUS RUN

There is often value in breaking long simulations into several short model runs. This allows one to decide, between runs, whether or not to continue the simulation. Although the model program in this report does not have a special option for making continuation runs, it is quite simple to continue a simulation by using the output of one run as input of the next. Simply save the heads from the run that is to be continued on a disk file, and specify that file as starting heads for the next run. The subroutine that reads starting heads (U2DREL) is capable of reading model-generated disk files of saved heads without the need for reformatting. Because volumetric budget terms are always set to zero at the start of a model run, the printed budget on a model run represents only that one run, not the total of all runs in a series of continuation runs. If a total budget for a series of continuation runs is desired, the totals from each run can be added externally. Similarly, the model program keeps track of simulation time only for single model runs, but total simulation time for a series of continuation runs can be calculated externally by adding the simulation times of each run.

APPENDIX D

SAMPLE PROBLEM

This sample problem is intended to illustrate input and output from the program. There are three simulated layers, as shown in the accompanying illustration, which are separated from each other by confining layers. Each layer is a square 75,000 feet on a side and is divided by a grid into 15 rows and 15 columns which form squares 5,000 feet on a side. Flow within the confining layers is not simulated, but the effects of the confining layers on flow between the active layers are incorporated in the vertical leakance (Vcont) terms. Flow into the system is infiltration from precipitation; flow out of the system is to buried drain tubes, discharging wells, and a lake which is represented by a constant-head boundary.



Between layers 1 and 2 vertical hydraulic conductivity divided by thickness = $2 \times 10^{-9}/s$

Between layers 2 and 3 vertical hydraulic conductivity divided by thickness = $1 \times 10^{-9}/s$

Setting starting heads equal to 0.0, the program was run to get a steady-state solution. The Strongly Implicit Procedure was used to solve the system of difference equations: the error criterion was set at 0.001 feet, the acceleration parameter was set to 1.0, and the maximum number of iterations was set equal to 50. A seed of 0.001 was specified for use in calculating the iteration parameters; 31 iterations were needed to close.

List of Wells

Q = 5 ft³/s for each well

<u>Layer</u>	<u>Row</u>	<u>Column</u>
3	5	11
2	4	6
2	6	12
1	9	8
1	9	10
1	9	12
1	9	14
1	11	8
1	11	10
1	11	12
1	11	14
1	13	8
1	13	10
1	13	12
1	13	14

List of Drains

Conductance = 1 ft²/s

<u>Layer</u>	<u>Row</u>	<u>Column</u>	<u>Elevation</u>
1	8	2	0.0
1	8	3	0.0
1	8	4	10.0
1	8	5	20.0
1	8	6	30.0
1	8	7	50.0
1	8	8	70.0
1	8	9	90.0
1	8	10	100.0

Input for FORTRAN unit 11 -- Block-Centered Flow Package:

1	0	ISS, IBCFBD	
1 0 0			
0	1.		TRPY
0	5000.		DELR
0	5000.		DELC
0	.001		HY-1
0	-150.		BOT-1
0	2.E-8		VHY/THICK-1
0	.01		T-2
0	1.E-8		VHY/THICK-2
0	.02		T-3

Input for FORTRAN unit 18 -- Recharge Package:

1	0	NRCHOP, IRCHBD	
1		INRECH	
0	3.E-8		RECH-1

Input for FORTRAN unit 19 -- Strongly Implicit Procedure Package:

50	5	MXITER, NPARM	
1.	.001	0	.001
			1 ACCL, ERR, IPCALC, WSEED

Input for FORTRAN unit 13 -- Drain Package:

9	0	MXDRAI, IDRNB	
9		NDRAIN	
1	8	2	0.
1	8	3	0.
1	8	4	10.
1	8	5	20.
1	8	6	30.
1	8	7	50.
1	8	8	70.
1	8	9	90.
1	8	10	100.

Input for FORTRAN unit 12 -- Well Package:

15	0	MXWELL, IWELBD	
15		ITMP (NWELLS)	
3	5	11	-5.
2	4	6	-5.
2	6	12	-5.
1	9	8	-5.
1	9	10	-5.
1	9	12	-5.
1	9	14	-5.
1	11	8	-5.
1	11	10	-5.
1	11	12	-5.
1	11	14	-5.
1	13	8	-5.
1	13	10	-5.
1	13	12	-5.
1	13	14	-5.

Sample Problem Output

Note that it should not be expected that the outputs from running the same problem on different computers will exactly match. Small variations in output can be caused by differences in the way real numbers are stored and calculated. Storage and calculation of real numbers depend on the specific computer hardware, the FORTRAN compiler, and the math library that is loaded with the compiled program. Output variations among computers also depend on the size of the problem, the number of iterations required for solution, and the precision used when printing results. In this sample problem, most values should not vary from one computer to another. Those few values that vary should generally vary only in the least significant digit; however, the budget term "IN-OUT", because it is the difference of two nearly identical numbers, may vary by as much as a factor of 3 from one computer to another.

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U.S. GEOLOGICAL SURVEY MODULAR FINITE-DIFFERENCE GROUND-WATER MODEL

SAMPLE----3 LAYERS, 15 ROWS, 15 COLUMNS; STEADY STATE; CONSTANT HEADS COLUMN 1, LAYERS 1 AND 2; RECHARGE, WELLS AND DRAINS
  3 LAYERS      15 ROWS      15 COLUMNS
  1 STRESS PERIOD(S) IN SIMULATION
MODEL TIME UNIT IS SECONDS

I/O UNITS:
ELEMENT OF IUNIT:  1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
I/O UNIT:         11 12 13  0  0  0  0 18 19  0  0  0  0  0  0  0  0  0  0  0  0  0  0

BAS1 -- BASIC MODEL PACKAGE, VERSION 1, 9/1/87 INPUT READ FROM UNIT 1
ARRAYS RHS AND BUFF WILL SHARE MEMORY.
START HEAD WILL NOT BE SAVED -- DRAWDOWN CANNOT BE CALCULATED
 5892 ELEMENTS IN X ARRAY ARE USED BY BAS
 5892 ELEMENTS OF X ARRAY USED OUT OF 30000

BCF1 -- BLOCK-CENTERED FLOW PACKAGE, VERSION 1, 9/1/87 INPUT READ FROM UNIT 11
STEADY-STATE SIMULATION
  LAYER  AQUIFER TYPE
  -----
    1         1
    2         0
    3         0
  453 ELEMENTS IN X ARRAY ARE USED BY BCF
 6345 ELEMENTS OF X ARRAY USED OUT OF 30000

WELL -- WELL PACKAGE, VERSION 1, 9/1/87 INPUT READ FROM 12
MAXIMUM OF 15 WELLS
  60 ELEMENTS IN X ARRAY ARE USED FOR WELLS
 6405 ELEMENTS OF X ARRAY USED OUT OF 30000

DRN1 -- DRAIN PACKAGE, VERSION 1, 9/1/87 INPUT READ FROM UNIT 13
MAXIMUM OF 9 DRAINS
  45 ELEMENTS IN X ARRAY ARE USED FOR DRAINS
 6450 ELEMENTS OF X ARRAY USED OUT OF 30000

RCH1 -- RECHARGE PACKAGE, VERSION 1, 9/1/87 INPUT READ FROM UNIT 18
OPTION 1 -- RECHARGE TO TOP LAYER
 225 ELEMENTS OF X ARRAY USED FOR RECHARGE
 6675 ELEMENTS OF X ARRAY USED OUT OF 30000

SIP1 -- STRONGLY IMPLICIT PROCEDURE SOLUTION PACKAGE, VERSION 1, 9/1/87 INPUT READ FROM UNIT 19
MAXIMUM OF 50 ITERATIONS ALLOWED FOR CLOSURE
 5 ITERATION PARAMETERS
 2905 ELEMENTS IN X ARRAY ARE USED BY SIP
 9580 ELEMENTS OF X ARRAY USED OUT OF 30000
```

SAMPLE---3 LAYERS, 15 ROWS, 15 COLUMNS; STEADY STATE; CONSTANT HEADS COLUMN 1, LAYERS 1 AND 2; RECHARGE, WELLS AND DRAINS

BOUNDARY ARRAY FOR LAYER 1 WILL BE READ ON UNIT 1 USING FORMAT: (15I3)

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

BOUNDARY ARRAY FOR LAYER 2 WILL BE READ ON UNIT 1 USING FORMAT: (15I3)

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

BOUNDARY ARRAY = 1 FOR LAYER 3
AQUIFER HEAD WILL BE SET TO 999.99 AT ALL NO-FLOW NODES (IBOUND=0).

INITIAL HEAD = 0.000000E+00 FOR LAYER 1

INITIAL HEAD = 0.000000E+00 FOR LAYER 2

INITIAL HEAD = 0.000000E+00 FOR LAYER 3

DEFAULT OUTPUT CONTROL -- THE FOLLOWING OUTPUT COMES AT THE END OF EACH STRESS PERIOD:
TOTAL VOLUMETRIC BUDGET
HEAD

COLUMN TO ROW ANISOTROPY = 1.000000

DEL R = 5000.000

DEL C = 5000.000

HYD. COND. ALONG ROWS = 0.9999999E-03 FOR LAYER 1

BOTTOM = -150.0000 FOR LAYER 1

VERT HYD COND /THICKNESS = 0.2000000E-07 FOR LAYER 1

TRANSMIS. ALONG ROWS = 0.1000000E-01 FOR LAYER 2

VERT HYD COND /THICKNESS = 0.1000000E-07 FOR LAYER 2

TRANSMIS. ALONG ROWS = 0.2000000E-01 FOR LAYER 3

SOLUTION BY THE STRONGLY IMPLICIT PROCEDURE

MAXIMUM ITERATIONS ALLOWED FOR CLOSURE = 50
ACCELERATION PARAMETER = 1.0000
HEAD CHANGE CRITERION FOR CLOSURE = 0.10000E-02
SIP HEAD CHANGE PRINTOUT INTERVAL = 1

5 ITERATION PARAMETERS CALCULATED FROM SPECIFIED WSEED = 0.00100000 :

0.0000000E+00 0.8221720E+00 0.9683772E+00 0.9943766E+00 0.9990000E+00

STRESS PERIOD NO. 1, LENGTH = 86400.00

NUMBER OF TIME STEPS = 1

MULTIPLIER FOR DELT = 1.000

INITIAL TIME STEP SIZE = 86400.00

15 WELLS

LAYER	ROW	COL	STRESS RATE	WELL NO.
3	5	11	-5.0000	1
2	4	6	-5.0000	2
2	6	12	-5.0000	3
1	9	8	-5.0000	4
1	9	10	-5.0000	5
1	9	12	-5.0000	6
1	9	14	-5.0000	7
1	11	8	-5.0000	8
1	11	10	-5.0000	9
1	11	12	-5.0000	10
1	11	14	-5.0000	11
1	13	8	-5.0000	12
1	13	10	-5.0000	13
1	13	12	-5.0000	14
1	13	14	-5.0000	15

9 DRAINS

LAYER	ROW	COL	ELEVATION	CONDUCTANCE	DRAIN NO.
1	8	2	0.0000E+00	1.000	1
1	8	3	0.0000E+00	1.000	2
1	8	4	10.00	1.000	3
1	8	5	20.00	1.000	4
1	8	6	30.00	1.000	5
1	8	7	50.00	1.000	6
1	8	8	70.00	1.000	7
1	8	9	90.00	1.000	8
1	8	10	100.0	1.000	9

RECHARGE = 0.3000000E-07

31 ITERATIONS FOR TIME STEP 1 IN STRESS PERIOD 1

MAXIMUM HEAD CHANGE FOR EACH ITERATION:

HEAD CHANGE	LAYER, ROW, COL	HEAD CHANGE	LAYER, ROW, COL	HEAD CHANGE	LAYER, ROW, COL	HEAD CHANGE	LAYER, ROW, COL	HEAD CHANGE	LAYER, ROW, COL
-22.41	(3, 5, 11)	12.48	(1, 1, 15)	13.39	(3, 1, 14)	48.21	(1, 1, 15)	35.90	(3, 1, 13)
2.482	(1, 9, 14)	1.430	(3, 10, 13)	6.214	(1, 12, 14)	7.411	(3, 11, 14)	13.66	(1, 15, 15)
0.5503	(3, 8, 7)	0.4821	(2, 6, 9)	0.4711	(3, 5, 10)	2.019	(1, 11, 14)	2.302	(3, 5, 13)
0.1108	(1, 13, 12)	0.7059E-01	(3, 12, 11)	0.2819	(1, 14, 14)	0.3141	(3, 13, 14)	0.3321	(1, 15, 15)
0.7855E-02	(1, 13, 12)	0.1586E-01	(2, 11, 11)	0.1777E-01	(3, 11, 10)	0.7911E-01	(1, 14, 14)	0.8500E-01	(3, 7, 14)
0.4169E-02	(1, 13, 14)	0.2555E-02	(3, 14, 15)	0.9771E-02	(1, 14, 14)	0.1082E-01	(3, 13, 14)	0.1030E-01	(1, 15, 15)
0.2426E-03	(1, 13, 12)								

HEAD IN LAYER 1 AT END OF TIME STEP 1 IN STRESS PERIOD 1

	1	2	3	4	5	6	7	8	9	10
	11	12	13	14	15					
1	0.0000E+00 117.4	24.94 121.3	44.01 124.3	59.26 126.4	71.82 127.4	82.52	91.91	100.0	106.9	112.6
2	0.0000E+00 115.7	24.45 119.6	43.10 122.7	57.98 124.9	70.17 126.1	80.57	90.12	98.40	105.3	111.0
3	0.0000E+00 112.0	23.45 116.1	41.30 119.6	55.43 122.1	66.78 123.4	76.21	86.51	95.20	102.2	107.6
4	0.0000E+00 106.1	21.92 110.7	38.61 114.9	51.75 117.9	61.79 119.4	68.03	81.34	90.75	97.64	102.5
5	0.0000E+00 97.29	19.73 103.1	34.92 108.8	47.32 112.5	57.69 114.3	66.74	77.09	85.76	92.22	96.15
6	0.0000E+00 93.03	16.51 94.23	29.50 102.1	40.90 106.4	51.30 108.4	61.21	71.19	79.85	86.47	90.82
7	0.0000E+00 88.60	11.55 91.66	21.10 96.43	31.21 99.82	41.40 101.8	51.84	63.08	72.68	79.95	84.92
8	0.0000E+00 81.99	3.483 85.00	6.832 89.27	16.25 91.72	26.30 94.33	36.97	52.59	64.31	72.52	77.25
9	0.0000E+00 73.93	10.54 73.79	19.11 80.84	28.12 80.17	36.92 86.49	45.27	52.95	55.38	65.15	66.07
10	0.0000E+00 70.39	14.62 72.44	25.86 76.72	35.38 78.26	43.49 81.79	50.11	54.93	57.55	62.95	65.55
11	0.0000E+00 66.43	17.11 65.45	29.96 72.22	40.01 71.04	47.78 77.62	53.24	55.81	53.33	60.27	59.29
12	0.0000E+00 67.12	18.68 68.50	32.56 72.29	43.07 73.46	50.81 76.85	55.92	58.33	58.47	61.93	63.18
13	0.0000E+00 67.22	19.67 65.75	34.24 71.90	45.14 70.35	53.01 76.48	58.04	59.91	56.75	62.59	60.91
14	0.0000E+00 71.64	20.27 73.18	35.27 75.84	46.48 77.03	54.61 79.09	60.08	63.17	64.52	67.25	68.79
15	0.0000E+00 74.29	20.56 76.22	35.78 78.22	47.16 79.66	55.48 80.82	61.26	65.02	67.52	69.94	72.01

HEAD IN LAYER 2 AT END OF TIME STEP 1 IN STRESS PERIOD 1

	1 11	2 12	3 13	4 14	5 15	6	7	8	9	10
1	0.0000E+00 117.2	24.66 121.1	43.73 124.1	59.02 126.2	71.61 127.3	82.32	91.72	99.86	106.7	112.5
2	0.0000E+00 115.5	24.17 119.4	42.83 122.6	57.74 124.8	69.95 125.9	80.36	89.93	98.22	105.1	110.8
3	0.0000E+00 111.8	23.17 116.0	41.03 119.5	55.19 121.9	66.53 123.2	75.77	86.29	95.02	102.0	107.4
4	0.0000E+00 105.4	21.65 110.4	38.34 114.8	51.50 117.7	61.35 119.2	60.17	80.90	90.55	97.45	102.3
5	0.0000E+00 91.09	19.48 102.1	34.65 108.6	47.07 112.4	57.44 114.2	66.30	76.85	85.57	92.00	95.41
6	0.0000E+00 92.06	16.27 86.23	29.24 101.7	40.65 106.2	51.07 108.3	60.98	70.98	79.65	86.28	90.54
7	0.0000E+00 88.35	11.38 91.24	20.95 96.22	31.05 99.65	41.25 101.6	51.70	62.90	72.48	79.76	84.73
8	0.0000E+00 81.81	4.209 84.86	8.330 89.10	17.58 91.59	27.58 94.17	38.25	52.94	64.19	72.34	77.12
9	0.0000E+00 73.87	10.38 74.48	18.96 80.77	27.98 80.84	36.79 86.38	45.16	52.86	56.13	65.08	66.79
10	0.0000E+00 70.24	14.40 72.37	25.61 76.57	35.15 78.20	43.27 81.64	49.91	54.76	57.48	62.79	65.49
11	0.0000E+00 66.37	16.87 66.18	29.70 72.16	39.78 71.75	47.56 77.51	53.05	55.68	54.09	60.20	60.04
12	0.0000E+00 66.98	18.43 68.44	32.31 72.15	42.85 73.40	50.60 76.69	55.73	58.16	58.41	61.78	63.12
13	0.0000E+00 67.16	19.42 66.48	33.98 71.84	44.91 71.06	52.80 76.37	57.85	59.78	57.50	62.53	61.65
14	0.0000E+00 71.48	20.02 73.06	35.02 75.68	46.26 76.91	54.41 78.93	59.88	62.99	64.39	67.08	68.66
15	0.0000E+00 74.11	20.30 76.04	35.52 78.04	46.94 79.49	55.28 80.65	61.07	64.84	67.34	69.76	71.84

HEAD IN LAYER 3 AT END OF TIME STEP 1 IN STRESS PERIOD 1

	1 11	2 12	3 13	4 14	5 15	6	7	8	9	10
1	1.800 117.0	24.34 120.9	43.36 123.9	58.70 126.0	71.33 127.1	82.06	91.48	99.63	106.5	112.3
2	1.764 115.3	23.85 119.2	42.46 122.4	57.42 124.6	69.66 125.7	80.07	89.68	97.99	104.9	110.6
3	1.691 111.5	22.86 115.7	40.67 119.3	54.87 121.7	66.20 123.0	75.28	85.98	94.77	101.7	107.2
4	1.578 104.1	21.35 110.0	37.98 114.5	51.17 117.5	60.85 119.0	62.69	80.41	90.28	97.19	101.9
5	1.415 77.46	19.18 100.7	34.30 108.2	46.75 112.1	57.10 114.0	65.80	76.54	85.30	91.67	94.17
6	1.176 90.60	15.99 88.55	28.91 101.2	40.33 106.0	50.76 108.0	60.67	70.70	79.38	86.01	90.12
7	0.8273 87.98	11.21 90.77	20.79 95.94	30.88 99.41	41.09 101.4	51.55	62.67	72.22	79.50	84.46
8	0.4331 81.58	5.131 84.68	10.19 88.88	19.27 91.44	29.19 93.95	39.84	53.40	64.07	72.11	76.95
9	0.7543 73.81	10.22 75.31	18.82 80.72	27.84 81.64	36.66 86.24	45.06	52.78	57.03	65.02	67.64
10	1.039 70.05	14.13 72.33	25.29 76.39	34.85 78.15	42.99 81.43	49.65	54.54	57.44	62.61	65.44
11	1.224 66.33	16.59 67.06	29.37 72.13	39.47 72.60	47.28 77.38	52.79	55.53	55.01	60.16	60.94
12	1.341 66.80	18.15 68.41	31.97 71.97	42.54 73.36	50.32 76.49	55.47	57.94	58.37	61.60	63.08
13	1.415 67.12	19.14 67.35	33.65 71.80	44.61 71.90	52.53 76.24	57.60	59.63	58.39	62.48	62.54
14	1.460 71.27	19.73 72.91	34.68 75.47	45.96 76.77	54.13 78.71	59.63	62.76	64.24	66.87	68.52
15	1.481 73.87	20.01 75.82	35.18 77.81	46.63 79.27	55.00 80.42	60.81	64.59	67.11	69.52	71.61

VOLUMETRIC BUDGET FOR ENTIRE MODEL AT END OF TIME STEP 1 IN STRESS PERIOD 1

CUMULATIVE VOLUMES		L**3	RATES FOR THIS TIME STEP		L**3/T
IN:			IN:		
STORAGE =	0.00000E+00		STORAGE =	0.00000E+00	
CONSTANT HEAD =	0.00000E+00		CONSTANT HEAD =	0.00000E+00	
WELLS =	0.00000E+00		WELLS =	0.00000E+00	
DRAINS =	0.00000E+00		DRAINS =	0.00000E+00	
RECHARGE =	0.13608E+08		RECHARGE =	157.50	
TOTAL IN =	0.13608E+08		TOTAL IN =	157.50	
OUT:			OUT:		
STORAGE =	0.00000E+00		STORAGE =	0.00000E+00	
CONSTANT HEAD =	0.43265E+07		CONSTANT HEAD =	50.075	
WELLS =	0.64800E+07		WELLS =	75.000	
DRAINS =	0.28011E+07		DRAINS =	32.420	
RECHARGE =	0.00000E+00		RECHARGE =	0.00000E+00	
TOTAL OUT =	0.13608E+08		TOTAL OUT =	157.49	
IN - OUT =	184.00		IN - OUT =	0.21210E-02	
PERCENT DISCREPANCY =	0.00		PERCENT DISCREPANCY =	0.00	

TIME SUMMARY AT END OF TIME STEP 1 IN STRESS PERIOD 1

	SECONDS	MINUTES	HOURS	DAYS	YEARS
TIME STEP LENGTH	86400.0	1440.00	24.0000	1.00000	0.273785E-02
STRESS PERIOD TIME	86400.0	1440.00	24.0000	1.00000	0.273785E-02
TOTAL SIMULATION TIME	86400.0	1440.00	24.0000	1.00000	0.273785E-02

APPENDIX E

ABBREVIATED INPUT INSTRUCTIONS

These input instructions are intended as a quick reference for the experienced user. Most explanations that are contained in the complete input instructions given in package documentation have been omitted. The format of input fields is given only for those records that contain fields that are not 10 characters wide. Each input item, for which format is not given, is identified as either a record or an array. For records, the fields contained in the record are named. For arrays, only the array name is given. Input fields which contain codes or flags are described. All other field and array descriptions have been dropped.

Array Input

The real two-dimensional array reader (U2DREL), the integer two-dimensional array reader (U2DINT), and the real one-dimensional array reader (U1DREL) read one array-control record and, optionally, a data array in a format specified on the array-control record.

FOR REAL ARRAY READER (U2DREL or U1DREL)

Data:	LOCAT	CNSTNT	FMTIN	IPRN
Format:	I10	F10.0	5A4	I10

FOR INTEGER ARRAY READER (U2DINT)

Data:	LOCAT	ICONST	FMTIN	IPRN
Format:	I10	I10	5A4	I10

IPRN--is a flag indicating that the array being read should be printed and a code for indicating the format that should be used. It is used only if LOCAT is not equal to zero. The format codes are different for each of the three modules. IPRN is set to zero when the specified value exceeds those defined in the chart below. If IPRN is less than zero, the array will not be printed.

<u>IPRN</u>	<u>U2DREL</u>	<u>U2DINT</u>	<u>U1DREL</u>
0	10G11.4	10I11	10G12.5
1	11G10.3	60I1	
2	9G13.6	40I2	
3	15F7.1	30I3	
4	15F7.2	25I4	
5	15F7.3	20I5	
6	15F7.4		
7	20F5.0		
8	20F5.1		
9	20F5.2		
10	20F5.3		
11	20F5.4		
12	10G11.4		

LOCAT--indicates the location of the data which will be put in the array.

If LOCAT < 0, unit number for unformatted records.

If LOCAT = 0, all elements are set equal to CNSTNT or ICONST.

If LOCAT > 0, unit number for formatted records.

Basic Package Input

Input for the Basic (BAS) Package except for output control is read from unit 1 as specified in the main program. If necessary, the unit number for BAS input can be changed to meet the requirements of a particular computer. Input for the output control option is read from the unit number specified in IUNIT(12).

FOR EACH SIMULATION

1. Record: HEADNG(32)
2. Record: HEADNG (continued)
3. Record: NLAY NROW NCOL NPER ITMUNI
4. Data: IUNIT(24)
Format: 24I3
(BCF WEL DRN RIV EVT XXX GHB RCH SIP XXX SOR OC)
 1 2 3 4 5 6 7 8 9 10 11 12
5. Record: IAPART ISTRT
6. Array: IBOUND(NCOL,NROW)
(One array for each layer in the grid)
7. Record: HNOFLO
8. Array: Shead(NCOL,NROW)
(One array for each layer in the grid)

FOR EACH STRESS PERIOD

9. Data: PERLEN NSTP TSMULT

ITMUNI--is the time unit of model data.

- | | |
|---------------|-----------|
| 0 - undefined | 3 - hours |
| 1 - seconds | 4 - days |
| 2 - minutes | 5 - years |

Consistent length and time units must be used for all model data. The user may choose one length unit and one time unit to be used to specify all input data.

IUNIT--is a 24-element table of input units for use by all major options.

IAPART--indicates whether array BUFF is separate from array RHS.

If IAPART = 0, the arrays BUFF and RHS occupy the same space. This option conserves space. This option should be used unless some other package explicitly says otherwise.

If IAPART ≠ 0, the arrays BUFF and RHS occupy different space.

ISTRT--indicates whether starting heads are to be saved.

If ISTRT = 0, starting heads are not saved.

If ISTRT ≠ 0, starting heads are saved.

IBOUND--is the boundary array.

If IBOUND(I,J,K) < 0, cell I,J,K has a constant head.

If IBOUND(I,J,K) = 0, cell I,J,K is inactive.

If IBOUND(I,J,K) > 0, cell I,J,K is active.

HNOFLO--is the value of head to be assigned to all inactive cells.

Shead--is head at the start of the simulation.

PERLEN--is the length of a stress period.

NSTP--is the number of time steps in a stress period.

TSMULT--is the multiplier for the length of successive time steps.

Output Control Input

Input to Output Control is read from the unit specified in IUNIT(12). All printer output goes to unit 6 as specified in the main program. If necessary, the unit number for printer output can be changed to meet the requirements of a particular computer.

FOR EACH SIMULATION

1. Record: IHEDFM IDDNFM IHEDUN IDDNUN

FOR EACH TIME STEP

2. Record: INCODE IHDDFL IBUDFL ICBCFL

3. Record: Hdpr Ddpr Hdsv Ddsv

(Record 3 is read 0, 1, or NLAY times, depending on the value of INCODE.)

IHEDFM--is a code for the format in which heads will be printed.

IDDNFM--is a code for the format in which drawdowns will be printed.

	0 - (10G11.4)	7 - (20F5.0)
	1 - (11G10.3)	8 - (20F5.1)
positive--wrap	2 - (9G13.6)	9 - (20F5.2)
	3 - (15F7.1)	10 - (20F5.3)
negative--strip	4 - (15F7.2)	11 - (20F5.4)
	5 - (15F7.3)	12 - (10G11.4)
	6 - (15F7.4)	

IHEDUN--is the unit number on which heads will be saved.

IDDNUN--is the unit number on which drawdowns will be saved.

INCODE--is the head/drawdown output code.

If INCODE < 0, layer-by-layer specifications from the last time steps are used. Input item 3 is not read.

If INCODE = 0, all layers are treated the same way. Input item 3 will consist of one record. IOFLG array will be read.

If INCODE > 0, input item 3 will consist of one record for each layer.

IHDDFL--is a head and drawdown output flag.

If IHDDFL = 0, neither heads nor drawdowns will be printed or saved.

If IHDDFL ≠ 0, heads and drawdowns will be printed or saved.

IBUDFL--is a budget print flag.

If IBUDFL = 0, overall volumetric budget will not be printed.

If IBUDFL ≠ 0, overall volumetric budget will be printed.

ICBCFL--is a cell-by-cell flow-term flag.

If ICBCFL = 0, cell-by-cell flow terms are not saved or printed.

If ICBCFL ≠ 0, cell-by-cell flow terms are printed or recorded on disk depending on flags set in the component of flow packages, i.e., IWELCB, IRCHCB, etc.

Hdpr--is the output flag for head printout.

If Hdpr = 0, head is not printed for the corresponding layer.

If Hdpr ≠ 0, head is printed for the corresponding layer.

Ddpr--is the output flag for drawdown printout.

If Ddpr = 0, drawdown is not printed for the corresponding layer.

If Ddpr ≠ 0, drawdown is printed for the corresponding layer.

Hdsv--is the output flag for head save.

If Hdsv = 0, head is not saved for the corresponding layer.

If Hdsv ≠ 0, head is saved for the corresponding layer.

Ddsv--is the output flag for drawdown save.

If Ddsv = 0, drawdown is not saved for the corresponding layer.

If Ddsv ≠ 0, drawdown is saved for the corresponding layer.

Block-Centered Flow Package Input

Input for the BCF Package is read from the unit specified in IUNIT(1).

FOR EACH SIMULATION

1. Record: ISS IBCFCB
2. Data: LAYCON(NLAY) (maximum of 80 layers)
Format: 40I2
(If there are 40 or fewer layers, use one record.)
3. Array: TRPY(NLAY)
4. Array: DELR(NCOL)
5. Array: DELC(NROW)

All of the arrays (items 6-12) for layer 1 are read first; then all of the arrays for layer 2, etc.

IF THE SIMULATION IS TRANSIENT

6. Array: sf1(NCOL,NROW)

IF THE LAYER TYPE CODE (LAYCON) IS ZERO OR TWO

7. Array: Tran(NCOL,NROW)

IF THE LAYER TYPE CODE (LAYCON) IS ONE OR THREE

8. Array: HY(NCOL,NROW)

9. Array: BOT(NCOL,NROW)

IF THIS IS NOT THE BOTTOM LAYER

10. Array: Vcont(NCOL,NROW)

IF THE SIMULATION IS TRANSIENT AND THE LAYER TYPE CODE (LAYCON) IS TWO OR THREE

11. Array: sf2(NCOL,NROW)

IF THE LAYER TYPE CODE IS TWO OR THREE

12. Array: TOP(NCOL,NROW)

ISS--is the steady-state flag.

If ISS \neq 0, the simulation is steady state.

If ISS = 0, the simulation is transient.

IBCFCB--is a flag and a unit number.

If IBCFCB > 0, cell-by-cell flow terms will be recorded if ICBCFL
(see Output Control) is set.

If IBCFCB = 0, cell-by-cell flow terms will not be printed or recorded.

If IBCFCB < 0, print flow for constant-head cells if ICBCFL is set.

LAYCON--is the layer type table: 0 - confined, 1 - unconfined,

2 - confined/unconfined (T constant), and 3 - confined/unconfined.

TRPY--is an anisotropy factor for each layer: T or K along a column to T or
K along a row.

DELR--is the cell width along rows.

DELC--is the cell width along columns.

sf1--is the primary storage factor.

Tran--is the transmissivity along rows.

HY--is the hydraulic conductivity along rows.

BOT--is the elevation of the aquifer bottom.

Vcont--is the vertical hydraulic conductivity divided by the thickness from
a layer to the layer beneath it.

sf2--is the secondary storage factor.

TOP--is the elevation of the aquifer top.

River Package Input

Input to the River (RIV) Package is read from the unit specified in IUNIT(4).

FOR EACH SIMULATION

1. Record: MXRIVR IRIVCB

FOR EACH STRESS PERIOD

2. Record: ITMP

3. Record: Layer Row Column Stage Cond Rbot
(Input item 3 normally consists of one record for each river reach. If ITMP is negative or zero, item 3 is not read.)

IRIVCB--is a flag and a unit number.

If IRIVCB > 0, cell-by-cell flow terms will be recorded.

If IRIVCB = 0, cell-by-cell flow terms will not be printed or recorded.

If IRIVCB < 0, river leakage will be printed if ICBCFL is set.

ITMP--is a flag and a counter.

If ITMP < 0, river data from the last stress period will be reused.

If ITMP \geq 0, ITMP will be the number of reaches active during the current stress period.

Recharge Package Input

Input to the Recharge (RCH) Package is read from the unit specified in IUNIT(8).

FOR EACH SIMULATION

1. Record: NRCHOP IRCHCB

FOR EACH STRESS PERIOD

2. Record: INRECH INIRCH

3. Array: RECH(NCOL,NROW)

IF THE RECHARGE OPTION IS EQUAL TO 2

4. Array: IRCH(NCOL,NROW)

NRCHOP--is the recharge option code.

1 - Recharge is only to the top grid layer.

2 - Vertical distribution of recharge is specified in array IRCH.

3 - Recharge is applied to the highest active cell in each vertical column.

IRCHCB--is a flag and a unit number.

If IRCHCB > 0, unit number for cell-by-cell flow terms.

If IRCHCB \leq 0, cell-by-cell flow terms will not be printed or recorded.

INRECH--is the RECH read flag.

If INRECH < 0, recharge fluxes from the preceding stress period are used.

If INRECH \geq 0, an array of recharge fluxes, RECH (Lt^{-1}), is read.

INIRCH--is similar to INRECH.

Well Package Input

Input for the Well (WEL) Package is read from the unit specified in IUNIT(2).

FOR EACH SIMULATION

1. Record: MXWELL IWELCB

FOR EACH STRESS PERIOD

2. Record: ITMP

3. Record: Layer Row Column 0

(Input item 3 normally consists of one record for each well. If ITMP is negative or zero, item 3 is not read.)

MXWELL--is the maximum number of wells used at any time.

IWELCB--is a flag and a unit number.

If IWELCB > 0, unit number for cell-by-cell flow terms.

If IWELCB = 0, cell-by-cell flow terms will not be printed or recorded.

If IWELCB < 0, well recharge will be printed whenever ICBCFL is set.

ITMP--is a flag and a counter.

If ITMP < 0, well data from the last stress period will be reused.

If ITMP > 0, ITMP will be the number of wells active during the current stress period.

Drain Package Input

Input to the Drain (DRN) Package is read from the unit specified in IUNIT(3).

FOR EACH SIMULATION

1. Record: MXDRN IDRNCB

FOR EACH STRESS PERIOD

2. Record: ITMP

3. Record: Layer Row Col Elevation Cond

(Input item 3 normally consists of one record for each drain. If ITMP is negative or zero, item 3 will not be read.)

MXDRN--is the maximum number of drain cells active at one time.

IDRNCB--is a flag and a unit number.

If IDRNCB > 0, unit number for cell-by-cell flow terms.

If IDRNCB = 0, cell-by-cell flow terms will not be printed or recorded.

If IDRNCB < 0, drain leakage for each cell will be printed whenever ICBCFL is set.

ITMP--is a flag and a counter.

If ITMP < 0, drain data from the last stress period will be reused.

If ITMP > 0, ITMP will be the number of drains active during the current stress period.

Evapotranspiration Package Input

Input to the Evapotranspiration (EVT) Package is read from the unit specified in IUNIT (5).

FOR EACH SIMULATION

1. Record: NEVTOP IEVTCB

FOR EACH STRESS PERIOD

2. Record: INSURF INEVTR INEXDP INIEVT

3. Array: SURF

4. Array: EVTR

5. Array: EXDP

IF THE ET OPTION IS EQUAL TO TWO

6. Array: IEVT

NEVTOP--is the evapotranspiration (ET) option code.

1 - ET is calculated only for cells in the top grid layer.

2 - The cell for each vertical column is specified by the user in array IEVT.

IEVTCB--is a flag and a unit number.

If IEVTCB > 0, unit number for cell-by-cell flow terms.

If IEVTCB < 0, cell-by-cell flow terms will not be printed or recorded.

INSURF--is the ET surface (SURF) read flag.

If INSURF > 0, an array containing the ET surface elevation will be read.

If INSURF < 0, the ET surface from the preceding stress period will be reused.

INEVTR--is similar to INSURF.

INEXDP--is similar to INSURF.

INIEVT--is similar to INSURF.

General-Head Boundary Package Input

Input for the General-Head Boundary (GHB) Package is read from the unit specified in IUNIT(7).

FOR EACH SIMULATION

1. Record: MXBND IGHBCB

FOR EACH STRESS PERIOD

2. Record: ITMP

3. Record: Layer Row Column Head Cond

(Input item 3 normally consists of one record for each GHB.

If ITMP is negative or zero, item 3 is not read.)

MXBND--is the maximum number of general-head boundary cells at one time.

IGHBCB--is a flag and a unit number.

If IGHBCB > 0, unit number for cell-by-cell flow terms.

If IGHBCB = 0, cell-by-cell flow terms will not be printed or recorded.

If IGHBCB < 0, boundary leakage for each cell will be printed whenever ICBCFL is set.

ITMP--is a flag and a counter.

If ITMP < 0, GHB data from the preceding stress period will be reused.

If ITMP > 0, ITMP is the number of general-head boundaries during the current stress period.

Strongly Implicit Procedure Package Input

Input to the Strongly Implicit Procedure (SIP) Package is read from the unit specified in IUNIT(9).

FOR EACH SIMULATION

1. Record: MXITER NPARM

2. Record: ACCL HCLOSE IPCALC WSEED IPRSIP

IPCALC--is a flag indicating where the iteration parameter seed will come from.

0 - the seed will be entered by the user.

1 - the seed will be calculated at the start of the simulation from problem parameters.

IPRSIP--is the printout interval for SIP.

Slice-Successive Overrelaxation Package Input

Input to the Slice-Successive Overrelaxation (SOR) Package is read from the unit specified in IUNIT(11).

FOR EACH SIMULATION

1. Record: MXITER

2. Record: ACCL HCLOSE IPRSOR

IPRSOR--is the printout interval for SOR.