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

Chapter C1

FINITE-DIFFERENCE MODEL FOR AQUIFER SIMULATION IN TWO DIMENSIONS WITH RESULTS OF NUMERICAL EXPERIMENTS

By P. C. Trescott, G. F. Pinder, and S. P. Larson

Book 7

AUTOMATED DATA PROCESSING AND COMPUTATIONS
If NWEL = 0 the following set of cards is omitted.

**DATA SET 1**

**COLUMNS** | **FORMAT** | **VARIABLE** | **DEFINITION**
---|---|---|---
1–10 | G10.0 | 1 | Row location of well.
11–20 | G10.0 | J | Column location of well.
21–30 | G10.0 | WELL (I,J) | Pumping rate \((L^3/T)\), negative for a pumping well.
31–40 | G10.0 | RADIUS | Real well radius \((L)\).

**NOTE.**—Radius is required only for those wells, if any, where computation of drawdown at a real well radius is to be made.

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

If another simulation is included in the same job, insert a blank card before the next group I cards.

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**Attachment IV**

**Sample Aquifer Simulation And Job Control Language**

This appendix includes examples of job control language (JCL) for several different runs and an example problem designed to illustrate many of the options in the program. The grid and boundary conditions for the problem are given in figure 25. Figure 30 illustrates in cross section the type of problem being simulated, but note that it is not to scale.

The listing of data with the JCL examples is not on a coding form, but it should not be difficult to determine the proper location of the numbers since the fields are either 4 or 10 spaces. Zero values have not been coded on the data cards to avoid unnecessary punching.

Figures 31 and 32 illustrate the JCL and data decks for two successive simulations of the sample problem. They are designed to show the use of disk facilities to store array data and interim results. The first run (fig. 31) is terminated after 5 iterations and interim results are stored on the data set specified by the FT04F001 DD statement. Note that arrays S, PERM, DELX, and DELY have been stored in the array data set specified by the FT02F001 DD statement (a 1 appears in column 40 of the parameter card for these arrays). The second run (fig. 32) continues computations from the previous stopping point and calculates a solution. Note that PHI, S, PERM, DELX, and DELY are read from disk storage. The final example (fig. 33) illustrates the JCL and data deck for a run without using the disk files. Following figure 33 is the output for the sample prob-
### TECHNIQUES OF WATER-RESOURCES INVESTIGATIONS

--- SAMPLE AQUIFER PROBLEM ---

<table>
<thead>
<tr>
<th>Group I</th>
<th>WATE LEAK</th>
<th>EVAP</th>
<th>RECCH</th>
<th>SIP</th>
<th>CHEC</th>
<th>DK2</th>
<th>NUME</th>
<th>HEAD</th>
</tr>
</thead>
<tbody>
<tr>
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<td>10</td>
<td>1</td>
<td>1</td>
<td>1500</td>
<td>1</td>
<td>1</td>
<td>+1 FEET</td>
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</table>

<table>
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<tbody>
<tr>
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<td>1</td>
</tr>
</tbody>
</table>

| Group III |                   |                   |                   |                   |
|-----------|-------------------|-------------------|-------------------|
| PERM      |                   |                   |                   |

<table>
<thead>
<tr>
<th>Group IV</th>
<th></th>
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</thead>
</table>

FIGURE 31.—JCL and data deck to copy some of the data sets on disk, compute for 5 iterations, and store the results on disk.
FINITE-DIFFERENCE MODEL FOR AQUIFER SIMULATION

EXEC FORTGCG

//FORT.SYSIN DD *

Model
source
cards

//GO.FT02F001 DD DSN=A442702.AZ100.AG4W0000.MATRIX,
//UNIT=ONLINE DISP=SHR VOL=SER=SYS5015
//GO.FT04F001 DD DSN=A442702.AZ100.AG4W0000.HEAD,
//UNIT=ONLINE DISP=SHR VOL=SER=SYS5011
//GO.SYSIN DD *

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<th>EVAP</th>
<th>RECH</th>
<th>SIP</th>
<th>CHEC</th>
<th>DKI</th>
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<td>1500</td>
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<td>1</td>
<td></td>
<td></td>
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<td></td>
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<td></td>
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</table>

--- SAMPLE AQUIFER PROBLEM ---

FIGURE 32.—JCL and data deck to continue the previous run (fig. 31) to a solution.

Figure generated using the JCL and problem deck shown in figure 33.

Figures 31 to 33 show that the source cards are being compiled for each run. It is more efficient, of course, to compile the source deck once and store it as a load module on disk. Subsequent runs can use the load module with considerable reduction in cards read, CPU time, and lines printed.
### TECHNIQUES OF WATER-RESOURCES INVESTIGATIONS

--- SAMPLE AQUIFER PROBLEM ---

<table>
<thead>
<tr>
<th>Group I WATE LEAK EVAP RECH SIP CHEC NUME</th>
<th>HEAD</th>
</tr>
</thead>
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</tr>
<tr>
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<td>1</td>
</tr>
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</table>

| Bottom | 0 |
| SY | |
| Rate | .3E-07 |
| River | 100 |
| M | 10 |
| Grnd | 105 |
| QRE | .2E-07 |

<table>
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<table>
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</table>

--- SAMPLE AQUIFER PROBLEM ---

**FIGURE 33.**—JCL and data deck to simulate the sample problem without using disk files.
Program Output using data deck illustrated in figure 33

--- SAMPLE AQUIFER PROBLEM ---

SIMULATION OPTIONS

<table>
<thead>
<tr>
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<th>REC</th>
<th>SIP</th>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- NUMBER OF ROWS = 10
- NUMBER OF COLUMNS = 14
- NUMBER OF WELLS FOR WHICH DRAWDOWN IS COMPUTED AT A SPECIFIED RADIUS = 1
- MAXIMUM PERMITTED NUMBER OF ITERATIONS = 50
- WORDS OF Y VECTOR USED = 3731

ON ALPHABETIC MAP:
- MULTIPLICATION FACTOR FOR X DIMENSION = 1.000000
- MULTIPLICATION FACTOR FOR Y DIMENSION = 1.000000
- MAP SCALE IN UNITS OF FEET = 1500.000
- MULTIPLICATION FACTOR FOR DRAWDOWN = 1.000000
- MULTIPLICATION FACTOR FOR HEAD = 0.999993E-01

- NUMBER OF PUMPING PERIODS = 1
- TIME STEPS BETWEEN PRINTOUTS = 1

- ERROR CRITERIA FOR CLOSURE = 0.3000000E-02
- STEADY STATE ERROR CRITERIA = 0.999993E-02

- SPECIFIC STORAGE OF CONFINING BED = 0.0
- EVAPOTRANSPIRATION RATE = 0.4000000E-06
- EFFECTIVE DEPTH OF ET = 10.00000

- MULTIPLICATION FACTOR FOR TRANSISIVITY IN X DIRECTION = 1.000000
- IN Y DIRECTION = 1.000000

- STARTING HEAD = 100.0000
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</tr>
</tbody>
</table>
AGUIFER HYDRAULIC CONDUCTIVITY MATRIX

\[
\begin{array}{cccccccccc}
1 & 0.0 & 0.0 & 0.0 & 0.0 & 0.0 & 0.0 & 0.0 & 0.0 & 0.0 \\
2 & 0.0 & 0.0 & 0.0 & 0.0 & 0.0 & 0.200E-02 & 0.200E-02 & 0.200E-02 & 0.400E-02 \\
   & 0.400E-02 & 0.400E-02 & 0.400E-02 & 0.400E-02 & 0.400E-02 & 0.400E-02 & 0.400E-02 \\
3 & 0.0 & 0.0 & 0.0 & 0.0 & 0.0 & 0.200E-02 & 0.200E-02 & 0.200E-02 & 0.400E-02 \\
   & 0.400E-02 & 0.400E-02 & 0.400E-02 & 0.400E-02 & 0.400E-02 & 0.400E-02 & 0.400E-02 \\
4 & 0.0 & 0.0 & 0.0 & 0.0 & 0.0 & 0.200E-02 & 0.200E-02 & 0.200E-02 & 0.400E-02 \\
   & 0.400E-02 & 0.400E-02 & 0.400E-02 & 0.400E-02 & 0.400E-02 & 0.400E-02 & 0.400E-02 \\
5 & 0.0 & 0.0 & 0.0 & 0.0 & 0.0 & 0.200E-02 & 0.200E-02 & 0.200E-02 & 0.400E-02 \\
   & 0.400E-02 & 0.400E-02 & 0.400E-02 & 0.400E-02 & 0.400E-02 & 0.400E-02 & 0.400E-02 \\
6 & 0.0 & 0.0 & 0.0 & 0.0 & 0.0 & 0.200E-02 & 0.200E-02 & 0.200E-02 & 0.400E-02 \\
   & 0.400E-02 & 0.400E-02 & 0.400E-02 & 0.400E-02 & 0.400E-02 & 0.400E-02 & 0.400E-02 \\
7 & 0.0 & 0.0 & 0.0 & 0.0 & 0.0 & 0.200E-02 & 0.200E-02 & 0.200E-02 & 0.400E-02 \\
   & 0.400E-02 & 0.400E-02 & 0.400E-02 & 0.400E-02 & 0.400E-02 & 0.400E-02 & 0.400E-02 \\
8 & 0.0 & 0.0 & 0.0 & 0.0 & 0.0 & 0.200E-02 & 0.200E-02 & 0.200E-02 & 0.400E-02 \\
   & 0.400E-02 & 0.400E-02 & 0.400E-02 & 0.400E-02 & 0.400E-02 & 0.400E-02 & 0.400E-02 \\
9 & 0.0 & 0.0 & 0.0 & 0.0 & 0.0 & 0.200E-02 & 0.200E-02 & 0.200E-02 & 0.400E-02 \\
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   & 0.400E-02 & 0.400E-02 & 0.400E-02 & 0.400E-02 & 0.400E-02 & 0.400E-02 & 0.400E-02 \\
\end{array}
\]

AGUIFER BASE ELEVATION = 0.0
SPECIFIC YIELD = 0.0
CONFINING BED HYDRAULIC CONDUCTIVITY = 0.3000000E-07
RIVER HEAD = 100,000
CONFINING BED THICKNESS = 10.00000
LAND SURFACE ELEVATION = 105.00000
AREAL RECHARGE RATE = 0.2000000E-07
GRID SPACING IN PROTOTYPE IN X DIRECTION

1000, 700, 450, 450, 700, 1050, 1550, 2050, 1050, 1250, 850, 550
450, 650

GRID SPACING IN PROTOTYPE IN Y DIRECTION

500, 250, 350, 500, 700, 900, 1350, 1500, 1550, 600

SOLUTION BY THE STRONGLY IMPLICIT PROCEDURE

BETA= 1.00

10 ITERATION PARAMETERS: 0.0 0.6903903 0.9044180 0 0.9703214 0 0 0.9908112 0 0 0.6903903 0.9044180 0 0.9703214 0 0 0.9908112 0

PUMPING PERIOD NO. 1: 1.00 DAYS

NUMBER OF TIME STEPS= 1
DELT IN HOURS = 24.000
MULTIPLIER FOR DELT = 1.000

6 WELLS

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FINITE-DIFFERENCE MODEL FOR AQUIFER SIMULATION

--------- TIME STEP NUMBER = 1 ---------

SIZE OF TIME STEP IN SECONDS = 86400.00
TOTAL SIMULATION TIME IN SECONDS = 86400.00
MINUTES = 1440.00
HOURS = 24.00
DAYS = 1.00
YEARS = 0.00

DURATION OF CURRENT PUMPING PERIOD IN DAYS = 1.00
YEARS = 0.00

CUMULATIVE MASS BALANCE:

L**3

SOURCE:

STORAGE = 0.0
RECHARGE = 11873
CONSTANT FLUX = 0.2000
EVAPOTRANSPIRATION = -0.2412
CONSTANT HEAD = 16419
LEAKAGE = 0.0
OUT = 1748559.00
TOTAL SOURCES = 1748559.00

DISCHARGE:

EVAPOTRANSPIRATION = 20837.56
CONSTANT HEAD = 0.0
QUANTITY PUMPED = 1727998.00
LEAKAGE = 0.0
TOTAL DISCHARGE = 1748835.00

DISCHARGE SOURCES = 276.00

SUM OF RATES = -0.0032
TOTAL = 24313

MAXIMUM HEAD CHANGE FOR EACH ITERATION:

9.5204 4.8325 3.7815 7.4434 3.4337 2.6980 1.3149 1.8210 1.1354 0.8168
0.4495 0.5055 0.3512 0.3693 0.2610 0.2107 0.0960 0.1267 0.0765 0.0509
0.0297 0.0322 0.0225 0.0234 0.0179 0.0139 0.0060 0.0080 0.0048 0.0032
0.0019

MAXIMUM CHANGE IN HEAD FOR THIS TIME STEP = 32.067

TIME STEP = 1

ITERATIONS = 30
TECHNIQUES OF WATER-RESOURCES INVESTIGATIONS

EXPLANATION

R = CONSTANT HEAD BOUNDARY
*** = VALUE EXCEEDED 3 FIGURES
MULTIPLICATION FACTOR = 1,000

PLOT OF DRAWDOWN

23 23 19 16 R R
2525 24 20 15 9 1 R
2728 32 21 14 9 3 R 10500.00
1919 18 16 12 8 4 R 9000.00
1413 13 12 10 8 4 R 7500.00
13 13 12 11 9 6 R X DISTANCE IN 6000.00 FEET
17 17 17 16 14 12
2020 21 22 27 18 15
2021 21 22 22 18 15
21 21 21 21 18 16 16
16
0.0 1500.00 3000.00 4500.00 6000.00 7500.00 0.0

DISTANCE FROM ORIGIN IN Y DIRECTION, IN FEET
FINITE-DIFFERENCE MODEL FOR AQUIFER SIMULATION

**PLOT OF HYDRAULIC HEAD**

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<th>X Distance (Feet)</th>
<th>Y Distance (Feet)</th>
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**EXPLANATION**

- R = CONSTANT HEAD BOUNDARY
- *** = VALUE EXCEEDED 3 FIGURES
- MULTIPLICATION FACTOR = 0.100
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### Head and Drawdown in Pumping Wells

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Attachment V
Generalized Flow Chart For Aquifer Simulation Model

A. MAIN PROGRAM

Start

New problem: Read and write title, program options and dimensions

A1

Compute dimensions of arrays

A1

Pass addresses of arrays to subroutines

B1

Read and write data for Groups II and III

A2

WATER=CHK(2)

Yes

E2

No

A3

D1

Compute iteration parameters

A4

CONTR=CHK(3)

Yes

G1

No

A5

WATER=CHK(2)

Yes

B2

A6

No

E8

A7

C1

New pumping period

New time step

A8

Transient Leakage

Yes

E1

No

A9

D2

Numerical solution

A10

C2

Check for steady state; print results

2

1
FINITE-DIFFERENCE MODEL FOR AQUIFER SIMULATION

Flow chart—Continued

A11

IFINAL=1 ?

No

A7

Yes

A6

KP<NP\(\)E \(\)R ?

No

A12

Yes

C8

A13

PNCH=CHK(1) ?

No

New Problem ?

Yes

A1

No

STOP

B, DATA1

B1

Read and write scalar parameters and arrays

A2

Initialize variables for the simulation

B2

Read approximate time parameters

C8

Compute and print actual time parameters

Initialize SUMP, STRT, SL, WELL and WR for the pumping period

C9

A1

Read and write well pumping rates and well radii
C, STEP

C1  Initialize variables for the time step

C2  Check for steady state

C3  KOUNT > IMAX ?
    No
    Yes
    Write results on disk
    Yes
    No
    Punch results

    IDK2 = CHK(15) ?
    No
    Yes
    PNCII = CHK(11) ?

    CHK1 = CHK(5) ?
    No
    Yes
    F1

    MOD(KT, KTH) = 0, or IFINAL = 1, or IERR = 2 ?
    No
    Yes
    Print heading

    CHK1 = CHK(5) ?
    Yes
    No
    Print other information

C5  Print other information

C6  CONTR = CHK(3) ?
    No
    Yes
    G2

C7  HEAD = CHK(6) ?
    No
    Yes
    Print PHI

    NUM = CHK(4) ?
    No
    Yes
    E3

    NW = 0 ?
    No
    Yes
    E5

    Compute and print drawdown at wells

    IERR = 2 ?
    No
    Yes
    A11

    STOP

C8  Write results on disk

C9  Punch results

A8

G2

E3A

A12

A13

E4
Finite-difference model for aquifer simulation

Flow chart—Continued

D, Solve

D1
Compute and print iteration parameters

A4

D2
Initialize data for a new iteration

E2

D3
WATER = CHK(2)

D4

LEAK = CHK(9)

D5

Yes

No

Solution algorithm

Solution?

Yes

No

Compute SL and U

D2

D4

No

A10

Yes

D4

Compute B, D, F, H

No

EVAP = CHK(6)

No

Compute ETQ, ETQD

Yes

CONVRT = CHK(7)

No

Compute RHO

Yes

D4

Compute RHO and SUBS

5

1

2

3

4

5

6

7

8

9

10
Flow chart—Continued

**F, CHECKI**

- **F1**
  - Initialize variables
  - Compute rates, storage and pumping for this step
  - Compute cumulative volumes, totals and differences

- **F2**
  - Print Mass Balance

**G, PRNTAI**

- **G1**
  - Initialize variables for map

- **G2**
  - Compute location of axes, labels and symbols
  - Print map

**Flowchart Description**

1. **F1**
   - Initialize variables
   - Compute rates, storage and pumping for this step
   - Compute cumulative volumes, totals and differences

2. **F2**
   - Print Mass Balance

3. **G1**
   - Initialize variables for map

4. **G2**
   - Compute location of axes, labels and symbols
   - Print map
Attachment VI
Definition Of Program Variables

A
IN DATA1, DUMMY ARRAY (DOES NOT USE CORE SPACE) USED TO
OBTAIN ADDRESSES OF ARRAY DATA SETS;
ALFA
CORRECTION VECTOR FOR ROWS (LSOR);
PARAMETER IN SIP ALGORITHM;
B
TC(I,J)/DELY(I) (1/T);
NE
PARAMETER IN THOMAS ALGORITHM;
BOTTOM
ELEVATION OF THE BOTTOM OF THE AQUIFER (L);
CDLT
MULTIPLYING FACTOR FOR THE TIME STEP;
CHECK
CONTAINS CHARACTER STRING FOR MASS BALANCE OPTION;
CMK
VECTOR CONTAINING PROBLEM OPTIONS;
CONTR
CONTAINS CHARACTER STRING FOR OPTION TO PRINT
MARS OF DRAWDOWN AND/OR HEAD;
CONVRT
CONTAINS CHARACTER STRING FOR WATER TABLE-ARTESIAN OPTION;
D
TR(I,J)/DELY(J) (1/T);
DDN
VECTOR THAT CONTAINS DRAWDOWN VALUES (L);
DEL
ARRAY USED IN SIP ALGORITHM;
DELT
TIME INCREMENT (T);
DELY
GRID SPACING IN THE Y DIRECTION (L);
DIML
NUMBER OF ROWS;
DIMM
NUMBER OF COLUMNS;
ERROR
FINITE ELEMENT ERROR CRITERION (L);
ERR
CLOSURE CRITERION (L);
ETA
ARRAY用于在 SIP 算法中使用;
ETDIST
DEPTH AT WHICH EVAPOTRANSPIRATION CEASES BELOW LAND
SURFACE (L);
ETQG
THAT PART OF ET SOURCE TERM TREATED IMPLICITLY;
ETQD
THAT PART OF ET SOURCE TERM TREATED EXPLICITLY;
EVAP
CONTAINS CHARACTER STRING FOR EVAPOTRANSPIRATION OPTION;
F
TR(I,J)/DELY(J) (1/T);
FACT
SEE EXPLANATION IN GROUP III: ARRAY DATA;
FACTX
MULTIPLICATION FACTOR FOR TRANSMISSIVITY IN X DIRECTION;
FACTY
MULTIPLICATION FACTOR FOR TRANSMISSIVITY IN Y DIRECTION;
G
PARAMETER IN THOMAS ALGORITHM;
H
TC(I,J)/DELY(I) (1/T);
GRND
ELEVATION OF LAND SURFACE (L);
HEAD
CONTAINS CHARACTER STRING FOR OPTION TO PRINT HEAD VALUES;
HEADING
TITLE FOR SIMULATION;
IMAX
MAXIMUM ITERATION PARAMETER (ADI);
ACCEL
ACCELERATION PARAMETER (LSOR);
BETA
PARAMETER (SIP);
IC
INDICATOR USED TO DETERMINE THE TYPE OF ARRAY DATA;
IFERR
= 0 PUMPING Wells ARE IN SATURATED PART
OF WATER TABLE AQUIFER;
= 1 PUMPING WELL HAS GONE DRY;
IFIN
= 0 ALL TIME STEPS EXCEPT THE LAST;
= 1 LAST TIME STEP IN PUMPING PERIOD;
IFMT1, IFMT2, IFMT3 VARIABLE "FORMAT ARRAYS PASSED TO DATA1 VIA ARRAY
ENTRY POINT;
IN
IN DATA1, DUMMY ARRAY TO WHICH NAME IS PASSED;
IN1
DIML=11;
IPRN
SEE EXPLANATION IN GROUP III: ARRAY DATA;
IRECS, IRECD SEE EXPLANATION IN GROUP III: ARRAY DATA;
IRN
RECORD NUMBER USED FOR DISK STORAGE AND RETRIEVAL OF
ARRAY DATA;
FINITE-DIFFERENCE MODEL FOR AQUIFER SIMULATION

Definition of program variables—Continued

ITMAX  MAXIMUM NUMBER OF ITERATIONS PER TIME STEP;
IVAR   SEE EXPLANATION IN GROUP III: ARRAY DATA;
ISUM   THE CUMULATIVE WORDS OF STORAGE USED IN THE Y VECTOR;
IZ, JZ ETC. DIMENSIONS OF ARRAYS IN MODEL COMPUTED IN MAIN PROGRAM;
JNO1   DIMW=11;
KEEP   HYDRAULIC HEAD AT THE PREVIOUS TIME STEP (L);
KK    ASSOCIATED VARIABLE IN DEFINE FILE; INDICATES NUMBER OF
      NEXT RECORD;
Kount  ITERATION COUNTER;
KP     NUMBER OF THE PUMPING PERIOD;
KPM1   NUMBER OF PREVIOUS PUMPING PERIOD;
KT     TIME STEP COUNTER;
KTH    NUMBER OF TIME STEPS BETWEEN PRINTOUTS;
L      VECTOR CONTAINING INITIAL ADDRESS OF ARRAYS;
Leak   CONTAINS CHARACTER STRING FOR LEAKAGE OPTION;
Length  NUMBER OF ITERATION PARAMETERS (SIP=ADI);
M      NUMBER OF ITERATIONS BETWEEN Z-D CORRECTION (LSOR);
Ner    THICKNESS OF CONFINING OR STREAM BED (L);
NPER   NUMBER OF PUMPING PERIODS;
Num    CONTAINS CHARACTER STRING FOR OPTION TO PRINT DRAWDOWN;
Numt   NUMBER OF TIME STEPS;
NW     NUMBER OF PUMPING WELLS FOR WHICH DRAWDOWN IS TO BE
      COMPUTED AT A 'REAL' WELL RADIUS;
NWel   NUMBER OF WELLS FOR A PUMPING PERIOD;
NWr    LOCATION OF WELLS;
Pnch   CONTAINS CHARACTER STRING FOR OPTION TO PUNCH HYDRAULIC
      HEAD VALUES;
P     PRINTER UNIT NUMBER;
Param  ITERATION PARAMETER;
Perm   HYDRAULIC CONDUCTIVITY OF THE AQUIFER (L/T);
Phe   HYDRAULIC HEAD AT THE START OF THE ITERATION (L);
Pmi   HYDRAULIC HEAD (L);
Pu     PUNCH UNIT NUMBER;
Qet    MAXIMUM EVAPOTRANSPIRATION RATE (L/T);
Qre    RECHARGE RATE (L/T);
R      READER UNIT NUMBER;
Radius  REAL WELL RADIUS (L);
Rate   VERTICAL HYDRAULIC CONDUCTIVITY OF THE CONFINING BED
      OR STREAM BED (L/T);
Rech   CONTAINS CHARACTER STRING FOR RECHARGE OPTION;
Rho   S/DELT (1/T);
Rhomp  VECTOR CONTAINING ITERATION PARAMETERS;
River  HYDRAULIC HEAD OF THE STREAM OR IN THE AQUIFER
      ABOVE OR BELOW THE PUMPED AQUIFER (L);
Rw    WELL AND RECHARGE SOURCE TERM (L/T);
S      STORAGE COEFFICIENT;
Sip    CONTAINS CHARACTER STRING FOR SIP OPTION;
Sl     STEADY PART OF LEAKAGE COEFFICIENT (L/T);
Sleak  INITIAL & TRANSIENT LEAKAGE (L/T);
Ss     SPECIFIC STORAGE OF CONFINING BED (1/L);
Store  CONTAINS EITHER THE STORAGE COEFFICIENT OR SPECIFIC
      YIELD DEPENDING ON THE TYPE OF AQUIFER;
Strat  HYDRAULIC HEAD AT THE BEGINNING OF THE CURRENT
      PUMPING PERIOD (L);
Subs   MODIFIES STORAGE TERM IN WATER TABLE-ARTESIAN CONVERSION;
Sum    TOTAL ELAPSED TIME IN THE SIMULATION (T);
Sump   TOTAL ELAPSED TIME IN THE PUMPING PERIOD (T);
Sure  HYDRAULIC HEAD AT THE START OF THE SIMULATION (L);
Sy    SPECIFIC YIELD;
T     TRANSMISSIVITY (L*2/T);
Tc    HARMONIC AVERAGE OF T/DELY = I*1/2*J (L/T);
Definition of program variables—Continued

TEMP VECTOR FOR TEMPORARY STORAGE OF HYDRAULIC HEAD (L)
TEST = 0 CLOSURE CRITERION SATISFIED;
= 1 CLOSURE CRITERION NOT SATISFIED;
TEST2 MAXIMUM CHANGE IN HEAD FOR THE TIME STEP (L)
TEST3 VECTOR CONTAINING THE SUM OF THE ABSOLUTE VALUES
OF HEAD CHANGES FOR EACH ITERATION (L)
TL TRANSIENT PART OF LEAKAGE COEFFICIENT (1/T)
TMAX NUMBER OF DAYS IN THE PUMPING PERIOD (T)
TMIN MINIMUM VALUE OF DIMENSIONLESS TIME FOR THE CURRENT
PUMPING PERIOD
TOP ELEVATION OF THE TOP OF THE AQUIFER (L)
TR HARMONIC AVERAGE OF T/DELX @ I,J+1/2 (L/T)
TT MAXIMUM VALUE OF DIMENSIONLESS TIME FOR THE CURRENT
PUMPING PERIOD
U = 0 EXPLICIT TREATMENT OF TRANSIENT LEAKAGE;
= 1 IMPLICIT TREATMENT OF TRANSIENT LEAKAGE;
U INDICATES DEFINE FILE RECORD LENGTH SPECIFICATION IN WORDS;
V ARRAY USED IN SIP ALGORITHM
VF4 VARIABLE FORMAT FOR PRINTING HEAD AND DRAWDOWN;
WATER CONTAINS CHARACTER STRING FOR WATER TABLE OPTION;
WELL WELL DISCHARGE (L**3/T)
WP WELL RADIUS (L)
XI ARRAY CONTAINING INCREMENTAL HEAD VALUES IN SIP SOLUTION (L)
YDLENGTH OF AQUIFER IN Y DIRECTION (L).

DEFINITION OF VARIABLES IN CHECK1 SUBROUTINE
--------------------------------------------------
CFLUX INFLOW FROM RECHARGE WELLS (L**3/T)
CFLUX1 CUMULATIVE VOLUME OF WATER FROM RECHARGE WELLS (L**3)
CHD1 RATE OF OUTFLOW TO CONSTANT HEAD BOUNDARY (L**3/T)
CHD2 RATE OF INFLOW FROM CONSTANT HEAD BOUNDARY (L**3/T)
CHDT CUMULATIVE DISCHARGE TO CONSTANT HEAD BOUNDARY (L**3)
CHST CUMULATIVE VOLUME OF WATER INFLOW FROM CONSTANT
HEAD BOUNDARY (L**3)
DIFF ERROR IN MASS BALANCE (L**3)
ETFLUX EVAPOTRANSPIRATION RATE (L**3/T)
ETFLXT CUMULATIVE DISCHARGE BY ET (L**3)
FLUX RATE OF LEAKAGE DUE TO GRADIENTS AT THE START
OF THE PUMPING PERIOD (L**3/T)
FLUXS NET LEAKAGE RATE (L**3/T)
FLXN RATE OF DISCHARGE BY LEAKAGE (L**3/T)
FLXNT CUMULATIVE VOLUME OF WATER DISCHARGED BY LEAKAGE (L**3)
FLXPT CUMULATIVE VOLUME OF WATER INFLOW FROM LEAKAGE (L**3)
PERCNT PERCENT ERROR IN CUMULATIVE MASS BALANCE
PUMP DISCHARGE FROM WELLS (L**3/T)
PUMPT CUMULATIVE VOLUME OF WATER DISCHARGED BY PUMPING WELLS (L**3)
QREFLX RECHARGE RATE (L**3/T)
QRT CUMULATIVE VOLUME OF WATER DERIVED FROM RECHARGE (L**3)
STOR RATE OF CHANGE IN STORAGE FOR THE TIME STEP (L**3/T)
STORT CUMULATIVE VOLUME OF WATER DERIVED FROM STORAGE (L**3)
SUMR SUM OF RECHARGE AND DISCHARGE RATES FOR THE TIME STEP (L**3/T)
TOTL1 CUMULATIVE VOLUME OF WATER FROM ALL SOURCES (L**3)
TOTL2 CUMULATIVE VOLUME OF WATER DISCHARGED FROM THE SYSTEM (L**3)
XNET NET LEAKAGE RATE FOR A CELL (L**3/T).

DEFINITION OF VARIABLES IN THE PRINTAI SUBROUTINE
--------------------------------------------------
BLANK CONTAINS BLANK SYMBOLS;
DINCH NUMBER OF MAP UNITS PER INCH;
DIST LOCATION OF NEXT COLUMN OF NODAL VALUES TO BE PRINTED;
Definition of variables in the PRNTAI subroutine—Continued

FACT1  FACTOR FOR ADJUSTING VALUE OF DRAWDOWN PRINTED;
FACT2  FACTOR FOR ADJUSTING VALUE OF HEAD PRINTED;
K     ADJUSTED VALUE OF DRAWDOWN OR HEAD;
MESUR  NAME OF MAP LENGTH UNIT;
N     INDEX FOR SYMBOLS;
NA     INDICES FOR LOCATING X LABEL;
NC     NUMBER OF BLANKS BEFORE GRAPH;
N1     NUMBER OF LINES PER INCH;
N2     NUMBER OF CHARACTERS PER INCH;
N3     NUMBER OF CHARACTERS PER LINE;
N4     NUMBER OF LINES IN THE PLOT;
N5     MAXIMUM NUMBER OF CHARACTERS IN Y DIRECTION;
NXD    NUMBER OF INCHES IN THE X DIMENSION OF PLOT;
NYD    NUMBER OF INCHES IN THE Y DIMENSION OF PLOT;
PRNT   CONTAINS THE ARRANGEMENT OF SYMBOLS FOR EACH LINE;
SPACNG CONTOUR INTERVAL (L);
SYM     VECTOR CONTAINING SYMBOLS USED IN THE PLOT;
TITLE  TITLE FOR PLOT;
VF1,VF2,VF3 VARIABLE FORMATS FOR CENTERING PLOT;
XLAB   LABEL FOR X AXIS;
XN     NUMBERS FOR X AXIS;
XN1    1 INCH/(N1+2);
XSCL   MULTIPLICATION FACTOR TO CONVERT MODEL LENGTH UNIT TO UNIT USED IN X DIRECTION ON MAPS;
XSF    X SCALE FACTOR;
YLAB   LABEL FOR Y AXIS;
YLEN   LOCATION OF NEXT VALUE IN THE COLUMN TO BE PRINTED;
YN     NUMBERS FOR Y AXIS;
YSCAL   MULTIPLICATION FACTOR TO CONVERT MODEL LENGTH UNIT TO UNIT USED IN Y DIRECTION ON MAPS;
YSF    Y SCALE FACTOR;
Z     LOCATION OF NEXT LINE TO BE PRINTED.