

Basic Aquifer Simulation Using a Two-Dimensional Groundwater Model**Introduction**

In GEY 674--Hydrogeology you were introduced to the concepts of well hydraulic and various analytic and graphic methods for estimating drawdowns and their effect on the water table. The purpose of this assignment is to learn how to prepare input data sets, execute the program, and analyze modeling results.

Problem No. 1

Using the FORTRAN compiler on the UNIXs (or PCs) in the Hydrology Computing Lab, copy the code (pltest.for) located in /home1/gey715/ to your working directory and run the program. Figure 2 in Yu's paper (1997) illustrates the parameters used for the simulation in this assignment. The program is used here for analyzing cause and effect relationship involving drawdowns or hydraulic heads in a non-steady-state, nonhomogeneous and/or homogeneous, isotropic aquifer system under nonleaky unconfined aquifers.

The two-dimensional flow problem in Figure 2 will be modeled with uniform grid spacing (31x31), homogeneous and isotropic aquifer system properties, initial heads set at the zero reference level, and equal time increments (or you can use unequal time increments). A pumping well needs to be set in grid block (16,16) in an unconfined aquifer with a grid of 31 columns and 31 rows. First, you need to benchmark the code by running the model and re-producing Figure 3. Figure 3 contains the simulated results and estimates through Theis curve method at $t=21$ days. Then conduct additional simulations to answer following questions.

1. With current parameters, what are the drawdowns at times of 1, 5, and 10 days.
2. How would the change in K value affect the drawdowns (with simulation runs and results)?
3. How would the thickness affect the drawdowns (with simulation runs and results)?

Preparing the input file

```
      READ(5,10)NSTEPS,DELTA,ERROR,  
      1NC,NR,TT,S1,HH,QQ  
10  FORMAT(I6,2F6.0/2I6,4F6.0)
```

where	NSTEPS: number of time steps	(42)
	DELTA: time increment	(0.5)
	ERROR: convergence error	(1.0)
	NC: number of columns	(31)
	NR: number of rows	(31)
	TT: transmissivity (gpg/ft)	(74800)
	S1: storativity factor $S1=6.23$ (delta x) (delta y)	(75000)
	HH: initial water level	(0.0)
	QQ: recharge	(0.0)

```
30  READ(5,40,END=50)I,J,T(I,J,1),  
      1T(I,J,2),SF1(I,J),H(I,J),Q(I,J)  
40  FORMAT(2I3,2F6.0,2F4.0,1F6.0)
```

where	I: number of columns	(16)
	J: number of rows	(16)
	TT: transmissivity (gpg/ft)	(74800)
	S1: storativity factor $S1=6.23$ (delta x) (delta y)	(75000)
	HH: initial water level	(0.0)
	QQ: recharge	(1E6)

```

C    PRICKETT AND LONNQUIST (1971)
C    BASIC AQUIFER SIMULATION PROGRAM
C    (MODIFICATIONS - G. MCCLYMONT)
    IMPLICIT REAL*8 (A-H,O-Z)
    DIMENSION H(40,40),HO(40,40),
    1SF1(40,40),Q(40,40),T(40,40,2),
    2B(40),G(40),DL(40,40)
C
C    DEFINE INPUT AND OUTPUT DEVICE NUMBERS
C
    CHARACTER*20 INFILE
    CHARACTER*20 OUTFILE
    WRITE(*,900)
    900 FORMAT (' INPUT FILE NAME- ')
    READ(*,910) INFILE
    910 FORMAT (A)
    WRITE(*,920)
    920 FORMAT(' OUTPUT FILE NAME-')
    READ(*,910) OUTFILE
    OPEN(5,FILE=INFILE)
    OPEN(6,FILE=OUTFILE,STATUS='NEW')
C
C    READ PARAMETER CARD AND
C    DEFAULT VALUE CARD
C
    READ(5,10)NSTEPS,DELTA,ERROR,
    1NC,NR,TT,S1,HH,QQ
    10  FORMAT(I6,2F6.0/2I6,4F6.0)
    WRITE(6,743)NSTEPS,DELTA,ERROR,NC,NR,TT,S1,HH,QQ
    743  FORMAT(I10,' : NSTEPS'/F10.2,' : DELTA'/F10.2,' : ERROR'/
    1    I10,' : NC'/I10,' : NR'/F10.2,' : TT'/F10.2,' : SF1'/
    2    F10.2,' : HH'/F10.2,' : QQ'//)
C
C    FILL ARRAYS WITH DEFAULT VALUES
C
    DO 20 I=1,NC
    DO 20 J=1,NR
    T(I,J,1)=TT
    T(I,J,2)=TT
    SF1(I,J)=S1
    H(I,J)=HH
    HO(I,J)=HH
    20  Q(I,J)=QQ
C
C    READ NODE CARDS
C

```

```

WRITE(6,753)
753 FORMAT(' I J    T1    T2    SF1    H',
1 '    Q')
30 READ(5,40,END=50)I,J,T(I,J,1),
1T(I,J,2),SF1(I,J),H(I,J),Q(I,J)
40 FORMAT(2I3,2F6.0,2F4.0,1F6.0)
WRITE(6,754)I,J,T(I,J,1),T(I,J,2),SF1(I,J),H(I,J),Q(I,J)
754 FORMAT(I5,I5,1X,E10.3,1X,E10.3,1X,E10.3,2F10.2)
GO TO 30
C
C    START OF SIMULATION
C
50 TIME=0
DO 320 ISTEP=1,NSTEPS
TIME=TIME+DELTA
C
C    PREDICT HEADS FOR NEXT
C    TIME INCREMENT
C
DO 70 I=1,NC
DO 70 J=1,NR
D=H(I,J)-HO(I,J)
HO(I,J)=H(I,J)
F=1.0
IF(DL(I,J).EQ.0.0)GO TO 60
IF(ISTEP.GT.2)F=D/DL(I,J)
IF(F.GT.5)F=5.0
IF(F.LT.0.0)F=0.0
60 DL(I,J)=D
70 H(I,J)=H(I,J)+D*F
C
C    REFINE ESTIMATES OF HEADS BY IADI METHOD
C
ITER=0
80 E=0.0
ITER=ITER+1
C
C    COLUMN CALCULATIONS
C
DO 190 II=1,NC
I=II
IF(MOD(ISTEP+ITER,2).EQ.1) I=NC-I+1
DO 170 J=1,NR
C
C    CALCULATE B AND G ARRAYS
C

```

```

BB=SF1(I,J)/DELTA
DD=HO(I,J)*SF1(I,J)/DELTA-Q(I,J)
AA=0.0
CC=0.0
IF(J-1)90,100,90
90  AA=-T(I,J-1,1)
    BB=BB+T(I,J-1,1)
100 IF(J-NR)110,120,110
110 CC=-T(I,J,1)
    BB=BB+T(I,J,1)
120 IF(I-1)130,140,130
130 BB=BB+T(I-1,J,2)
    DD=DD+H(I-1,J)*T(I-1,J,2)
140 IF(I-NC)150,160,150
150 BB=BB+T(I,J,2)
    DD=DD+H(I+1,J)*T(I,J,2)
160 W=BB-AA*B(J-1)
    B(J)=CC/W
170 G(J)=(DD-AA*G(J-1))/W
C
C    RE-ESTIMATE HEADS
C
E=E+ABS(H(I,NR)-G(NR))
H(I,NR)=G(NR)
N=NR-1
180 HA=G(N)-B(N)*H(I,N+1)
    E=E+ABS(HA-H(I,N))
    H(I,N)=HA
    N=N-1
    IF(N)190,190,180
190 CONTINUE
C
C    ROW CALCULATIONS
C
DO 300 JJ=1,NR
J=JJ
IF(MOD(ISTEP+ITER,2).EQ.1) J=NR-J+1
DO 280 I=1,NC
BB=SF1(I,J)/DELTA
DD=HO(I,J)*SF1(I,J)/DELTA-Q(I,J)
AA=0.0
CC=0.0
IF(J-1)200,210,200
200 BB=BB+T(I,J-1,1)
    DD=DD+H(I,J-1)*T(I,J-1,1)
210 IF(J-NR)220,230,220

```

```

220 DD=DD+H(I,J+1)*T(I,J,1)
    BB=BB+T(I,J,1)
230 IF(I-1)240,250,240
240 BB=BB+T(I-1,J,2)
    AA=-T(I-1,J,2)
250 IF(I-NC)260,270,260
260 BB=BB+T(I,J,2)
    CC=-T(I,J,2)
270 W=BB-AA*B(I-1)
    B(I)=CC/W
280 G(I)=(DD-AA*G(I-1))/W
C
C    RE-ESTIMATE HEADS
C
    E=E+ABS(H(NC,J)-G(NC))
    H(NC,J)=G(NC)
    N=NC-1
290 HA=G(N)-B(N)*H(N+1,J)
    E=E+ABS(H(N,J)-HA)
    H(N,J)=HA
    N=N-1
    IF(N)300,300,290
300 CONTINUE
    print *, e
    IF(ITER.GT.100)GO TO 999
    IF(E.GT.ERROR) GO TO 80
C
C    PRINT RESULTS
C
    WRITE(6,310)TIME,E,ITER, H(16,17), H(16,26)
310 FORMAT(2F10.3,I5, 2F10.3)
320 DELTA=DELTA*1.2
C    DO 320 J=1,NR
C320 WRITE(6,330)J,(H(I,J),I=1,NC)
C330 FORMAT(I5,5X,10F10.4/(12X10F10.4))
    STOP
C
999 WRITE(6,307)
307 FORMAT(//'*** ITERATION LIMIT EXCEEDED ***')
    STOP
    END

```