REGIONAL GROUND WATER BALANCE

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1.0 INTRODUCTION

Groundwater remains in dynamic condition and the block boundaries do not form the hydrologic boundaries. To carry out groundwater balance, considering block boundaries as boundaries would need intense monitoring of water level along the periphery of each block or district. As the continuous monitoring of water level along the boundary of the block do not exist, a methodology has been developed to assess the monthly groundwater availability in a block considering the inflows due to abstractions and outflows due to recharge at different points.

The groundwater potential of an area depends not only on the recharge in the area, but also on the inflow and outflow in that zone. In the present method, these quantities have also been considered keeping the dynamic nature of the groundwater in mind.

2.0 ESTIMATION OF RECHARGE AND DRAFT

The details of the water balance components which are considered in the groundwater assessment are described below:

2.1 Monsoon Recharge

a) Monsoon Recharge due to rainfall

Let n be the total number of blocks in the study area. Considering the i^{th} block, let

(i) Geographical area of the i^{th} block = A(i)

(ii) Total number of wells in the i^{th} block = P

(iii) Maximum depth to water table in j^{th} year at p^{th} well

$= a_{max,p}(i,j)$

(iv) Minimum depth to water table in j^{th} year at p^{th} well

$= b_{min,p}(i,j)$

(v) Period for which the groundwater hydrographs are available = N years

The temporal average maximum depth to water table below ground level at p^{th} well has been computed as:

$$\bar{a}_{max,p}(i) = \frac{a_{max,p}(i,1)+a_{max,p}(i,2)\ldots+a_{max,p}(i,N)}{N}$$

The temporal average minimum depth to water table below ground level at p^{th} well has been computed as:

$$\bar{b}_{min,p}(i) = \frac{b_{min,p}(i,1)+b_{min,p}(i,2)+..+b_{min,p}(i,N)}{N}$$

The average temporal water table fluctuation at p^{th} well in the i^{th} block has been computed as:

$$c_p(i) = \bar{a}_{max,p}(i) - \bar{b}_{min,p}(i)$$

The average spatial and temporal water table fluctuation in the i^{th} block which has P number of wells has been computed as:

$$C(i) = \sum_{p=1}^{P} c_p(i)/P$$

(vi) Non-monsoon rainfall in i^{th} block = NNM(i)

(vii) Yearly rainfall in the i^{th} block = YR(i)

(viii) Monsoon rainfall in the i^{th} block = I(i)

(ix) Total draft = D_T

(x) Gross kharif draft (ham), which has been assumed to be $0.20D_T$, in the i^{th} block = D(i)

The monsoon recharge due to rainfall only has been found as:

Monsoon Recharge due to rainfall

$$= [A(i).Y(i).C(i)+D(i)-E(i)-F(i)-G(i)]$$

in which

Y(i) = specific yield of the i^{th} block

E(i) = recharge due to canal seepage during monsoon in the i^{th} block

F(i) = Recharge due to surface water irrigation during monsson

G(i) = Recharge due to groundwater irrigation during monsoon = 0.3D(i)

This recharge can be considered at a point at the centre of the block.

b) Monsoon Canal Seepage

This quantity is given by

E(i) = length of the canal (m). wetted perimeter of the canal (m). $F_s/10^6$. running days of canal during monsoon

F_s = Seepage factor for canals = 15 to 25 ham/day/10^6 sq.m. of wetted perimeter

It can be taken at the centre of the canal command area for mathematical simplicity.

c) Monsoon Recharge due to irrigation

This recharge can be calculated as

F(i) = Area irrigated (ha). Average water depth(m).f(i)/100

where f(i) is the percentage infiltration factor. The recharge can be considered at the centre of the block.

Monsoon recharge is divided into four monsoon months according to the rainfall in each month.

2.2 Non-monsoon Recharge

a) Non-monsoon rainfall recharge from the i^{th} block has been estimated using the following relation:

Non-monsoon rainfall recharge from the i^{th} block

= A(i).NNM(i).f(i)/100

It can be taken at the centre of the block.

b) Recharge from Surface Sources

(i) Non-monsoon Recharge From Canals

The recharge from canals during non-monsoon period has been computed in the following manner:

Non-monsoon recharge from canals = Length of the canal(m). wetted perimeter(m). $F_s/10^6$.running days during non-monsoon

which can be considered at the centre of canal command area.

(ii) Recharge From Surface Water Irrigation During Non-monsoon

The recharge from surface water irrigation depends upon crop type. It has been computed as:

Seepage from surface water irrigation during non-monsoon = Area irrigated(ha).Average water depth(m).$f_t/100$

It can be taken at centre of canal command area because irrigation during non-monsoon is done only in canal command area.

Non-monsoon recharge may be sub divided into 8 non-monsoon months, if monthly data is not available.

2.3 Recharge from tanks

Let the water spread area of the i^{th} tank(ha) $= A_t(i)$

Seepage factor for the i^{th} tank in the block $= f_t(i)$ (cm/year)

Duration of storage in the i^{th} tank in days $= d_s(i)$

Total number of tanks $= n_t$

Recharge from all the tanks in the p^{th} block

$$= \sum_{i=1}^{n_t} A_t(i).f_t/100.d_s(i)/365$$

which is taken at the centre of block.

2.4 Potential Recharge

a) Recharge from Flood Prone Areas

Let the flooded area during the i^{th} flood in a year in p^{th} block (ha) $= A_f(i)$

Seepage factor for the flooded area(cm/year) $= f$

Duration of flood days for the i^{th} flood $= d(i)$

Total number of flood $= n_f$

Recharge from the flood area $= \sum_{i=1}^{n_f} A_f(i).f/100.d(i)/365$

b) Recharge from Shallow Water Table Areas

Potential recharge from shallow water table areas (ham) has been computed as (permissible depth to water table-premonsoon depth to water table). A'(i).y(i), where, A'(i) is the area in the ith block in which water table is within 5m depth below ground level. The permissible depth to water table has been taken as 5m. The total potential recharge is summation of item (a) and (b), and is considered at the centre of the block. Potential recharge may be added to those months when the flood occurs.

The total annual recharge = Monsoon Recharge + Non-monsoon Recharge + Recharge from Tanks + Potential Recharge.

Check on Water Table Fluctuation Assessment:

Monsoon rainfall recharge = Monsoon recharge computed by water table fluctuation approach (ham) - seepage from canals and surface water irrigation during monsoon(ham).

Monsoon rainfall recharge calculated by ad-hoc norms (ham)

= Geographical area(ha).IMD normal monsoon rainfall(m).recharge factor/100

Let

a = (monsoon rainfall recharge computed by water table fluctuation approach - monsoon rainfall recharge computed by ad-hoc method - gross kharif draft)

Percentage variation = a/monsoon rainfall recharge on ad-hoc norms.100

If percentage variation <20, water table fluctuation approach has been recommended for assessment of monsoon rainfall recharge. If percentage variation >20, ad-hoc norms approach has been recommended for assessment of monsoon rainfall recharge.

3.0 STATMENT OF THE PROBLEM

It is intended to find the temporal groundwater availability in a particular area considering the dynamic nature of groundwater, i.e. all the inflows from the adjacent aquifers and outflows to the adjacent aquifers due to withdrawal and recharge of groundwater are taken into account.

The monthly availability of groundwater is to be assessed using the given recharge and withdrawal data.

3.1 METHODOLOGY

The area of the district is approximated by circular zones. The centre of the each circle defines a local origin of a polar co-ordinate system (Fig.1). Let the radius of the circular zone be R. Let A_i be an abstraction point whose polar co-ordinates are (r_i, Θ_i). The inflow to the aquifer from the adjacent area across the circle at time t due to a continuous withdrawal at unit rate at point A_i is given by

$$K(r_i, \Theta_i, R, t) = \int_0^t \int_0^{2\pi} \frac{R}{2\pi} \frac{e^{\frac{-[R^2 + r_i^2 - 2Rr_i \mathrm{Cos}(\Theta_i - \Theta]}{4\beta\tau}}}{(R^2 + r_i^2 - 2Rr_i \mathrm{Cos}(\Theta_i - \Theta))} [R - r_i \mathrm{Cos}(\Theta_i - \Theta)] d\tau d\Theta$$

where

$$\beta = \frac{T}{\emptyset}$$

T = transmissivity of the aquifer

$\emptyset$ = storage coefficient

Integrating with respect to

$$K(r_i,\Theta_i,R,t) = \int_0^{2\pi} \frac{Rd\Theta}{2\pi} \frac{[R-r_i\cos(\Theta_i-\Theta)]}{[R^2+r_i^2-2Rr_i\cos(\Theta_i-\Theta)]}$$

$$[t\, e^{-\frac{C}{t}} - C\, E_1(\tfrac{C}{t})]$$

where

$$C = \frac{R^2+r_i^2-2Rr_i\cos(\Theta_i-\Theta)}{4\beta}$$

and $$E_1(\tfrac{C}{t}) = \int_{\frac{C}{t}}^{\infty} \frac{e^{-u}}{u}\, du$$

If unit withdrawal takes place at the first unit time, and no withdrawal after that, the flow at the end of n^{th} time step, across the circle, is given by

$$\delta_{Ii}(n) = K_i(r_i,\Theta_i,R,n)-K_i(r_i,\Theta_i,R,n-1)$$

and

$$\delta_{Ii}(1) = K_i(r_i,\Theta_i,R,1)$$

The inflow at the end of n^{th} time-step across the circle due to varying abstraction is given by

$$Q_{PI}(n) = \sum_{\gamma=1}^{n} Q_{Pi}(\gamma)\delta_{Ii}(n-\gamma+1)$$

$Q_{Pi}(\gamma)$: quantity of withdrawal during γ^{th} time-step at i^{th} point.

If there are M no. of abstraction points, then total inflow due to withdrawal is expressed by

$$Q_{PI}(n) = \sum_{i=1}^{M} \sum_{\gamma=1}^{n} Q_{Pi}(\gamma)\delta_{Ii}(n-\gamma+1)$$

Similarly, total outflow from the circular zone due to recharge $Q_{Rj}(\gamma)$ during γ^{th} time-step at N points of recharge at the end of n^{th} time-step is

$$Q_{RO}(n) = \sum_{j=1}^{N} \sum_{\gamma=1}^{n} Q_{Rj}(\gamma)\delta_{Oj}(n-\gamma+1)$$

If the number of abstraction points and recharge points inside the circular zone are M_c and N_c, respectively, then the amount of draft and recharge at the end of n^{th} time-step will be

$$Q_P(n) = \sum_{j=1}^{N_c} \sum_{\gamma=1}^{n} Q_{Pi}(\gamma), \text{ respectively.}$$

The groundwater availability in that particular circular zone at the end of n^{th} time-step can be expressed by

$$GW(n) = Q_R(n)-Q_P(n)-Q_{RO}(n)+Q_{PI}(n)$$

or

$$GW(n) = \sum_{j=1}^{N_c} \sum_{\gamma=1}^{n} Q_{Rj}(\gamma) - \sum_{i=1}^{M_c} \sum_{\gamma=1}^{n} Q_{Pi}(\gamma)$$

$$- \sum_{j=1}^{N} \sum_{\gamma=1}^{n} Q_{Rj}(\gamma)\delta_{Oj}(n-\gamma+1)$$

$$- \sum_{i=1}^{M} \sum_{\gamma=1}^{n} Q_{Pi}(\gamma)\delta_{Ii}(n-\gamma+1)$$

Which is the required solution to the problem.

Similar solutions for all the circular zones, by which the area is approximated, is obtained and the algebraic addition of all these will give the required groundwater availability of the district, or block.

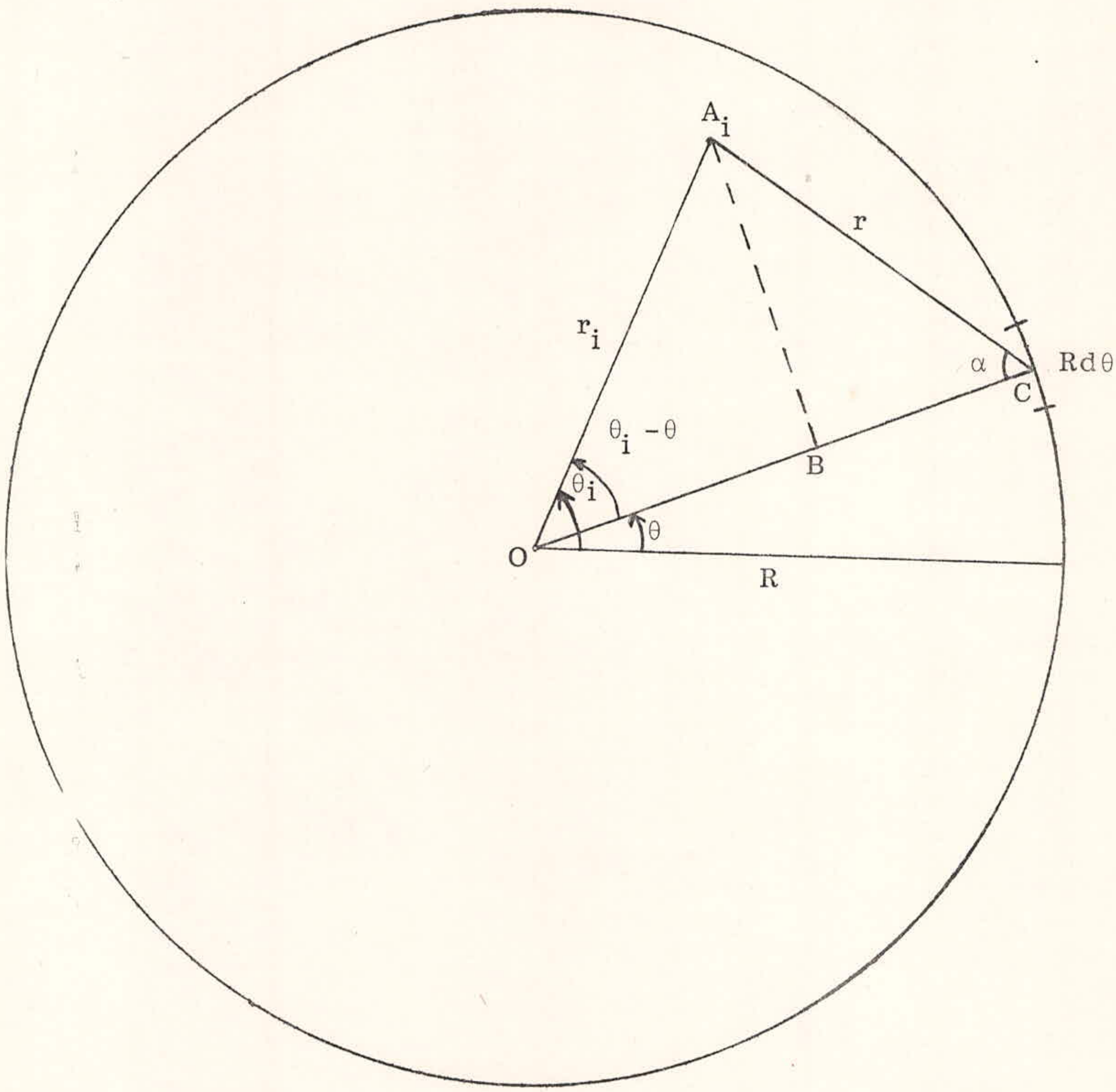

Fig.1. Geometry of Circular Zone for the Model

```
C         Ground Water Availability Study
C         -      -     -            -
C
          CHARACTER *15 BLNAME
          CHARACTER *7 MONTH
          CHARACTER *10 INPUT,OUTPUT
          DIMENSION RABST(50),THABST(50),RRECH(50),THRECH(50),
          1QP(50,20),QR(50,20),SUMQP(20),SUMQR(20),SUMQPI(20)
          1,SUMQRO(20),GAVAIL(20),DELP(50,20),DELPF(50,20)
          2,DELR(50,20),DELRF(50,20),MONTH(20),BLNAME(20),BLAREA(20)
          3,BLWATER(20)
          WRITE (5,30)
30        FORMAT(4X,' INPUT FILE NAME:  '$)
          READ(5,29)INPUT
          WRITE(5,31)
31        FORMAT(4X,'OUTPUT FILE NAME:  '$)
          READ(5,29)OUTPUT
29        FORMAT(A)
          OPEN(UNIT=1,FILE=INPUT,STATUS='OLD')
          OPEN(UNIT=2,FILE=OUTPUT,STATUS='NEW')
          READ(1,*)NABSTP,NRECHP,NTIME,NFPC,NLPC
          READ(1,*)R,T,PHI,AVFL,NBL
C         R:radius of the zone
C         T:transmissivity of the aquifer
C         PHI:storage coefficient
          PPHI=PHI*100.
          PAI=4.*ATAN(1.)
          AREA=PAI*R*R/1000000.
          READ(1,46)(MONTH(N),N=1,NTIME)
          DO K=1,NBL
          READ(1,42)BLNAME(K),BLAREA(K)
          ENDDO
          READ(1,*)(RABST(I),I=1,NABSTP)
          READ(1,*)(THABST(I),I=1,NABSTP)
          DO 1 I=NABSTP
          THABST(I)=THABST(I)*PAI/180.
1         CONTINUE
          READ(1,*)(RRECH(I),I=1,NRECHP)
          READ(1,*)(THRECH(I),I=1,NRECHP)
          DO 2 I=1,NRECHP
          THRECH(I)=THRECH(I)*PAI/180.
2         CONTINUE
          DO I=1,NABSTP
          READ(1,*)(QP(I,J),J=1,NTIME)
          ENDDO
          SUM1=0.
          SUM2=0.
          DO 50 I=NFPC,NLPC
          DO 51 J=1,4
          SUM1=SUM1+QP(I,J)
51        CONTINUE
          DO 52 J=5,12
          SUM2=SUM2+QP(I,J)
52        CONTINUE
50        CONTINUE
```

```
      QMP=SUM1
      QNMP=SUM2
      DO 4 I=1,NABSTP
      DO J=1,NTIME
      QP(I,J)=QP(I,J)*1000000.
      ENDDO
4     CONTINUE
      DO I=1,NRECHP
      READ(1,*)(QR(I,J),J=1,NTIME)
      ENDDO
      SUM1=0.
      SUM2=0.
      DO 53 I=NFPC,NLPC
      DO 54 J=1,4
      SUM1=SUM1+QR(I,J)
54    CONTINUE
      DO 55 J=5,12
      SUM2=SUM2+QR(I,J)
55    CONTINUE
53    CONTINUE
      QMR=SUM1
      QNMR=SUM2
      DO 5 I=1,NRECHP
      DO J=1,NTIME
      QR(I,J)=QR(I,J)*1000000.
      ENDDO
5     CONTINUE
      WRITE(2,32)AVFL
      WRITE(2,33)AREA
      WRITE(2,34)PPHI
      WRITE(2,35)T
      WRITE(2,36)QMR
      WRITE(2,37)QNMR
      WRITE(2,38)QMP
      WRITE(2,39)QNMP
      WRITE(2,40)
      WRITE(2,41)
      WRITE(2,28)
      WRITE(2,26)
      DO 6 I=1,NABSTP
      THETA=THABST(I)
      AAR=RABST(I)
      DO 7 J=1,NTIME
      AJ=J
      CALL DEL(THETA,AAR,AJ,R,T,PHI,RES)
      DELP(I,J)=RES
7     CONTINUE
6     CONTINUE
      DO 8 I=1,NABSTP
      DELPF(I,1)=DELP(I,1)
      DO 9 J=2,NTIME
      DELPF(I,J)=DELP(I,J)-DELP(I,J-1)
9     CONTINUE
8     CONTINUE
      DO 10 I=1,NRECHP
```

```
      THETA=THRECH(I)
      AAR=RRECH(I)
      DO 11  J=1,NTIME
      AJ=J
      CALL DEL(THETA,AAR,AJ,R,T,PHI,RES)
      DELR(I,J)=RES
11    CONTINUE
10    CONTINUE
      DO 12  I=1,NRECHP
      DELRF(I,1)=DELR(I,1)
      DO 13  J=2,NTIME
      DELRF(I,J)=DELR(I,J)-DELR(I,J-1)
13    CONTINUE
12    CONTINUE
      DO 14  N=1,NTIME
      SUM=0.
      DO 15  I=1,NABSTP
      DO 16  NGAMA=1,N
16    SUM=SUM+QP(I,NGAMA)*DELPF(I,N-NGAMA+1)
15    CONTINUE
      SUMQPI(N)=SUM
14    CONTINUE
      DO 27  N=1,NTIME
      SUM=0.
      DO 17  I=1,NRECHP
      DO 18  NGAMA=1,N
18    SUM=SUM+QR(I,NGAMA)*DELRF(I,N-NGAMA+1)
17    CONTINUE
      SUMQRO(N)=SUM
27    CONTINUE
      DO 19  N=1,NTIME
19    GAVAIL(N)=0.
      DO 20  N=1,NTIME
      SUMQP(N)=0.
      SUMQR(N)=0.
      DO 21  I=NFPC,NLPC
21    SUMQP(N)=SUMQP(N)+QP(I,N)
      DO 22  I=NFPC,NLPC
22    SUMQR(N)=SUMQR(N)+QR(I,N)
20    CONTINUE
      DO 23  N=1,NTIME
      SUM=0.
      DO 24  NGAMA=1,N
      SUM=SUM+SUMQPI(NGAMA)-SUMQRO(NGAMA)-SUMQP(NGAMA)+SUMQR(NGAMA)
24    CONTINUE
      GAVAIL(N)=SUM/1000000.
      WRITE(2,25)N,MONTH(N),GAVAIL(N),SUMQR(N),SUMQP(N),SUMQRO(N),
     1SUMQPI(N)
23    CONTINUE
      WRITE(2,47)
      DO 99  K=1,NBL
      WRITE(2,43)BLNAME(K)
      WRITE(2,48)
      WRITE(2,45)
C
```

```
      DO 98 N=1,NTIME
      BLWATER(N)=GAVAIL(N)
      BLWATER(N)=BLWATER(N)*BLAREA(K)/AREA
      WRITE(2,44)MONTH(N),BLWATER(N)
98    CONTINUE
      WRITE(2,47)
99    CONTINUE
25    FORMAT(X,I2,X,A5,2X,F8.3,4(2X,E10.3))
26    FORMAT(17x,'(mcm)',8x,'(cum)',9x,'(cum)',9x,'(cum)',9X,'(cum)'//)
28    FORMAT(X,'N',2X,'MONTH',2X,'WATER BALANCE',3X,'RECHARGE',5X,
     1'WITHDRAWAL',7X,'OUTFLOW',7X,'INFLOW')
32    FORMAT(2X,'Average water level fluctuation=',X,F5.2,X,'m',/)
33    FORMAT(29X,'Area='X,F7.2,X,'sq.km.',/)
34    FORMAT(14X,'Storage coefficient=',X,F5.3,X,'percent',/)
35    FORMAT(19x,'Transmissivity=',X,F7.2,X,'sqm/month',/)
36    FORMAT(17X,'Monsoon recharge='X,F7.3,X,'mcm',/)
37    FORMAT(14X,'Nonmonsoon recharge='X,F7.3,X,'mcm',/)
38    FORMAT(20X,'Monsoon draft='X,F7.3,X,'mcm',/)
39    FORMAT(17X,'Nonmonsoon draft=',X,F7.3,X,'mcm',/)
40    FORMAT(2X,'TEMPORAL GROUNDWATER AVAILABILITY:')
41    FORMAT(2X,34('*'),/)
42    FORMAT(A10,F8.2)
43    FORMAT(26X,'BLOCK:',X,A10)
44    FORMAT(24X,A7,4X,F10.5)
45    FORMAT(24X,'Month',5X,'WATER BALANCE(in mcm)',/)
46    FORMAT(12A5)
47    FORMAT(/)
48    FORMAT(25X,18('*'))
      STOP
      END
C
C     ****************************************************************
C                          Numerical Integration
C     ****************************************************************
C
      SUBROUTINE DEL(THETA,AAR,AJ,R,T,PHI,RES)
      PAI=4.*ATAN(1.)
      N=100
      A=0.
      B=2.*PAI
      H=B/FLOAT(N)
      CALL EVAL(A,THETA,AAR,AJ,R,T,PHI,FINAL)
      FA=FINAL
      CALL EVAL(B,THETA,AAR,AJ,R,T,PHI,FINAL)
      FB=FINAL
      SUM=FA+FB
      NN=N-1
      DO 10 K=1,NN
      X=A+FLOAT(K)*H
      CALL EVAL(X,THETA,AAR,AJ,R,T,PHI,FINAL)
      SUM=SUM+2.*FINAL
10    CONTINUE
      RES=H*SUM/2.
      RETURN
      END
```

```
C
C      ************************************************************
C                    Computation of the Integrand
C      ************************************************************
C
       SUBROUTINE EVAL(TH,THETA,AAR,AJ,R,T,PHI,FINAL)
       PAI=4.*ATAN(1.)
       F1=AAR*COS(THETA-TH)
       F2=R*R+AAR*AAR
       F3=R-F1
       F4=F2-2.*R*F1
       BETA=4.*T/PHI
       F5=F4/(BETA*AJ)
       CALL EXI(F5,EXFN)
       F6=AJ*EXP(-F5)-EXFN*F5*AJ
       F7=R*F3/(2.*PAI*F4)
       FINAL=F7*F6
       RETURN
       END
C
C      ************************************************************
C                 Computation of Exponential Integral
C      ************************************************************
C
C
       SUBROUTINE EXI(X,EXFN)
       IF(X-1.0)1,1,22
1      EXFN=-ALOG(X)-0.57721566+0.99999193*X-0.24991055*X**2
      1+0.05519968*X**3-0.00976004*X**4+0.00107857*X**5
       GO TO 3
22     CONTINUE
       IF(X-80.)5,4,4
5      CONTINUE
       EXFN=((X**4+8.5733287*X**3+18.059017*X**2+8.6347608*X
      1+0.26777373)/(X**4+9.5733223*X**3+25.632956*X**2
      2+21.099653*X+3.9584969))/(X*EXP(X))
       GO TO 3
4      EXFN=0.
3      CONTINUE
       RETURN
       END
```

```
18,18,12,8,16
41250.,9000.,0.0277,3.77,4
JUN  JUL  AUG  SEP  OCT  NOV  DEC  JAN  FEB  MAR  APR  MAY  JUN
    LALPUR  1075.6
JAMJODHPUR  1084.2
   KALAVAD  1244.5
  JAMNAGAR  1226.2
107750.,85000.,55750.,53000.,45750.,47750.,53500.,34750.,20500.,31500.,
31250.,27750.,21000.,23500.,20250.,26500.,48750.,71000.
177.0,194.5,180.5,185.0,217.5,222.0,244.5,173.0,180.0,260.5,142.5,137.5,
82.0,69.0,26.0,347.5,42.0,60.5
107750.,85000.,55750.,53000.,45750.,47750.,53500.,34750.,20500.,31500.,
31250.,27750.,21000.,23500.,20250.,26500.,48750.,71000.
177.0,194.5,180.5,185.0,217.5,222.0,244.5,173.0,180.0,260.5,142.5,137.5,
82.0,69.0,26.0,347.5,42.0,60.5
0.845,0.897,0.553,0.865,1.586,1.586,1.586,1.586,1.586,1.586,1.586,1.586,0.845
3.587,2.990,2.087,3.325,5.998,5.998,5.998,5.998,5.998,5.998,5.998,5.998,3.587
0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0
1.455,1.197,0.913,1.356,2.455,2.455,2.455,2.455,2.455,2.455,2.455,2.455,1.455
0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0
5.348,4.392,3.154,4.217,8.558,8.558,8.558,8.558,8.558,8.558,8.558,8.558,5.348
0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0
0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0
3.683,3.156,2.649,3.151,6.321,6.321,6.321,6.321,6.321,6.321,6.321,6.321,3.683
4.680,4.057,3.627,3.848,8.113,8.113,8.113,8.113,8.113,8.113,8.113,8.113,4.680
0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0
0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0
5.644,4.035,3.896,4.755,9.165,9.165,9.165,9.165,9.165,9.165,9.165,9.165,5.644
0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0
0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0
3.628,3.189,2.613,2.630,6.024,6.024,6.024,6.024,6.024,6.024,6.024,6.024,3.628
2.605,2.320,1.185,2.019,4.064,4.064,4.064,4.064,4.064,4.064,4.064,4.064,2.605
0.736,0.655,0.466,0.643,1.251,1.251,1.251,1.251,1.251,1.251,1.251,1.251,0.736
2.413,1.923,5.123,2.223,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0
2.393,3.583,6.703,2.923,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0
1.438,1.438,1.438,1.438,0.637,0.637,0.637,0.637,0.637,0.637,0.637,0.637,0.0
1.828,3.248,4.818,2.378,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0
1.109,1.109,1.109,1.109,0.8,0.8,0.8,0.8,0.8,0.8,0.8,0.8,0.0
1.176,3.086,[illegible],[illegible],0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0
0.388,0.388,0.388,0.388,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0
0.336,0.336,0.336,0.336,0.275,0.275,0.275,0.275,0.275,0.275,0.275,0.275,0.0
1.863,3.273,6.303,3.293,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0
2.393,4.143,5.323,4.713,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0
0.995,0.995,0.995,0.995,0.665,0.665,0.665,0.665,0.665,0.665,0.665,0.665,0.0
2.708,2.708,2.708,2.708,3.443,3.443,3.443,3.443,3.443,3.443,3.443,3.443,0.0
1.593,5.283,10.353,3.633,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0
1.443,1.443,1.443,1.443,1.772,1.772,1.772,1.772,1.772,1.772,1.772,1.772,0.0
0.56,0.56,0.56,0.56,1.249,1.249,1.249,1.249,1.249,1.249,1.249,1.249,0.0
1.568,2.868,5.518,4.458,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0
0.731,2.241,10.471,3.831,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0
3.848,5.058,10.178,5.228,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0
```

Average water level fluctuation= 3.77 m

Area= 5345.62 sq.km.

Storage coefficient= 2.770 percent

Transmissivity= 9000.00 sqm/month

Monsoon recharge= 90.746 mcm

Nonmonsoon recharge= 59.232 mcm

Monsoon draft= 59.241 mcm

Nonmonsoon draft= 236.984 mcm

TEMPORAL GROUNDWATER AVAILABILITY:
****

N	MONTH	WATER BALANCE (mcm)	RECHARGE (cum)	WITHDRAWAL (cum)	OUTFLOW (cum)	INFLOW (cum)
1	JUN	-4.17600	0.1346E+08	0.1764E+08	-0.4382E-03	-0.5398E-10
2	JUL	2.99601	0.2161E+08	0.1444E+08	-0.7384E+01	-0.3189E-02
3	AUG	23.75027	0.3354E+08	0.1279E+08	-0.2608E+03	-0.1850E+01
4	SEP	31.50703	0.2214E+08	0.1438E+08	-0.1811E+04	-0.5373E+02
5	OCT	9.29396	0.7404E+07	0.2962E+08	-0.6380E+04	-0.4487E+03
6	NOV	-12.91113	0.7404E+07	0.2962E+08	-0.1587E+05	-0.1960E+04
7	DEC	-35.10373	0.7404E+07	0.2962E+08	-0.3225E+05	-0.5847E+04
8	JAN	-57.27896	0.7404E+07	0.2962E+08	-0.5747E+05	-0.1371E+05
9	FEB	-79.43216	0.7404E+07	0.2962E+08	-0.9328E+05	-0.2747E+05
10	MAR	-101.55968	0.7404E+07	0.2962E+08	-0.1410E+06	-0.4952E+05
11	APR	-123.66007	0.7404E+07	0.2962E+08	-0.2012E+06	-0.8260E+05
12	MAY	-145.73483	0.7404E+07	0.2962E+08	-0.2740E+06	-0.1297E+06

BLOCK: LALPUR
****

Month	WATER BALANCE(in mcm)
JUN	-0.84026
JUL	0.60283
AUG	4.77883
SEP	6.33958
OCT	1.87005
NOV	-2.59787
DEC	-7.06328
JAN	-11.52519
FEB	-15.98267
MAR	-20.43499
APR	-24.88184
MAY	-29.32354

BLOCK: JAMJODHPUR
****

Month	WATER BALANCE(in mcm)
JUN	-0.84698
JUL	0.60765
AUG	4.81704
SEP	6.39027
OCT	1.88500
NOV	-2.61864
DEC	-7.11975
JAN	-11.61734
FEB	-16.11046
MAR	-20.59838
APR	-25.08079
MAY	-29.55800

BLOCK: KALAVAD
****

Month	WATER BALANCE(in mcm)
JUN	-0.97220
JUL	0.69749
AUG	5.52924
SEP	7.33507
OCT	2.16370
NOV	-3.00581
DEC	-8.17241
JAN	-13.33498
FEB	-18.49241
MAR	-23.64387
APR	-28.78900
MAY	-33.92817

BLOCK: JAMNAGAR
****

Month	WATER BALANCE(in mcm)
JUN	-0.95791
JUL	0.68724
AUG	5.44794
SEP	7.22721
OCT	2.13189
NOV	-2.96161
DEC	-8.05224
JAN	-13.13889
FEB	-18.22048
MAR	-23.29619
APR	-28.36567
MAY	-33.42927