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
Module Documentation for the General-Head Boundary Package

The General-Head Boundary Package (GHBl) consists of four modules, all of which are called by the MAIN program. The modules are:

GHBlAL Allocates space for an array that contains the general-head boundary list (BNDS).

GHBlRP Reads location, boundary head, and boundary conductance ($C_m$) of each cell containing general-head boundary $m$.

GHBlFM Adds the terms $-C_m$ and $-C_mHB_m$ to the accumulators $HCOF_{i,j,k}$ and $RHS_{i,j,k}$, respectively.

GHBlBD Calculates the rates and accumulated volume of flow to and from general-head boundaries.
Narrative for Module GHBLAL

This module allocates space in the X array to store the list of general-head boundaries (GHB).

1. Print a message identifying the package and initialize NBOUND (number of general-head boundaries).

2. Read and print MXBND (the maximum number of general-head boundaries) and IGHBCB (the unit number for saving cell-by-cell flow terms or a flag indicating that cell-by-cell flow terms should be printed).

3. Set LCBNDS, which will point to the first element in the boundary list (BNDS), equal to ISUM which is currently pointing to the first unallocated element in the X array.

4. Calculate the amount of space needed for the boundary list (five values for each boundary--row, column, layer, head, and conductance) and add it to ISUM so that it continues to point to the first unallocated element in X.

5. Print the number of elements in the X array used by the GHB Package.

6. RETURN.
NBOUND is the number of general-head boundaries being simulated at any given time.

MXBND is the maximum number of general-head boundaries simulated.

IGHBCB is a flag and a unit number.

If IGHBCB > 0, it is the unit number on which cell-by-cell flow terms will be recorded whenever ICBCFL is set.

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

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

LCBNDS is the location in the X array of the list of general-head boundaries data (BNDS).

BNDS is a table containing data for general-head boundaries.
SUBROUTINE GHBlAL(ISUM, LENX, LCBNDS, NBOUND, MXBND, IN, IOUT, IGHBCB)

C ------ VERSION 1610 12MAY1987 GHBlAL
C
C ALLOCATE ARRAY STORAGE FOR HEAD-DEPENDENT BOUNDARIES
C
C SPECIFICATIONS:
C
C1------ IDENTIFY PACKAGE AND INITIALIZE # OF GENERAL HEAD BOUNDS
WRITE(IOUT,1)IN
  1 FORMAT(1HO,'GHBl -- GHB PACKAGE, VERSION 1, 9/1/87',
        1' INPUT READ FROM UNIT',I3)
  NBOUND=0
C
C2------ READ AND PRINT MXBND AND IGHBCB (MAX # OF BOUNDS AND UNIT
C2------ FOR CELL-BY-CELL FLOW TERMS FOR GHB)
READ(IN,2) MXBND, IGHBCB
  2 FORMAT(2110)
WRITE(IOUT,3)
  3 FORMAT(1H1, 'MAXIMUM OF',I5,' HEAD-DEPENDENT BOUNDARY NODES')
  IF(IGHBCB.GT.0) WRITE(IOUT,9) IGHBCB
  IF(IGHBCB.LT.0) WRITE(IOUT,8)
  8 FORMAT(1X, 'CELL-BY-CELL FLOW WILL BE PRINTED WHEN ICBCFL NOT 0'
C
C3------ SET LCBNDS EQUAL TO ADDRESS OF FIRST UNUSED SPACE IN X.
  LCBNDS=ISUM
C
C4------ CALCULATE AMOUNT OF SPACE USED BY THE GENERAL HEAD LIST.
  ISP=5*MXBND
  ISUM=ISUM+ISP
C
C5------ PRINT AMOUNT OF SPACE USED BY THE GHB PACKAGE
WRITE(IOUT,4) ISP
  4 FORMAT(1X, ' ELEMENTS OF X ARRAY USED FOR HEAD',
            1 'DEPENDENT BOUNDARIES'
               1)
  ISUM1=ISUM-1
WRITE(IOUT,5) ISUM1, LENX
  5 FORMAT(1X, ' ELEMENTS OF X ARRAY USED OUT OF',I8)
  IF(ISUM1.GT.LENX) WRITE(IOUT,6)
  6 FORMAT(1X, ' ***X ARRAY MUST BE DIMENSIONED LARGER***')
C
C6------ RETURN
RETURN
END
### List of Variables for Module GHB1AL

<table>
<thead>
<tr>
<th>Variable</th>
<th>Range</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>IGHRCR</td>
<td>Package</td>
<td>Flag and a unit number.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&gt; 0, unit number on which the cell-by-cell flow terms will be recorded whenever ICBCFL is set.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>= 0, cell-by-cell flow terms will not be printed or recorded.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&lt; 0, boundary leakage for each cell will be printed whenever IGHBFIL is set.</td>
</tr>
<tr>
<td>IN</td>
<td>Package</td>
<td>Primary unit number from which input for this package will be read.</td>
</tr>
<tr>
<td>IOUT</td>
<td>Global</td>
<td>Primary unit number for all printed output. IOUT = 6.</td>
</tr>
<tr>
<td>ISP</td>
<td>Module</td>
<td>Number of words in the X array allocated by this module.</td>
</tr>
<tr>
<td>ISUM</td>
<td>Global</td>
<td>Index number of the lowest element in the X array which has not yet been allocated. When space is allocated for an array, the size of the array is added to ISUM.</td>
</tr>
<tr>
<td>ISUM1</td>
<td>Module</td>
<td>ISUM-1.</td>
</tr>
<tr>
<td>LCBNDS</td>
<td>Package</td>
<td>Location in the X array of the first element of array RNDS.</td>
</tr>
<tr>
<td>LENX</td>
<td>Global</td>
<td>Length of the X array in words. This should always be equal to the dimension of X specified in the MAIN program.</td>
</tr>
<tr>
<td>MXBND</td>
<td>Package</td>
<td>Maximum number of head boundaries active at any one time.</td>
</tr>
<tr>
<td>NBOUND</td>
<td>Package</td>
<td>Number of head boundaries active during the current stress period.</td>
</tr>
</tbody>
</table>
Narrative for Module GHBlRP

This module reads data to build the general-head boundary list.

1. Read ITMP. ITMP is the number of general-head boundaries or a flag indicating that data from the previous stress period should be reused.

2. Test ITMP. If ITMP is less than zero, the general-head boundary data read for the last stress period will be reused. Print a message to that effect and RETURN.

3. If ITMP is greater than or equal to zero, it is the number of general-head boundaries for this stress period. Set the number of general-head boundaries (NBOUND) in the current stress period equal to ITMP.

4. Compare the number of general-head boundaries (NBOUND) in the current stress period to the number specified as the maximum for the simulation (MXBND). If NBOUND is greater than MXBND, STOP.

5. Print the number of general-head boundaries in the current stress period (NBOUND).

6. See if there are any general-head boundaries. If there are none in the current stress period (NBOUND = 0), bypass further boundary processing (SKIP STEP 7).

7. Read and print the layer, row, column, head, and conductance for each general-head boundary.

8. RETURN.
ITMP is both a flag and a counter. If it is greater than or equal to zero, it is the number of general-head boundaries to be simulated during the stress period. If it is less than zero, it indicates that the boundaries simulated in the last stress period should be simulated in the current stress period.

MXBND is the maximum number of general-head boundaries to be simulated.
SUBROUTINE GHB1RP(BNDS,NBOUND,MXBND,IN,IOUT)

C--VERSION 1651 02FEB1983 GHB1RP
C******************************************************************
C READ DATA FOR GHB
C******************************************************************
C
C SPECIFICATIONS:
---------------------------------------------------------------
DIMENSION BNDS(5,MXBND)
---------------------------------------------------------------

C1------READ ITMP(# OF GENERAL HEAD BOUNDS OR FLAG TO REUSE DATA.)
READ(IN,8) ITMP
8 FORMAT(I10)

C2------TEST ITMP
IF(ITMP.GE.0) GO TO 50

C2A------IF ITMP<0 THEN REUSE DATA FROM LAST STRESS PERIOD
WRITE(IOUT,7)
7 FORMAT(I10,'REUSING HEAD-DEPENDENT BOUNDS FROM LAST STRESS',
1      ' PERIOD')
GO TO 260

C3------IF ITMF>=0 THEN IT IS THE # OF GENERAL HEAD BOUNDS.
50 NBOUND=ITMP

C4------IF MAX NUMBER OF BOUNDS IS EXCEEDED THEN STOP
IF(NBOUND.LE.MXBND) GO TO 100
WRITE(IOUT,99) NBOUND, MXBND
99 FORMAT(I10,'NBOUND(',I4,') IS GREATER THAN MXBND(',I4,')')

C4A------ABNORMAL STOP
STOP

C5------PRINT # OF GENERAL HEAD BOUNDS THIS STRESS PERIOD
100 WRITE(IOUT,1) NBOUND
1 FORMAT(I10,'/1X,I5,' HEAD-DEPENDENT BOUNDARY NODES')

C6------IF THERE ARE NO GENERAL HEAD BOUNDS THEN RETURN.
IF(NBOUND.EQ.0) GO TO 260

C7------READ & PRINT DATA FOR EACH GENERAL HEAD BOUNDARY.
WRITE(IOUT,3)
3 FORMAT(I10,15X,'LAYER',5X,'ROW',5X
1,'COL ELEVATION CONDUCTANCE BOUND NO.',/1X,15X,60('E'))
DO 250 II=1,NBOUND
READ (IN,4) K,I,J,BNDS(4,II),BNDS(5,II)
4 FORMAT(3I10,2F10.0)
WRITE (IOUT,5) K,I,J,BNDS(4,II),BNDS(5,II)
5 FORMAT(1X,15X,I4,I9,18,G13.4,G14.4,18)
BNDS(1,II)=K
BNDS(2,II)=I
BNDS(3,II)=J
250 CONTINUE

C8------RETURN
260 RETURN
END
<table>
<thead>
<tr>
<th>Variable</th>
<th>Range</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>BNDS</td>
<td>Package</td>
<td>DIMENSION (5,MXBND), Layer, row, column, head and conductance from boundary for each general-head boundary.</td>
</tr>
<tr>
<td>I</td>
<td>Module</td>
<td>Row number.</td>
</tr>
<tr>
<td>II</td>
<td>Module</td>
<td>Index for general-head boundaries.</td>
</tr>
<tr>
<td>IN</td>
<td>Package</td>
<td>Primary unit number from which input for this package will be read.</td>
</tr>
<tr>
<td>IOUT</td>
<td>Global</td>
<td>Primary unit number for all printed output. IOUT = 6.</td>
</tr>
</tbody>
</table>
| ITMP     | Module  | Flag or number of boundaries.  
\geq 0, number of bounds active during the current stress period.  
< 0, same bounds active during the last stress period will be active during the current stress period. |
| J        | Module  | Column number. |
| K        | Module  | Layer number. |
| MXBND    | Package | Maximum number of head boundaries active at any one time. |
| NBOUND   | Package | Number of head boundaries active during the current stress period. |
Narrative for Module GHB1FM

This module adds terms representing riverhead boundaries to the accumulators HCOF and RHS.

1. If NBOUND is less than or equal to zero in the current stress period, there are no general-head boundaries. RETURN.

2. For each boundary in the BNDS list, DO STEPS 3-6.

3. Determine the column (IC), row (IR), and layer (IL).

4. If the cell is external (IBOUND(IC, IR, IL) ≤ 0), bypass processing on this boundary and go on to the next one.

5. If the cell is internal, get the boundary data (head and conductance).

6. Add the -C*HB term (C is the conductance and HB is the boundary head) to the accumulator RHS and the term -C to the accumulator HCOF.

7. RETURN.
RHS is an accumulator in which the right hand side of the equation is formulated.

HCOF is an accumulator in which the coefficient of head in the cell is formulated.
SUBROUTINE GHB1FM(NBOUND, MXBND, BNDS, HCOF, RHS, IBOUND,
  NCOL, NROW, NLAY)

C------VERSION 1037 10APR1985 GHB1FM
C ********************************************
C ADD GHB TERMS TO RHS AND HCOF
C ********************************************
C
C SPECIFICATIONS:
C -----------------------------------------------
DIMENSION BNDS(5, MXBND), HCOF(NCOL, NROW, NLAY),
  RHS(NCOL, NROW, NLAY), IBOUND(NCOL, NROW, NLAY)
C -----------------------------------------------
C
C1------IF NBOUND<=0 THEN THERE ARE NO GENERAL HEAD BOUNDS. RETURN.
  IF(NBOUND.LE.0) RETURN
C
C2------PROCESS EACH ENTRY IN THE GENERAL HEAD BOUND LIST (BNDS)
  DO 100 L=1, NBOUND
C
C3------GET COLUMN, ROW AND LAYER OF CELL CONTAINING BOUNDARY
  IL=BNDS(1,L)
  IR=BNDS(2,L)
  IC=BNDS(3,L)
C
C4------IF THE CELL IS EXTERNAL THEN SKIP IT.
  IF(IBOUND(IC,IR,IL).LE.0) GO TO 100
C
C5------SINCE THE CELL IS INTERNAL GET THE BOUNDARY DATA.
  HB=BNDS(4,L)
  C=BNDS(5,L)
C
C6------ADD TERMS TO RHS AND HCOF
  HCOF(IC,IR,IL)=HCOF(IC,IR,IL)-C
  RHS(IC,IR,IL)=RHS(IC,IR,IL)-C*HB
  100 CONTINUE
C
C7------RETURN
  RETURN
END
### List of Variables for Module GHB1FM

<table>
<thead>
<tr>
<th>Variable</th>
<th>Range</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>BNDS</td>
<td>Package</td>
<td>DIMENSION (5, MXBND), Layer, row, column, head and conductance from boundary for each general-head boundary.</td>
</tr>
<tr>
<td>C</td>
<td>Module</td>
<td>Conductance from the external boundary.</td>
</tr>
<tr>
<td>HB</td>
<td>Module</td>
<td>Head on boundary.</td>
</tr>
<tr>
<td>HCOF</td>
<td>Global</td>
<td>DIMENSION (NCOL, NROW, NLAY), Coefficient of head in the cell (J, I, K) in the finite-difference equation.</td>
</tr>
<tr>
<td>IBOUND</td>
<td>Global</td>
<td>DIMENSION (NCOL, NROW, NLAY), Status of each cell. &lt; 0, constant-head cell = 0, inactive cell &gt; 0, variable-head cell</td>
</tr>
<tr>
<td>IC</td>
<td>Module</td>
<td>Index for columns.</td>
</tr>
<tr>
<td>IL</td>
<td>Module</td>
<td>Index for layers.</td>
</tr>
<tr>
<td>IOUT</td>
<td>Global</td>
<td>Primary unit number for all printed output. IOUT = 6.</td>
</tr>
<tr>
<td>IR</td>
<td>Module</td>
<td>Index for rows.</td>
</tr>
<tr>
<td>L</td>
<td>Module</td>
<td>Index for boundaries.</td>
</tr>
<tr>
<td>MXBND</td>
<td>Package</td>
<td>Maximum number of head boundaries active at any one time.</td>
</tr>
<tr>
<td>NBOUND</td>
<td>Package</td>
<td>Number of head boundaries active during the current stress period.</td>
</tr>
<tr>
<td>NCOL</td>
<td>Global</td>
<td>Number of columns in the grid.</td>
</tr>
<tr>
<td>NLAY</td>
<td>Global</td>
<td>Number of layers in the grid.</td>
</tr>
<tr>
<td>NROW</td>
<td>Global</td>
<td>Number of rows in the grid.</td>
</tr>
<tr>
<td>RHS</td>
<td>Global</td>
<td>DIMENSION (NCOL, NROW, NLAY), Right hand side of the finite-difference equation. RHS is an accumulation of terms from several different packages.</td>
</tr>
</tbody>
</table>

11-20
Narrative for Module GHB1BD

This module calculates rates and volumes transferred between the aquifer and general-head boundaries.

1. Initialize the cell-by-cell flow-term flag (IBD) and the rate accumulator (RATOUT).

2. If there are no general-head boundaries (NBOUND = 0), skip down to step 13 and put zeros into the budget terms for general-head boundaries.

3. Test to see if cell-by-cell flow terms are to be saved on disk. They will not be saved if either of the following conditions hold: (1) this is not the proper time step (ICBCFL = 0) or (2) cell-by-cell flow terms are not needed for general-head boundaries during this simulation (IGHBCB ≤ 0). If cell-by-cell flow terms will be saved for this package, clear the buffer in which they will be accumulated (BUFF) and set the cell-by-cell flow-term flag (IBD).

4. For each general-head boundary, DO STEPS 5-13 accumulating flows from or into the general-head boundary.

5. Determine the row, column, and layer of the cell containing the general-head boundary.

6. If the cell is external (IBOUND(I,J,K) ≤ 0), bypass further processing of this boundary.

7. Get the boundary parameters from the boundary list (BNDS).

8. Set RATE equal to the boundary conductance times the boundary head minus the head in the cell (RATE = C*(HB - HHNEW)).
9. If cell-by-cell flow terms are to be printed (IGHBCB < 0 and ICBCFL ≠ 0), print RATE.

10. If budget terms for individual cells are to be saved, add the RATE to the buffer (BUFF).

11. Check to see whether flow is into or out of the aquifer.

12. If RATE is negative, add it to RATOUT.

13. If RATE is positive, add it to Ratin.

14. See if cell-by-cell flow terms for individual cells are to be saved (IBD = 1). If they are, call module UBUDSV to record the buffer (BUFF) onto disk.

15. Move Ratin and RATOUT into the VBVL array for printing by BAS1OT. Add Ratin and RATOUT multiplied by the time-step length to the volume accumulators in VBVL for printing by BAS1OT. Move the general-head boundary budget-term labels to VBNM for printing by BAS1OT.

16. Increment the budget-term counter (MSUM). See the section in the Basic Package for a detailed explanation of VBVL, VBNM, and MSUM.

17. RETURN.
IBD is a flag which, if set, causes cell-by-cell flow terms for general-head boundary to be recorded.

EXTERNAL: a cell is said to be external if it is either no flow or constant head (i.e., an equation is not formulated for the cell).

RATE is the leakage rate into the aquifer from the boundary in a cell.

BUFFER is an array in which values are stored as they are being gathered for printing or recording.

RATOUT is an accumulator to which all flows out of the aquifer are added.

RATIN is an accumulator to which all flows into the aquifer are added.

C is the conductance between the boundary and the cell.

HB is the boundary head.

HHNEW is the head in the cell.

IGHBCB is a flag and a unit number.

If IGHBCB > 0, it is the unit number on which cell-by-cell flow terms will be recorded whenever ICBCFL is set.

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.

ICBCFL is a flag.

If ICBCFL ≠ 0, cell-by-cell flow terms will be either recorded or printed depending on IGHBCB for the current time step.
SUBROUTINE GHBlBD(NBOUND, MXBND, VBNM, VBVL, MSUM, BNDS, DELT, HNEW, 
1 NCOL, NROW, NLAY, IBOUND, KSTP, KPER, IGHBCB, ICBCFL, BUFF, IOUT)

C-----VERSION 1612 12MAY1987 GHBlBD
C ***************************~**~**~****~**************~*******~****
C CALCULATE VOLUMETRIC BUDGET FOR GHB
C *****************************************************~*******~****
C
C SPECIFICATIONS:
C ---------------------------------~------------
CHARACTER*4 VBNM, TEXT
DOUBLE PRECISION HNEW
DIMENSION VBNM(4,MSUM), VBVL(4,MSUM), BNDS(5, MXBND),
1 HNEW(NCOL, NROW, NLAY), IBOUND(NCOL, NROW, NLAY),
2 BUFF(NCOL, NROW, NLAY)
DIMENSION TEXT(4)
DATA TEXT(1), TEXT(2), TEXT(3), TEXT(4) /' HEA','D DE','P BO','UNDs'/

C1-------INITIALIZE CELL-BY-CELL FLOW TERM FLAG (IBD) AND
C1-------ACCUMULATORS (RATIN AND RATOUT)
   IBD=0
   RATOUT=0.
   RATIN=0.

C C2-------IF NO BOUNDARIES THEN KEEP ZEROES IN ACCUMULATORS.
   IF(NBOUND.EQ.0) GO TO 200

C C3-------TEST TO SEE IF CELL-BY-CELL FLOW TERMS ARE NEEDED.
   IF(ICBCFL.EQ.0 .OR. IGHBCB.LE.0) GO TO 10

C C3A------SINCE CELL-BY-CELL FLOW TERMS ARE NEEDED CLEAR BUFFER & SET
C3A------THE FLAG IBD.
   IBD=1
   DO 5 IL=1,NLAY 
   DO 5 IR=1,NROW 
   DO 5 IC=1,NCOL 
     BUFF(IC,IR,IL)=0.
   5 CONTINUE

C C4------FOR EACH GENERAL HEAD BOUND ACCUMULATE FLOW INTO AQUIFER
   10 DO 100 L=1,NBOUND

C C5------GET LAYER, ROW AND COLUMN OF EACH GENERAL HEAD BOUNDARY.
   IL=BNDS(1,L)
   IR=BNDS(2,L)
   IC=BNDS(3,L)

C C6------IF CELL IS EXTERNAL THEN IGNORE IT.
   IF(BOUND(IC,IR,IL).LE.0) GO TO 100
C7------GET PARAMETERS FROM BOUNDARY LIST.
   HNEW=HNEW(IC,IR,IL)
   HB=BNDS(4,L)
   C=BNDS(5,L)
C
C8------CALCULATE THE FLOW RATE INTO THE CELL
   RATE=C*(HB-HNEW)
C
C9------PRINT THE INDIVIDUAL RATES IF REQUESTED(IGHBCB<0).
   IF(IGHBCB.LT.0.AND.IBCFL.NE.0) WRITE(IOUT,900) (TEXT(N),N=1,4),
   1       KPER,KSTP,L,IR,IC,RATE
   900 FORMAT(1H0,4A4,' PERIOD',I3,' STEP',I3,' BOUNDARY',I4,
   1       ' LAYER',I3,' ROW',I4,' COL',I4,' RATE',G15.7)
C
C10------IF CELL-BY-CELL TERMS ARE TO BE SAVED THEN PUT RATE IN BUFFER
   IF(IBD.EQ.1) BUFF(IC,IR,IL)=BUFF(IC,IR,IL)+RATE
C
C11------SEE IF FLOW IS INTO AQUIFER OR OUT OF AQUIFER.
   IF(RATE).LT.0,100,96
C
C12------FLOW IS OUT OF AQUIFER SUBTRACT RATE FROM RATOUT
   94 RATOUT=RATOUT-RATE
   GO TO 100
C
C13------FLOW IS INTO AQUIFER ADD RATE TO RATIN
   96 RATIN=RATIN+RATE
   100 CONTINUE
C
C14------IF CELL-BY-CELL TERMS ARE TO BE SAVED THEN CALL
C14------UTILITY MODULE UBUDSV
   IF(IBD.EQ.1) CALL UBUDSV(KSTP,KPER,TEXT,IGHBCB,BUFF,NCOL,NROW,
   1       NLAY,IOUT)
C
C15------MOVE RATES, VOLUMES AND LABELS INTO ARRAYS FOR PRINTING
   200 VBVL(3,MSUM)=RATIN
   VBVL(1,MSUM)=VBVL(1,MSUM)+RATIN*DELT
   VBVL(4,MSUM)=RATOUT
   VBVL(2,MSUM)=VBVL(2,MSUM)+RATOUT*DELT
   VBNM(1,MSUM)=TEXT(1)
   VBNM(2,MSUM)=TEXT(2)
   VBNM(3,MSUM)=TEXT(3)
   VBNM(4,MSUM)=TEXT(4)
C
C16------INCREMENT THE BUDGET TERM COUNTER
   MSUM=MSUM+1
C
C17------RETURN
   RETURN
   END
### List of Variables for Module GHBlBD

<table>
<thead>
<tr>
<th>Variable</th>
<th>Range</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>BNDS</td>
<td>Package</td>
<td>DIMENSION (5,MXBND), layer, row, column, head and conductance from the boundary for each general-head boundary.</td>
</tr>
<tr>
<td>BUFF</td>
<td>Global</td>
<td>DIMENSION (NcOL,NROW,NLAY), Buffer used to accumulate information before printing or recording it.</td>
</tr>
<tr>
<td>C</td>
<td>Module</td>
<td>Conductance from the external boundary.</td>
</tr>
<tr>
<td>DELT</td>
<td>Global</td>
<td>Length of the current time step.</td>
</tr>
<tr>
<td>HB</td>
<td>Module</td>
<td>Head on boundary.</td>
</tr>
<tr>
<td>HNEW</td>
<td>Module</td>
<td>HNEW (J,I,K), Single precision.</td>
</tr>
<tr>
<td>HNEW</td>
<td>Global</td>
<td>DIMENSION (NcOL,NROW,NLAY), Most recent estimate of head in each cell. HNEW changes at each iteration.</td>
</tr>
<tr>
<td>IBD</td>
<td>Package</td>
<td>Flag.</td>
</tr>
<tr>
<td>IBOUND</td>
<td>Global</td>
<td>DIMENSION (NcOL,NROW,NLAY), Status of each cell.</td>
</tr>
<tr>
<td>IC</td>
<td>Module</td>
<td>Index for columns.</td>
</tr>
<tr>
<td>IGHBCB</td>
<td>Package</td>
<td>Flag and a unit number.</td>
</tr>
<tr>
<td>ICBCFL</td>
<td>Global</td>
<td>Flag.</td>
</tr>
<tr>
<td>IL</td>
<td>Module</td>
<td>Index for layers.</td>
</tr>
<tr>
<td>IOUT</td>
<td>Global</td>
<td>Primary unit number for all printed output. IOUT = 6.</td>
</tr>
<tr>
<td>IR</td>
<td>Module</td>
<td>Index for rows.</td>
</tr>
<tr>
<td>KPER</td>
<td>Global</td>
<td>Stress period counter.</td>
</tr>
<tr>
<td>KSTP</td>
<td>Global</td>
<td>Time step counter. Reset at the start of each stress period.</td>
</tr>
<tr>
<td>L</td>
<td>Module</td>
<td>Index for general-head boundaries.</td>
</tr>
<tr>
<td>MSUM</td>
<td>Global</td>
<td>Counter for budget entries and labels in VBVL and VBNM.</td>
</tr>
<tr>
<td>MXBND</td>
<td>Package</td>
<td>Maximum number of head boundaries active at any one time.</td>
</tr>
<tr>
<td>NBOUND</td>
<td>Package</td>
<td>Number of head boundaries active during the current stress period.</td>
</tr>
<tr>
<td>NCOL</td>
<td>Global</td>
<td>Number of columns in the grid.</td>
</tr>
<tr>
<td>NLAY</td>
<td>Global</td>
<td>Number of layers in the grid.</td>
</tr>
<tr>
<td>NROW</td>
<td>Global</td>
<td>Number of rows in the grid.</td>
</tr>
<tr>
<td>Variable</td>
<td>Range</td>
<td>Definition</td>
</tr>
<tr>
<td>----------</td>
<td>--------</td>
<td>------------------------------------------------------------------</td>
</tr>
<tr>
<td>RATE</td>
<td>Module</td>
<td>Flow from a bound into a cell. (Reverse the sign to get flow into the bound.)</td>
</tr>
<tr>
<td>RATIN</td>
<td>Module</td>
<td>Accumulator for the total flow into the flow field out of the bounds.</td>
</tr>
<tr>
<td>RATOUT</td>
<td>Module</td>
<td>Accumulator for the total flow out of the flow field into the bounds.</td>
</tr>
<tr>
<td>TEXT</td>
<td>Module</td>
<td>Label to be printed or recorded with the array data.</td>
</tr>
<tr>
<td>VBNM</td>
<td>Global</td>
<td>DIMENSION (4,20), Labels for entries in the volumetric budget.</td>
</tr>
<tr>
<td>VBVL</td>
<td>Global</td>
<td>DIMENSION (4,20), Entries for the volumetric budget.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>For flow component N, the values in VBVL are:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(1,N), Rate for the current time step into the flow field.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(2,N), Rate for the current time step out of the flow field.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(3,N), Volume into the flow field during simulation.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(4,N), Volume out of the flow field during simulation.</td>
</tr>
</tbody>
</table>