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Description of a post-processor for MODFLOW

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Description of a post-processor for MODFLOW

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1 Introduction

To facilitate data output and data presentation from MODFLOW model runs, the post processor “MOD-PP” has been written. This program reads MODFLOW’s binary and ASCII output files and writes the results into comma delimited files to be viewed in Excel. The program is able to: write (i) head data for user specified observation boreholes for all stress periods, (ii) water balances for all stress periods for all boundary conditions used in a model, (iii) river flow to and from the aquifer for all river cells over time, as well as for up to five specified river sections and for the entire river course and iv) stream leakage to and from the aquifer for all stream cells and for the entire stream course over time, as well as flows within stream cells and within the entire stream over time. The program, which is written in Visual Basic 6.0 can be applied to any steady-state or transient MODFLOW model and has no restrictions on layer, column or row numbers.

This manual describing the post-processor is divided into 7 sections. After this introduction, section 2 gives an overview of how the program operates and which MODFLOW output files are required in the various modules of the program. Section 3 introduces the water balance module. The module for reading and writing groundwater head data for user-specified observation boreholes is described in section 4, while section 5 and 6 give information about running the river and stream modules.

2 General procedure of running the post-processor

2.1 DATA ENTRY

To run the post-processor on MODFLOW output files, the file MOD-PP.exe must be executed. The main menu screen which appears contains three menu items: “File”, “Calculate” and “Help”. Under the “File” menu, information on the relevant MODFLOW model can be entered and the post processor can be exited. Under the menu “Calculate” the various modules of the program can be selected. These include: the “Heads vs. time” module, the “Water Balance” module, the “River leakage” module and the “Stream flow and leakages” module. The “Help” menu gives explanations on the running of the post processor as well as on the various modules. In order to access the “Help” menu, the help files associated with the post processor have to be copied into the same directory as the post processor itself.

In a first step, the MODFLOW output files have to be located. For this the menu item “Model information” is selected under the main menu “File” (Figure 1). Select the appropriate path to the model data and give the name of the MODFLOW root file without the extension. Then the numbers of columns, rows and layers of the MODFLOW model have to be entered. By clicking OK, the “Model information” window closes and the input data is loaded into all the modules in the program.

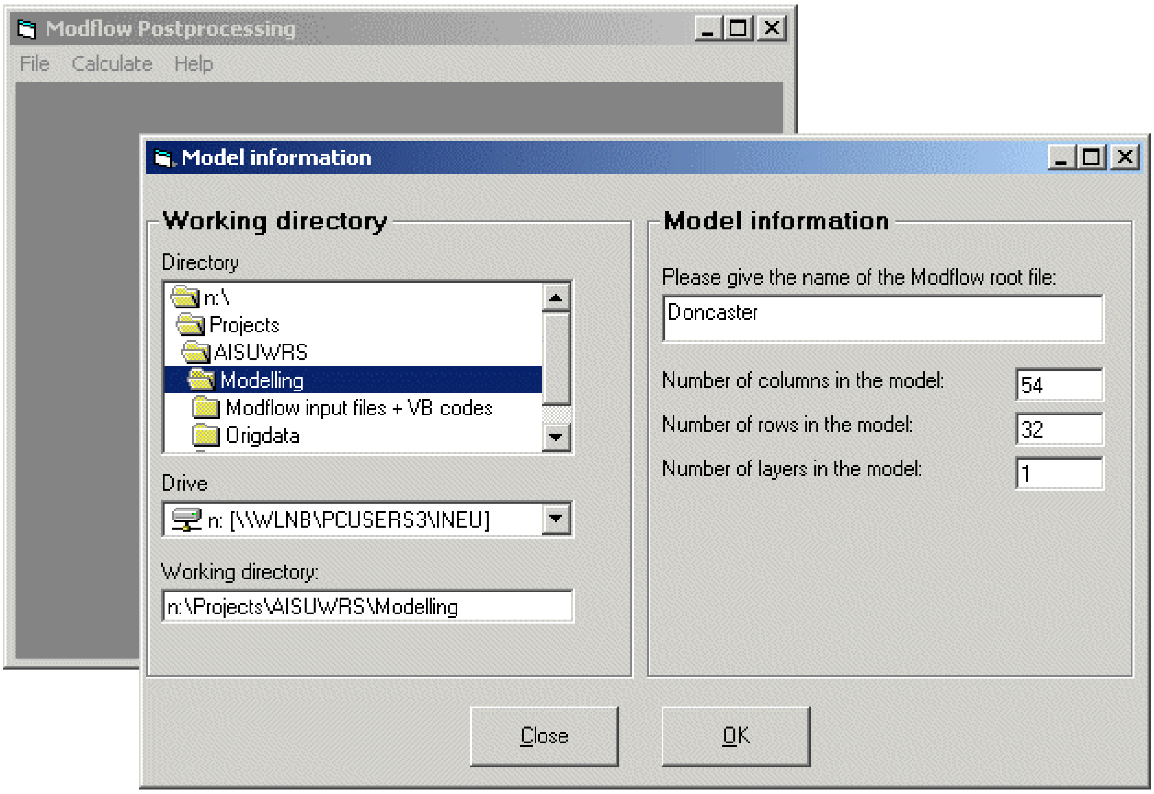


Figure 1 Specification of file directories and model information

The program does not check if the numbers of columns, rows and layers corresponds to the MODFLOW model data and hence care is required when inputting these parameter values.

2.2 REQUIRED MODFLOW FILES

Depending on how many modules of the post-processor are being run, up to eight MODFLOW output files are required:

(i) MODFLOW output control file (extension .oc)

Required for all modules.

(ii) MODFLOW output file (extension .out)

Required for the “Water Balance” module

(iii) MODFLOW cell-by-cell head-save file (extension .hds)

Required for the “Head vs. time” module

(iv) MODFLOW cell-by-cell river flow file (extension .crv) and the MODFLOW river location file (extension .riv)

Required for the “River leakage” module

(v) MODFLOW cell-by-cell stream flow file (extension .cs1) and the MODFLOW stream location file (extension .str)

Required for the “Stream flow and leakages” module

MODFLOW output files differ slightly depending on the user-interface used to create them. The post-processor is programmed to run on GroundwaterVistas© output files. The “Water Balance” module as well as the “Heads vs. time” module are able to run on output files from other user-interfaces as well, e.g. PMWIN©. However, the structure of the stream and river output files differ according to user-interface used. Consequently the “River leakage” and the “Stream flow and leakage” module might not run if GroundwaterVistas© is not used to run MODFLOW.

2.3 EXIT

To exit the post-processor, the menu item “Exit” from the main menu “File” has to be selected. This closes the application and saves all the input data. The program recalls these automatically the next time the application is run.

2.4 NOTES FOR THE USE OF THE PROGRAM ON THE BGS NETWORK UNDER NOVELL

Currently (February 2004), the program will run very slowly over the BGS network, if using PCs converted to NOVELL. This is not the case if the program is run on local drives or on PCs, that have not been converted. However, this matter is being investigated and the program should be able to run satisfactorily via the network on PCs converted to NOVELL in the near future.

3 "Water Balance" Module

3.1 INTRODUCTION

The "Water Balance" module is used to extract rates and cumulative volumes of water entering and leaving the model over time. The data is provided for all boundary conditions used in the model (e.g. wells, drains, recharge etc).

The module is called by selecting the "Water Balance" option from the main menu "Calculate" (Figure 2).

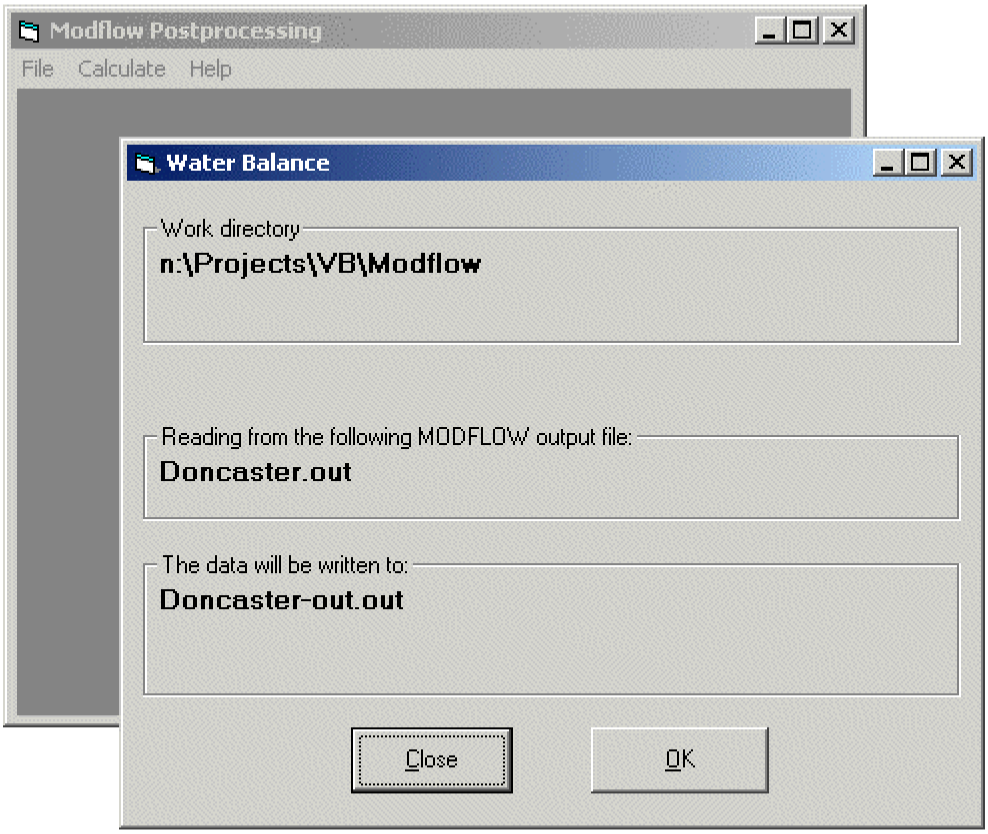


Figure 2 "Water Balance" module screen

The working directory, relevant MODFLOW output files and post-processing output files are displayed automatically in this module if the information in the menu option "Model information" was confirmed by pressing OK (see section 2). If model information is not entered or if the menu item is exited using "Close", data are not transferred to the "Water Balance" module and file names are not displayed.

To execute the "Water Balance" module the OK button is pressed. The computing time depends on the size of the MODFLOW model file but is usually a few seconds. After the data are written to the specified output file, the "Water Balance" window closes automatically and a message is displayed with file name and path of the output file.

3.2 DATA OUTPUT FORMAT

The water balance data for every boundary condition, for every stress period and time step is written to a comma delimited file. This file (*prefix*-out.out) can be viewed and edited in Excel. Figure 3 shows an example of a water balance output file, and Figure 4 displays a plot of the data. The output file lists cumulative volumes as well as rates for every boundary condition present in the model and for every stress period and time step.

Cumulative Volumes L**3													
Stress periods	Timestep	Total simulation time [hrs]	In-STORAGE	In-WELLS	In-RECHARGE	In-RIVER LEAKAGE	In-HEAD DEP BOUNDS	In- TOTAL IN	Out-STORAGE	Out-WELLS	Out-RIVER LEAKAGE	Out-STREAM LEAKAGE	Out-HEAD DEP BOUNDS
1	1	0.0648821	343.58	7.356	184.3	61.263	185.18	781.68	499.78	165.39	0.7411	1.219	113.87
1	2	0.142741	755.04	16.183	405.46	134.78	407.24	1718.7	1095.9	363.86	1.6304	2.6819	250.5
1	3	0.236171	1248.9	26.776	670.86	223	673.5	2843	1814.3	602.02	2.6976	4.4372	414.42
1	4	0.348287	1841.2	39.487	989.33	328.86	992.71	4191.6	2674.7	887.81	3.9782	6.5437	611.1
1	5	0.482826	2551.4	54.74	1371.5	455.89	1375.3	5808.8	3705.5	1230.8	5.515	9.0713	847.05
1	6	0.644274	3403.4	73.044	1830.1	608.34	1833.9	7748.8	4944.6	1642.3	7.3592	12.104	1130.1
1	7	0.838011	4424.4	95.009	2380.4	791.26	2383.4	10075	6428	2136.2	9.5722	15.744	1469.7
1	8	1.07049	5649.4	121.37	3040.8	1010.8	3041.7	12864	8213	2728.8	12.228	20.112	1877
2	1	1.34948	7117.6	153	3833.3	1274.2	3830.2	16208	10350	3439.9	15.415	25.352	2365.5
2	2	1.68425	8877.6	190.95	4784.2	1590.3	4774.3	20217	12909	4293.3	19.239	31.641	2951.4
2	3	2.08599	10988	236.5	5925.4	1969.6	5904.7	25024	15980	5317.4	23.828	39.187	3654
3	1	2.56807	13516	291.15	7294.7	2424.8	7257.8	30785	19652	6546.2	29.335	48.241	4496.4
3	2	3.14656	16545	356.74	8938	2971	8877.1	37688	24056	8020.8	35.944	59.106	5506.3
3	3	3.84075	20171	435.44	10910	3626.5	10815	45958	29321	9790.4	43.875	72.142	6716.7
Rates for this time step L**3/T													
Stress periods	Timestep	Total simulation time [hrs]	In-STORAGE	In-WELLS	In-RECHARGE	In-RIVER LEAKAGE	In-HEAD DEP BOUNDS	In-TOTAL IN	Out-STORAGE	Out-WELLS	Out-RIVER LEAKAGE	Out-STREAM LEAKAGE	Out-HEAD DEP BOUNDS
1	1	0.0648821	127090	2721	68173	22661	68498	289150	184870	61178	274.13	450.93	42121
1	2	0.142741	126830	2721	68173	22661	68451	288840	183750	61178	274.13	450.92	42115
1	3	0.236171	126850	2721	68173	22661	68396	288800	184540	61178	274.14	450.91	42109
1	4	0.348287	126790	2721	68173	22661	68332	288680	184180	61178	274.14	450.91	42100
1	5	0.482826	126690	2721	68173	22661	68257	288500	183880	61178	274.14	450.9	42091
1	6	0.644274	126660	2721	68173	22661	68170	288390	184210	61178	274.14	450.89	42079
1	7	0.838011	126480	2721	68173	22661	68070	288110	183750	61178	274.15	450.88	42065
1	8	1.07049	126450	2721	68173	22661	67957	287970	184280	61178	274.15	450.86	42048
2	1	1.34948	126310	2721	68173	22661	67829	287690	183840	61178	274.15	450.85	42027
2	2	1.68425	126170	2721	68173	22661	67686	287420	183430	61178	274.16	450.83	42003
2	3	2.08599	126050	2721	68173	22661	67530	287140	183480	61178	274.16	450.8	41974
3	1	2.56807	125890	2721	68173	22661	67361	286810	182810	61178	274.17	450.77	41939
3	2	3.14656	125670	2721	68173	22661	67182	286400	182720	61178	274.18	450.74	41897
3	3	3.84075	125360	2721	68173	22661	66998	285920	182030	61178	274.19	450.7	41847

Figure 3 Example of a “Water Balance “ module output file (*prefix*-out.out).

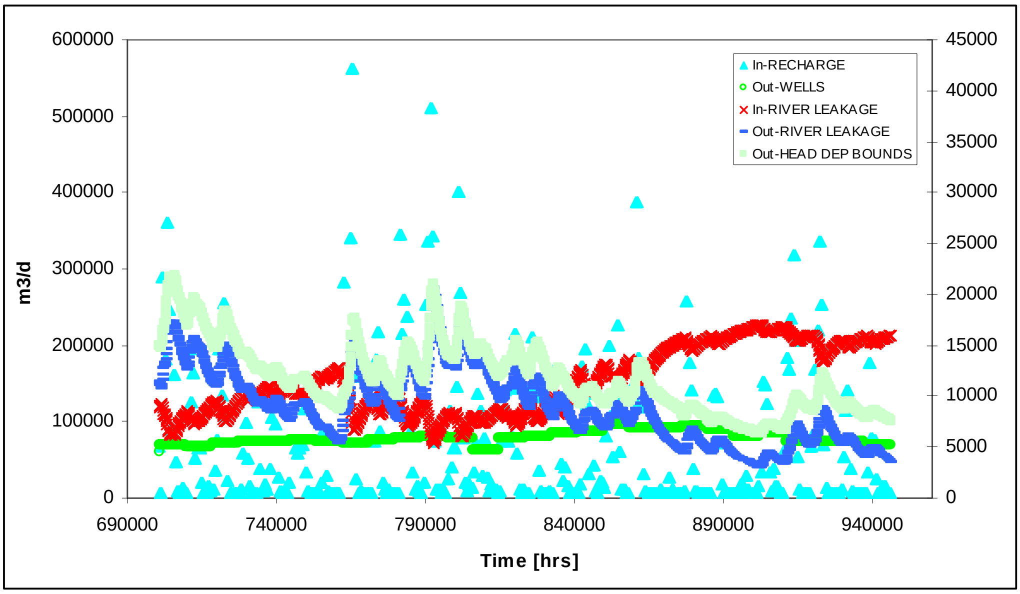


Figure 4 Example of the “Water Balance “ module results

4 "Heads vs. time" module

4.1 INTRODUCTION

The groundwater heads module reads time-variant head data from the MODFLOW binary head file for user specified cells. The module is called by selecting the "Heads vs. time" option from the main menu "Calculate" (FIGURE 5).

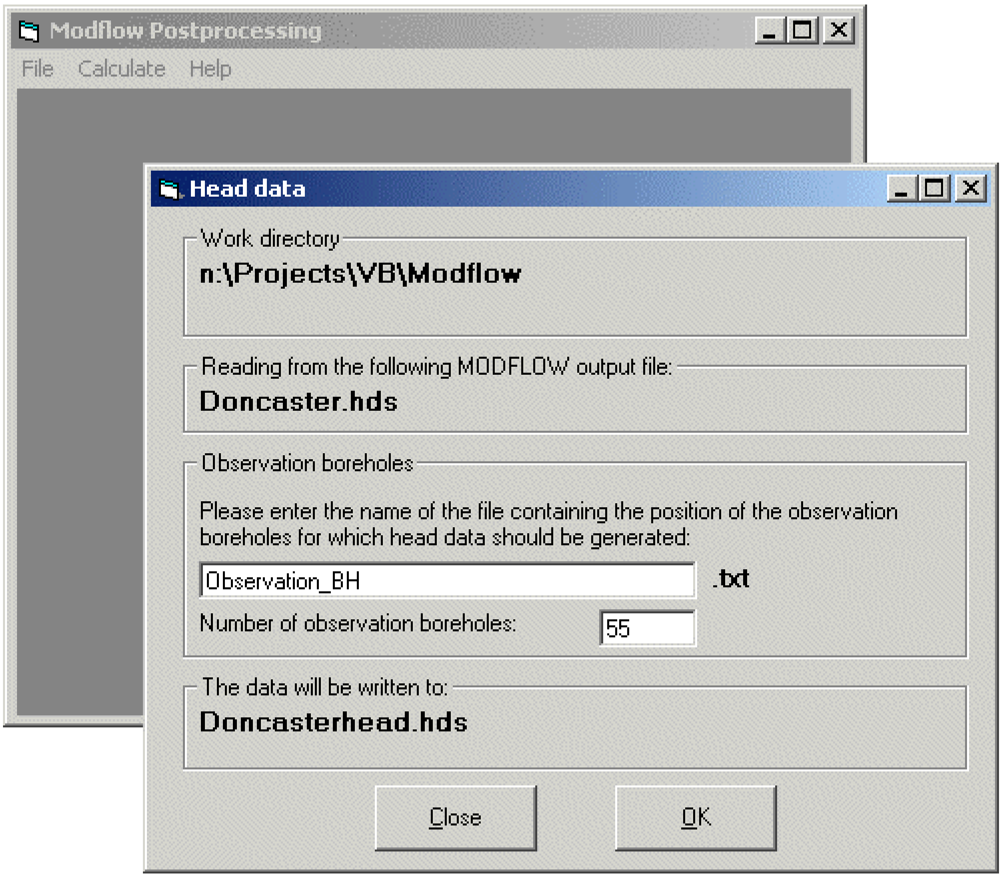


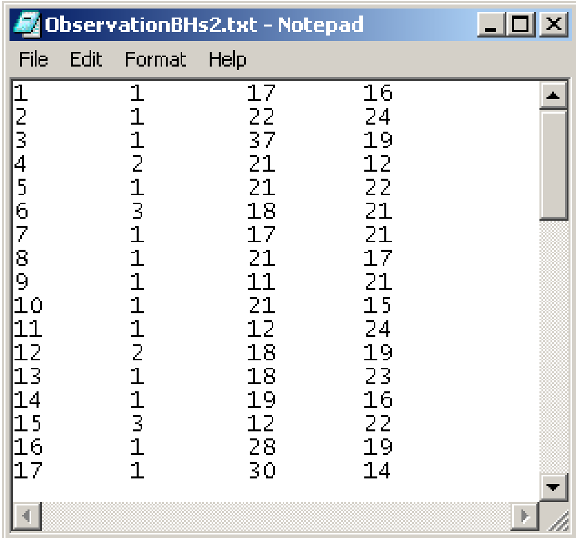
Figure 5 "Heads vs. time" module screen

The working directory, relevant MODFLOW output files and post-processing output files are displayed automatically on the "Heads vs. time" module screen, if model information has previously been defined using the "Model information" module (section 2). The user then has to enter the name of a text file, containing information on observation boreholes for which head values should be read. Additionally, the number of observation boreholes must be given. If all data are confirmed by pressing the OK button, the program generates the output file *prefix*.head.hds. This will take a couple of seconds, depending on the size of the MODFLOW files. When the output file is written, the window closes and a message is displayed giving output file name and path.

If the post-processor is closed using the "Exit" option under the main "File" menu, the name of the observation borehole file and the number of boreholes is saved and called up automatically the next time the program is run.

4.2 OBSERVATION BOREHOLE FILE

To read head data for user specified cells over time, a text file is required, containing the column, row and layer number of the cells, for which head information is required. Figure 6 displays the structure of this file (*prefix*.txt). It should be tab or comma delimited, with four data entries for every borehole: ID, layer, row, column. The observation borehole file has to be located within the same directory as the other MODFLOW files required by this module.



ObservationBHs2.txt - Notepad

File Edit Format Help

1	1	17	16
2	1	22	24
3	1	37	19
4	2	21	12
5	1	21	22
6	3	18	21
7	1	17	21
8	1	21	17
9	1	11	21
10	1	21	15
11	1	12	24
12	2	18	19
13	1	18	23
14	1	19	16
15	3	12	22
16	1	28	19
17	1	30	14

Figure 6 Example of an observation borehole file to be used within the post-processor.

4.3 DATA OUTPUT FORMAT

The groundwater heads module generates a comma delimited file containing time-variant head data for each user specified cell (Figure 7). The ID number of the observation boreholes is displayed in the first row, followed in subsequent rows by the head data

Total ellapsed time	1	2	4	5	6	7
1.45E-02	-13.8899	0.528279	0.847922	-10.2724	-6.13885	-4.81636
4.46E-02	-13.8899	0.524706	0.847941	-10.2723	-6.13878	-4.81629
0.1070027	-13.8899	0.517329	0.847976	-10.272	-6.13863	-4.81613
0.2363928	-13.8899	0.502188	0.84803	-10.2716	-6.13833	-4.8158
0.5046962	-13.8899	0.471623	0.848098	-10.2706	-6.13769	-4.81513
1.06105	-13.8898	0.412723	0.848185	-10.2686	-6.13638	-4.81373
2.214706	-13.8898	0.310508	0.848332	-10.2643	-6.13365	-4.81083
4.606926	-13.8895	0.161068	0.848629	-10.2546	-6.12799	-4.80487
9.567436	-13.8887	-1.00E-02	0.849238	-10.2315	-6.11628	-4.79268
19.85355	-13.8857	-0.14972	0.85048	-10.1732	-6.09205	-4.76805
41.18284	-13.8733	-0.22063	0.852966	-10.0204	-6.04228	-4.71901
85.41126	-13.8228	-0.22109	0.857764	-9.63971	-5.94136	-4.62175
177.1233	-13.6346	-0.15197	0.866396	-8.84406	-5.73625	-4.4211
367.2975	-13.0779	-2.09E-02	0.88013	-7.56608	-5.28292	-3.97938
761.6428	-11.868	0.147776	0.898524	-5.94286	-4.23194	-3.02275
1579.357	-9.83135	0.33616	0.920468	-4.13464	-2.30873	-1.30763

Figure 7 Output file of the groundwater heads module.

5 “River leakage“ module

5.1 INTRODUCTION

The “River leakage” module extracts flows leaving and entering the model through each river cell. In addition, flows are provided for up to 5 river reaches and for the sum of all river cells. The module is called by selecting the “River leakage” option from the main “Calculate” menu (Figure 8).

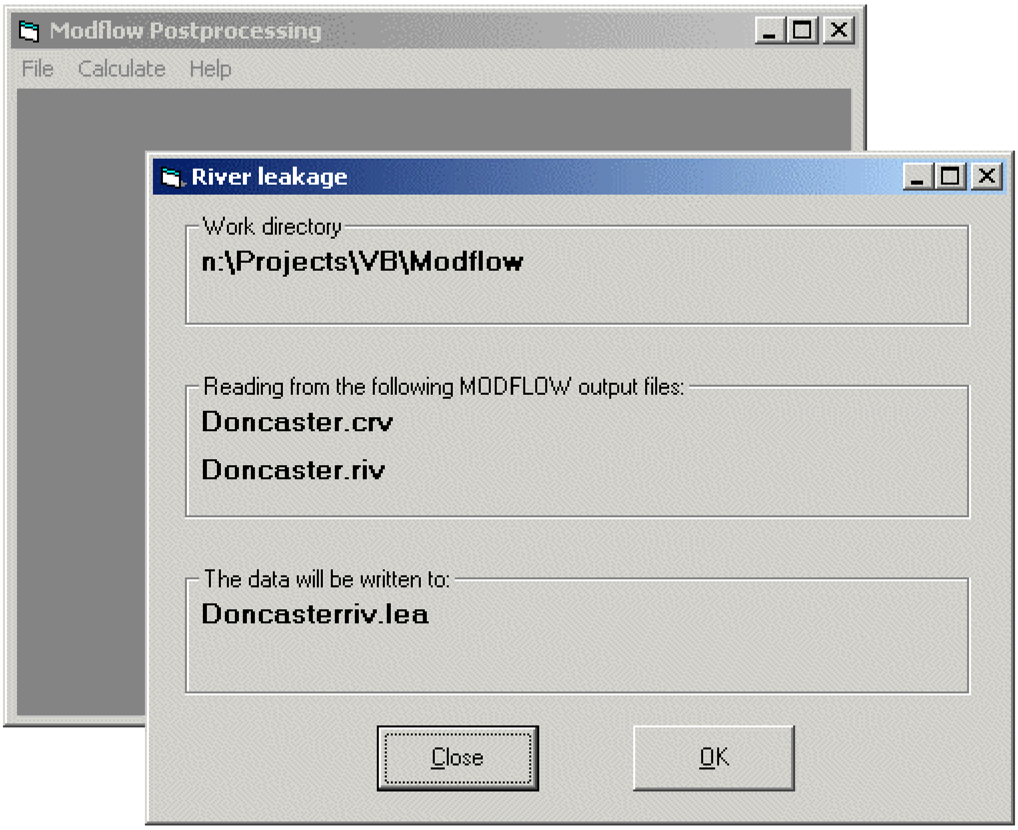


Figure 8 “River leakage” module screen

The working directory, relevant MODFLOW output files and post-processing output files are displayed automatically on the “River leakage” module screen, if model information has been defined using the “Model information” module (section 2). The program is executed by pressing the OK button. After the output file is written, the window closes and a message is displayed giving the output file name and path.

5.2 DATA OUTPUT

Figure 10 shows an example “River leakage” module output file (*prefix*.riv.lea), and Figure 11 and Figure 12 display plots of the data.

The output file lists flows in and out of the model through each river cell. Data are provided for all stress periods and time steps available within the MODFLOW binary cell-by-cell river file. The number of stress periods/time steps depends on the settings in the “Output control” menu within Groundwater Vistas (Figure 9). If the user selected the cell-by-cell flows to be saved every single time step, then river flows for all stress periods and times steps are available. However, if for example, information is saved every four time steps, then river flows will be available for every fourth time step.

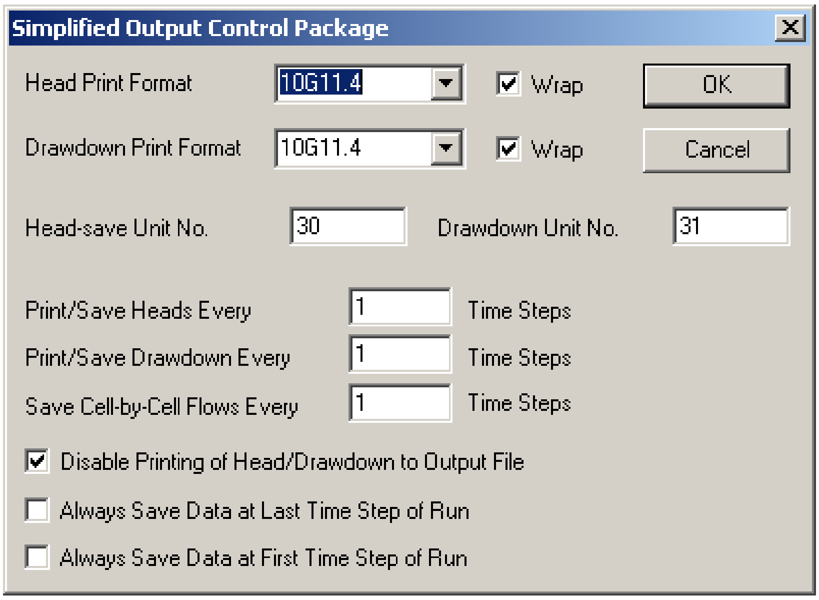


Figure 9 Output control menu in Groundwater Vistas.

In addition to the flow rates for each river cell, the post-processor calculates flow rates for river sections or reaches. River reaches are specified within Groundwater Vistas in its “River” module by assigning river cells a reach number. The “River leakage” module within the post-processor is then able to provide the flows in and out of the model for these river reaches. Up to 5 reaches (reach numbers in Groundwater Vistas have to be 1 to 5) can be dealt with. If the model contains less than 5 river reaches, zero values will appear in the output file for all “missing” reaches. If the model contains more than 5 river reaches, the data for 5 reaches is provided, while data for any other reaches will be lumped together under “Reachrest” (Figure 10). The flows in the reaches are baseflows, i.e. the difference between inflows into the river (out of the model) and outflows from the river (into the model).

Besides river reaches, information is provided for all the river cells in the model. Total river outflows (into the model) and inflows (out of the model) are listed as well as the river baseflow, i.e. difference between inflows and outflows. Inflows and outflows are thereby equivalent to the data generated under the “Water Balance “ module for the river boundary condition.

Figure 10 shows an example “River leakage” module output file, with column 1 to 3 giving information on the record number, stress period and time step number. Column 4 to column N (N = maximum number of river cells in model) lists the flows [L^3/T] in or out of the model through each river cells, and columns labelled “Diff reachX” give the baseflow [L^3/T] in river reach X. “Riff reachrest” lists the baseflow [L^3/T] of all reaches with reach numbers other than 1 to 5. Column “Flow out (all river cells)” displays the inflow into the entire river through all river cells (out of the model), and “Flow in (all river cells)” gives the outflows. Column “Diff all river cells” lists the baseflow [L^3/T] for the entire river.

Flow rates [L³/T] for single river cells | Flow rates for entire river reaches (reach 1 to 5) | Flow rates for all river cells

Rivercell(lay/row/col)			1 / 31 / 13	1 / 30 / 12	1 / 30 / 13	1 / 30 / 14									
Rivercell-ID	Stress period	Timestep	1	2	3	4	Diff reach1 (in - out)	Diff reach2 (in - out)	Diff reach3 (in - out)	Diff reach4 (in - out)	Diff reach5 (in - out)	Diff reachrest (in - out)	Flux out (all river cells)	Flux in (all river cells)	Diff all river cells (in-out)
1	1	1	-274.133	261.4474	156.4513	217.2266	7060.99252	15326.1755	0	0	0	0	-274.133	22661.3	22387.168
2	1	2	-274.134	261.4454	156.4496	217.2249	7060.98595	15326.1679	0	0	0	0	-274.134	22661.29	22387.154
3	1	3	-274.135	261.4431	156.4479	217.2229	7060.97855	15326.1588	0	0	0	0	-274.135	22661.27	22387.137
4	1	4	-274.137	261.4403	156.4456	217.2203	7060.9688	15326.1479	0	0	0	0	-274.137	22661.25	22387.117
5	1	5	-274.14	261.4368	156.4427	217.2172	7060.95705	15326.1348	0	0	0	0	-274.139	22661.23	22387.092
6	1	6	-274.142	261.4328	156.439	217.2132	7060.94246	15326.1191	0	0	0	0	-274.142	22661.2	22387.062
7	1	7	-274.145	261.4283	156.4347	217.2086	7060.92613	15326.1003	0	0	0	0	-274.145	22661.17	22387.026
8	1	8	-274.149	261.4228	156.4299	217.2031	7060.907	15326.0777	0	0	0	0	-274.149	22661.13	22386.985
9	1	9	-274.153	261.416	156.4236	217.1963	7060.88266	15326.0506	0	0	0	0	-274.153	22661.09	22386.933
10	1	10	-274.158	261.4077	156.4161	217.1883	7060.85406	15326.018	0	0	0	0	-274.158	22661.03	22386.872
11	1	11	-274.164	261.3979	156.4073	217.1785	7060.81973	15325.979	0	0	0	0	-274.164	22660.96	22386.799
12	1	12	-274.171	261.3859	156.3964	217.1671	7060.77853	15325.9321	0	0	0	0	-274.171	22660.88	22386.711
13	1	13	-274.179	261.3719	156.3835	217.1536	7060.72987	15325.8759	0	0	0	0	-274.179	22660.78	22386.606
14	1	14	-274.189	261.355	156.3681	217.1371	7060.67068	15325.8085	0	0	0	0	-274.189	22660.67	22386.479
15	1	15	-274.202	261.335	156.3495	217.1176	7060.60001	15325.7276	0	0	0	0	-274.202	22660.53	22386.328
16	1	16	-274.217	261.3112	156.3271	217.0936	7060.51532	15325.6306	0	0	0	0	-274.216	22660.36	22386.146
17	1	17	-274.235	261.2823	156.3005	217.0655	7060.41345	15325.5143	0	0	0	0	-274.235	22660.16	22385.928
18	1	18	-274.256	261.248	156.2688	217.0318	7060.29243	15325.3748	0	0	0	0	-274.256	22659.92	22385.667
19	1	19	-274.281	261.2065	156.231	216.9911	7060.14711	15325.2076	0	0	0	0	-274.281	22659.64	22385.355
20	1	20	-274.312	261.1567	156.1855	216.9428	7059.97313	15325.0072	0	0	0	0	-274.312	22659.29	22384.98
21	1	21	-274.348	261.097	156.1306	216.8844	7059.76372	15324.767	0	0	0	0	-274.348	22658.88	22384.531

Figure 10 River module output file.

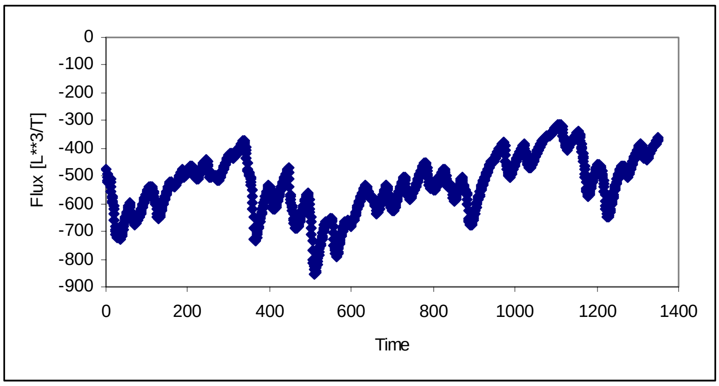


Figure 11 Flow over time at one specific river cell

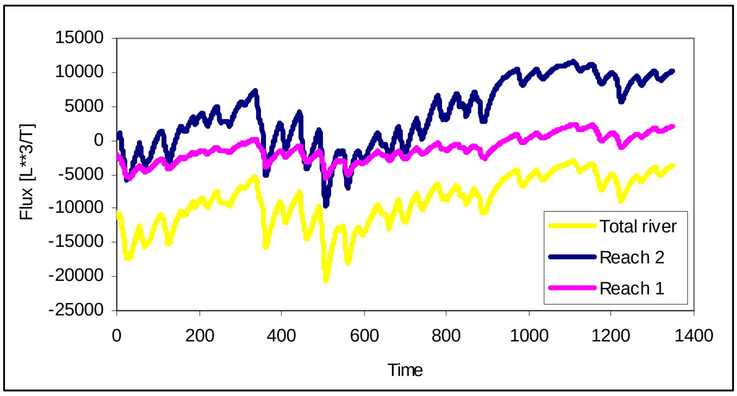


Figure 12 Flow over time for river reaches 1 and 2 and for all river cells

6 “Stream flow and leakage“ module

6.1 INTRODUCTION

The “Stream flow and leakage” module provides leakages in and out of the model through stream cells, as well as actual flows within a stream. The data is provided for single stream cells, stream reaches and for the sum of all stream cells. The module is called by selecting the “Stream flow and leakage” option under the main “Calculate” menu (Figure 13).

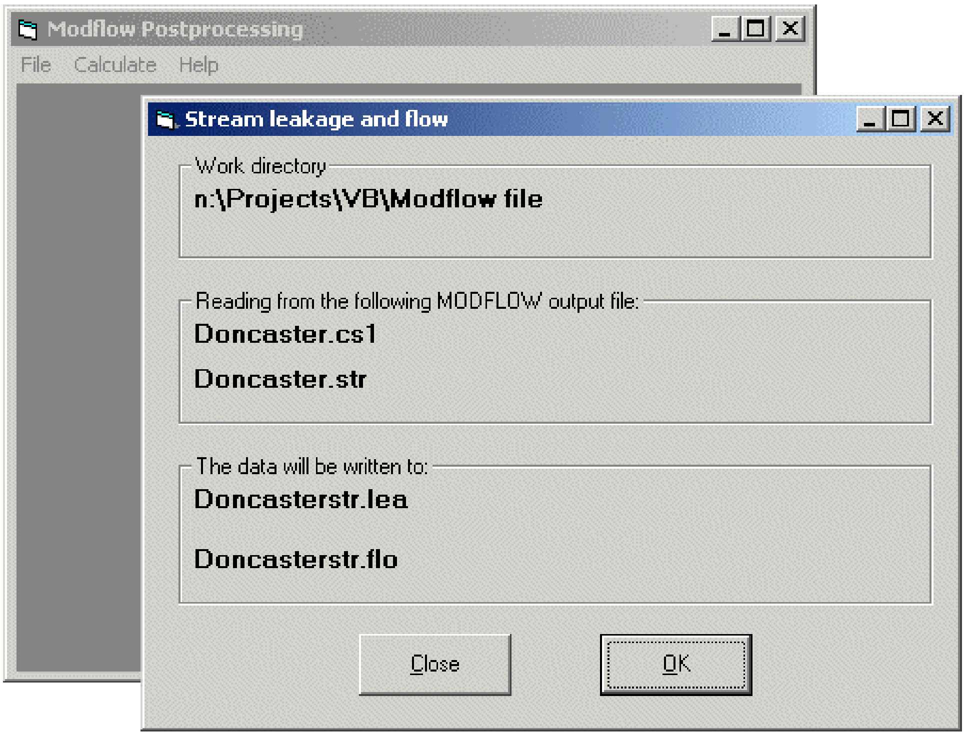


Figure 13 “Stream flow and leakage” module screen

The working directory, relevant MODFLOW output files and post-processing output files are displayed automatically on the “Stream flow and leakage” module screen, if the model information has been defined using the “Model information” module (section 2). The program is executed by pressing the OK button. After the output files are written, the window closes and a message is displayed giving output file names and path.

6.2 DATA OUTPUT

The “Stream flow and leakage” module generates two output files: a file listing stream flows (*prefix*str.flo) and a file displaying stream leakages (*prefix*str.lea) into and out of the model over time (Figure 14 and Figure 15).

The structure of both output files is similar to the “River leakage” module output (Figure 10). Data are provided for each stream cell for all stress periods and time steps available within the MODFLOW binary cell-by-cell stream file. The number of stress period/time step records available depends on the settings in the “Output control” menu within Groundwater Vistas (Figure 9). If the user selected the cell-by-cell flows to be saved every single time step, then stream flows/leakages for all stress periods/times steps are available. However, if for example data are saved every four time steps, then stream flows/leakages will be available for every fourth time step.

In addition to flow and leakage rates for single stream cells, the post-processor provides data for stream reaches in [L^3/T]. Stream reaches are specified within MODFLOW in the stream module by giving stream cells a reach number. The "Stream flow and leakage" module within the post-processor is then able to provide flow within reaches as well as leakages in and out of stream reaches. Up to 5 reaches (reach numbers in MODFLOW have to be 1 to 5) can be dealt with. If the model contains less than 5 stream reaches, zero values will appear in the output file for all "missing" reaches. If the model contains more than 5 stream reaches, the data for five reaches is provided, while data for any other reaches will be lumped together under "Reachrest" (Figure 10). Reach leakages are stream baseflows, i.e. the difference between inflows into the stream reach (out of the model) and outflows from the stream reach (into the model).

Besides stream reaches, data is provided for the sum of all steam cells in [L^3/T].

Figure 14 is an example of the output file "*prefix*str.flo". The first two rows give information on stream cell locations and stream reach and segment numbers respectively. Data are then divided into three sections relating to flow rates for single stream cells, flows for stream reaches and the flows for the sum of stream cells in the model.

Flow in single stream cells [L^3/T] — Flow in stream reaches [L^3/T] — Flow [L^3/T] for the sum of all stream cells

Streamcell(lay/row/col)			1 / 7 / 44	1 / 8 / 45	1 / 11 / 45	1 / 13 / 45							
Streamcell(segment/reach)			1 / 1	1 / 2	2 / 2	2 / 3							
File	Stress Period	Timestep					Diff reach1 (in - out)	Diff reach2 (in - out)	Diff reach3 (in - out)	Diff reach4 (in - out)	Diff reach5 (in - out)	reach rest (in - out)	Flux in (all stream cells)
STREAM FLOW OUT	1	1	275.1054	304.2561	403.8271	485.1304	354.0885	1854.88	2949.117	0	0	0	5158.08791
STREAM FLOW OUT	1	2	275.1052	304.2556	403.8254	485.1279	354.0874	1854.88	2949.099	0	0	0	5158.062307
STREAM FLOW OUT	1	3	275.1048	304.2548	403.8234	485.1248	354.086	1854.87	2949.077	0	0	0	5158.031258
STREAM FLOW OUT	1	4	275.1044	304.254	403.821	485.1212	354.0844	1854.86	2949.051	0	0	0	5157.993595
STREAM FLOW OUT	1	5	275.104	304.253	403.8182	485.1168	354.0825	1854.85	2949.019	0	0	0	5157.949162
STREAM FLOW OUT	1	6	275.1034	304.2518	403.8148	485.1117	354.0802	1854.83	2948.982	0	0	0	5157.896317
STREAM FLOW OUT	1	7	275.1028	304.2503	403.8107	485.1053	354.0774	1854.82	2948.937	0	0	0	5157.831661
STREAM FLOW OUT	1	8	275.102	304.2486	403.8058	485.0979	354.0741	1854.8	2948.883	0	0	0	5157.755541
STREAM FLOW OUT	1	9	275.101	304.2466	403.8	485.089	354.0701	1854.78	2948.818	0	0	0	5157.664127
STREAM FLOW OUT	1	10	275.0999	304.2441	403.793	485.0783	354.0654	1854.75	2948.741	0	0	0	5157.555162
STREAM FLOW OUT	1	11	275.0985	304.2412	403.7847	485.0655	354.0598	1854.72	2948.649	0	0	0	5157.424532
STREAM FLOW OUT	1	12	275.0969	304.2377	403.7747	485.0503	354.053	1854.68	2948.54	0	0	0	5157.269114
STREAM FLOW OUT	1	13	275.095	304.2336	403.7629	485.0322	354.0451	1854.63	2948.409	0	0	0	5157.084206
STREAM FLOW OUT	1	14	275.0927	304.2287	403.7488	485.0106	354.0355	1854.57	2948.254	0	0	0	5156.863747
STREAM FLOW OUT	1	15	275.0901	304.2229	403.7321	484.985	354.0242	1854.51	2948.069	0	0	0	5156.602215
STREAM FLOW OUT	1	16	275.0869	304.216	403.7122	484.9546	354.0108	1854.43	2947.851	0	0	0	5156.292831

Figure 14 Example of a stream flow output file (*prefix*str.flo) from the module "Stream flow and leakages"

In/Outflow from/into single Baseflow in stream reaches In/Outflow stream cells [L³/T] [L³/T]
from/into
all stream cells

Streamcell(lay/row/col)			1 / 4 / 44	1 / 10 / 45	1 / 12 / 45	1 / 17 / 46									
Streamcell(segment/reach)			1 / 1	1 / 2	2 / 2	2 / 3									
File	Stress Period	Time step					Diff reach1 (in - out)	Diff reach2 (in - out)	Diff reach3 (in - out)	Diff reach4 (in - out)	Diff reach5 (in - out)	Diff reachrest (in - out)	Flux out (all stream cells)	Flux in (all stream cells)	Diff all stream cells (in-out)
STREAM LEAKAGE	1	68	-1.82276	-0.02564	-0.99964	-1.58865	-4.851803	-0.606957	-6.75502	0	0	0	-13.316054	1.1022763	-12.21377778
STREAM LEAKAGE	1	69	-1.12016	0.73389	-0.24565	-0.7884	-2.043367	3.191116	-2.84686	0	0	0	-6.4741867	4.7750733	-1.699113369
STREAM LEAKAGE	1	70	-0.68742	1.201133	0.217888	-0.29699	-0.313859	5.527556	-0.44598	0	0	0	-2.9859143	7.7536327	4.767718375
STREAM LEAKAGE	1	71	-0.44509	1.462608	0.477175	-2.24E-02	0.654571	6.835033	0.896199	0	0	0	-1.4324925	9.8182955	8.385803014
STREAM LEAKAGE	1	72	-0.32281	1.594444	0.607832	0.11585	1.143183	7.494245	1.572047	0	0	0	-0.9910763	11.200551	10.20947489
STREAM LEAKAGE	1	73	-0.26782	1.653636	0.666423	0.177691	1.362841	7.790198	1.87468	0	0	0	-0.8262548	11.853974	11.0277189
STREAM LEAKAGE	1	74	-0.24614	1.676884	0.689366	0.20176	1.449381	7.906419	1.992738	0	0	0	-0.7613013	12.109839	11.34853818
STREAM LEAKAGE	1	75	-0.2389	1.684578	0.696894	0.209513	1.478267	7.944861	2.031035	0	0	0	-0.7396041	12.193767	11.45416334
STREAM LEAKAGE	1	76	-0.23702	1.6865	0.698718	0.211257	1.485689	7.954444	2.039912	0	0	0	-0.7340148	12.214059	11.48004442
STREAM LEAKAGE	1	77	-0.23681	1.686665	0.698822	0.211227	1.486517	7.955252	2.040032	0	0	0	-0.7333782	12.215179	11.48180054
STREAM LEAKAGE	1	78	-0.23695	1.686463	0.698583	0.210876	1.485904	7.954227	2.038507	0	0	0	-0.7338274	12.212466	11.47863825
STREAM LEAKAGE	1	79	-0.2371	1.686275	0.698373	0.210594	1.485284	7.953277	2.037244	0	0	0	-0.7342865	12.210092	11.47580589
STREAM LEAKAGE	1	80	-0.2372	1.68616	0.698245	0.210425	1.484906	7.952699	2.036484	0	0	0	-0.7345677	12.208656	11.47408855
STREAM LEAKAGE	2	1	-0.2372	1.68616	0.698246	0.210426	1.484903	7.952701	2.03649	0	0	0	-0.7345691	12.208663	11.47409432
STREAM LEAKAGE	2	2	-0.2372	1.686161	0.698248	0.210426	1.484901	7.952703	2.036496	0	0	0	-0.7345707	12.208671	11.47410008
STREAM LEAKAGE	2	3	-0.2372	1.686161	0.698249	0.210426	1.484899	7.952705	2.0365	0	0	0	-0.7345725	12.208676	11.47410314
STREAM LEAKAGE	2	4	-0.2372	1.686161	0.698249	0.210421	1.484895	7.952705	2.03649	0	0	0	-0.7345748	12.208666	11.47409083

Figure 15 Example of a stream leakage output file (*prefix*.lea) from the module “Stream flow and leakages”

Figure 15 is an example for the output file “*prefix*str.lea”. The first two rows give information on stream cell locations and stream reach and segment numbers respectively. Then data are provided on stress period and time step numbers, followed by columns containing leakages into or out of individual stream cells. This is followed by baseflows for stream reaches and in the last three columns leakages into the model through all stream cells, leakages out of the model through all stream cells and the baseflow over time for the entire stream, i.e. difference of flow in/flow out. Leakages into and out of the model through the entire stream cells correspond to the water balance figures for the stream boundary condition given in the MODFLOW output file and “Water Balance” module output file.

7 Summary

A post processor for MODFLOW has been developed in order to simplify the manipultation and analysis of MODFLOW model results. The program reads MODFLOW binary and ASCII output files and converts data stored in these into comma delimited ASCII files to be viewed in Excel. The program is developed using Visual Basic 6.0.

The program is able to provide the following output:

- Flow rates and cumulative volumes of water entering and leaving the groundwater model through all boundary conditions for every time step and stress period.
- Groundwater heads for user-specified model cells (observation boreholes) for every time step and stress period.
- Flows into the model and out of the model through single river cells, through river reaches and entire rivers for every time step and stress period.
- Flows into the model and out of the groundwater model through single stream cells, stream reaches and entire streams for every time step and stress period.
- Flows within single stream cells, stream reaches and entire streams for every time step and stress period.