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Input Guide and Revisions for GW-WETLAND (Version 1.1): A Computer Program to Simulate Groundwater-Wetland Interactions.

BY:

S.G. Shikaze, A.S. Crowe

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Input Guide and Revisions for GW-WETLAND (Version 1.1):

A Computer Program to Simulate Groundwater-Wetland Interactions

Steven G. Shikaze
Allan S. Crowe

NWRI Cont. # 00-65

Groundwater Assessment and Restoration Project
National Water Research Institute
Environment Canada
Box 5050
867 Lakeshore Road
Burlington, ON
L7R 4A6

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Input Guide and Revisions for GW-WETLAND (version 1.1): A Computer Program to Simulate Groundwater-Wetland Interaction

Management perspective

The DOE Great Lakes 2000 policy needs reliable information on the potential environmental stress caused by human activities on the marsh ecosystem at Point Pelee National Park. It is suspected that nutrients from the Park's septic-system are entering the Point Pelee marsh via groundwater discharge and may be contributing to a deterioration in the health and natural biodiversity of the marsh. This model contributes to our basic understanding of the hydrogeological environment at Point Pelee and allows us to simulate the transport of nutrients to the marsh. It also has wider implications for the control of contaminant loadings to Point Pelee marsh, and its detrimental impact on this fragile aquatic ecosystem. This program fits under the COA activity1.6: Groundwater.

Long-term monitoring of the groundwater flow regime at Point Pelee National Park has shown that hydrogeological environment is highly complex. Hence, the development of the GW-WETLAND model was necessary to understand the seasonal reversals in the direction of flow, and the impact of Lake Erie, the marsh, precipitation, evapotranspiration, and the width of the barrier bar on the groundwater regime. The recent modifications to the GW-WETLAND model will permit (1) more accurate simulation of groundwater contamination from surface water sources, simulation of impact of drainage ditches within a marsh. These modifications have allowed us to conduct modelling studies to aid in the restoration of the Wainfleet Bog, Ontario.

The model is currently being expand and generalized to make it more applicable for other wetlands and groundwater-surface water environments, not only within the Great Lakes basin, for wetland environments across Canada. The model is also currently being used to assess the impact of drainage ditches within the Wainfleet Bog, Ontario, and test various scenarios for restoring the hydrologic regime within the Bog.

Guide et révisions du GW-WETLAND (version 1.1) : Programme informatique simulant l'interaction entre l'eau souterraine et les milieux humides

Sommaire à l'intention de la direction

La politique Grands Lacs 2000 d'EC doit pouvoir disposer d'informations fiables sur le stress environnemental que les activités humaines pourraient imposer à l'écosystème de marais au Parc national de la Pointe-Pelée. On soupçonne que les nutriments du système septique du parc pénètrent dans le marais par décharge dans les eaux souterraines et peuvent contribuer à une détérioration de la santé et de la biodiversité naturelle du marais. Ce modèle aide à avoir une compréhension de base de l'environnement hydrogéologique à la Pointe-Pelée et permet de simuler le transport de nutriments vers le marais. Cette situation a aussi des implications plus vastes pour la maîtrise des charges de contaminants vers le marais de la Pointe-Pelée, et leur effet néfaste sur cet écosystème aquatique fragile. Le programme s'inscrit dans le cadre de l'activité 1.6 de l'ACO : Les eaux souterraines.

La surveillance à long terme du régime d'écoulement des eaux souterraines au Parc national de la Pointe-Pelée a montré que l'environnement hydrogéologique y est très complexe. Il a donc fallu développer le modèle GW-WETLAND pour comprendre les renverses saisonnières de la direction de l'écoulement, ainsi que l'impact du lac Érié, du marais, des précipitations, de l'évapotranspiration, et de la largeur de la barre sur le régime des eaux souterraines. Les modifications récemment apportées au modèle GW-WETLAND permettront 1) de simuler avec plus de précision la contamination des eaux souterraines par les sources d'eau de surface, 2) de simuler l'impact des fossés de drainage dans un marais. Ces modifications nous ont permis de mener des études par modélisation pour aider au rétablissement de la tourbière Wainfleet, en Ontario.

Le modèle est en cours d'agrandissement et de généralisation, ce qui le rendra mieux applicable à d'autres milieux humides et environnements d'eaux souterraines-eaux de surface, non seulement dans le bassin des Grands Lacs, mais dans tout le Canada. Il est aussi présentement utilisé pour évaluer l'impact des fossés de drainage dans la tourbière Wainfleet, en Ontario, et pour tester divers scénarios de restauration du régime hydrologique au sein de la tourbière.

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ABSTRACT

GW-WETLAND is a numerical model that can be used to simulate transient groundwater flow and contaminant transport in a 2-D cross section. Although the model was originally written for groundwater-wetland interactions, it is general enough for a variety of groundwater problems. Moreover, the model is constantly being updated in order to allow it to be used for new scenarios. In the past year, the numerical model GW-WETLAND has gone through a series of updates and modifications. First, the model now has the capability to include contaminant source zones that are associated with surface water boundaries. This new option allows the user to examine the potential for groundwater contamination as a result of, for example, a flooding event in a river. The second major addition to the model involves the ability to include a vertical-walled drainage ditch along the ground surface. For this option, a portion of the domain along the surface is removed. The ditch can also have a water level that can vary in time, in the same manner as a surface-water boundary. This report describes the modifications that have been made to the model in the past year as well as two illustrative examples which are included to show these new features.

RÉSUMÉ

Le GW-WETLAND est un modèle numérique qui peut être utilisé pour simuler aux états transitoires l'écoulement de l'eau souterraine et le transport des contaminants dans une coupe bidimensionnelle. Bien qu'il ait été écrit au départ pour les interactions milieux humides-eau souterraine, il est assez général pour se prêter à divers problèmes d'eaux souterraines. De plus, il est constamment mis à jour pour qu'on puisse l'utiliser avec de nouveaux scénarios. Dans la dernière année, on a apporté au modèle numérique GW-WETLAND une série de mises à jour et de modifications. D'abord, il a maintenant la capacité d'inclure les zones sources de contaminants qui sont associées aux limites des eaux de surface. Cette nouvelle option permet à l'utilisateur d'examiner le risque de contamination des eaux souterraines en raison, par exemple, du débordement d'un cours d'eau. La deuxième grande addition au modèle concerne sa capacité d'inclure un fossé de drainage à parois verticales le long de la surface du sol. Pour cette option, on enlève une portion du domaine le long de la surface. Le fossé peut aussi avoir un niveau d'eau variable dans le temps, de la même manière qu'une limite d'eaux de surface. Le rapport décrit les modifications qui ont été apportées au modèle dans la dernière année, ainsi que deux exemples illustrant ces nouvelles caractéristiques.

1.0 INTRODUCTION

GW-WETLAND is a numerical model that can be used to simulate transient groundwater flow and contaminant transport in a 2-D cross section for a variety of groundwater-wetland scenarios as well as other problems such as the response of an aquifer to a short-term flood of a river, or the presence of a drainage ditch. The model makes use of the finite-element method to solve the transient groundwater flow equation, and solute transport can be solved either by deterministic-probabilistic particle tracking or by finite-element solution to the advection-dispersion equation. For groundwater flow, several different options are available for boundary conditions. These include specified hydraulic head boundaries that can change in time (e.g., seasonal changes in the water levels in a river).

One of the unique features of the model is the ability to simulate a water table boundary that can change both spatially and temporally. Although the model does not include flow in the unsaturated zone, the top surface of the finite-element mesh is allowed conform to the position of the water table (Crowe et al., 1999). Specifically, if the water table rises above a given tolerance, new nodes and elements can be added such that the existing stratigraphy is not distorted by stretching elements in the vertical direction. Conversely, if the water table falls below a specified tolerance, nodes and elements are removed from the mesh while avoiding distortion of the finite element mesh, which frequently results from compressing elements. Also, because boundary cond7itions can change at any time throughout the simulation, the position of the water table can also change in time. As a result, the finite element mesh may change from one time-step to the next.

Since the GW-WETLAND model was introduced, changes have been made to the model in order to make the program more flexible with more options. This report provides a brief description of the changes to the numerical model GW-WETLAND including a detailed chapter on the revised input requirements for the program, a line-by-line input guide for the input data file, and illustrative examples with sample input and output files. For a more detailed description of the model including a discussion of the governing equations and numerical methods used, the reader is referred to Version 1.0 of the User's Manual (Shikaze and Crowe, 1999).

Although this computer program was originally created to simulate groundwater flow and contaminant transport in the vicinity of wetlands, it is now flexible enough to simulate various

other scenarios. For example, when a river floods, flood waters may contain contamination that can act as a source for groundwater contamination, even if the duration of the flood is relatively short. The short-term, high water levels in the river can be simulated along with a contaminant source in the river itself. Another scenario is groundwater flow in the vicinity of a drainage ditch, which is typically used to lower the water table. Also, the ditch can have water levels that can vary in time. In this case, the model can be used to predict the response of the water table to the presence of the drainage ditch as well as the water level in the ditch.

This user's guide is set up to provide some relevant background material, a detailed description of the procedure required to set up an input data file, as well as some example test cases and data files. In Chapter 2, modifications made to the code since Version 1.0 are presented. The main modifications to the code include the ability to have a contaminant source boundary associated with a surface-water boundary, and the ability to include a vertical-walled drainage ditch along the ground surface. Chapter 3 describes the revised input procedure to aid in setting up the input data file. Chapter 4 provides two example problems that illustrate some of the new features of the model. These include (1) the response of an aquifer to the short-term flood of an adjacent river including an examination of the potential for contamination of groundwater from contaminated flood waters, and (2) the effectiveness of a drainage ditch at draining the adjacent porous material. A step-by-step input guide for the input data file is provided in Appendix A, and Appendices B and C list the input data file and output file for the flood example, respectively, while Appendix D lists the input data file for the example that includes drainage ditch.

2.0 MODIFICATIONS TO THE PROGRAM

The two main modifications to the GW-WETLAND code since Version 1.0 are outlined in this chapter. First, for surface-water boundaries which have levels that can fluctuate in time, the user can now specify whether or not the water in the surface-water boundary represents a contaminated source zone. As before, the user can specify one of two options for contaminant transport from a surface-water boundary – these include (a) particle tracking based on a deterministic-probabilistic approach and (b) advection-dispersion based on a finite-element formulation of the solute transport equation. The second addition to the GW-WETLAND code is the ability to handle drainage ditches along the ground surface. These ditches can be added anywhere within the interior of the computational domain (along the ground surface), and can also contain water levels that vary in time.

2.1 Contaminant source associated with a surface-water boundary

In the previous version of GW-WETLAND (Shikaze and Crowe, 1999), surface-water boundaries could be added for transient groundwater flow simulations. These types of boundaries are first-type, or specified head boundaries, where the hydraulic head is allowed to exceed the elevation of the ground surface and the water level in the surface-water body is allowed to vary in time. This option can be useful in simulating lakes, ponds or rivers where the water-level history is known.

One of the limitations of Version 1.0, was that if the water associated with the surface-water boundary was contaminated, addition of contaminant source nodes with this zone was not intuitive. With the new version (Version 1.1), we have created an option whereby the user can specify whether or not a surface-water boundary is a contaminant source zone. In particular, this option was added to evaluate the potential for a flooded river to contaminate an adjacent aquifer (Shikaze and Crowe, 1998). In this case, the duration of the flood (and, consequently, the length of time that the river may be contaminated) may be fairly short. The user can choose one of two options by which to simulate solute transport.

The first solute transport option is particle tracking whereby particles, which represent contaminants, are individually tracked in two steps – the first being a deterministic advection step, followed by a probabilistic dispersion step (Ahlstrom et al., 1977). If this option is chosen,

particles are added to each element that is in contact with the surface-water boundary for a length of time that is user-specified. As the water level in the surface-water body rises, the number of elements that represent the contaminant source zone may increase (the model will detect this automatically). Moreover, when the water level in the surface-water body falls, the number of contaminant-source elements may decrease. The user specifies a single value for the number of particles that are to be added to each cell (Note: each cell consists of two triangular finite elements).

The second solute-transport option available for surface-water bodies is a finite-element solution to the advection-dispersion equation (e.g. Pinder and Gray, 1977). In this formulation, the same mesh that was used for the groundwater flow solution is used for the advection-dispersion solution at each time step (and this mesh, as mentioned previously, can change in time). If the user selects this option, nodes that are associated with the surface-water body are set as first-type concentration nodes for a period of time that is specified by the user. Also, as the water level in the surface-water body rises or falls, the number of first-type concentration nodes that are associated with the surface-water body will increase or decrease, respectively. Additionally, the user can specify the start and end times at which the contaminant source zone will be turned on and off, respectively.

Each of the two methods for solute transport has its own advantages. When dispersion is very low (i.e., advection dominated), the particle tracking routine will be a more appropriate choice because it is not subjected to constraints such as the Peclet and Courant stability criteria. Moreover, this method can be used in cases where dispersion is completely neglected. The finite-element solution to the advection-dispersion equation allows a more direct method for solving solute transport, whereby advection and dispersion are solved simultaneously. Dispersion is solved directly, rather than as a 'random' component, as is the case with particle tracking. Also, this finite-element method includes options to include simple retardation and degradation processes.

The user can specify either method for solute transport (or both) from a surface-water boundary. Results (i.e., cell concentrations for particle tracking; nodal concentrations for finite-element solution of the advection-dispersion equation) can be viewed in a manner described in

Version 1.0 of the User's Guide for particle-tracking or advection-dispersion results (Shikaze and Crowe, 1999).

2.2 Drainage ditches

Another feature of the new version of GW-WETLAND is the ability to include drainage ditches along the ground surface of the computational domain. This option was originally included to simulate the effectiveness of ditches at draining adjacent zones of peat (Crowe et al., 2000). More specifically, the purpose of the drainage ditches was to lower the water table in the peat unit between two ditches such that the peat could be mined.

For this new option, the ground surface elevation for each column of nodes is entered as before. However, the user can then specify a surface ditch with vertical walls anywhere in the domain. This input overrides the previously entered ground surface data. In the previous version of the code (Shikaze and Crowe, 1999), if the user desired a drainage ditch, the elevation and location of the ditch would have to be entered using the ground-surface elevation input. With this previous method, in the case of a deep ditch, the finite-element mesh that is generated by the program could be highly distorted in the area adjacent to the ditch. The new method (Version 1.1) will not have the same mesh problems because a portion of the finite-element mesh is actually removed from the domain to accurately represent the ditch.

Also, the ditch can have water levels that can change in time. This feature can be useful for simulating conditions that change annually or seasonally. The water-level history for the ditch is entered in a manner similar to that for surface water bodies (see Version 1.0 of the User's Manual – Shikaze and Crowe, 1999). As the water level in the ditch rises, additional nodes along the walls of the ditch may be turned 'on' as constant head nodes. Similarly, as the water level in the ditch falls, some nodes along the walls of the ditch may be turned 'off' as constant head nodes (this is done automatically by the program).

Currently, the ditch must exist throughout the entire simulation. In other words, a ditch cannot be added in the middle of a transient simulation, and cannot be filled at any later time. A future addition to the program will be to allow a re-filling of the ditch at some time during the simulation. This could be used to simulate, for example, the restoration of water levels in adjacent peat units by refilling the drainage ditches.

3.0 OPERATION OF THE MODEL

This chapter describes the requirements as well as the procedure for running the models. A detailed User's Guide, including step-by-step instructions for setting up the input data files, is shown in Appendix A.

3.1 Computing Requirements

The model has been programmed in FORTRAN, and compiled with Microsoft PowerStation, version 4.0. Some of the utilities in the code make use of functions that are specific to Microsoft PowerStation, and thus if the user wants to compile the code with another FORTRAN compiler, they should contact the authors before doing so. The minimum system requirements are:

- Pentium processor (166 MHz is recommended as the minimum)
- 32 MB RAM (actual memory requirements will depend on the size of the problem)
- A hard disk with at least 40 MB free.

The illustrative examples provided in this manual have been simulated using a Pentium-II PC (400 MHz) running Windows NT and equipped with 128 MB RAM.

The executable program runs in a DOS environment, and it is recommended that the user open a DOS-window from Windows95 (or 98 or NT) to run the program. Output files are in ASCII format, and specific output has been designed to be used in *GridBuilder* (McLaren, 1998) for visualization.

3.2 Dimensioning of the Arrays

Dimensioning arrays is done through an INCLUDE file (pelee.inc), listed in APPENDIX A.4. Thus, if the user requires larger dimensions for a specific problem, changes only need to be made to this INCLUDE file before re-compiling the program.

3.3 Input Operations

This section describes the data requirements for input to the model. The complete input guide, which includes a detailed line-by-line description of the input data files, is shown in Appendix A. A sample-input file is shown in Appendix B.

The user has the option of undertaking the simulations using either English or metric units for length. However, units of time must be in days and units of mass must be input in milligrams. We recommend units of metres/days/milligrams, and the illustrative examples provided in this report make use of these units. Appendix A.5 summarizes input parameters that have units as well as acceptable combinations of units.

Although the input data file is in ASCII format, there are several features that make creating and editing this file easier. For example, any line within the data file that begins with a "!" is taken to be a comment line, and is ignored by the program. Also, on any given line, comments can be added after the input parameters by typing a ";". Anything that follows the semi-colon will be ignored by the program. This feature can be useful when the user wishes to add comments throughout the input file to aid in finding their way through the file.

The first information that the user must enter is a one-line title or problem identifier (**title**). This can be used to provide a description of both the input data set and the output. Twenty-four program control parameters (**option(n)**) are used to control the nature of the simulation and the type of output generated. If the user wishes to choose one of the particular functions, **option** should be set to **".TRUE."** (a value of **".FALSE."** indicates that the option or output is not required). The user has the option of running various routines, such as:

option(5) : calculate heads

option(12) : generate hydraulic gradients (including direction) for each cell

option(15) : calculate the velocity in each element

option(17) : run mass transport simulation using particle tracking

option(24) : run mass transport simulation using the finite-element Galerkin method

The finite element grid and hydraulic head distribution are automatically calculated at the beginning of the simulation - based on initial information supplied by the user – as well as at each subsequent time step. Information about the mesh and domain may be output to a file at each time step:

option(1) : node coordinates

option(2) : finite element incidences

option(3) : hydraulic conductivity and storativity of the element

option(6) : nodal hydraulic heads

option(13) : hydraulic gradients including direction

option(18) : particle and concentration distributions

option(23) : coordinates of particles and associated mass

It is worth noting that if these options are turned on, the resulting output files can be quite large. Also, the following information may be output to files that could be used for plotting, for example with GridBuilder:

option(4) : nodal coordinates and element incidences

option(7) : head distribution at each time step

option(8) : head distribution at the final time step only

option(14) : hydraulic gradients

option(16) : velocity field

option(19) : concentrations and distribution of reference particles

option(20) : distribution of reference particles

Additional options allow the user to control various aspects of the simulation, and check its convergence:

option(9) : print water table convergence information

option(10) : input final heads from a previous run to continue a simulation

option(11) : output final heads to continue the simulation

option(21) : output the final distribution of particles to continue a simulation

option(22) : input the final distribution of particles to continue a simulation

The grid for the model is constructed of an array of nodes and elements. This grid is constructed within the program according to the user's input parameters. The user must specify the number of rows (**nrow**) and columns (**ncol**) of nodes and the vertical (**delz**) and horizontal (**xe**) spacing between nodes. The vertical node spacing is the same for each row of cells, but the horizontal node spacing may be constant or variable. If the horizontal grid spacing is constant, set **var_x** to **.TRUE.** and enter one value for **xe**, else set **var_x** to **.FALSE.** and enter the different values of **xe**. The horizontal and vertical grid spacings are used to create a mesh of cells, where each cell consists of 2, triangular finite elements.

The cross section may contain up to 9 different hydrostratigraphic units (**ngeol**), each with unique values of horizontal and vertical hydraulic conductivity (**khorz, kvert**), storativity (**stor**), porosity (**por**), longitudinal dispersivity (**disperl**), and transverse dispersivity (**dispert**). These units are used to represent the stratigraphy of the subsurface from the base of the cross section to the ground surface, whether or not the entire cross section will be saturated. The units are defined as an array (**mapgeo**) by assigning a numbered code, from 1 to 9, which represents the specific hydrostratigraphic unit at each cell within the domain. The codes are entered one row at a time starting with the uppermost row of cells, with one code value assigned to each cell on that row, and each subsequent lower row in the cross section starts a new line. Thus, once the values for **mapgeo** are entered, it should appear exactly the same as illustrated in the drawn cross section. The values of the parameters assigned to each hydrostratigraphic unit (**khorz, kvert, stor, por, disperl, dispert**) are input with the hydrostratigraphic unit identifier (l) corresponding to the unit in the cross section (**mapgeo**). Also, entered on this line are the codes to indicate whether or not a particle is allowed to move (**code**) within the specified unit. As illustrated in the example in Appendix B, a simple graphical representation of the cross section for the particular variable is formed. This style of data input facilitates convenient entry of data for complex settings, rapid alterations, and easy checking of input data. At this time, only one value of specific yield (**specyd**) for the unsaturated zone is entered.

Additional parameters and values are used to define the shape of the cross section and its initial hydrogeological conditions. The elevation of the ground surface (**elvgrd**) and elevation of the base of the cross section (**elvbas**) are input for each column of nodes. Because these values need not be constant, the cross section may have an irregular shape.

A single drainage ditch can be added by setting variable **ditch** to **.TRUE.**. If this is selected, the user must then enter **dleft, dright,** and **dbottom** to define the left, right and bottom boundaries (in grid coordinates – usually metres). The water level in the ditch can change in time, and is entered via a separate data file. This new file name is input into the standard data file, and the variable is **ditchheadfile**. In this file, the user must first specify the number of times at which the water level will change (**n_ditchhead_chg**), followed by a list where each line contains a time (**t_ditch_head**) and a new water level (**ditch_head**).

A single initial value of hydraulic head for the entire saturated domain is required (**headi**); to help the solution converge, this initial value should be set equal to the average value of the head along the water table. The initial values of hydraulic head along the water table, (i.e. the elevation of the water table) (**headwt**) are specified for each column of nodes. The user must also indicate at which nodes along the water table the hydraulic heads will be allowed to fluctuate in response to changes to the flow domain (set **wtmove** = **.TRUE.**) and which may not move (set **wtmove** = **.FALSE.**). If surface water nodes or drains are specified, **wtmove** should be specified as **.FALSE.** for these columns of nodes.

The user can specify various boundary conditions for the flow domain, including infiltration/evapotranspiration boundaries (second-type) and constant head boundaries (first-type). Infiltration and evapotranspiration are input separately to accurately simulate field conditions. Both recharge and evapotranspiration can vary over time and spatially across the cross section. Recharge is entered by first indicating the number of different recharge periods (**nrestp**) that will occur during a simulation, and the time at which each recharge period starts (**t_rech**) (e.g., if recharge changes twice, **nrestp** = 3). If recharge occurs from the beginning of the simulation, then the first value of **t_rech** = 0.0. For each recharge period, the spatial distribution along the cross section is indicated by specifying the number of zones of constant recharge across the cross section (**nrzones**), the starting and ending column number (**nxfrom, nxto**) bounding each recharge zone, and the value of recharge within each zone (**rval**). Recharge values of 0.0 should be entered for **rval** to indicate that no recharge occurs in a given zone and at a specific time. If no recharge occurs throughout the simulation, then the user simply enters a value of 0 for **nrestp**, and values for **t_rech**, **nrzones**, **nxfrom**, **nxto** and **rval** are not entered. Evapotranspiration is handled in the same way. The user enters the number of time periods in which different values of evapotranspiration are desired (**netper**), the times at which these evapotranspiration periods begin (**t_et**), the number of spatial zones along the cross section (**netzone**), and starting and ending columns for these zones (**nxfrom_et, nxto_et**), and the values of evapotranspiration within each zone (**etval**). If evapotranspiration is not to be simulated, then the user simply enters a value of **netper** = 0, and no values for **t_et**, **netzone**, **nxfrom_et**, **nxto_et**, and **etval** are required.

Constant head nodes are typically used to represent surface water bodies (lakes, rivers, wetlands), drains, or anywhere in the domain where the hydraulic head is known. Surface water bodies can be represented as constant head nodes by two different methods within the model. However, it is recommended that, if the water level in the surface water body changes frequently over time, the user select and input information using the 'Surface Water Body Data' option of entering data (see Appendix A.2.9). If the user selects this method, the user must create a separate file containing the water-level history of the surface water body. This file should be set up in ASCII format, and the first line in this file should contain number of entries in the file, and each successive line should contain a value of time, followed by a new hydraulic head value. Within the input data set, the user first specifies the number of distinct surface water bodies (**nwb**) within the cross section. For each surface water body, the user must specify the number of columns of nodes associated with a surface water body (**nchnodes_wb**), and the corresponding columns of nodes which represent the location of the surface water bodies (**icolumns**), as well as the file name that contains the water-level history described above (**file_wb**). The columns chosen should include every nodal column where the maximum hydraulic head in the water-level history of the surface water body exceeds the elevation of the ground surface, even if during parts or most of the simulation, the elevation of the surface water body is above ground surface at only a few columns. For example, if the surface of the water body specified in **file_wb** range between 100.0 an 101.0 m during the simulation period and has an initial elevation of 100.2 m, then all columns at the location of the surface water body where the ground surface is less than or equal to 101.0 m should be listed in **icolumns**. If the user does not want to enter surface water bodies or constant head nodes in this manner, then set **nwb** = 0 and do not enter values for **nchnodes_wb, icolumns**, and **file_wb**.

Surface-water boundaries can be simulated as contaminant sources in one of two ways. First, these water boundaries can be set up as source zones for particle transport. In this case, **option(18)** must be **.TRUE.**. If the user wishes to simulate particle tracking from a surface-water boundary, **nwbpart** should be set to **.TRUE.**, and values should be entered for the number of particles for each source cell (**npart_wb**) and the start and end times for the source zone (**ton_part_wb, toff_part_wb**). The second method available is solution to the advection-dispersion equation by the Galerkin finite element technique. If this method is desired,

option(18) must be set to **.TRUE.**, and **nwb_ad** should also be set to **.TRUE.**. Also, the user must specify values for the source concentration (**conc_wb**) and the start and end times between which the source is applied to the water boundary (**ton_ad_wb, toff_ad_wb**). The remaining parameters for advective-dispersive flow are to be added later in the data file (see Appendix A, section A.2.13).

Regular constant head nodes (non-surface water bodies) can also be specified (e.g., drains). With this method, the user specifies the number of constant head nodes (**nchead**). If a node is to be designated as a constant head node during a later time in the simulation (e.g., it is originally not a constant head node), then it should still be included in **nchead**. For each constant head node, the following must be specified. The location of each of these constant head nodes (or future constant head nodes) is specified by its the nodal column (**ich**) and row (**jch**). The original head value (**chval**) assigned to the node must also be entered, as well as the number of times the head value (for the current constant head node) will change during the simulation (**nchg_head**). If the node is originally not a constant head node, then assign a value of -1.0×10^{-35} to **chval** to designate that it will become a constant head node later during the simulation. The user may read the changing hydraulic head values for the constant head node from separate file (set **chead_file** = **.TRUE.**), or from the current input data file (set **chead_file** = **.FALSE.**). If **chead_file** is **.TRUE.**, then the name of the file that contains the changing head data (**chead_file_name**) must be specified. If this is the case, a list containing the time at which the value of head at the specific node changes (**t_new**) and the new value of head (**chg_h_val**) should be entered in **chead_file_name** and no additional information is required in the input data set. If **chead_file** is **.FALSE.**, a list of **t_new** and **chg_h_val** should be specified within the input data set and an additional file is not required. If the constant head node changes from a constant head node to a regular node during the simulation, then assign a value of -1.0×10^{-35} to **chg_h_val** to designate that it will become a regular node at time **t_new**. In either case, this list should contain **nchg_head** values. If the value of the constant head node does not change during the simulation, then set **nchg_head** = 0, and do not enter values for **chead_file**, **chead_file_name**, **t_new**, and **chg_h_val**. If the user does not wish to enter constant head nodes in this manner, then simply set **nchead** = 0 and do not enter any values for **ich**, **jch**, **chval**, **nchg_head**, **chead_file**, **chead_file_name**, **t_new**, and **chg_h_val**.

The model also has the flexibility to include pumping wells within the cross section. The location within the cross section from which the pumping actually occurs (i.e., screened interval of the well), is defined by identifying the nodes from which pumping occurs. The user first enters the number of pumping wells (**nwells**). For each well, the "well screen" is located by entering the left and right x-coordinates (**x1, x2**) and the upper and lower z-coordinates (**z1, z2**) of a box representing the location of the well screen. All nodes within this box are identified as the well screen, and a pumping rate is applied to each of these nodes. The user can change the pumping rate during the simulation, by entering the number of pumping periods (**n_pump_per**), the time at which the change occurs (**ton_pw**), and the new pumping rates (**prate**). The pumping rate specified is that which is assigned to each node within the well screen box. If only one period of pumping occurs, enter **n_pump_per** = 1. If there are no pumping wells, the user simply enters a value of **nwells** = 0, and does not enter values for **x1, x2, z1, z2, n_pump_per, ton_pw**, and **prate**.

The length of the simulation, size of the time steps, and times at which information is output are controlled by the user. Rather than running the model to a specific number of time steps, the user specifies the actual time in which the simulation should stop (**ftime**). This is done because the size of the time step is allowed to vary and thus, desired times can be attained regardless of the size or number of time steps. The user selects an initial time step (**delt**), and the rate at which the time step increases in size (**deltin**). If a constant time step is desired, the user enters **deltin** = 1.0, else the time step will increase in size until the specific maximum time step size (**dtmax**) is reached, at which point the time step (**delt**) will remain constant for the rest of the simulation. Because of the nonlinear nature of the solution, the user must also enter the convergence tolerance (**tolrnc**) for convergence within an iteration. A value of 0.001 is recommended. This value represents 1 mm of hydraulic head, if the units of length are metres. The user must also specify the maximum number of iterations for the nonlinear portion of the code (**nitmax**). Typically, the code will converge in less than 10 iterations, but in some cases, more iterations may be required (for example, when water levels in surface water boundaries change rapidly).

Output is generated at times specified by the user in two ways. First, a variety of information about the grid, hydrogeology, and contaminant distribution of the cross section (see **options** above) is output as either printed output or as data files which can be used as input to other

software (see **options** above and Appendix A.3). The number of times at which information is to be printed (**n_out_time**) and the desired times (**t_out**) are input by the user. The user should specify at least one output time. Because the simulation may proceed with a varying time step, it may be difficult to know the exact simulate times throughout the simulation. However, the time step calculated by the program will adjust such that the user-specified output times will be reached. Secondly, the elevation of the water table at any location along the cross section can be printed, producing a time series record of water table elevations for all time steps. This could be used to compare the model's prediction of water table elevations to a water table well located along the cross section. Any number of observation points can be selected by entering the number of observation points along the water table (**n_obs**) and the column correspond to the desired location of output of water table elevations (**nobs_col**).

The user can also simulate solute transport and basic reactions using one of two methods. When the particle tracking method, which uses the deterministic-probabilistic mass transport method is selected (**option(17)** = **.TRUE.**), only mass transport by advection and dispersion occurs. The user defines the initial mass of each particle (**xmassi**), and then enters the number of source zones within the cross section (**npart_zones**). Then for each source zone, the user defines the location and size of the source zone by entering the left and right columns (**plcol, prcol**), and bottom and top rows (**pbrow, ptrow**), bounding the source zone. The user specifies the number of solute particles are added to each source zone (**npper**), the time at which particles are introduced into the source zone (**t_start_part**), and the time at which particles stop entering the source zone (**t_stop_part**). If the user wishes to enter particles for only one time step, they should enter the same time for both **t_start_part** and **t_stop_part**. Each source zone can have a different size, number of particles entered, and different times at which particles are placed in the source zone. If mass transport by this method is not selected (**option(17)** = **.FALSE.**), none of these data are entered.

When solute transport using the Galerkin method for the solution of the advection-dispersion equation is selected (**option(24)** = **.TRUE.**), the user can simulation both advective and dispersive transport as well as limited reactions that retard (**retfact**) or decay (**decay**) the contaminant. **retfact** represents the dimensionless retardation factor, and **decay** represents the decay coefficient or degradation rate constant. Also required are the free-solution diffusion

coefficient (**dstar**) and the tortuosity of the medium (**tort**). There are also options for the time-weighting formulation for the Galerkin solution for the advection-dispersion equation. **epsi** can be set to 0.0 (explicit formulation), 0.5 (Crank-Nicolson weighting) or 1.0 (implicit). It is recommended that 0.5 be used because this value results in the most stable solution. If **consist** = **.TRUE.**, consistent formulation is used, whereas if **consist** = **.FALSE.**, lumped formulation is used. This refers to the way in which concentrations are obtained from the Galerkin method. It has been shown that consistent formulation results in less error in the solution, and is thus recommended. Once this data is entered, the user must enter the number of source zones inside which the concentration must be specified (**n_conc_zones**). For each concentration source zone, the user must specify the x- (**x1conc, x2conc**) and z-coordinates (**z1conc, z2conc**) that define a box inside which all nodes will be assigned a fixed concentration value. **x1conc** and **x2conc** represent the minimum and maximum x-values of the 'box', respectively, while **z1conc** and **z2conc** represent the minimum and maximum z-values of the box. The final variable for this section is **cinit**, which represents the concentration value assigned to the current zone. The units are in relative concentrations, so all concentrations calculated in the domain will be relative to **cinit**.

Other programming hints are shown below:

- The values specified at constant head nodes are allowed to change in time. In addition, constant head nodes can be turned 'off' by specifying the value to be '$-1.0e^{+35}$'.
- When making use of the restart option (see **option(10), option(11), option(22)**), there are a few things to keep in mind.
  - If you wish to CREATE a restart file, **option (10)** should be **.TRUE.**. This will create a file called `prefix.hou`. Output will be written to this file at the most recent output time that is specified in the data file (`prefix.dat`). To input from a restart file, it is recommended that you rename the `prefix` to, for example, `prefix2`. Also, the `prefix.hou` file will have to be renamed `prefix2.hin`. The new data file (`prefix2.dat`) should be modified as discussed below. To restart `prefix2.dat`, **option(11)** should be set to **.TRUE.**.

- If you restart at time $t = t_{rs}$ you must change to following such that they do not include any data changes at $t < t_{rs}$.
    - constant head nodes
    - infiltration/evapotranspiration
    - pumping rate
    - output times.
- Make sure that at the first solution time, there are no changes in (1) the values of heads at constant head nodes, (2) infiltration and evapotranspiration rates (3) pumping rates.
- As of December 1998, the restart option only works for the flow solution, and particle tracking; it does not currently work for concentrations generated by the solution of the advection-dispersion equation.
- If particle tracking is simulated, the final locations of the particles are written to the `prefix.hou` file. So, if the `prefix2.dat` file is restarted as described above, you should remove the particle data, or you'll be starting particles from their original locations in addition to the restarted particles.

4.0 ILLUSTRATIVE EXAMPLES

The objective of this chapter is to demonstrate how the model can be used to simulate typical scenarios. Also, this chapter aids in understanding and interpreting results from the model. In this chapter, two illustrative examples are presented. The first example involves transient groundwater flow in the vicinity of a short-term river flood. In this case, the ambient groundwater flow direction is towards the river; however, as the water level in the river rises during, for example, a spring flood, the groundwater flow direction may reverse such that water flows from the river into the groundwater system. Moreover, if the flood water in the river is contaminated, the groundwater may also become contaminated. This example examines this issue by including particle tracking whereby contaminant particles are added adjacent to the river during the flooding event. The second example is used to illustrate the new feature of the model that allows the inclusion of a vertical-walled ditch in the centre of the domain. In this one-year simulation, the water level rises one metre in the spring, and then drops. The water table is examined as a result of this high water-level event.

4.1 Example 1: Contaminant transport from a river flood

In the first example, the water level in a river is steady for one year. During this time, groundwater flows from the aquifer into the river due to recharge that is applied to the aquifer. In the second year, the water level in the river rises rapidly during a flooding event and then drops to its previous low level. The water level history for the river is shown in Figure 4.1. The cross-section is 200 metres wide and the river exists on the right-hand side of the domain (Figure 4.2). Boundary conditions have been set up such that the nodes along the river are specified head nodes that have values which vary in time. The remaining nodes along the water table are specified-flux nodes to represent recharge. The remaining boundary nodes have been set to no-flow boundaries (left and right sides, and bottom). The input data file for this example is listed in Appendix B, and the output file is listed in Appendix C.

The initial water level in the river is 21 metres and during the flood, the maximum water level in the river is 29 metres, which represents the elevation of the flood plain, as shown in the schematic in Figure 4.2. The flood lasts approximately five days at its peak water level before falling to its initial value of 21 metres. For solute transport, particle tracking is carried out by

adding particles to cells adjacent to the river. Particles are only added during the time of the flood (approximately 365 to 370 days into the simulation).

Figure 4.3 shows results from this simulation at four different times. At 365 days, the flood has just started, and the river level is still low. Groundwater still appears to be flowing from the aquifer into the river, and particles remain close to the river along the interface between the river and the aquifer. At a time of 369 days, the water level in the river is at its maximum, and at this time, the number of source cells associated with particle tracking has increased because the river has reached the flood plain. Consequently, the distribution of particles is much more extensive. Also, near the river, groundwater appears to be flowing from the river into the aquifer. At 370 days, the water level in the river has begun to subside and immediately adjacent to the river, groundwater is now flowing from the aquifer into the river. However, there is still a noticeable groundwater mound that results in the particles flowing away from the river. By 500 days, the river level has reached its original level and all remaining particles are migrating towards the river. Assuming conditions remain constant, all of these remaining particles will eventually exit into the river.

4.2 Example 2: Groundwater flow in the vicinity of a ditch

Drainage ditches are commonly used to lower the water table in the surrounding area. For example, when mining peat, the water level must be lowered in order to make peat extraction more practical. The spacing between the drainage ditches will depend upon other factors, which control the water table, such as the rates of precipitation and evapotranspiration as well as hydraulic parameters of the peat such as the porosity, hydraulic conductivity and storage coefficient. In this illustrative example (Figure 4.4), a single drainage ditch is added to the central area of a 2D cross sectional domain. The computational domain has been set up to be 120 metres wide and 6 metres high with an irregular ground surface. The boundary conditions have been set up such that the ditch nodes are specified head nodes with values that change over time. The remain nodes along the water table are specified as constant flux nodes with a small amount of recharge in order to establish groundwater flow from the aquifer towards the ditch. All other boundary nodes (along the bottom and left and right boundaries) have been set as no-flow boundaries.

The simulation is 365 days long, and a schematic of the domain is shown in Figure 4.4. Figure 4.5 shows the water-level history for the ditch. The initial water level in the ditch is 3 metres, and rises to a peak of 4 metres from approximately 65 to 80 days. This is assumed to represent spring levels that may result from increased precipitation as well as melting of the winter snow pack.

Figure 4.6 shows results from this simulation at four different times. As the water level in the ditch rises, gradients reverse, and groundwater flows from the ditch into the aquifer (62.5 days). At 65 days, the water level in the ditch is at its maximum, and flow is still from the ditch into the aquifer. By 80 days when the water level in the ditch is still high, the water level in the surrounding aquifer has had time to rise in response to the high water level in the ditch. However, by 90 days, the water level in the ditch has dropped to its original level, and the groundwater flow direction is from the aquifer towards the ditch once again.

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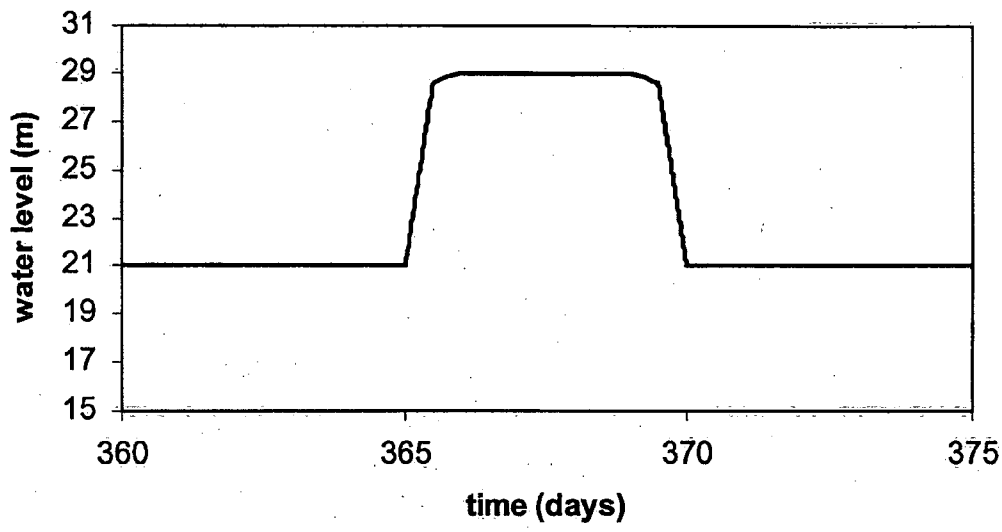

Figure 4.1 - Water-level history for the river flood

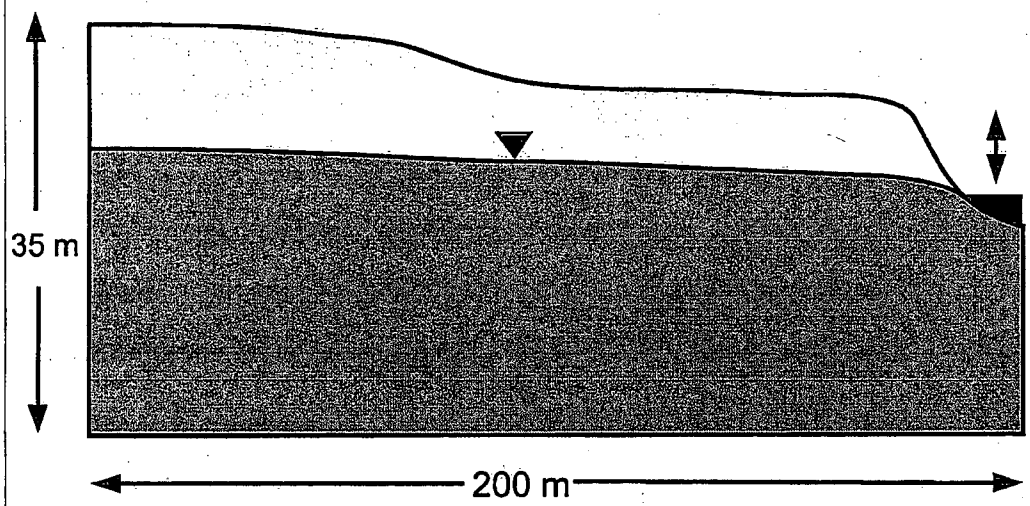

Figure 4.2 - Schematic of the river-flood example.

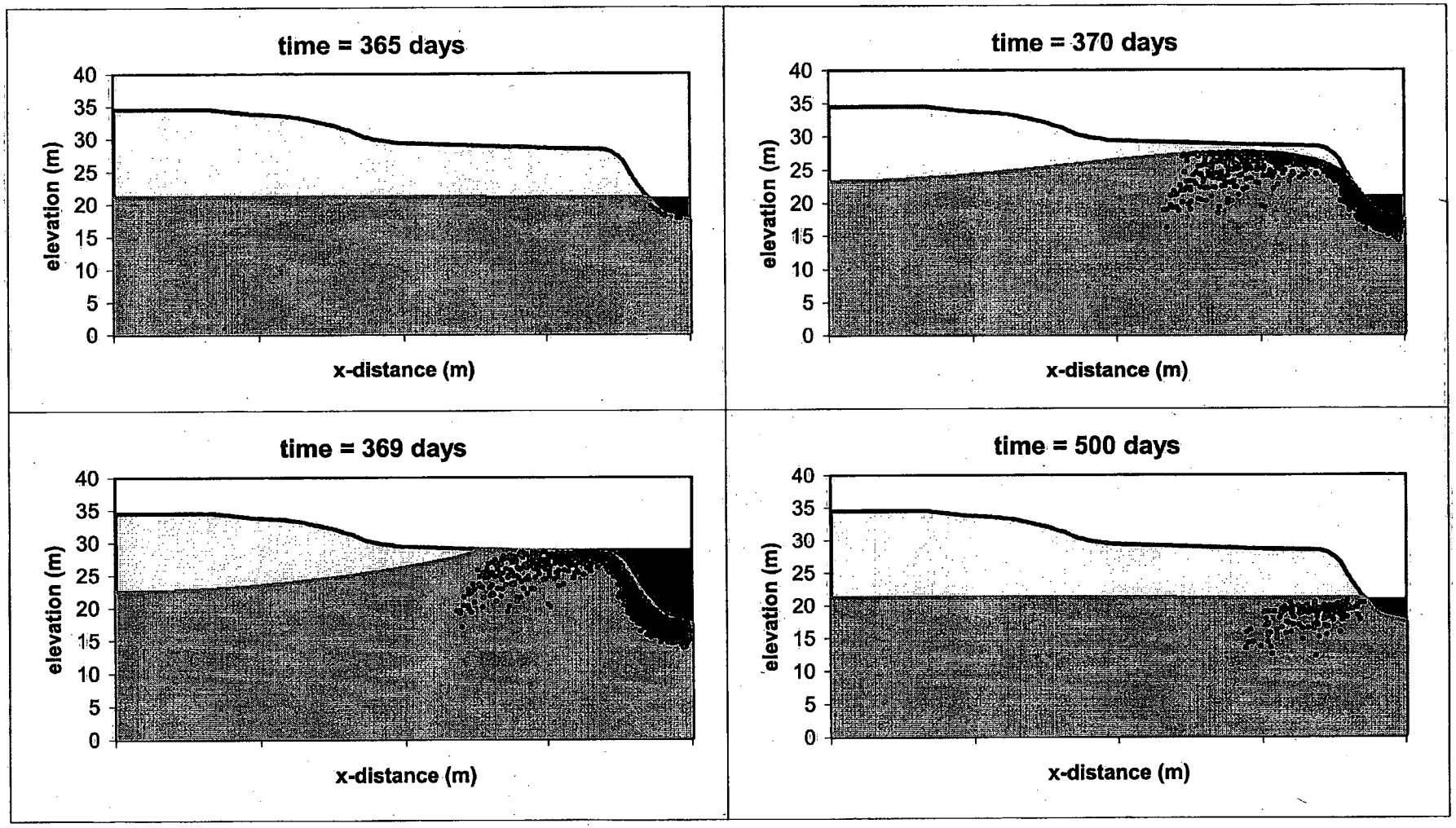

Figure 4.3 - Results from the river-flood example.

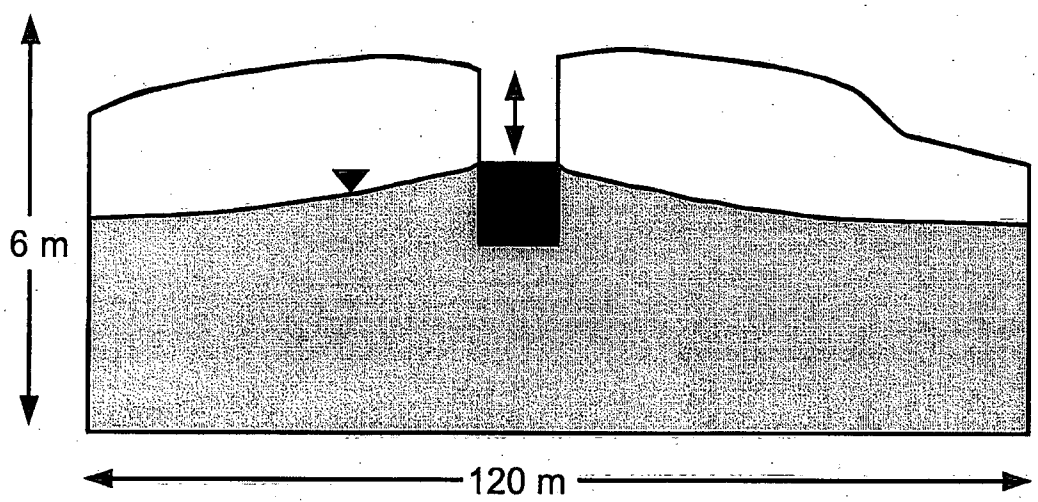

Figure 4.4 - Schematic of the ditch example.

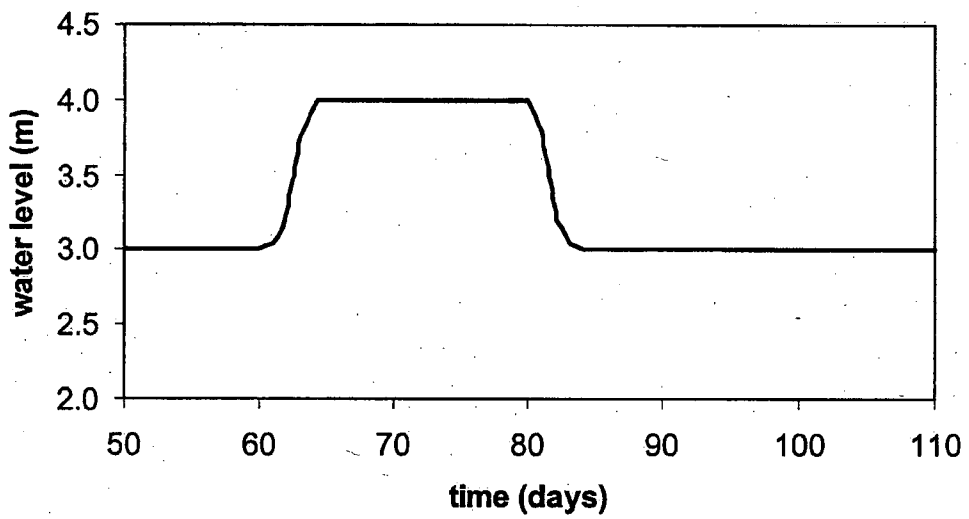

Figure 4.5 - Water level history for the ditch example.

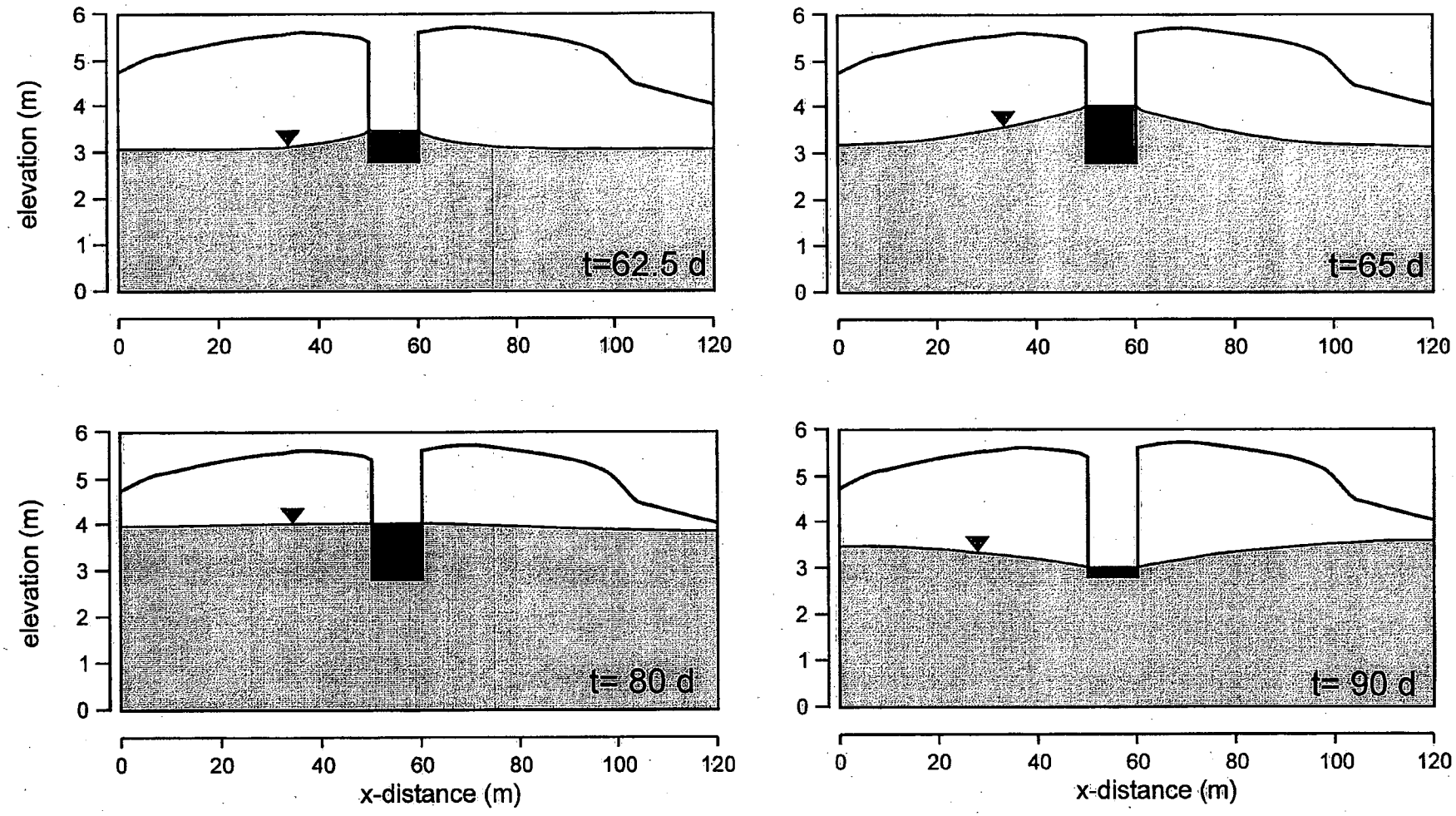

Figure 4.6 - Results from the ditch example.

APPENDIX A- INPUT GUIDE

This appendix is setup as follows: Section A.1 describes some general points with regards to input instructions. Section A.2 describes the specific input requirements for the data file that are used to run the code. Section A.3 lists files that are created by a successful simulation and Section A.4 lists the arrays and dimensions. Section A.5 lists some tips in ensuring that a simulation is completed successfully.

A.1 General Notes

- The executable file should be run through a DOS window.
- Once the code is run, the user will be asked to input the `prefix`. The prefix represents the filename without the three-letter extension. The prefix must have a '`.dat`' extension and be 7 characters or less in length. If the data file is not found on the current directory, an error message will appear and the program will stop.
- Any line in the `prefix.dat` file that begins with a '!' is a comment line and will be ignored by the program. This option is useful for placing statements within the data file to aid the user in finding exactly where specific parameters are located.
- All data is free-format. In other words, the user does not have to be concerned with aligning the input parameters in specific columns. Variables that occur on the same line must be separated by a space or a comma.

A.2 Input Guide

A.2.1 Program Title

1. **Title** - Any character string (up to 80 characters in length).

(**NOTE**: If the user needs more title lines, they can make use of the '!' option discussed above; however, you must have one legitimate title line that does not begin with '!'.)

A.2.2 Program Options

NOTE: For the program options listed below, all output is written in ASCII format to the file called `prefix.out` unless otherwise specified. Also, setting options (1), (2), (3), (9), (13), (18), (23), to **True** can result in a very large `prefix.out` file.

2. **option(1)** - LOGICAL - **True**: print nodal coordinates; **False**: do not print nodal coordinates.
3. **option(2)** - LOGICAL - **True**: print elemental incidences; **False**: do not print elemental incidences.
4. **option(3)** - LOGICAL - **True**: print elemental K, S; **False**: do not print elemental K, S.
5. **option(4)** - LOGICAL - **True**: print node/element data to `prefix.ele` file; **False**: do not print node/element data to `prefix.ele` file.

6. **option(5)** - LOGICAL - **True**: calculate heads; **False**: do not calculate heads.
7. **option(6)** - LOGICAL - **True**: print heads to output file; **False**: do not print heads to output file. **NOTE**: This must be set the **True** if GridBuilder files are desired as output.
8. **option(7)** - LOGICAL - **True**: print heads to `prefix.hds` file; **False**: do not print heads to `prefix.hds` file.
9. **option(8)** - LOGICAL - **True**: print only final heads to `prefix.hds` file; **False**: do not print only final heads to `prefix.hds` file.
10. **option(9)** - LOGICAL - **True**: print water table convergence data; **False**: do not print water table convergence data.
11. **option(10)** - LOGICAL - **True**: input old heads (from file `prefix.hin`) to continue a run; **False**: do not input old heads to continue a run.
12. **option(11)** - LOGICAL - **True**: output last heads for a later run (to file `prefix.hou`); **False**: do not output last heads for a later run.
13. **option(12)** - LOGICAL - **True**: generate gradients/directions; **False**: do not simulate gradients/directions.
14. **option(13)** - LOGICAL - **True**: print gradients to output file; **False**: do not print gradients to output file.
15. **option(14)** - LOGICAL - **True**: output gradients to `prefix.hyd` file; **False**: do not output gradients to `prefix.hyd` file.
16. **option(15)** - LOGICAL - **True**: generate velocity field (if **True**, **option(12)** must be **True**); **False**: do not generate velocity field.
17. **option(16)** - LOGICAL - **True**: print velocity field to `prefix.vel` file; **False**: do not print velocity field to `prefix.vel` file.
18. **option(17)** - LOGICAL - **True**: run solute transport using the deterministic-probabilistic routine; **False**: do not run the deterministic-probabilistic routine.
19. **option(18)** - LOGICAL - **True**: print concentrations/particle distribution; **False**: do not print concentrations/particle distribution.
20. **option(19)** - LOGICAL - **True**: output concentrations/particle distribution to `prefix.con` file; **False**: do not output concentrations/particle distributions.
21. **option(20)** - LOGICAL - **True**: output particle distribution (`prefix.prt` file); **False**: do not output particle distribution.
22. **option(21)** - LOGICAL - **True**: output last particle distribution for later input (to file `prefix.hou`); **False**: do not output last particle distribution for later input.
23. **option(22)** - LOGICAL - **True**: input particles from an old run (`prefix.hin` file); **False**: do not input particles from an old run (see section A.5 for more details).
24. **option(23)** - LOGICAL - **True**: print mass and particle coordinates; **False**: do not print mass and particle coordinates.
25. **option(24)** - LOGICAL - **True**: run solute transport using the Galerkin method; **False**: do not run solute transport using the Galerkin method.

A.2.3 Observation Points

26. **n_obs** – INTEGER – Number of observation points at which water table elevations will be output at every time step.
27. **nobs_col(n_obs)** – INTEGERS – Column corresponding to the desired location for output of water table elevations and nodal hydraulic heads (**NOTE** – repeat this line **n_obs** times. If **n_obs** = 0, skip this line.).
28. **nobs_row(n_obs)** – INTEGERS – row corresponding to the desired location for output of water table elevations and nodal hydraulic heads (**NOTE** – repeat this line **n_obs** times. If **n_obs** = 0, skip this line.).

A.2.4 Grid/Boundary Condition/Time Stepping Input

29. **nrow, ncol** - 2 INTEGERS - Number of rows of nodes; Number of columns of nodes. (**NOTE**: **ncol** must be exact and **nrow** must be large enough to accommodate the maximum elevation of the ground surface.)

30. **ngeol, nitmax** - 2 INTEGERS
    - Number of geological units
    - Maximum number of iterations per time step.

31. **var_x** - LOGICAL - **True**: variable grid spacing in x-direction; **False**: constant grid spacing in x-direction.

32. **xe(ncol-1)**: REAL – Grid spacing in the x-direction (horizontal). If **var_x** = **True**, enter (**ncol-1**) values of **xe** (for variable grid spacing in x); if **var_x** = **False**, enter only one value (constant grid spacing in x).

33. **delz** - REAL - Grid spacing in the z-direction (vertical).

34. **ftime** - REAL - Final simulation time (the simulation will stop when it reaches this time regardless of whether or not steady state has been reached).

35. **n_out_time** - INTEGER - Number of desired times at which to create output.

36. **t_out(n_out_time)** - REAL - Desired output times. The user must specify at least one output time.

37. **delt, dtmax**: 2 REALS - Initial time step size; Maximum time step size.

38. **headi**: REAL - Initial head value assigned to the entire computational domain.

39. **specyd, tolrnc, deltin** - 3 REALS
    - Specific Yield
    - Convergence tolerance (for both steady-state convergence and iteration convergence)

- Factor by which to increase the size of the time step (until **dtmax** is reached).

A.2.5 Column Data

40. **elvgrd(ncol)** - REAL - Elevation of the ground surface. Enter one value for each column of nodes.

41. **wtmove(ncol)** - LOGICAL - **True**: Water table is allowed to move; **False**: Water table is not allowed to move. Enter one value for each nodal column.

42. **headwt(ncol)** - REAL - Initial head values along the water table. Enter one value for each nodal column. If there are any constant head nodes along the water table, the value of **headwt** at these nodes should be set to the initial constant-head value.

43. **elvbas(ncol)** - REAL - Elevation of the base of the domain. Enter one value for each nodal column.

A.2.6 Drainage Ditches

44. **ditch** – LOGICAL - **True**: Include a drainage ditch; **False**: Do not include a drainage ditch. (NOTE: if **True**, include lines 45 and 46 below; if **False**, skip lines 45 and 46 and proceed directly to line 47.) Currently, only one single ditch can be added, and it must exist throughout the entire duration of the simulation.

45. **dleft, dright,dbottom** – 3 REALS
    - Left boundary of the desired ditch (in terms of grid coordinates, in metres).
    - Right boundary of the desired ditch (in terms of grid coordinates, in metres).
    - Right boundary of the desired ditch (in terms of grid coordinates, in metres).
    - NOTE: data input from this section will override the information for the elevation of the ground surface that has been previously entered.

46. **ditchheadfile** – CHARACTER – File name for the data file that contains the water-level history for the ditch. The format of this data file is as follows: on the first line of the data file, the number of water-level changes within the ditch is required (**n_ditchhead_chg**). Subsequent lines in this other file should contain, first, the time at which the new water level is to occur (**t_ditch_head(n_ditchhead_chg)**), and second, the new water level for the current time (**ditch_head(n_ditchhead_chg)**).

A.2.7 Infiltration/Evapotranspiration Data

47. **nrestp** – INTEGER - Number of different recharge periods. If **nrestp** = 0, skip to line 50. For each recharge period, the user can specify different zones, if the recharge varies spatially.

48. **t_rech, nrzones** - REAL, INTEGER (Repeat this line for each value of **nrestp**).
    - Time at which to apply the new recharge values
    - Number of spatial zones for current recharge period.

49. **nxfrom, nxto, rval** – 2 INTEGERS, REAL (Repeat this line for each value of **nrzones**).
    - Starting nodal column for current recharge zone
    - Ending nodal column for current recharge zone
    - Recharge value for current recharge zone.

50. **netper** – INTEGER - Number of different evapotranspiration periods. If **netper** = 0, skip to line 53. For each evapotranspiration period, the user can specify different zones, if the evapotranspiration varies spatially.

51. **t_et, netzone** - REAL, INTEGER (Repeat this for each value of **netper**)
    - Time at which to apply the new evapotranspiration values
    - Number of spatial zones for current evapotranspiration period.

52. **nxfrom_et, nxto_et, etval** – 2 INTEGERS, REAL (Repeat this for each value of **netper**)
    - Starting nodal column for current evapotranspiration zone
    - Ending nodal column for current evapotranspiration zone
    - Recharge value for current evapotranspiration zone.

A.2.8 Constant Head Data

53. **nchead** – INTEGER - Number of constant head nodes. If **nchead** = 0, skip to line 58. **NOTE**: For each **nchead**, repeat lines 54-57.

54: **ich(nchead), jch(nchead),chval, nchg_head(nchead)** - 2 INTEGERS, 1 REAL, INTEGER
    - Column number of current constant head node
    - Row number of current constant head node
    - Original value assigned to the current constant head node
    - Number of times to change the head value at the current constant head node (if **nchg_head** = 0 (i.e., a constant head node does not change, **chval** applies throughout the entire simulation, skip lines 55-57 for current constant head node).
    - * (**NOTE**: If the user wants to have a constant head node turned on at a later time, they must specify a value for **chval** here equal to -1.0×10^{-35}.)

55. **chead_file** - LOGICAL - **True**: if changing constant head data is read from another file (go to line 56, then skip 57. **NOTE**: if another file is used, data should be in the same format as line 57 below); **False**: if changing constant head data is read from this data file (skip line 56).

56. **chead_file_name** - Character String - filename which contains changing constant head data (if **chead_file** = **True**).

57: **t_new(nchg_head)**, **chg_h_val(nchg_head)** - 2 REALS

- Time at which to change the constant head value assigned to the current node
- New constant head value assigned to the current node.

* (**NOTE**: if a node is initially not a constant head node, the user must still flag it as a constant head node and assign it a value equal to -1.0×10^{-35}. The user can turn constant head nodes off at any time by specifying **chg_h_val** to be equal to -1.0×10^{-35}.)

A.2.9 Surface Water Body Data

58. **nwb** – INTEGER – Number of surface water bodies. **NOTE**: lines 59-67 must be repeated from 1 to **nwb** times. If **nwb** = 0, skip proceed directly to section A.2.10.

59. **nchnodes_wb(nwb)** – INTEGER - Number of columns associated with current surface water body. These nodes should be chosen where the maximum head in the water-level history for the current surface water body exceeds the elevation of the ground surface for the column.

60. **file_wb(nwb)** – CHARACTER - Filename that contains the water level history of the current surface water body. **NOTE**: the filename must be in ASCII format. The first row in the file should contain the number of entries in the file, and this must be followed by a list of time and water level.

61. **icolumns(nwb,nchnodes_wb)** – INTEGERS - Columns (of nodes) at which to apply data from current surface water body.

62. **nwbpart** – LOGICAL - **True**: include particle transport with current surface-water body as a source boundary (NOTE: make sure **option(18)** is set to **True**). **False**: do not include particle transport. (NOTE: if **nwbpart= True**, include steps 63 and 64 below. **nwbpart= False**, skip lines 63 and 64, and proceed to line 65).

63. **npart_wb(nwbpart)** – INTEGER - number of particles added to each cell that is associated with a surface-water boundary.

64. **ton_part_wb(nwbpart), toff_part_wb(nwbpart)** – 2 REALS
- Time at which to start adding particles to the surface-water boundary.
- Time at which to stop adding particles to the surface water boundary.

65. **nwb_ad** – LOGICAL - **True**: include advection-dispersion transport with current surface-water body as a source boundary (NOTE: make sure **Option(24)** is set to **True**). **False**: do not include advection-dispersion. (NOTE: if **nwb_ad= True**, include steps 66 and 67 below. **nwb_ad= False**, skip lines 66 and 67, and proceed to line 68).

66. **conc_wb(nwb_ad)** – INTEGER - source concentration that is associated with a surface-water boundary.

67. **ton_ad_wb(nwb_ad), toff_ad_wb(nwb_ad)** – 2 REALS
- Time at which to start advection-dispersion with the surface-water boundary as a source boundary
- Time at which to stop advectio-dispersion with the surface water boundary as a source boundary.

A.2.10 Pumping Well Data

68. **nwells** - INTEGER - Number of pumping wells. If **nwells** > 0, loop over lines 69 to 73 for each 'nwell', otherwise if **nwells** = 0, skip to line 71.

69. **x1, x2** - 2 REALS - X-range within which all nodes will be flagged as well nodes with the following well parameters.

70. **z1, z2** - 2 REALS - Z-range as above. **NOTE**: **x1, x2, z1, z2** define a box inside which all nodes will be assigned the following well parameters. Each node within the box will be assigned the same pumping rate, and the flux is not 'distributed'.

71. **n_pump_per(nwells)** - INTEGER - Number of pumping periods for current well (**NOTE**: if a constant pumping rate is desired, **n_pump_per** must be set to 1. Thus, this variable should always be > 0 if wells are considered.)

72. **ton_pw(nwells, n_change_pw(nwells))** - REAL - Time at which to change to new pumping rate for current pumping period(**NOTE**: repeat Lines 72 and 73 up to the value in Line 71).

73: **prate(nwells, n_change_pw(nwells))** - REAL - New pumping rate for current pumping period.

A.2.11 Stratigraphy Data

74. **l(ngeol)** - INTEGER - Zone number.

75. **khorz, kvert** - 2 REALS - Horizontal and vertical hydraulic conductivities for the current zone **l**.

76. **stor, por** - 2 REALS - Storage coefficient and porosity for the current zone **l**.

77. **disperl, dispert** - REAL - Longitudinal and transverse dispersivities of the current zone **l**. If transport is not done, these values are still read in, but are not used.

78. **code** - LOGICAL - **True**: particles are allowed to move within this zone; **False**: particles are not allowed to move within this zone (via particle tracking).

NOTE: Repeat lines 74 to 78 from (1 to **ngeol**).

79. **mapgeo(ncol, nrow)** - INTEGER - Map of zone numbers. Repeat, beginning at the top of the grid, for each row (where each row contains the code for each column). This map should be entered as it appears – in other words, the lower-left corner of the cross section should be entered in the lower-left corner of this map.

A.2.12 Particle Tracking Data

NOTE: This section is only used if **option(17)** is **True**.

80. **xmassi** -REAL - Initial mass added per particle.

81. **npart_zones** - INTEGER - Number of particle source zones.

NOTE: Lines 82-85 are repeated from (1 to **npart_zones**).

82. **npper** - INTEGER - Number of particles to add.

83. **t_start_part, t_stop_part** – 2 REALs - Time at which to add particle(s) for current particle source zone; time at which to stop adding particle(s) for current particle zone.

84. **plcol, prcol** - 2 INTEGERS - Left and Right columns of nodes defining the end columns for the current particle source zone.

85. **pbrow, ptrow** - 2 INTEGERS - Bottom and Top rows of nodes defining the end rows for the current particle source zone.

A.2.13 Advection/Dispersion Data

NOTE: This section is only used if **option(24)** is **True**.

86. **retfact, decay** - 2 REALS - Retardation factor; decay coefficient.

87. **dstar, tort** - 2 REALS - Diffusion coefficient; tortuosity.

88. **epsi** - REAL - Time-weighting factor (=0.5 for Crank-Nicolson time-weighting).

89. **consist** - LOGICAL - **True**: for consistent formulation; **False**: for lumped formulation.

90. **n_conc_zones** - INTEGER - Number of specified concentration zones.

NOTE: Lines 91-93 are repeated for (1 to **n_conc_zones**).

91. **x1conc, x2conc** - 2 REALS - X-coordinates of the start and end values that define a box inside which all nodes are constant concentration.

92. **z1conc, z2conc** - 2 REALS - Z-coordinates of the start and end values that define a box inside which all nodes are constant concentration.

93. **cinit** - REAL - Concentration value assigned to current zone.

A.3 Output Files

The current version of the code produces the following output files:

`prefixn.imp` - Files that can be 'imported' into *GridBuilder* (**NOTE**: the '`n`' that is appended on the prefix represents a counter for each output time. For example, if three output times are specified, three files will be created: `prefix1.imp`, `prefix2.imp`, `prefix3.imp`)

`prefixn.n01` - Files containing hydraulic head values at each output time (`n`). As before, one file is created for each specified output time. These files are in ASCII format and can be read in as nodal files in *GridBuilder*.

`prefixn.e01` - Files containing elemental hydraulic conductivity values at each output time, (`n`). As before, one file is created for each specified output time. The files are in ASCII format and can be read in as element files in *GridBuilder*. (**NOTE**: One file is created at each specified output time because the finite element grid may be changing in time.)

`prefixn.e02` - Files containing particle concentrations at each output time, (`n`). Because particle concentrations are formulated on a cell basis, cell concentrations are converted to an elemental basis (where each cell is comprised of two triangular finite elements). As before, one file is created for each specified output time. The files are in ASCII format and can be read in as element files in *GridBuilder*. (**NOTE**: One file is created at each specified output time because the finite element grid may be changing in time.)

`prefixn.v01` - Files containing elemental velocity values (V_x, V_z) at each output time. As before, one file is created for each specified output time. The files are in ASCII format and can be read in as velocity files (in 'Edit Elements') in *GridBuilder*.

`prefixn.f01` - Files containing cell concentrations from the particle tracking routine. This file can be read by *GridBuilder* using the 'Field Data' option.

`prefixn.f02` - Files containing particle locations from the particle tracking routine. This file can be read by *GridBuilder* using the 'Field Data' option.

`prefixn.c01` - Files containing nodal concentrations from the advection/dispersion equation. These are ASCII files and can be read by *GridBuilder* as nodal files.

`prefix.ob1` - `prefix.ob9` – Files containing water-table heads versus time for specified columns. Up to 9 columns can be specified.

`prefix.mb1` – Fluid mass balance information.

`prefix.swb` – Fluxes at surface water bodies. For example, if two surface water bodies exist, this file will contain a list of columns containing (1) time, (2) fluid flux at the first surface water body, (3) fluid flux at the second water body.

`prefix.tim` – Computation time. This file contains 2 columns of data: (1) cumulative CPU time at each time step and (2) total elapsed time at each time step. **NOTE**: CPU time calculations will only work for the current version of the program, which as been compiled using Microsoft PowerStation Fortran, version 4.0.

The procedure for using *GridBuilder* to view output is as follows:

In *GridBuilder*, click on 'File/Import'. Go to the directory the contains the `prefixn.imp` and click on the file which you want to import. After a series of prompts, the grid should appear in the *GridBuilder* window. On the main *GridBuilder* menu, choose 'File/Save' and create a new file name. Then convert the file to ASCII format, and save all subsequent files that are imported in ASCII format. In a DOS window, copy the prefixn.n01 (and/or .v01, .e01, .f01, .f02, .c01) file to a new file with the new prefix which you specified in *GridBuilder* . The extension must

remain the same. (**NOTE**: the *.c01 files must be renamed with .n01 extensions to be read as nodal files in *GridBuilder*).

A.4 Dimensioning of Arrays

Included with the program is a file that contains arrays that are used in the program. If you require dimensions that are larger than those specified in the file, you must change the values that are shown below in the 'parameter' statements and recompile the program. The parameters and values are outlined below. The values listed below have been set to be large enough to run the example problems.

```
parameter(maxnx=211,maxnz=201)
parameter(maxnxe=maxnx-1,maxnze=maxnz-1)
parameter(maxnn=maxnx*maxnz,maxne=maxnxe*maxnze*2)
parameter(mxzone=3)
parameter(mxchd=235)
parameter(maxbnd=251)
parameter(maxtime_chd=4300)
parameter(maxtime_chg_rch=180)
parameter(maxtime_chg_et=121)
parameter(max_outtime=300)
parameter(maxwell=1,maxwellnode=maxwell*60)
parameter(maxwellperiod=1)
parameter(maxpt=250000)
parameter(maxts=4000)
parameter(mx_conc_zone=1)
parameter(max_part_zone=10)
parameter(mx_conc_node=50)
parameter(maxnwb=5)
```

maxnx	= maximum number of nodes in x-direction (i.e., columns of nodes)
maxnz	= maximum number of nodes in z-direction (i.e., rows of nodes)
maxnxe	= maximum number of columns of elements
maxnze	= maximum number of rows of elements
maxnn	= maximum total number of nodes
maxne	= maximum total number of elements
maxzone	= maximum number of different K zones
mxchd	= maximum number of constant head nodes
maxtime_chd	= maximum number of times to change the value of head at a constant head node
maxtime_chg_rch	= maximum number of times to change the recharge values
maxtime_chg_et	= maximum number of times to change evapotranspiration values
max_outtime	= maximum number of output times
maxwell	= maximum number of pumping wells

maxwellnode	= maximum total number of nodes that represent wells
maxwellperiod	= maximum number of times to specify different pumping rates
maxpt	= maximum total number of particles
maxts	= maximum number of time steps
max_part_zone	= maximum number of source zones for particles
mx_conc_zone	= maximum number of fix (Dirichlet) concentration zones
maxnwb	= maximum number of surface water bodies.

A.5 Units

grid spacing	m
hydraulic conductivity	m/d
elevations (w.t., ground surface, base of domain)	m
initial value of head	m
initial value heads along w.t.	m
initail values of constant heads	m
value of recharge	m/d
value of evapotranspiration	m/d
pumping rates	m/d
time step	d
output times	d
times when recharge or evapotranspiration applied	d
dispersivity	m
solute concentration	mg/L
initial mass of each particle	mg

APPENDIX B - INPUT DATA FILE FOR EXAMPLE 1

```
! flood simulation
! March 22, 2000
Flood.dat
f   ;(1)Print nodal coordinates
f   ;(2)Print elemental incidences
f   ;(3)Print elemental K and S
f   ;(4)Print nodes/elements to file
t   ;(5)Calculate Heads
f   ;(6)Print Heads
t   ;(7)Print Heads to a file (*.hds)
f   ;(8)Print only last heads to a file (*.hds)
f   ;(9)Print water table convergence info
f   ;(10)Input old heads to continue a run
f   ;(11)print last heads for input for a later run
t   ;(12)generate gradient/direction field
f   ;(13)print gradients/directions
f   ;(14)output gradients/directions
t   ;(15)generate velocity field
f   ;(16)output velocity field
t   ;(17)run mass transport
f   ;(18)print concentrations/particle distributions
f   ;(19)output concentrations/particle distributions
f   ;(20)output particle distribution
f   ;(21)output last particles for input to continue a run
f   ;(22)input last particles to continue a run
f   ;(23)print mass, X,Z coordinates of particles
f   ;(24) Run advection/dispersion
0            ;nobspts
 181   201   ;nrow, ncol
  1  100     ;ngeol,nitmax
f            ;var_x (T for var. delx, F for const. delx - if F, enter only 1 value)
1.0
.2d0         ;delz
730.0        ;ftime
2            ;n_out_time
365.0
730.0
0.5  2.5     ;delt,dtmax
21.0         ;headi
0.200 .005  1.05   ;specyd,tolrnc,deltin
!  elvgrd
34.5 34.5 34.5 34.5 34.5 34.5 34.5 34.5 34.5 34.5
34.5 34.5 34.5 34.5 34.5 34.5 34.5 34.5 34.5 34.5
34.5 34.5 34.5 34.5 34.5 34.5 34.5 34.5 34.5 34.5
34.5 34.5 34.5 34.5 34.45 34.4 34.35 34.3 34.25 34.2
34.15  34.1 34.05 34 33.95 33.9 33.85 33.8 33.775 33.75
33.725 33.7 33.675 33.65 33.625 33.6 33.575 33.55 33.525 33.5
33.4 33.35 33.3 33.25 33.2 33.1 33 32.9 32.8 32.7
32.6 32.5 32.4 32.3 32.2 32.1 32 31.8 31.65 31.5
31.4 31.3 31.1 30.9 30.7 30.5 30.3 30.2 30.1 30
29.9 29.8 29.75 29.7 29.65 29.6 29.5 29.415 29.4 29.385
!
29.37 29.355 29.34 29.325 29.31 29.295 29.28 29.265 29.25 29.235
29.22  29.205 29.19 29.175 29.16 29.145 29.13 29.115 29.1 29.085
29.07  29.055 29.04 29.025 29.01 28.995 28.98 28.965 28.95 28.935
28.92 28.905 28.89 28.875 28.86 28.845 28.83 28.815 28.8 28.785
28.77 28.755 28.74 28.725 28.71 28.695 28.68 28.665 28.65 28.635
28.62 28.61 28.6 28.59 28.58 28.57 28.56 28.55 28.54 28.53
28.52 28.51 28.5 28.49 28.48 28.47 28.46 28.45 28.44 28.42
28.4 28.3 28.2 28 27.7 27.4 27 26.5 25.7 24.9
24.2 23.5 22.9 22.3 21.7 21.2 20.7 20.1 19.6 19.2
18.8 18.5 18.3 18.2 18.1 18 17.9 17.8 17.7 17.6
17.5
!
ttttttt
```

```
21.0 21.0 21.0 21.0 21.0 21.0 21.0 21.0 21.0 21.0 21.0 21.0 21.0 21.0 21.0
21.0 21.0 21.0 21.0 21.0 21.0 21.0 21.0 21.0 21.0 21.0 21.0 21.0 21.0 21.0
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21.0 21.0 21.0 21.0 21.0 21.0 21.0 21.0 21.0 21.0 21.0 21.0 21.0 21.0 21.0
21.0 21.0 21.0 21.0 21.0 21.0 21.0 21.0 21.0 21.0 21.0   ;headwt
! ELEVATION OF BASE
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
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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   ;elvbas
F               ;DITCH
1               ;NRESTP
0.0 1           ;time to start recharge, number of recharge zones
1 201 0.0015    ;start column, end column, recharge value
!E/T
0               ;NETPER
!
0               ;NCHEAD
! surface water bodies
1               ;NWB
76              ;number of nodes associated with current surface water body
!datafile containing water level history
rivflood.hed
126 127 128 129 130 131 132 133 134 135
136 137 138 139 140 141 142 143 144 145
146 147 148 149 150 151 152 153 154 155
156 157 158 159 160 161 162 163 164 165
166 167 168 169 170 171 172 173 174 175
176 177 178 179 180 181 182 183 184 185
186 187 188 189 190 191 192 193 194 195
196 197 198 199 200 201
T               ;T=include particle tracking for current surface water body.
1               ;number of particles per cell for each timestep
365.0 386.0     ;tstart, tend for particles to be added
F               ;F=do not include Finite Element solution for advection/dispersion
0               ;nwells
   1                    ;l
8.64E-0   8.64E-0       ;khorz,kvert
0.50E-3   0.30E+0       ;stor,porsty
1.00E-0   0.10e-0       ;disper
T                       ;ptcode
!MAPGEO
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! comment out random walk
0.10      ;XMASSI
0                    ;# Particle source zones
```

APPENDIX C – OUTPUT FILE FROM EXAMPLE 1

```
*******************************************************************************

                          Program GW-Wetland
                              Version 1.0

                   written by: Steve Shikaze, Allan Crowe
                       Last Update: February 1999

Title:   Flood.dat

*******************************************************************************


-----------------------------------------------------
OUTPUT LISTINGS AND PROBLEM CONTROL (Options)
-----------------------------------------------------

 ( 1)= F :Print the nodal co-ordinates
 ( 2)= F :Print the elemental incidences
 ( 3)= F :Print the elemental hydraulic conductivities and storativities
 ( 4)= F :Plot the finite element grid
 ( 5)= T :Calculate the head distributions
 ( 6)= F :Print the head distributions
 ( 7)= T :Plot all head distributions
 ( 8)= F :Plot only the last head values
 ( 9)= F :Print the water table convergence information at each iteration
 (10)= F :Input previously calculated heads to continue an earlier run
 (11)= F :Output the last head distribution for use as input in a later run
 (12)= T :Calculate the hydraulic gradient and the direction of the gradient field
 (13)= F :Print the hydraulic gradient and its direction fields
 (14)= F :Plot the hydraulic gradient and its Direction
 (15)= T :Calculate the velocity field
 (16)= F :Print the velocity field
 (17)= T :Run the deterministic/probabilistic mass transport
 (18)= F :Print the concentration and particle distributions
 (19)= F :Plot the particle concentration
 (20)= F :Plot the particle distribution
 (21)= F :Output the last particle distribution to continue the run
 (22)= F :Input the last particle distribution to continue a previous run
 (23)= F :Print the mass, X and Z coordinates of the reference particles
 (24)= F :Run Galerkin method for advection/dispersion

-----------------------------------------------------
GRID AND TIME STEP DATA
-----------------------------------------------------
 Constant horizontal grid spacing
 Delta x =        1.000000000000000

 There are   2 output times:
   Output times      365.000000000000000      730.000000000000000


         181 :Number of rows
         201 :Number of columns
           1 :Number of geological units
      .20000 :Vertical node spacing
      .50000 :Time step size
    21.00000 :Initial head value
      .20000 :Specific yield
      .00500 :Convergence tolerance
     1.05000 :Time step increment factor
         100 :Maximum number of iterations


-----------------------------------------------------
GROUND SURFACE PARAMETERS
-----------------------------------------------------

 COL ELEVATION   COL ELEVATION   COL ELEVATION   COL ELEVATION   COL ELEVATION

   1 T   34.50     2 T   34.50     3 T   34.50     4 T   34.50     5 T   34.50
```

6	T	34.50	7	T	34.50	8	T	34.50	9	T	34.50	10	T	34.50
11	T	34.50	12	T	34.50	13	T	34.50	14	T	34.50	15	T	34.50
16	T	34.50	17	T	34.50	18	T	34.50	19	T	34.50	20	T	34.50
21	T	34.50	22	T	34.50	23	T	34.50	24	T	34.50	25	T	34.50
26	T	34.50	27	T	34.50	28	T	34.50	29	T	34.50	30	T	34.50
31	T	34.50	32	T	34.50	33	T	34.50	34	T	34.50	35	T	34.45
36	T	34.40	37	T	34.35	38	T	34.30	39	T	34.25	40	T	34.20
41	T	34.15	42	T	34.10	43	T	34.05	44	T	34.00	45	T	33.95
46	T	33.90	47	T	33.85	48	T	33.80	49	T	33.77	50	T	33.75
51	T	33.73	52	T	33.70	53	T	33.67	54	T	33.65	55	T	33.63
56	T	33.60	57	T	33.58	58	T	33.55	59	T	33.52	60	T	33.50
61	T	33.40	62	T	33.35	63	T	33.30	64	T	33.25	65	T	33.20
66	T	33.10	67	T	33.00	68	T	32.90	69	T	32.80	70	T	32.70
71	T	32.60	72	T	32.50	73	T	32.40	74	T	32.30	75	T	32.20
76	T	32.10	77	T	32.00	78	T	31.80	79	T	31.65	80	T	31.50
81	T	31.40	82	T	31.30	83	T	31.10	84	T	30.90	85	T	30.70
86	T	30.50	87	T	30.30	88	T	30.20	89	T	30.10	90	T	30.00
91	T	29.90	92	T	29.80	93	T	29.75	94	T	29.70	95	T	29.65
96	T	29.60	97	T	29.50	98	T	29.41	99	T	29.40	100	T	29.39
101	T	29.37	102	T	29.36	103	T	29.34	104	T	29.32	105	T	29.31
106	T	29.30	107	T	29.28	108	T	29.27	109	T	29.25	110	T	29.23
111	T	29.22	112	T	29.20	113	T	29.19	114	T	29.18	115	T	29.16
116	T	29.15	117	T	29.13	118	T	29.11	119	T	29.10	120	T	29.09
121	T	29.07	122	T	29.06	123	T	29.04	124	T	29.02	125	T	29.01
126	F	29.00	127	F	28.98	128	F	28.97	129	F	28.95	130	F	28.93
131	F	28.92	132	F	28.91	133	F	28.89	134	F	28.88	135	F	28.86
136	F	28.84	137	F	28.83	138	F	28.82	139	F	28.80	140	F	28.79
141	F	28.77	142	F	28.75	143	F	28.74	144	F	28.73	145	F	28.71
146	F	28.70	147	F	28.68	148	F	28.66	149	F	28.65	150	F	28.64
151	F	28.62	152	F	28.61	153	F	28.60	154	F	28.59	155	F	28.58
156	F	28.57	157	F	28.56	158	F	28.55	159	F	28.54	160	F	28.53
161	F	28.52	162	F	28.51	163	F	28.50	164	F	28.49	165	F	28.48
166	F	28.47	167	F	28.46	168	F	28.45	169	F	28.44	170	F	28.42
171	F	28.40	172	F	28.30	173	F	28.20	174	F	28.00	175	F	27.70
176	F	27.40	177	F	27.00	178	F	26.50	179	F	25.70	180	F	24.90
181	F	24.20	182	F	23.50	183	F	22.90	184	F	22.30	185	F	21.70
186	F	21.20	187	F	20.70	188	F	20.10	189	F	19.60	190	F	19.20
191	F	18.80	192	F	18.50	193	F	18.30	194	F	18.20	195	F	18.10
196	F	18.00	197	F	17.90	198	F	17.80	199	F	17.70	200	F	17.60
201	F	17.50												

WATER TABLE ELEVATION

COL	ELEVATION	COL	ELEVATION	COL	ELEVATION	COL	ELEVATION	COL	ELEVATION
1	21.0000	2	21.0000	3	21.0000	4	21.0000	5	21.0000
6	21.0000	7	21.0000	8	21.0000	9	21.0000	10	21.0000
11	21.0000	12	21.0000	13	21.0000	14	21.0000	15	21.0000
16	21.0000	17	21.0000	18	21.0000	19	21.0000	20	21.0000
21	21.0000	22	21.0000	23	21.0000	24	21.0000	25	21.0000
26	21.0000	27	21.0000	28	21.0000	29	21.0000	30	21.0000
31	21.0000	32	21.0000	33	21.0000	34	21.0000	35	21.0000
36	21.0000	37	21.0000	38	21.0000	39	21.0000	40	21.0000
41	21.0000	42	21.0000	43	21.0000	44	21.0000	45	21.0000
46	21.0000	47	21.0000	48	21.0000	49	21.0000	50	21.0000
51	21.0000	52	21.0000	53	21.0000	54	21.0000	55	21.0000
56	21.0000	57	21.0000	58	21.0000	59	21.0000	60	21.0000
61	21.0000	62	21.0000	63	21.0000	64	21.0000	65	21.0000
66	21.0000	67	21.0000	68	21.0000	69	21.0000	70	21.0000
71	21.0000	72	21.0000	73	21.0000	74	21.0000	75	21.0000
76	21.0000	77	21.0000	78	21.0000	79	21.0000	80	21.0000
81	21.0000	82	21.0000	83	21.0000	84	21.0000	85	21.0000
86	21.0000	87	21.0000	88	21.0000	89	21.0000	90	21.0000
91	21.0000	92	21.0000	93	21.0000	94	21.0000	95	21.0000
96	21.0000	97	21.0000	98	21.0000	99	21.0000	100	21.0000
101	21.0000	102	21.0000	103	21.0000	104	21.0000	105	21.0000
106	21.0000	107	21.0000	108	21.0000	109	21.0000	110	21.0000
111	21.0000	112	21.0000	113	21.0000	114	21.0000	115	21.0000
116	21.0000	117	21.0000	118	21.0000	119	21.0000	120	21.0000
121	21.0000	122	21.0000	123	21.0000	124	21.0000	125	21.0000
126	21.0000	127	21.0000	128	21.0000	129	21.0000	130	21.0000
131	21.0000	132	21.0000	133	21.0000	134	21.0000	135	21.0000

136	21.0000	137	21.0000	138	21.0000	139	21.0000	140	21.0000
141	21.0000	142	21.0000	143	21.0000	144	21.0000	145	21.0000
146	21.0000	147	21.0000	148	21.0000	149	21.0000	150	21.0000
151	21.0000	152	21.0000	153	21.0000	154	21.0000	155	21.0000
156	21.0000	157	21.0000	158	21.0000	159	21.0000	160	21.0000
161	21.0000	162	21.0000	163	21.0000	164	21.0000	165	21.0000
166	21.0000	167	21.0000	168	21.0000	169	21.0000	170	21.0000
171	21.0000	172	21.0000	173	21.0000	174	21.0000	175	21.0000
176	21.0000	177	21.0000	178	21.0000	179	21.0000	180	21.0000
181	21.0000	182	21.0000	183	21.0000	184	21.0000	185	21.0000
186	21.0000	187	21.0000	188	21.0000	189	21.0000	190	21.0000
191	21.0000	192	21.0000	193	21.0000	194	21.0000	195	21.0000
196	21.0000	197	21.0000	198	21.0000	199	21.0000	200	21.0000
201	21.0000								

BOTTOM BOUNDARY ELEVATION

1	.0000	2	.0000	3	.0000	4	.0000	5	.0000
6	.0000	7	.0000	8	.0000	9	.0000	10	.0000
11	.0000	12	.0000	13	.0000	14	.0000	15	.0000
16	.0000	17	.0000	18	.0000	19	.0000	20	.0000
21	.0000	22	.0000	23	.0000	24	.0000	25	.0000
26	.0000	27	.0000	28	.0000	29	.0000	30	.0000
31	.0000	32	.0000	33	.0000	34	.0000	35	.0000
36	.0000	37	.0000	38	.0000	39	.0000	40	.0000
41	.0000	42	.0000	43	.0000	44	.0000	45	.0000
46	.0000	47	.0000	48	.0000	49	.0000	50	.0000
51	.0000	52	.0000	53	.0000	54	.0000	55	.0000
56	.0000	57	.0000	58	.0000	59	.0000	60	.0000
61	.0000	62	.0000	63	.0000	64	.0000	65	.0000
66	.0000	67	.0000	68	.0000	69	.0000	70	.0000
71	.0000	72	.0000	73	.0000	74	.0000	75	.0000
76	.0000	77	.0000	78	.0000	79	.0000	80	.0000
81	.0000	82	.0000	83	.0000	84	.0000	85	.0000
86	.0000	87	.0000	88	.0000	89	.0000	90	.0000
91	.0000	92	.0000	93	.0000	94	.0000	95	.0000
96	.0000	97	.0000	98	.0000	99	.0000	100	.0000
101	.0000	102	.0000	103	.0000	104	.0000	105	.0000
106	.0000	107	.0000	108	.0000	109	.0000	110	.0000
111	.0000	112	.0000	113	.0000	114	.0000	115	.0000
116	.0000	117	.0000	118	.0000	119	.0000	120	.0000
121	.0000	122	.0000	123	.0000	124	.0000	125	.0000
126	.0000	127	.0000	128	.0000	129	.0000	130	.0000
131	.0000	132	.0000	133	.0000	134	.0000	135	.0000
136	.0000	137	.0000	138	.0000	139	.0000	140	.0000
141	.0000	142	.0000	143	.0000	144	.0000	145	.0000
146	.0000	147	.0000	148	.0000	149	.0000	150	.0000
151	.0000	152	.0000	153	.0000	154	.0000	155	.0000
156	.0000	157	.0000	158	.0000	159	.0000	160	.0000
161	.0000	162	.0000	163	.0000	164	.0000	165	.0000
166	.0000	167	.0000	168	.0000	169	.0000	170	.0000
171	.0000	172	.0000	173	.0000	174	.0000	175	.0000
176	.0000	177	.0000	178	.0000	179	.0000	180	.0000
181	.0000	182	.0000	183	.0000	184	.0000	185	.0000
186	.0000	187	.0000	188	.0000	189	.0000	190	.0000
191	.0000	192	.0000	193	.0000	194	.0000	195	.0000
196	.0000	197	.0000	198	.0000	199	.0000	200	.0000
201	.0000								

RECHARGE DATA

There are 1 recharge period(s)

RECHARGE VALUES (+VE=RECHARGE; -VE=EVAPORATION)

CHANGE AT TIME: .000

COL	RECHARGE	COL	RECHARGE	COL	RECHARGE	COL	RECHARGE	COL	RECHARGE
1	.0015	2	.0015	3	.0015	4	.0015	5	.0015

6	.0015	7	.0015	8	.0015	9	.0015	10	.0015
11	.0015	12	.0015	13	.0015	14	.0015	15	.0015
16	.0015	17	.0015	18	.0015	19	.0015	20	.0015
21	.0015	22	.0015	23	.0015	24	.0015	25	.0015
26	.0015	27	.0015	28	.0015	29	.0015	30	.0015
31	.0015	32	.0015	33	.0015	34	.0015	35	.0015
36	.0015	37	.0015	38	.0015	39	.0015	40	.0015
41	.0015	42	.0015	43	.0015	44	.0015	45	.0015
46	.0015	47	.0015	48	.0015	49	.0015	50	.0015
51	.0015	52	.0015	53	.0015	54	.0015	55	.0015
56	.0015	57	.0015	58	.0015	59	.0015	60	.0015
61	.0015	62	.0015	63	.0015	64	.0015	65	.0015
66	.0015	67	.0015	68	.0015	69	.0015	70	.0015
71	.0015	72	.0015	73	.0015	74	.0015	75	.0015
76	.0015	77	.0015	78	.0015	79	.0015	80	.0015
81	.0015	82	.0015	83	.0015	84	.0015	85	.0015
86	.0015	87	.0015	88	.0015	89	.0015	90	.0015
91	.0015	92	.0015	93	.0015	94	.0015	95	.0015
96	.0015	97	.0015	98	.0015	99	.0015	100	.0015
101	.0015	102	.0015	103	.0015	104	.0015	105	.0015
106	.0015	107	.0015	108	.0015	109	.0015	110	.0015
111	.0015	112	.0015	113	.0015	114	.0015	115	.0015
116	.0015	117	.0015	118	.0015	119	.0015	120	.0015
121	.0015	122	.0015	123	.0015	124	.0015	125	.0015
126	.0015	127	.0015	128	.0015	129	.0015	130	.0015
131	.0015	132	.0015	133	.0015	134	.0015	135	.0015
136	.0015	137	.0015	138	.0015	139	.0015	140	.0015
141	.0015	142	.0015	143	.0015	144	.0015	145	.0015
146	.0015	147	.0015	148	.0015	149	.0015	150	.0015
151	.0015	152	.0015	153	.0015	154	.0015	155	.0015
156	.0015	157	.0015	158	.0015	159	.0015	160	.0015
161	.0015	162	.0015	163	.0015	164	.0015	165	.0015
166	.0015	167	.0015	168	.0015	169	.0015	170	.0015
171	.0015	172	.0015	173	.0015	174	.0015	175	.0015
176	.0015	177	.0015	178	.0015	179	.0015	180	.0015
181	.0015	182	.0015	183	.0015	184	.0015	185	.0015
186	.0015	187	.0015	188	.0015	189	.0015	190	.0015
191	.0015	192	.0015	193	.0015	194	.0015	195	.0015
196	.0015	197	.0015	198	.0015	199	.0015	200	.0015
201	.0015								

EVAPOTRANSPIRATION DATA

There are 0 E/T period(s)

CONSTANT HEAD DATA

There are 0 constant regular head nodes

SURFACE WATER BODY (constant head) DATA

There are 1 surface water body (constant head) zones

ZONE 1
Reads head history from file rivflood.hed
There are 154 head changes for this water body
There are 76 nodes associated with this water body

PUMPING WELL DATA

There are no Pumping Wells

HYDROGEOLOGICAL PARAMETERS OF THE GEOLOGICAL UNITS

UNIT	Kh	Kv	STOR.	POROSITY	Long.DISP.	Trans.DISP
1	.8640E+01	.8640E+01	.5000E-03	.3000E+00	.1000E+01	.1000E+00

MAP OF THE GEOLOGICAL UNITS

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CONTAMINANT TRANSPORT PARAMETERS

    .100 :INITIAL MASS ADDED PER PARTICLE


 # of Particle Source Zones          0


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 FINITE ELEMENT GRID SUMMARY
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  21270: Actual number of nodes
  41944: Actual number of elements
     15: Actual number of constant head nodes
  21255: Number of nodes with unknown heads


 ITERATION:   1          TIME: 365.00000
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COL		NODEWT	Z(OLD)	Z(NEW)	HEADWT(OLD)	HEADWT(NEW)	PREV.HEADWT	ELVGRD	
1	0	107	21.1041	21.1042	21.1042	21.1042	21.1041	34.5000	T
2	0	214	21.1041	21.1042	21.1042	21.1042	21.1041	34.5000	T
3	0	321	21.1041	21.1041	21.1041	21.1041	21.1041	34.5000	T
4	0	428	21.1041	21.1041	21.1041	21.1041	21.1041	34.5000	T
5	0	535	21.1041	21.1041	21.1041	21.1041	21.1041	34.5000	T
6	0	642	21.1041	21.1041	21.1041	21.1041	21.1041	34.5000	T
7	0	749	21.1041	21.1041	21.1041	21.1041	21.1041	34.5000	T
8	0	856	21.1040	21.1040	21.1040	21.1040	21.1040	34.5000	T
9	0	963	21.1040	21.1040	21.1040	21.1040	21.1040	34.5000	T
10	0	1070	21.1040	21.1040	21.1040	21.1040	21.1040	34.5000	T
11	0	1177	21.1039	21.1039	21.1039	21.1039	21.1039	34.5000	T
12	0	1284	21.1039	21.1039	21.1039	21.1039	21.1039	34.5000	T
13	0	1391	21.1038	21.1038	21.1038	21.1038	21.1038	34.5000	T
14	0	1498	21.1037	21.1037	21.1037	21.1037	21.1037	34.5000	T
15	0	1605	21.1037	21.1037	21.1037	21.1037	21.1037	34.5000	T
16	0	1712	21.1036	21.1036	21.1036	21.1036	21.1036	34.5000	T
17	0	1819	21.1035	21.1035	21.1035	21.1035	21.1035	34.5000	T
18	0	1926	21.1034	21.1035	21.1035	21.1035	21.1034	34.5000	T
19	0	2033	21.1034	21.1034	21.1034	21.1034	21.1034	34.5000	T
20	0	2140	21.1033	21.1033	21.1033	21.1033	21.1033	34.5000	T
21	0	2247	21.1032	21.1032	21.1032	21.1032	21.1032	34.5000	T
22	0	2354	21.1031	21.1031	21.1031	21.1031	21.1031	34.5000	T
23	0	2461	21.1030	21.1030	21.1030	21.1030	21.1030	34.5000	T
24	0	2568	21.1029	21.1029	21.1029	21.1029	21.1029	34.5000	T
25	0	2675	21.1028	21.1028	21.1028	21.1028	21.1028	34.5000	T
26	0	2782	21.1026	21.1026	21.1026	21.1026	21.1026	34.5000	T
27	0	2889	21.1025	21.1025	21.1025	21.1025	21.1025	34.5000	T
28	0	2996	21.1024	21.1024	21.1024	21.1024	21.1024	34.5000	T
29	0	3103	21.1022	21.1023	21.1023	21.1023	21.1022	34.5000	T
30	0	3210	21.1021	21.1021	21.1021	21.1021	21.1021	34.5000	T

31	0	3317	21.1020	21.1020	21.1020	21.1020	21.1020	34.5000	T
32	0	3424	21.1018	21.1018	21.1018	21.1018	21.1018	34.5000	T
33	0	3531	21.1017	21.1017	21.1017	21.1017	21.1017	34.5000	T
34	0	3638	21.1015	21.1015	21.1015	21.1015	21.1015	34.5000	T
35	0	3745	21.1013	21.1013	21.1013	21.1013	21.1013	34.4500	T
36	0	3852	21.1012	21.1012	21.1012	21.1012	21.1012	34.4000	T
37	0	3959	21.1010	21.1010	21.1010	21.1010	21.1010	34.3500	T
38	0	4066	21.1008	21.1008	21.1008	21.1008	21.1008	34.3000	T
39	0	4173	21.1006	21.1006	21.1006	21.1006	21.1006	34.2500	T
40	0	4280	21.1004	21.1005	21.1005	21.1005	21.1004	34.2000	T
41	0	4387	21.1003	21.1003	21.1003	21.1003	21.1003	34.1500	T
42	0	4494	21.1001	21.1001	21.1001	21.1001	21.1001	34.1000	T
43	0	4601	21.0999	21.0999	21.0999	21.0999	21.0999	34.0500	T
44	0	4708	21.0996	21.0997	21.0997	21.0997	21.0996	34.0000	T
45	0	4815	21.0994	21.0994	21.0994	21.0994	21.0994	33.9500	T
46	0	4922	21.0992	21.0992	21.0992	21.0992	21.0992	33.9000	T
47	0	5029	21.0990	21.0990	21.0990	21.0990	21.0990	33.8500	T
48	0	5136	21.0988	21.0988	21.0988	21.0988	21.0988	33.8000	T
49	0	5243	21.0985	21.0985	21.0985	21.0985	21.0985	33.7750	T
50	0	5350	21.0983	21.0983	21.0983	21.0983	21.0983	33.7500	T
51	0	5457	21.0981	21.0981	21.0981	21.0981	21.0981	33.7250	T
52	0	5564	21.0978	21.0978	21.0978	21.0978	21.0978	33.7000	T
53	0	5671	21.0976	21.0976	21.0976	21.0976	21.0976	33.6750	T
54	0	5778	21.0973	21.0973	21.0973	21.0973	21.0973	33.6500	T
55	0	5885	21.0970	21.0970	21.0970	21.0970	21.0970	33.6250	T
56	0	5992	21.0968	21.0968	21.0968	21.0968	21.0968	33.6000	T
57	0	6099	21.0965	21.0965	21.0965	21.0965	21.0965	33.5750	T
58	0	6206	21.0962	21.0962	21.0962	21.0962	21.0962	33.5500	T
59	0	6313	21.0959	21.0959	21.0959	21.0959	21.0959	33.5250	T
60	0	6420	21.0956	21.0956	21.0956	21.0956	21.0956	33.5000	T
61	0	6527	21.0953	21.0954	21.0954	21.0954	21.0953	33.4000	T
62	0	6634	21.0950	21.0951	21.0951	21.0951	21.0950	33.3500	T
63	0	6741	21.0947	21.0947	21.0947	21.0947	21.0947	33.3000	T
64	0	6848	21.0944	21.0944	21.0944	21.0944	21.0944	33.2500	T
65	0	6955	21.0941	21.0941	21.0941	21.0941	21.0941	33.2000	T
66	0	7062	21.0938	21.0938	21.0938	21.0938	21.0938	33.1000	T
67	0	7169	21.0935	21.0935	21.0935	21.0935	21.0935	33.0000	T
68	0	7276	21.0931	21.0931	21.0931	21.0931	21.0931	32.9000	T
69	0	7383	21.0928	21.0928	21.0928	21.0928	21.0928	32.8000	T
70	0	7490	21.0925	21.0925	21.0925	21.0925	21.0925	32.7000	T
71	0	7597	21.0921	21.0921	21.0921	21.0921	21.0921	32.6000	T
72	0	7704	21.0918	21.0918	21.0918	21.0918	21.0918	32.5000	T
73	0	7811	21.0914	21.0914	21.0914	21.0914	21.0914	32.4000	T
74	0	7918	21.0910	21.0911	21.0911	21.0911	21.0910	32.3000	T
75	0	8025	21.0907	21.0907	21.0907	21.0907	21.0907	32.2000	T
76	0	8132	21.0903	21.0903	21.0903	21.0903	21.0903	32.1000	T
77	0	8239	21.0899	21.0899	21.0899	21.0899	21.0899	32.0000	T
78	0	8346	21.0895	21.0896	21.0896	21.0896	21.0895	31.8000	T
79	0	8453	21.0892	21.0892	21.0892	21.0892	21.0892	31.6500	T
80	0	8560	21.0888	21.0888	21.0888	21.0888	21.0888	31.5000	T
81	0	8667	21.0884	21.0884	21.0884	21.0884	21.0884	31.4000	T
82	0	8774	21.0880	21.0880	21.0880	21.0880	21.0880	31.3000	T
83	0	8881	21.0875	21.0875	21.0875	21.0875	21.0875	31.1000	T
84	0	8988	21.0871	21.0871	21.0871	21.0871	21.0871	30.9000	T
85	0	9095	21.0867	21.0867	21.0867	21.0867	21.0867	30.7000	T
86	0	9202	21.0863	21.0863	21.0863	21.0863	21.0863	30.5000	T
87	0	9309	21.0858	21.0858	21.0858	21.0858	21.0858	30.3000	T
88	0	9416	21.0854	21.0854	21.0854	21.0854	21.0854	30.2000	T
89	0	9523	21.0850	21.0850	21.0850	21.0850	21.0850	30.1000	T
90	0	9630	21.0845	21.0845	21.0845	21.0845	21.0845	30.0000	T
91	0	9737	21.0840	21.0841	21.0841	21.0841	21.0840	29.9000	T
92	0	9844	21.0836	21.0836	21.0836	21.0836	21.0836	29.8000	T
93	0	9951	21.0831	21.0831	21.0831	21.0831	21.0831	29.7500	T
94	0	10058	21.0826	21.0827	21.0827	21.0827	21.0826	29.7000	T
95	0	10165	21.0822	21.0822	21.0822	21.0822	21.0822	29.6500	T
96	0	10272	21.0817	21.0817	21.0817	21.0817	21.0817	29.6000	T
97	0	10379	21.0812	21.0812	21.0812	21.0812	21.0812	29.5000	T
98	0	10486	21.0807	21.0807	21.0807	21.0807	21.0807	29.4150	T
99	0	10593	21.0802	21.0802	21.0802	21.0802	21.0802	29.4000	T
100	0	10700	21.0797	21.0797	21.0797	21.0797	21.0797	29.3850	T
101	0	10807	21.0792	21.0792	21.0792	21.0792	21.0792	29.3700	T
102	0	10914	21.0786	21.0787	21.0787	21.0787	21.0786	29.3550	T
103	0	11021	21.0781	21.0781	21.0781	21.0781	21.0781	29.3400	T
104	0	11128	21.0776	21.0776	21.0776	21.0776	21.0776	29.3250	T
105	0	11235	21.0771	21.0771	21.0771	21.0771	21.0771	29.3100	T
106	0	11342	21.0765	21.0765	21.0765	21.0765	21.0765	29.2950	T

107	0	11449	21.0760	21.0760	21.0760	21.0760	21.0760	29.2800	T
108	0	11556	21.0754	21.0754	21.0754	21.0754	21.0754	29.2650	T
109	0	11663	21.0748	21.0748	21.0748	21.0748	21.0748	29.2500	T
110	0	11770	21.0743	21.0743	21.0743	21.0743	21.0743	29.2350	T
111	0	11877	21.0737	21.0737	21.0737	21.0737	21.0737	29.2200	T
112	0	11984	21.0731	21.0731	21.0731	21.0731	21.0731	29.2050	T
113	0	12091	21.0725	21.0725	21.0725	21.0725	21.0725	29.1900	T
114	0	12198	21.0719	21.0719	21.0719	21.0719	21.0719	29.1750	T
115	0	12305	21.0713	21.0713	21.0713	21.0713	21.0713	29.1600	T
116	0	12412	21.0707	21.0707	21.0707	21.0707	21.0707	29.1450	T
117	0	12519	21.0701	21.0701	21.0701	21.0701	21.0701	29.1300	T
118	0	12626	21.0695	21.0695	21.0695	21.0695	21.0695	29.1150	T
119	0	12733	21.0689	21.0689	21.0689	21.0689	21.0689	29.1000	T
120	0	12840	21.0682	21.0682	21.0682	21.0682	21.0682	29.0850	T
121	0	12947	21.0676	21.0676	21.0676	21.0676	21.0676	29.0700	T
122	0	13054	21.0670	21.0670	21.0670	21.0670	21.0670	29.0550	T
123	0	13161	21.0663	21.0663	21.0663	21.0663	21.0663	29.0400	T
124	0	13268	21.0657	21.0657	21.0657	21.0657	21.0657	29.0250	T
125	0	13375	21.0650	21.0650	21.0650	21.0650	21.0650	29.0100	T
126	0	13482	21.0643	21.0643	21.0643	21.0643	21.0643	28.9950	T
127	0	13589	21.0637	21.0637	21.0637	21.0637	21.0637	28.9800	T
128	0	13696	21.0630	21.0630	21.0630	21.0630	21.0630	28.9650	T
129	0	13803	21.0623	21.0623	21.0623	21.0623	21.0623	28.9500	T
130	0	13910	21.0616	21.0616	21.0616	21.0616	21.0616	28.9350	T
131	0	14017	21.0609	21.0609	21.0609	21.0609	21.0609	28.9200	T
132	0	14124	21.0602	21.0602	21.0602	21.0602	21.0602	28.9050	T
133	0	14231	21.0595	21.0595	21.0595	21.0595	21.0595	28.8900	T
134	0	14338	21.0587	21.0587	21.0587	21.0587	21.0587	28.8750	T
135	0	14445	21.0580	21.0580	21.0580	21.0580	21.0580	28.8600	T
136	0	14552	21.0573	21.0573	21.0573	21.0573	21.0573	28.8450	T
137	0	14659	21.0565	21.0565	21.0565	21.0565	21.0565	28.8300	T
138	0	14766	21.0558	21.0558	21.0558	21.0558	21.0558	28.8150	T
139	0	14873	21.0550	21.0550	21.0550	21.0550	21.0550	28.8000	T
140	0	14980	21.0543	21.0543	21.0543	21.0543	21.0543	28.7850	T
141	0	15087	21.0535	21.0535	21.0535	21.0535	21.0535	28.7700	T
142	0	15194	21.0527	21.0527	21.0527	21.0527	21.0527	28.7550	T
143	0	15301	21.0519	21.0519	21.0519	21.0519	21.0519	28.7400	T
144	0	15408	21.0512	21.0512	21.0512	21.0512	21.0512	28.7250	T
145	0	15515	21.0504	21.0504	21.0504	21.0504	21.0504	28.7100	T
146	0	15621	21.0496	21.0496	21.0496	21.0496	21.0496	28.6950	T
147	0	15727	21.0487	21.0487	21.0487	21.0487	21.0487	28.6800	T
148	0	15833	21.0479	21.0479	21.0479	21.0479	21.0479	28.6650	T
149	0	15939	21.0471	21.0471	21.0471	21.0471	21.0471	28.6500	T
150	0	16045	21.0463	21.0463	21.0463	21.0463	21.0463	28.6350	T
151	0	16151	21.0454	21.0454	21.0454	21.0454	21.0454	28.6200	T
152	0	16257	21.0446	21.0446	21.0446	21.0446	21.0446	28.6100	T
153	0	16363	21.0437	21.0437	21.0437	21.0437	21.0437	28.6000	T
154	0	16469	21.0429	21.0429	21.0429	21.0429	21.0429	28.5900	T
155	0	16575	21.0420	21.0420	21.0420	21.0420	21.0420	28.5800	T
156	0	16681	21.0411	21.0411	21.0411	21.0411	21.0411	28.5700	T
157	0	16787	21.0402	21.0402	21.0402	21.0402	21.0402	28.5600	T
158	0	16893	21.0393	21.0393	21.0393	21.0393	21.0393	28.5500	T
159	0	16999	21.0384	21.0384	21.0384	21.0384	21.0384	28.5400	T
160	0	17105	21.0375	21.0375	21.0375	21.0375	21.0375	28.5300	T
161	0	17211	21.0366	21.0366	21.0366	21.0366	21.0366	28.5200	T
162	0	17317	21.0357	21.0357	21.0357	21.0357	21.0357	28.5100	T
163	0	17423	21.0347	21.0347	21.0347	21.0347	21.0347	28.5000	T
164	0	17529	21.0338	21.0338	21.0338	21.0338	21.0338	28.4900	T
165	0	17635	21.0328	21.0328	21.0328	21.0328	21.0328	28.4800	T
166	0	17741	21.0318	21.0318	21.0318	21.0318	21.0318	28.4700	T
167	0	17847	21.0308	21.0308	21.0308	21.0308	21.0308	28.4600	T
168	0	17953	21.0298	21.0298	21.0298	21.0298	21.0298	28.4500	T
169	0	18059	21.0288	21.0288	21.0288	21.0288	21.0288	28.4400	T
170	0	18165	21.0278	21.0278	21.0278	21.0278	21.0278	28.4200	T
171	0	18271	21.0267	21.0267	21.0267	21.0267	21.0267	28.4000	T
172	0	18377	21.0257	21.0257	21.0257	21.0257	21.0257	28.3000	T
173	0	18483	21.0246	21.0246	21.0246	21.0246	21.0246	28.2000	T
174	0	18589	21.0234	21.0234	21.0234	21.0234	21.0234	28.0000	T
175	0	18695	21.0223	21.0223	21.0223	21.0223	21.0223	27.7000	T
176	0	18801	21.0211	21.0211	21.0211	21.0211	21.0211	27.4000	T
177	0	18907	21.0199	21.0199	21.0199	21.0199	21.0199	27.0000	T
178	0	19013	21.0187	21.0187	21.0187	21.0187	21.0187	26.5000	T
179	0	19119	21.0174	21.0174	21.0174	21.0174	21.0174	25.7000	T
180	0	19225	21.0160	21.0160	21.0160	21.0160	21.0160	24.9000	T
181	0	19331	21.0146	21.0146	21.0146	21.0146	21.0146	24.2000	T
182	0	19437	21.0130	21.0130	21.0130	21.0130	21.0130	23.5000	T

183	0	19543	21.0113	21.0113	21.0113	21.0113	21.0113	22.9000	T
184	0	19649	21.0095	21.0095	21.0095	21.0095	21.0095	22.3000	T
185	0	19755	21.0074	21.0074	21.0074	21.0074	21.0074	21.7000	T
186	0	19861	21.0049	21.0049	21.0049	21.0049	21.0049	21.2000	T
187	2	19966	20.7000	20.7000	21.0000	21.0000	21.0000	20.7000	F
188	2	20068	20.1000	20.1000	21.0000	21.0000	21.0000	20.1000	F
189	2	20167	19.6000	19.6000	21.0000	21.0000	21.0000	19.6000	F
190	2	20264	19.2000	19.2000	21.0000	21.0000	21.0000	19.2000	F
191	2	20359	18.8000	18.8000	21.0000	21.0000	21.0000	18.8000	F
192	2	20453	18.5000	18.5000	21.0000	21.0000	21.0000	18.5000	F
193	2	20546	18.3000	18.3000	21.0000	21.0000	21.0000	18.3000	F
194	2	20638	18.2000	18.2000	21.0000	21.0000	21.0000	18.2000	F
195	2	20730	18.1000	18.1000	21.0000	21.0000	21.0000	18.1000	F
196	2	20821	18.0000	18.0000	21.0000	21.0000	21.0000	18.0000	F
197	2	20912	17.9000	17.9000	21.0000	21.0000	21.0000	17.9000	F
198	2	21002	17.8000	17.8000	21.0000	21.0000	21.0000	17.8000	F
199	2	21092	17.7000	17.7000	21.0000	21.0000	21.0000	17.7000	F
200	2	21181	17.6000	17.6000	21.0000	21.0000	21.0000	17.6000	F
201	2	21270	17.5000	17.5000	21.0000	21.0000	21.0000	17.5000	F

ITERATION CONVERGENCE; ERROR: .0010111587 TOLERENCE: .005

FINITE ELEMENT GRID SUMMARY

21293: Actual number of nodes
41990: Actual number of elements
15: Actual number of constant head nodes
21278: Number of nodes with unknown heads

ITERATION: 1 TIME: 730.00000

COL		NODEWT	Z(OLD)	Z(NEW)	HEADWT(OLD)	HEADWT(NEW)	PREV.HEADWT	ELVGRD	
1	0	107	21.1975	21.1975	21.1975	21.1975	21.1975	34.5000	T
2	0	214	21.1975	21.1975	21.1975	21.1975	21.1975	34.5000	T
3	0	321	21.1975	21.1975	21.1975	21.1975	21.1975	34.5000	T
4	0	428	21.1974	21.1974	21.1974	21.1974	21.1974	34.5000	T
5	0	535	21.1974	21.1974	21.1974	21.1974	21.1974	34.5000	T
6	0	642	21.1973	21.1973	21.1973	21.1973	21.1973	34.5000	T
7	0	749	21.1973	21.1973	21.1973	21.1973	21.1973	34.5000	T
8	0	856	21.1972	21.1972	21.1972	21.1972	21.1972	34.5000	T
9	0	963	21.1971	21.1971	21.1971	21.1971	21.1971	34.5000	T
10	0	1070	21.1970	21.1970	21.1970	21.1970	21.1970	34.5000	T
11	0	1177	21.1969	21.1969	21.1969	21.1969	21.1969	34.5000	T
12	0	1284	21.1968	21.1968	21.1968	21.1968	21.1968	34.5000	T
13	0	1391	21.1967	21.1967	21.1967	21.1967	21.1967	34.5000	T
14	0	1498	21.1966	21.1965	21.1965	21.1965	21.1966	34.5000	T
15	0	1605	21.1964	21.1964	21.1964	21.1964	21.1964	34.5000	T
16	0	1712	21.1962	21.1962	21.1962	21.1962	21.1962	34.5000	T
17	0	1819	21.1961	21.1961	21.1961	21.1961	21.1961	34.5000	T
18	0	1926	21.1959	21.1959	21.1959	21.1959	21.1959	34.5000	T
19	0	2033	21.1957	21.1957	21.1957	21.1957	21.1957	34.5000	T
20	0	2140	21.1955	21.1955	21.1955	21.1955	21.1955	34.5000	T
21	0	2247	21.1953	21.1953	21.1953	21.1953	21.1953	34.5000	T
22	0	2354	21.1951	21.1951	21.1951	21.1951	21.1951	34.5000	T
23	0	2461	21.1948	21.1948	21.1948	21.1948	21.1948	34.5000	T
24	0	2568	21.1946	21.1946	21.1946	21.1946	21.1946	34.5000	T
25	0	2675	21.1943	21.1943	21.1943	21.1943	21.1943	34.5000	T
26	0	2782	21.1940	21.1940	21.1940	21.1940	21.1940	34.5000	T
27	0	2889	21.1938	21.1938	21.1938	21.1938	21.1938	34.5000	T
28	0	2996	21.1935	21.1935	21.1935	21.1935	21.1935	34.5000	T
29	0	3103	21.1932	21.1932	21.1932	21.1932	21.1932	34.5000	T
30	0	3210	21.1929	21.1929	21.1929	21.1929	21.1929	34.5000	T
31	0	3317	21.1925	21.1925	21.1925	21.1925	21.1925	34.5000	T
32	0	3424	21.1922	21.1922	21.1922	21.1922	21.1922	34.5000	T
33	0	3531	21.1919	21.1919	21.1919	21.1919	21.1919	34.5000	T
34	0	3638	21.1915	21.1915	21.1915	21.1915	21.1915	34.5000	T
35	0	3745	21.1911	21.1911	21.1911	21.1911	21.1911	34.4500	T
36	0	3852	21.1908	21.1908	21.1908	21.1908	21.1908	34.4000	T
37	0	3959	21.1904	21.1904	21.1904	21.1904	21.1904	34.3500	T
38	0	4066	21.1900	21.1900	21.1900	21.1900	21.1900	34.3000	T
39	0	4173	21.1896	21.1896	21.1896	21.1896	21.1896	34.2500	T

40	0	4280	21.1891	21.1891	21.1891	21.1891	21.1891	34.2000	T
41	0	4387	21.1887	21.1887	21.1887	21.1887	21.1887	34.1500	T
42	0	4494	21.1883	21.1883	21.1883	21.1883	21.1883	34.1000	T
43	0	4601	21.1878	21.1878	21.1878	21.1878	21.1878	34.0500	T
44	0	4708	21.1874	21.1874	21.1874	21.1874	21.1874	34.0000	T
45	0	4815	21.1869	21.1869	21.1869	21.1869	21.1869	33.9500	T
46	0	4922	21.1864	21.1864	21.1864	21.1864	21.1864	33.9000	T
47	0	5029	21.1859	21.1859	21.1859	21.1859	21.1859	33.8500	T
48	0	5136	21.1854	21.1854	21.1854	21.1854	21.1854	33.8000	T
49	0	5243	21.1849	21.1849	21.1849	21.1849	21.1849	33.7750	T
50	0	5350	21.1844	21.1843	21.1843	21.1843	21.1844	33.7500	T
51	0	5457	21.1838	21.1838	21.1838	21.1838	21.1838	33.7250	T
52	0	5564	21.1833	21.1833	21.1833	21.1833	21.1833	33.7000	T
53	0	5671	21.1827	21.1827	21.1827	21.1827	21.1827	33.6750	T
54	0	5778	21.1821	21.1821	21.1821	21.1821	21.1821	33.6500	T
55	0	5885	21.1816	21.1816	21.1816	21.1816	21.1816	33.6250	T
56	0	5992	21.1810	21.1810	21.1810	21.1810	21.1810	33.6000	T
57	0	6099	21.1804	21.1804	21.1804	21.1804	21.1804	33.5750	T
58	0	6206	21.1798	21.1798	21.1798	21.1798	21.1798	33.5500	T
59	0	6313	21.1791	21.1791	21.1791	21.1791	21.1791	33.5250	T
60	0	6420	21.1785	21.1785	21.1785	21.1785	21.1785	33.5000	T
61	0	6527	21.1779	21.1779	21.1779	21.1779	21.1779	33.4000	T
62	0	6634	21.1772	21.1772	21.1772	21.1772	21.1772	33.3500	T
63	0	6741	21.1765	21.1765	21.1765	21.1765	21.1765	33.3000	T
64	0	6848	21.1759	21.1759	21.1759	21.1759	21.1759	33.2500	T
65	0	6955	21.1752	21.1752	21.1752	21.1752	21.1752	33.2000	T
66	0	7062	21.1745	21.1745	21.1745	21.1745	21.1745	33.1000	T
67	0	7169	21.1738	21.1738	21.1738	21.1738	21.1738	33.0000	T
68	0	7276	21.1731	21.1731	21.1731	21.1731	21.1731	32.9000	T
69	0	7383	21.1724	21.1723	21.1723	21.1723	21.1724	32.8000	T
70	0	7490	21.1716	21.1716	21.1716	21.1716	21.1716	32.7000	T
71	0	7597	21.1709	21.1709	21.1709	21.1709	21.1709	32.6000	T
72	0	7704	21.1701	21.1701	21.1701	21.1701	21.1701	32.5000	T
73	0	7811	21.1693	21.1693	21.1693	21.1693	21.1693	32.4000	T
74	0	7918	21.1686	21.1686	21.1686	21.1686	21.1686	32.3000	T
75	0	8025	21.1678	21.1678	21.1678	21.1678	21.1678	32.2000	T
76	0	8132	21.1670	21.1670	21.1670	21.1670	21.1670	32.1000	T
77	0	8239	21.1662	21.1662	21.1662	21.1662	21.1662	32.0000	T
78	0	8346	21.1654	21.1654	21.1654	21.1654	21.1654	31.8000	T
79	0	8453	21.1645	21.1645	21.1645	21.1645	21.1645	31.6500	T
80	0	8560	21.1637	21.1637	21.1637	21.1637	21.1637	31.5000	T
81	0	8667	21.1628	21.1628	21.1628	21.1628	21.1628	31.4000	T
82	0	8774	21.1620	21.1620	21.1620	21.1620	21.1620	31.3000	T
83	0	8881	21.1611	21.1611	21.1611	21.1611	21.1611	31.1000	T
84	0	8988	21.1602	21.1602	21.1602	21.1602	21.1602	30.9000	T
85	0	9095	21.1594	21.1594	21.1594	21.1594	21.1594	30.7000	T
86	0	9202	21.1585	21.1585	21.1585	21.1585	21.1585	30.5000	T
87	0	9309	21.1575	21.1575	21.1575	21.1575	21.1575	30.3000	T
88	0	9416	21.1566	21.1566	21.1566	21.1566	21.1566	30.2000	T
89	0	9523	21.1557	21.1557	21.1557	21.1557	21.1557	30.1000	T
90	0	9630	21.1548	21.1548	21.1548	21.1548	21.1548	30.0000	T
91	0	9737	21.1538	21.1538	21.1538	21.1538	21.1538	29.9000	T
92	0	9844	21.1528	21.1528	21.1528	21.1528	21.1528	29.8000	T
93	0	9951	21.1519	21.1519	21.1519	21.1519	21.1519	29.7500	T
94	0	10058	21.1509	21.1509	21.1509	21.1509	21.1509	29.7000	T
95	0	10165	21.1499	21.1499	21.1499	21.1499	21.1499	29.6500	T
96	0	10272	21.1489	21.1489	21.1489	21.1489	21.1489	29.6000	T
97	0	10379	21.1479	21.1479	21.1479	21.1479	21.1479	29.5000	T
98	0	10486	21.1469	21.1469	21.1469	21.1469	21.1469	29.4150	T
99	0	10593	21.1458	21.1458	21.1458	21.1458	21.1458	29.4000	T
100	0	10700	21.1448	21.1448	21.1448	21.1448	21.1448	29.3850	T
101	0	10807	21.1438	21.1438	21.1438	21.1438	21.1438	29.3700	T
102	0	10914	21.1427	21.1427	21.1427	21.1427	21.1427	29.3550	T
103	0	11021	21.1416	21.1416	21.1416	21.1416	21.1416	29.3400	T
104	0	11128	21.1405	21.1405	21.1405	21.1405	21.1405	29.3250	T
105	0	11235	21.1395	21.1394	21.1394	21.1394	21.1395	29.3100	T
106	0	11342	21.1384	21.1383	21.1383	21.1383	21.1384	29.2950	T
107	0	11449	21.1372	21.1372	21.1372	21.1372	21.1372	29.2800	T
108	0	11556	21.1361	21.1361	21.1361	21.1361	21.1361	29.2650	T
109	0	11663	21.1350	21.1350	21.1350	21.1350	21.1350	29.2500	T
110	0	11770	21.1338	21.1338	21.1338	21.1338	21.1338	29.2350	T
111	0	11877	21.1327	21.1327	21.1327	21.1327	21.1327	29.2200	T
112	0	11984	21.1315	21.1315	21.1315	21.1315	21.1315	29.2050	T
113	0	12091	21.1304	21.1304	21.1304	21.1304	21.1304	29.1900	T
114	0	12198	21.1292	21.1292	21.1292	21.1292	21.1292	29.1750	T
115	0	12305	21.1280	21.1280	21.1280	21.1280	21.1280	29.1600	T

116	0	12412	21.1268	21.1268	21.1268	21.1268	21.1268	29.1450	T
117	0	12519	21.1256	21.1256	21.1256	21.1256	21.1256	29.1300	T
118	0	12626	21.1243	21.1243	21.1243	21.1243	21.1243	29.1150	T
119	0	12733	21.1231	21.1231	21.1231	21.1231	21.1231	29.1000	T
120	0	12840	21.1219	21.1219	21.1219	21.1219	21.1219	29.0850	T
121	0	12947	21.1206	21.1206	21.1206	21.1206	21.1206	29.0700	T
122	0	13054	21.1194	21.1194	21.1194	21.1194	21.1194	29.0550	T
123	0	13161	21.1181	21.1181	21.1181	21.1181	21.1181	29.0400	T
124	0	13268	21.1168	21.1168	21.1168	21.1168	21.1168	29.0250	T
125	0	13375	21.1155	21.1155	21.1155	21.1155	21.1155	29.0100	T
126	0	13482	21.1142	21.1142	21.1142	21.1142	21.1142	28.9950	T
127	0	13589	21.1129	21.1129	21.1129	21.1129	21.1129	28.9800	T
128	0	13696	21.1116	21.1116	21.1116	21.1116	21.1116	28.9650	T
129	0	13803	21.1102	21.1102	21.1102	21.1102	21.1102	28.9500	T
130	0	13910	21.1089	21.1089	21.1089	21.1089	21.1089	28.9350	T
131	0	14017	21.1075	21.1075	21.1075	21.1075	21.1075	28.9200	T
132	0	14124	21.1062	21.1062	21.1062	21.1062	21.1062	28.9050	T
133	0	14231	21.1048	21.1048	21.1048	21.1048	21.1048	28.8900	T
134	0	14338	21.1034	21.1034	21.1034	21.1034	21.1034	28.8750	T
135	0	14445	21.1020	21.1020	21.1020	21.1020	21.1020	28.8600	T
136	0	14552	21.1006	21.1006	21.1006	21.1006	21.1006	28.8450	T
137	0	14659	21.0992	21.0992	21.0992	21.0992	21.0992	28.8300	T
138	0	14766	21.0978	21.0978	21.0978	21.0978	21.0978	28.8150	T
139	0	14873	21.0964	21.0964	21.0964	21.0964	21.0964	28.8000	T
140	0	14980	21.0949	21.0949	21.0949	21.0949	21.0949	28.7850	T
141	0	15087	21.0935	21.0935	21.0935	21.0935	21.0935	28.7700	T
142	0	15194	21.0920	21.0920	21.0920	21.0920	21.0920	28.7550	T
143	0	15301	21.0906	21.0905	21.0905	21.0905	21.0906	28.7400	T
144	0	15408	21.0891	21.0891	21.0891	21.0891	21.0891	28.7250	T
145	0	15515	21.0876	21.0876	21.0876	21.0876	21.0876	28.7100	T
146	0	15622	21.0861	21.0861	21.0861	21.0861	21.0861	28.6950	T
147	0	15729	21.0846	21.0846	21.0846	21.0846	21.0846	28.6800	T
148	0	15836	21.0831	21.0830	21.0830	21.0830	21.0831	28.6650	T
149	0	15943	21.0815	21.0815	21.0815	21.0815	21.0815	28.6500	T
150	0	16050	21.0800	21.0800	21.0800	21.0800	21.0800	28.6350	T
151	0	16157	21.0784	21.0784	21.0784	21.0784	21.0784	28.6200	T
152	0	16264	21.0769	21.0769	21.0769	21.0769	21.0769	28.6100	T
153	0	16371	21.0753	21.0753	21.0753	21.0753	21.0753	28.6000	T
154	0	16478	21.0737	21.0737	21.0737	21.0737	21.0737	28.5900	T
155	0	16585	21.0721	21.0721	21.0721	21.0721	21.0721	28.5800	T
156	0	16692	21.0705	21.0705	21.0705	21.0705	21.0705	28.5700	T
157	0	16799	21.0689	21.0689	21.0689	21.0689	21.0689	28.5600	T
158	0	16906	21.0673	21.0673	21.0673	21.0673	21.0673	28.5500	T
159	0	17013	21.0657	21.0657	21.0657	21.0657	21.0657	28.5400	T
160	0	17120	21.0640	21.0640	21.0640	21.0640	21.0640	28.5300	T
161	0	17227	21.0624	21.0623	21.0623	21.0623	21.0624	28.5200	T
162	0	17334	21.0607	21.0607	21.0607	21.0607	21.0607	28.5100	T
163	0	17441	21.0590	21.0590	21.0590	21.0590	21.0590	28.5000	T
164	0	17548	21.0573	21.0573	21.0573	21.0573	21.0573	28.4900	T
165	0	17655	21.0556	21.0556	21.0556	21.0556	21.0556	28.4800	T
166	0	17762	21.0538	21.0538	21.0538	21.0538	21.0538	28.4700	T
167	0	17869	21.0521	21.0521	21.0521	21.0521	21.0521	28.4600	T
168	0	17976	21.0503	21.0503	21.0503	21.0503	21.0503	28.4500	T
169	0	18082	21.0485	21.0485	21.0485	21.0485	21.0485	28.4400	T
170	0	18188	21.0467	21.0467	21.0467	21.0467	21.0467	28.4200	T
171	0	18294	21.0449	21.0449	21.0449	21.0449	21.0449	28.4000	T
172	0	18400	21.0430	21.0430	21.0430	21.0430	21.0430	28.3000	T
173	0	18506	21.0411	21.0411	21.0411	21.0411	21.0411	28.2000	T
174	0	18612	21.0392	21.0392	21.0392	21.0392	21.0392	28.0000	T
175	0	18718	21.0372	21.0372	21.0372	21.0372	21.0372	27.7000	T
176	0	18824	21.0352	21.0352	21.0352	21.0352	21.0352	27.4000	T
177	0	18930	21.0332	21.0332	21.0332	21.0332	21.0332	27.0000	T
178	0	19036	21.0310	21.0310	21.0310	21.0310	21.0310	26.5000	T
179	0	19142	21.0288	21.0288	21.0288	21.0288	21.0288	25.7000	T
180	0	19248	21.0265	21.0265	21.0265	21.0265	21.0265	24.9000	T
181	0	19354	21.0241	21.0241	21.0241	21.0241	21.0241	24.2000	T
182	0	19460	21.0215	21.0215	21.0215	21.0215	21.0215	23.5000	T
183	0	19566	21.0187	21.0187	21.0187	21.0187	21.0187	22.9000	T
184	0	19672	21.0156	21.0156	21.0156	21.0156	21.0156	22.3000	T
185	0	19778	21.0121	21.0121	21.0121	21.0121	21.0121	21.7000	T
186	0	19884	21.0080	21.0080	21.0080	21.0080	21.0080	21.2000	T
187	2	19989	20.7000	20.7000	21.0000	21.0000	21.0000	20.7000	F
188	2	20091	20.1000	20.1000	21.0000	21.0000	21.0000	20.1000	F
189	2	20190	19.6000	19.6000	21.0000	21.0000	21.0000	19.6000	F
190	2	20287	19.2000	19.2000	21.0000	21.0000	21.0000	19.2000	F
191	2	20382	18.8000	18.8000	21.0000	21.0000	21.0000	18.8000	F

192	2	20476	18.5000	18.5000	21.0000	21.0000	21.0000	18.5000	F
193	2	20569	18.3000	18.3000	21.0000	21.0000	21.0000	18.3000	F
194	2	20661	18.2000	18.2000	21.0000	21.0000	21.0000	18.2000	F
195	2	20753	18.1000	18.1000	21.0000	21.0000	21.0000	18.1000	F
196	2	20844	18.0000	18.0000	21.0000	21.0000	21.0000	18.0000	F
197	2	20935	17.9000	17.9000	21.0000	21.0000	21.0000	17.9000	F
198	2	21025	17.8000	17.8000	21.0000	21.0000	21.0000	17.8000	F
199	2	21115	17.7000	17.7000	21.0000	21.0000	21.0000	17.7000	F
200	2	21204	17.6000	17.6000	21.0000	21.0000	21.0000	17.6000	F
201	2	21293	17.5000	17.5000	21.0000	21.0000	21.0000	17.5000	F

ITERATION CONVERGENCE; ERROR: .0007625488 TOLERENCE: .005

Time Step:455 STEADY STATE CONVERGENCE; ERROR: .000 TOLERENCE: .005
time= 730.0000 nn=21293 niter= 1 dt= 2.5000

NODES ALONG WATER TABLE

107	214	321	428	535	642	749	856	963	1070	1177	1284
1391	1498	1605	1712	1819	1926	2033	2140	2247	2354	2461	2568
2675	2782	2889	2996	3103	3210	3317	3424	3531	3638	3745	3852
3959	4066	4173	4280	4387	4494	4601	4708	4815	4922	5029	5136
5243	5350	5457	5564	5671	5778	5885	5992	6099	6206	6313	6420
6527	6634	6741	6848	6955	7062	7169	7276	7383	7490	7597	7704
7811	7918	8025	8132	8239	8346	8453	8560	8667	8774	8881	8988
9095	9202	9309	9416	9523	9630	9737	9844	9951	10058	10165	10272
10379	10486	10593	10700	10807	10914	11021	11128	11235	11342	11449	11556
11663	11770	11877	11984	12091	12198	12305	12412	12519	12626	12733	12840
12947	13054	13161	13268	13375	13482	13589	13696	13803	13910	14017	14124
14231	14338	14445	14552	14659	14766	14873	14980	15087	15194	15301	15408
15515	15622	15729	15836	15943	16050	16157	16264	16371	16478	16585	16692
16799	16906	17013	17120	17227	17334	17441	17548	17655	17762	17869	17976
18082	18188	18294	18400	18506	18612	18718	18824	18930	19036	19142	19248
19354	19460	19566	19672	19778	19884	19989	20091	20190	20287	20382	20476
20569	20661	20753	20844	20935	21025	21115	21204	21293			

APPENDIX D – INPUT DATA FILE FROM EXAMPLE 2

```
! March 27, 2000
ditch.dat
f   ;(1)Print nodal coordinates
f   ;(2)Print elemental incidences
f   ;(3)Print elemental K and S
f   ;(4)Print nodes/elements to file
t   ;(5)Calculate Heads
t   ;(6)Print Heads
t   ;(7)Print Heads to a file (*.hds)
f   ;(8)Print only last heads to a file (*.hds)
t   ;(9)Print water table convergence info
f   ;(10)Input old heads to continue a run
t   ;(11)print last heads for input for a later run
t   ;(12)generate gradient/direction field
f   ;(13)print gradients/directions
f   ;(14)output gradients/directions
t   ;(15)generate velocity field
f   ;(16)output velocity field
t   ;(17)run mass transport
f   ;(18)print concentrations/particle distributions
f   ;(19)output concentrations/particle distributions
t   ;(20)output particle distribution
t   ;(21)output last particles for input to continue a run
f   ;(22)input last particles to continue a run
f   ;(23)print mass, X,Z coordinates of particles
f   ;(24) Run advection/dispersion
4           ;n_obs
37 25       ;col(1),row(1)
57 25
75 25
97 25       ;col(4),row(4)
 84   121   ;nrow, ncol
  1   100   ;ngeol,nitmax
f           ;var_x (T for var. delx, F for const. delx - if F, enter only 1 value)
1.0
.1d0        ;delz
365         ;ftime
6           ;n_out_time
60.0
62.5
65
100
101.5
110
0.5 1.0                 ;delt,dtmax
3.0                     ;headi
 0.200  .001   1.01     ;specyd,tolrnc,deltin
!
4.7     4.76    4.82    4.88    4.94    5       5.06    5.08    5.1     5.12
5.14    5.16    5.18    5.2     5.22    5.24    5.26    5.28    5.3     5.32
5.34    5.36    5.38    5.4     5.42    5.44    5.46    5.48    5.5     5.51
5.52    5.53    5.54    5.55    5.56    5.57    5.58    5.59    5.6     5.6
5.6     5.59    5.58    5.57    5.55    5.53    5.51    5.49    5.47    5.45
2.8     2.8     2.8     2.8     2.8     2.8     2.8     2.8     2.8     2.8
2.8     5.61    5.62    5.63    5.64    5.65    5.66    5.68    5.7     5.7
5.7     5.7     5.69    5.68    5.67    5.65    5.64    5.63    5.62    5.61
5.6     5.58    5.56    5.54    5.52    5.5     5.48    5.46    5.44    5.42
5.4     5.37    5.34    5.31    5.28    5.24    5.2     5.15    5.1     5
4.9     4.8     4.67    4.55    4.48    4.45    4.42    4.39    4.36    4.33
4.3     4.27    4.24    4.21    4.18    4.15    4.12    4.09    4.06    4.03
4       ;elvgrd
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50.0 60.0 2.8
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0        ;nwells
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8.64E-0    8.64E-0       ;khorz,kvert
0.50E-3    0.30E+0       ;stor,porsty
0.00E-0    0.00e-0       ;disper
T                        ;ptcode
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Environment Canada
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P.O. Box 5050
867 Lakeshore Road
Burlington, Ontario
L7R 4A6 Canada

National Hydrology Research Centre
11 Innovation Boulevard
Saskatoon, Saskatchewan
S7N 3H5 Canada

NATIONAL WATER RESEARCH INSTITUTE

INSTITUT NATIONAL DE RECHERCHE SUR LES EAUX

Institut national de recherche sur les eaux
Environnement Canada
Centre canadien des eaux intérieures
Case postale 5050
867, chemin Lakeshore
Burlington, Ontario
L7R 4A6 Canada

Centre national de recherche en hydrologie
11, boul. Innovation
Saskatoon, Saskatchewan
S7N 3H5 Canada

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