

FIPR Hydrologic Model

Part III:

USERS GUIDE

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CHAPTER 1. DATA COLLECTION AND ORGANIZATION

Introduction

FHM is an integrated hydrologic model combining both the surface water and ground water system. Modeling both surface and ground water requires collection of data, preparation of data into model parameters, and interactively adjusting coefficients until the model reasonably represents both systems. This documentation will help define what data is required and how to enter the data into the model. Also included are sections describing the model simulations and how to trouble shoot common simulation errors, briefly how to calibrate the water budget model, and how to post-process the model results.

The typical integrated model application includes the separate application and calibration of the surface water component and the ground water component followed by the complete integrated simulations. This part of the documentation describes parameter entry and model simulation.

FHM needs both temporal and spatial data. Recorded climatological and hydrological data are required to drive the model. Observed hydraulic response data must also be available for calibration. Spatial data includes land form maps describing the basins: land use/land cover, soils, topography, and hydrography. Hydrogeologic data, including defined hydrostratigraphic layers and potentiometric elevations, often the most difficult to obtain, are essential to help determine the aquifer parameters and define the boundary conditions of the ground water system. Formatting of all this data into the input required by the models is performed by the model pre-processors. Performing the spatial analysis on the collected thematic maps can be performed manually or using HydroGIS (see Part II). HydroGIS is an interface to ARC/INFO which provides spatial analysis of the thematic maps and creates characteristic files for use in FHM pre-processors.

Simulation features which require advanced user expertise must be entered into the input files without the aid of the pre-processors of FHM. Data formats for advanced user options are found in the HSPF (Bicknell 1993) and MODFLOW (McDonald and Harbaugh 1984) documentation.

Meteorological and Hydrologic Time Series

Time series data are continuous records of hourly or daily observations at given station locations. The time series data required by FHM include climatological model input: i.e., rainfall and evapotranspiration. Hydrologic data series include records of stream flow diversions (e.g., surface water withdrawals) and ground water withdrawals (e.g., well pumping records). Other time series data required for proper model application include: observed stream flows, lake or reservoir stage, and observed monitor well hydrographs. The time series data must be compiled into formatted ASCII files for use by the model as input and formatted ASCII files for use by the

post-processor (this is actually optional but is necessary to perform model calibration). The ASCII files are referred to as plot files, which are used by HSPF, the surface water component of FHM. The format of these files is illustrated by an example rainfall series shown in Appendix A. The post-processor of FHM uses this plot file format to help provide interpretation of the vast model results.

Precipitation

Precipitation is the primary input time series for HSPF. Only precipitation in the form of rainfall is included in FHM. However, HSPF has snowfall/snow melt subroutines that can be employed by the advanced user. Rainfall data must be supplied to the model on an hourly time basis in inches/hour. At a minimum, hourly rainfall is required to adequately represent infiltration and runoff processes governed by the physical response of the vadose zone. The rainfall data is also stored in a HSPF plot file format. The file must be given an eight character name with *.DRF extension and placed in the project work space which is created by the interface of FHM. The present version of FHM allows for 10 different rainfall stations (although the advanced user can utilize more). Using as many stations as possible allows the model to account for the spatial variability in rainfall. If more than one station is specified, a fractional distribution must be defined to properly distribute the rainfall data to subbasins and reaches. This can be accomplished using a Thiessen distribution created by the GIS (see Part II). The station distribution will be discussed later in the surface water pre-processing advanced user options.

Historic rainfall data is available from many sources, for example, the National Climatic Data Center, local water management agencies, the National Weather Service, or commercial sources. In many cases, site specific rainfall can be easily collected for modeling use. The data should be void of missing or erroneous entries. Also the hourly rainfall data should be compared to the surrounding daily recording stations (typically a much greater number of stations). This will insure that the hourly record represents the regional rainfall for the area of interest (e.g., basin). The rainfall data must also contain the record and dates for the period of the desired simulation.

Potential Evapotranspiration

Potential evapotranspiration (PET) is another very important input time series for FHM. Typically, ET is the second largest water budget term after rainfall. The PET must be estimated using either measured pan values (including a pan coefficient, e.g., 0.7) or based on other estimates, for example, the use of Penman equations. As with the rainfall time series, the PET time series must be defined hourly and in units of inches/hour. For PET model input the HSPF plot file format is used. The file should be named *.ETD (where the * is the eight character user defined simulation name). Similar to rainfall, the user interface of FHM allows for up to 10 different stations. If more than one station is used then a distribution must be specified for both basins and reaches. Again, the data should be void of any missing or erroneous entries. Also, the data must cover the period of simulation.

Diversions Flows

Surface water diversions can occur for various reasons. Diversions can be measured or modeled inflows from outside the model domain. If the area of interest is downstream of a large complex watershed with measured discharges, then it is convenient to simply use the measured stream-flows as an off-site inflow to the region of interest. Off-site inflows can also be derived from large-scale simulation results during multi-scale modeling to drive boundary conditions in a near-field model. Another common diversion type is measured augmentation/withdrawals or surface water pumping into or out of a stream or wetland. Surface water to surface water (e.g., reservoir to reservoir) pumping can be performed, first using a negative time series representing the withdrawal and a second identical but positive time series representing the augmentation. Ground water augmentation of a surface water reservoir would require that the water be withdrawn from the ground water domain via a well pumping record specified in the MODFLOW well package and then re-introduced into the surface water feature as a diversion inflow. Conservation of total water budget must be maintained. Diversion data follows the same format as the rainfall and ET data (plot file format). The time series must be defined on a hourly time interval. The units of the diversion data are cubic feet per second. The model interface allows input of 10 different time series. Advanced users can employ more (discussed later). The diversion plot file must be given the eight character run name followed by a .OFD extension and placed in the project workspace.

Observed Stream Flows and Baseflow Separation

Observed stream flows are typically used in model calibration. In some cases, they can be used as an offsite inflow. (See previous section.) Measured data can be plotted against simulated results in the post-processor (or any graphing software) of FHM. To plot observed streamflow with the post-processor of FHM the data must be formatted into an HSPF plot file. The created files should be named *.S81-*.S85 for hourly data and *.S91-*.S95 for daily data (where the * is a user defined name different from the simulation name). Observed stream flow can be plotted against simulated streamflow at either hourly or daily intervals. Again the files will contain up to 10 different columns of data. Five separate files are allowed in FHM for a total of 50 stations.

Also, stream flows can be separated into baseflow and runoff components. Baseflow separation can be done using many different methods. The reader is referred to any elementary hydrology text for baseflow separation techniques (see, for example, Viessman et al., 1995). It must be stressed, that it is very important to quantify the baseflow component of total stream flow for surface water only, ground water only, or integrated simulations to fully evaluate model performance against the prototype water budget. Baseflow quantities should be prepared in time series and summary (total) form for evaluating model performance.

Observed Well Elevations

Observed well hydrographs are required to calibrate predicted heads in the ground water model (ground water only or integrated simulation). The observed well elevations should be placed in the same HSPF plot file format used earlier (see Appendix A). The interval of the data will vary depending on the simulation type. To compare against the ground water only simulation, the data must be stored at the same interval used for MODFLOW stress periods. For comparison with integrated output, the interval for the data should be the same as the integration time step (typically weekly). As before, the plot file format allows 10 columns per file, with a maximum of 5 files, for a total maximum of 50 well comparisons. The files produced should be named *.WP1-*.WP5 (where the * is a user defined name different from the simulation name).

Ground Water Pumping and Injection

Time series data for ground water pumping and injection are necessary for independent ground water and integrated simulations. The available time series data must be transformed to match the ground water stress periods of the simulation. If a GIS is used to store the location of each well, a unique ID must be assigned to each well in the GIS and in the time series data. The unique ID allows the location data to be matched uniquely to the rate data (time series). Location and rate data are required input for the model simulation. More information is provided about location data for wells later in this chapter in the Ground Water Data section. Also refer to the Existing Wells operation in Chapter 3 of Part II if employing the GIS to construct model data.

Basins and Hydrography

The collection of basin data is important only for the surface water model and the surface water component of the integrated model. However, the information collected for basins has a profound influence on the ground water model domain (grid based system). This data can, however, affect the ground water recharge rates by affecting the basin water budget. As with most surface water models, the surface water budget is simulated using catchments or sub-basins. The catchment parameters will be defined from the data collected below and the water budget calibration performed with the model.

Basin Selection and Classification

The basin boundaries are defined by the topography including roads and ditches which significantly alter the runoff patterns. The basin boundaries define the region from which the basin parameters will be developed. The basins should define the regions that contribute to stream gaging stations for model calibration. FHM Version 3.0 is capable of simulating 50 basins in one simulation. The more basins used to describe a region the better the resolution of model parameters (varying slope, land use conditions, etc.). Basin resolution is relative to desired model scale. It is best if a basin is of relatively homogeneous land use and soil type for the scale of

resolution so that the average basin parameters are representative of the actual response in most of the domain of the basin. For integrated modeling, the selected basins are required to cover the entire ground water model domain to quantify recharge, even though the basin may not contribute directly to a downstream surface water feature of interest. However, it is acceptable for a basin that contributes to a region of interest to lie partially outside the ground water grid domain (see Figure 1.1). In this instance both the total area of the basin and the area outside the grid must be determined. Basins must be numbered (i.e., classified) sequentially beginning with one. Once the basins are selected and numbered, basin hydrologic parameters can be developed (discussed later). However, basin numbering must be done in conjunction with hydrography selection, classification, and routing which are discussed below.

Hydrography Selection and Classification

There are two types of hydrography necessary to accurately simulate the water budget of a catchment; routing hydrography, and storage hydrography. The routing hydrography is required to route the basin discharge hydrographs (and any diversions) to the outfall of the region or to downstream surface water features of interest. The routing hydrography represents the perennial streams which carry the storm water runoff to the outfall. The routing reaches should be classified such that basin hydrographs can be assigned to the reach as an inflow at the upstream end of the reach, including any diversion inflows and converging reaches (e.g., see Figure 1.2). Many reaches can converge into one downstream reach, but divergent reaches are currently not explicitly simulated in FHM.

Storage hydrography is required in a surface water model to attenuate overland flow runoff from basins, especially large basin discharges to perennial streams. The storage hydrography is the cumulative storage of all alluvial wetlands, ponds, storm water pipes, ditches, and ephemeral streams that are inter-connected and contributing to a routing reach or to the outfall. Non-inter-connected hydrography exists, and is represented in the model as storage without discharge and macro-depressional storage (see Part I). The actual overland flow regime, where infiltration dominates, occurs for very short distances (< 300 feet typically). Small channelized flows dominate over the next 1000 feet (e.g., gutters, small ditches, wetlands, and ephemeral stream contributions). Before surface water runoff reaches a water body of interest (typically a perennial stream, lake, etc.) much channelized storage attenuation has occurred. To account for this in the model, all of the small hydrography (often not shown on a map) must be accumulated into a single storage/attenuation element for a basin. As with the basin classification, the hydrography has to be identified numerically and sequentially beginning with one. The reach number 0 is reserved for the outfall which will be discussed in basin and reach routing.

Lastly, associating ground water river cells, which are usually pieces of a stream segment, to HSPF reaches requires static/dynamic classification (see Part I for definitions). Static river cells contribute to baseflow of an HSPF reach but the river stages are considered constant in the ground water algorithms. Dynamic stream segments contribute to HSPF baseflow and the stages in the ground water model are adjusted from the temporally varying elevation of the associated HSPF routing reach. Each reach must have at least one dynamic element. However, integrated models can include reaches which are completely static. Only the ground water component data set includes reaches which are completely static, which must be given the highest reach numbers.

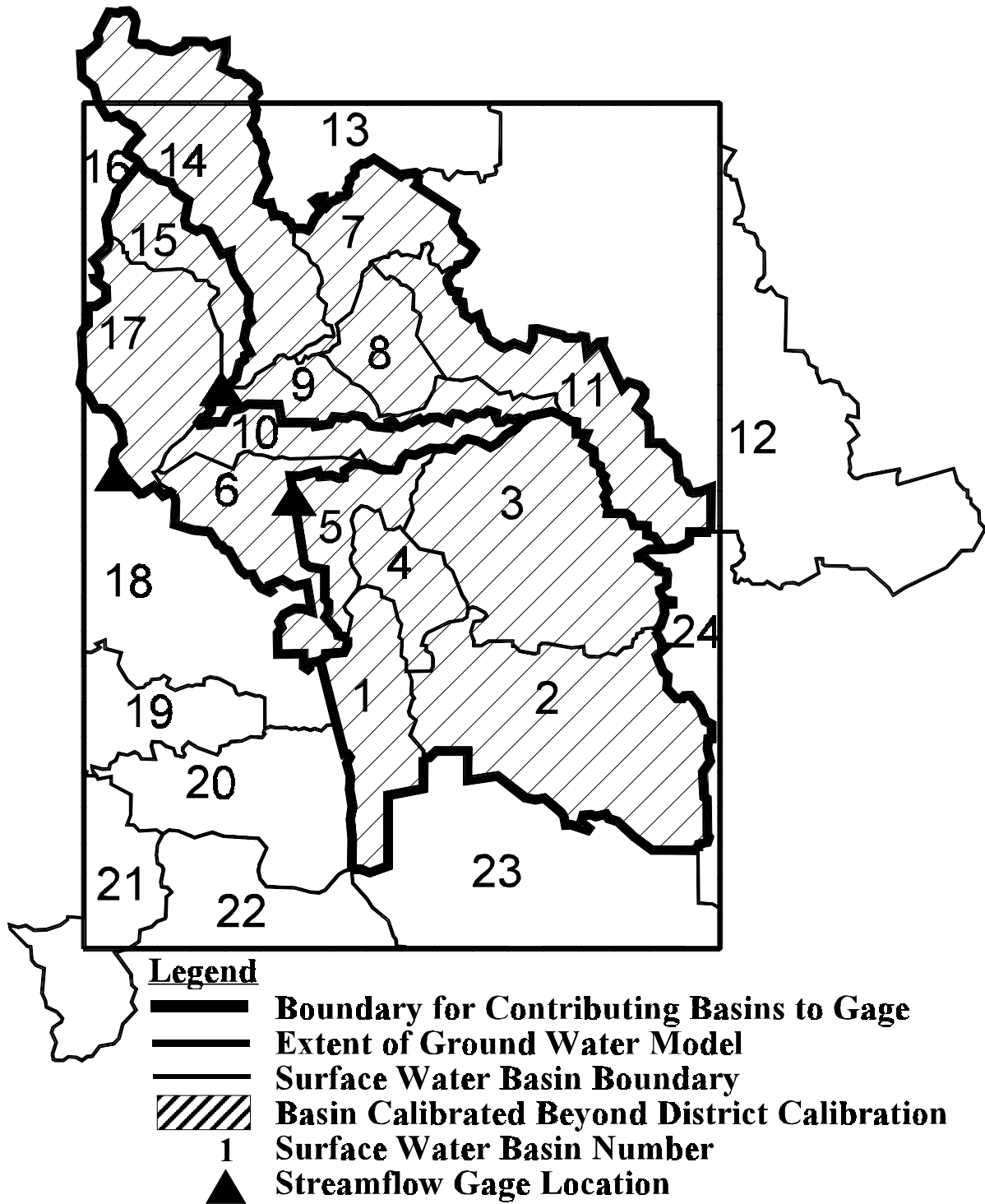


Figure 1.1 Example of Subbasin Coverage of an Active Ground Water Domain.

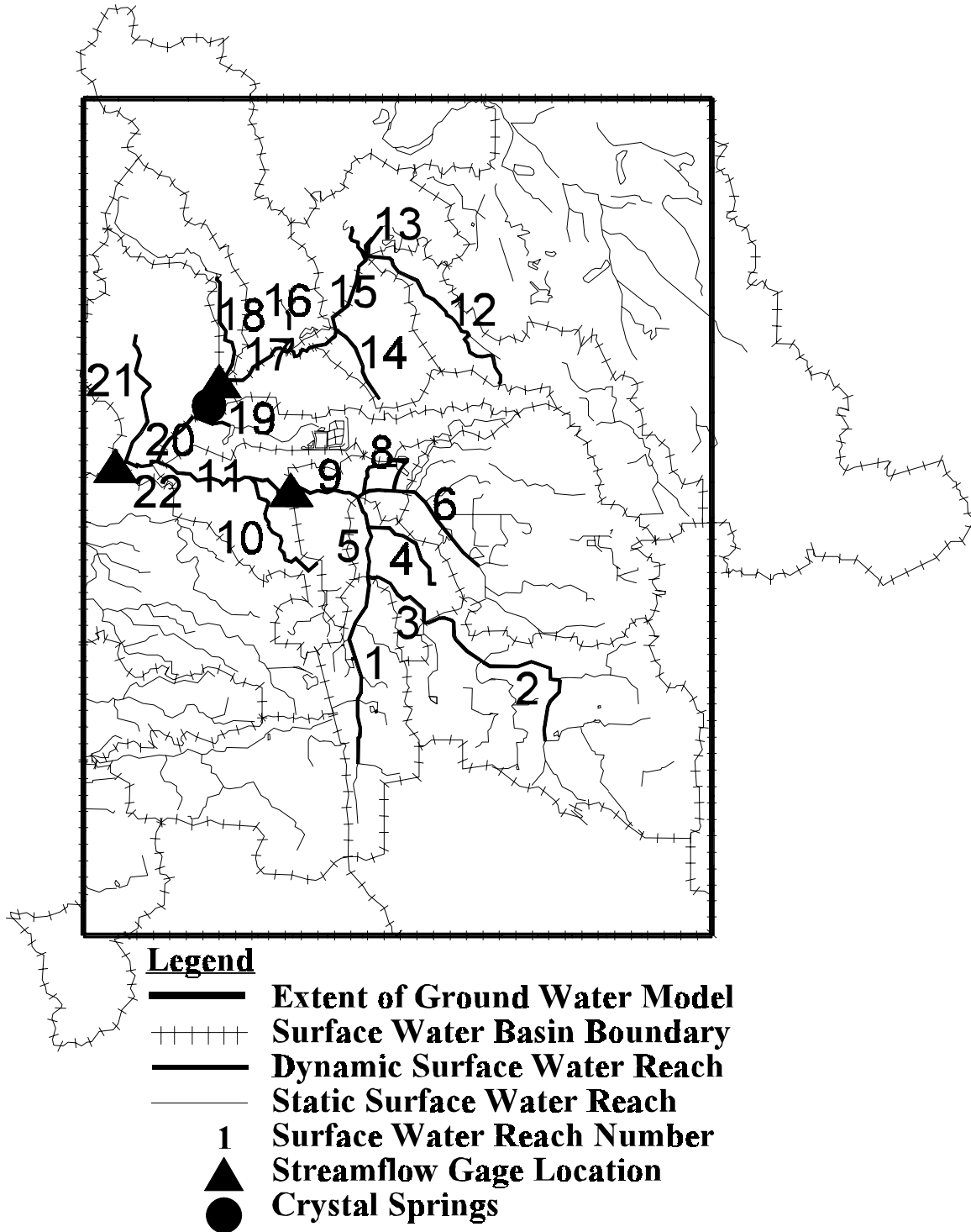


Figure 1.2 Example of Hydrography Delineation (Static and Dynamic) in Relation to Basins.

Ground Water Data

Beyond the standard application of MODFLOW, there are unique requirements for conceptualization of an integrated simulation with FHM. The following text will briefly describe how to set up a ground water simulation in FHM using MODFLOW, which also applies to integrated simulation. For general MODFLOW information on the river package, the reader is directed to McDonald and Harbaugh (1988).

Conceptualization

The first step in developing a ground water model is model conceptualization. Defining the number of layers, the layer types, grid spacing, and boundary conditions are all part of the model conceptualization. The following section describes the preparation of this collected data into the files formats and parameters required for FHM. The model data requirements are dependent on the layer type chosen to represent the aquifers. In FHM the first layer must be of layer type (**LAYCON**) three. For integrated modeling, the region to be modeled (active area) in MODFLOW must be represented with surface water model basins described previously. As with any ground water model, the grid should extend to regions where reasonable flux or head boundary conditions can be defined. The current version of FHM does not allow variable grid spacing but, perhaps more desirably, does include nested multi-scale modeling for improving the model resolution. The model currently works with grid dimensions of no greater than 106 rows and 60 columns. The limitation in ground water layers is defined by MODFLOW at 80. The x-array is limited to 1,500,000 data elements (including wells, rivers, drains, GHBs, recharge, ET).

Hydrography Segments

Described earlier, hydrography must be selected, classified (numbered), and separated into dynamic and static elements. Recorded stream flow must be separated into baseflow and runoff fractions. Routing must be organized for basins and hydrography. The ground water domain grid must be compared (overlaid) with the selected basins and reaches. The grid superposition yields sections (pieces and segments) that will be “river reaches” in the MODFLOW ground water domain. These are operations that can be greatly facilitated by, the GIS (see Part II). In FHM, the MODFLOW river package is utilized with an additional column entry beyond the standard MODFLOW input. The extra column is the reach id assigned to the river segments. For integrated simulations the reach id is the HSPF reach number. A positive or negative reach id signifies a dynamic or static reach respectively. This id insures river stages will be adjusted by the depth reported by HSPF for dynamic streams (positive reach id) and baseflows will be accumulated for all segments (by the absolute value of the id described in Part I. For ground water only simulations the reach id should coincide with the known stream flow gaging stations. Data input for river segments for both surface and ground water are explained in more detail in the chapters that follow.

Data that must be gathered for the river reaches include the cross-section geometry, lengths (if GIS is not used), bed elevations and stream bed leakance (although this is typically a calibration

parameter) and annual mean stages. This information will ultimately contribute to the development of storage rating (storage vs. stage), and ground water model parameters. Discharge rating (discharge vs. stage) is also required in the model for the gaging station locations and the downstream ends of all selected routing reaches. For gaging stations, rating is usually available. However, for ungaged reach discharge locations, frictional and/or structural conditions may need to be measured or field estimated for the routing described in Chapter 2.

Location and Layer Assignment for Pumping and Injection Wells

For each pumping and injection well in the time series data, the grid cell location and vertical discretization of the rate (i.e., distribution of total rate to each model layer) must also be provided. The grid cell location is in the form of a row and column number from the finite-difference grid. Assignment of each well to a grid cell is either performed manually or by means of GIS overlays. Vertical discretization of the rate requires the following data:

1. elevation for casing depth and total depth for each well
2. elevations for the units which represent the top and bottom of each model layer
3. hydraulic characteristics for each model layer

From the elevation data, each well is assigned to one or more model layers. If a well is assigned to one layer, the entire rate for the well is assigned to the layer. If a well is assigned to multiple layers, the hydraulic characteristics of the contributing layers can be used to vertically discretize the rate among the contributing layers. For each well, the sum of the rates from all layers must equal the original rate within each stress period.

As stated in the time series section of this chapter, a unique ID must be available in the location and time series data to match the two data elements together for the model simulation. The unique ID is especially critical when the GIS is used to construct the model data for pumping and injection wells. Refer to the Ground Water Data Preparation Utilities, Existing Wells operation, and Proposed Wells operation sections in Chapter 3 of Part II for information about employing the GIS to construct model data for wells.

Data Specific to Integration

Additional data are required for the integrated simulation. Recall, for the model to be conceptualized properly, the basins must cover the entire grid domain. The ground water component should also have the correct HSPF reach id and sign for static or dynamic element associated with each river cell (extra column entry). The additional data required for an integrated simulation are the grid based basin numbers, grid based soil field capacity, and the grid based plant ET coefficient. The basin number array provides the spatial linkage between the surface water basins and the ground water grids (required to pass the basin recharge and remaining PET to the MODFLOW grid cells). For every number in the basin array there must be a coinciding basin in the HSPF simulation. The field capacity array is necessary to characterize the unsaturated zone dynamics during integration. The model expects the field capacity in decimal ratio units (volume ratio). The plant ET coefficient is a decimal percentage which factors the remaining PET

that is passed to the ground water component. The plant ET coefficient is a model calibration parameter dependent on the plant community efficiency of extracting saturated water from the water table.

CHAPTER 2. FHM INPUT PREPARATION

The previous chapter described the collection and organization of basic hydrologic, meteorologic and topology data. This chapter describes the preparation of this collected data into the files, formats and parameters required for FHM. The data requirements are divided into the three parts: surface water, (principally, the data requirements of HSPF), ground water (MODFLOW), and additional data essential for model integration. The pre-processors of FHM create standard input files for HSPF and MODFLOW.

Surface Water Data

HSPF, the surface water component of FHM, simulates the basin water budget and the reach water budget in both the surface water only and integrated simulations. The input preparation, presented below, is in the order required by the pre-processor. Table 2.1 summarizes surface water input data files for FHM. For independent surface water models, the surface water pre-processor reads/creates the *.INS file for basins and the *.INR file for reaches. These same files are used in the simulation. For integrated models, the surface water pre-processor reads/creates the *.INS and *.INR files also. For the integrated mode, the *.ICS (basins) and *.ICR (reaches) files are created from the *.INS and *.INR files by the surface water pre-processor. The *.ICS and *.ICR files are used for the integrated simulation. The processing loop for an integration timestep is depicted in Figure 3.1 of Part I.

Rainfall Time Series and Simulation Date

The first definition for a model data set is the rainfall time series for the simulation. The pre-processor displays a list of all available rainfall data sets (all files with .DRF extension) within the project directory and the executable directory of FHM (during modification the existing rainfall data set, named *.RAN, is also in the list). Select the rainfall data set desired for the simulation. If more than one time series is found in the selected file then the GIS derived Thiessen output is automatically utilized. If the GIS Thiessen polygon analysis is not available, an even distribution for each gage is used. This even distribution can be edited later. The next prompt is for the definition of the start and stop dates for the simulation period. The dates must be contained within the rainfall data selected and all other time series files (e.g., ET and diversions). The user is prompted for the day and year for the start and end of the program. The pre-processors assumes the start time is midnight-a.m. (00:00) of the day indicated. The stop time is midnight-p.m. (24:00) at the end of the day indicated. Thus, the starting and ending day can be the same.

Basin and Reach Routing

The number of basins and reaches need to be specified for the pre-processor. There has to be at least one basin for the model, but the number of reaches may be zero (although this is

unrealistic). The maximum number of basins per simulation is limited to 50. Similarly, the maximum number of allowable reaches is limited to 50.

The discharge hydrographs of each basin must be routed to a reach or to the outfall (the outfall is “reach” zero). Recall, the outfall is basically a terminal routing designation for basins and hydrography that do not discharge or that flow off the model domain. When a basin is routed to a reach, the basin discharge is used as an inflow volume time series to the reach. If there is a storage reach associated with the basin, the basin will be routed to the numbered storage reach which in turn will be routed to the next receiving reach. At the same time the pre-processor is prompting for the routing information the basin areas are requested. The basin areas are defined in acres. The area assigned to a basin should not include the area of any hydrography included in the receiving reach (otherwise areas are double accounted for in both rainfall and ET). If GIS derived characteristic files are available then the basin area may be selected from the GIS information.

Table 2.1 Input Data Files Used in the FHM Integrated Model - Surface Water¹

Filename	(Temporary Filename) ² Description
Time Series Input for Independent Surface Water and Integrated Models	
*.ETD	PET input for HSPF event only (HSPF plot file)
*.OFD	Diversion inflow/outflow to/from reaches (HSPF plot file)
*.RAN	Rainfall input to HSPF (HSPF plot file)
Input for Independent Surface Water (SW) and Integrated (INT) Models	
*.INF	Basin information (routing and optional Thiessen polygon fractions)
*.INR	SW pre-processing and simulation and INT pre-processing for HSPF reaches
*.INS	SW pre-processing and simulation and INT pre-processing for HSPF subbasins
Additional Input for Integrated Models	
*.ICR	(RUNAR.INP) INT simulation for HSPF reaches
*.ICS	(RUNAS.INP) INT simulation for HSPF subbasins
*.MOD	(RUN.MOD) Run modifications file for integration time step
Temporary Transfer for Integrated Models	
HSPFBFx.DAT	Integrated base flows from MODFLOW (x=1-5, 0 is user defined)
RUNB.DAT	Ending surface water conditions for current integration timestep

¹ All files are ASCII unless otherwise indicated.

² Filenames in “()” are temporary files used and made during integrated simulations

Reaches must be routed to other reaches or the outfall. When a reach is routed to another reach the receiving reach must have an id that is numerically larger than the reach being routed. Reaches that discharge independently from the model domain are still routed to the outfall (reach zero). The outflow of a reach will be used as an inflow to the reach to which it is routed. For an integrated model, a reach can have the following sources for the HSPF inflow volume (**IVOL**): upstream reach, basin routed to reach, diversion inflows, baseflow inflows (inflows may be negative as in losing baseflow), precipitation, and evaporation.

Diversion Routing

First the number of diversion inflows needs to be specified. Up to ten diversions can be used in a simulation. Next, routing must be defined for each diversion. If the diversion file was created prior to pre-processing (see data collection section above) then the diversion titles are included in the pre-processing screen. Each diversion is routed to a reach which will become another component to the reach inflow volume (**IVOL**). The pre-processor multiplies the time series (specified in cfs) by a factor to convert to the HSPF required inflow volume specified in acre-feet per hour.

Basin Parameters

Input parameters must be specified for each basin selected for the region. These parameters will control model hydrologic response of the basin. Four different data entry screens are required to supply all the parameters for HSPF. The basin parameters are broken down into the following categories: capacity parameters, outflow parameters, initial storages, and evapotranspiration parameters.

Capacity Parameters (Storages)

The basin capacity parameters describe the storages and infiltration flux capacities. These basin parameters can be estimated from an overlay between basin boundaries, soil and land use maps (See Part II). However, in most cases the estimated parameters will require calibration adjustment. From the land use map the following parameters can be related: interception storage capacity (**CEPSC**) and depressional storage capacity (**UZSN**). These storage capacities are volumes of storage but are related to inches over the basin area (as with all water budget input and output in HSPF). From the soils map the infiltration capacity index (**INFILT**), infiltration exponent (**INFEXP**), and infiltration ratio can be estimated. The basin ground water influx parameter, **DEEPPFR**, is a fraction which determines the quantity of water that enters the inactive ground water from the water that infiltrates past the lower zone (the remainder enters the active ground water storage). In a surface water only application, **DEEPPFR** is an important parameter that indirectly effects baseflow and ground water ET. In the integrated mode of FHM, this parameter is set to 1.0 so that all the water that infiltrated past the lower zone will enter the inactive ground water storage. The integration codes will use the inactive ground water inflow

(IGWI) as recharge in the ground water component. Table 2.2 summarizes the basin capacity parameters, ranges and defaults in FHM.

Table 2.2 Basin Capacity Parameters

Parameter	Range	Default
CEPSC ¹ Interception Storage Capacity [in.]	0.0 - 1.0	0.1 ¹
LZSN ¹ Lower Zone Nominal Storage [in.]	0.01 - 100	7.1 ¹
INFILT ¹ Infiltration Capacity Index [in./hr.]	0.001 - 20.0	0.3 ¹
INEXP Infiltration Exponent	1.0 - 10.0	1.6
INFILD Maximum/Mean Ratio	1.0 - 2.0	2.0
UZSN ¹ Upper Zone Nominal Storage [in.]	0.01 - 10.0	0.3 ¹
DEEPPFR Fraction to Deep Aquifer Inflow	0.0 - 1.0	0.0 ² 1.0 ³
INTFW Interflow Inflow Parameter	0.0 - 1.0	0.0
¹ GIS value available ² Default for surface water only simulation. Other values are also possible. ³ Default which must be used for integrated simulations. Sources: HSPF manual and FHM project.		

Outflow Parameters

The first three outflow parameters, **LSUR**, **SLSUR**, and **NSUR** (see Table 2.3), affect the overland flow rate and quantity of runoff. Reduced overland flow rate results in higher infiltration, thereby reducing runoff volume. From the basin delineations and topographic map the basin slope (**SLSUR**) and basin hydraulic length (**LSUR**) can be subjectively determined (systematically in the GIS, see Part II). With careful analysis, high confidence can be achieved and little calibration adjustments should be made or required of this parameter. The basin slope is the average slope of the basin in units of feet/feet. The hydraulic length (units of feet) of a basin is the average distance of overland flow and early channelized flow to the nearest water body used as receiving hydrography in the model (including combined storage hydrography). Manning's n friction factor is the average overland flow friction factor (much higher than for open channel flow) which can be estimated from the land use/land cover maps.

Manning's n values should, however, be something less than listed for overland (sheet) flow regime due to inclusion of small channelized flow regimes in the hydraulic length determination. The parameters **KVARY**, **AGWRC**, and **GWVS** control outflow from the active ground water. In the integrated model these variables are not required. In the integrated model active ground water is replaced with simulated base flows from MODFLOW. These parameters should be adjusted such that the baseflow component of total streamflow fits well with the measured data (after baseflow separation). Baseflow in the surface water model is important for

proper storage attenuation and low flow discharge in the streams. The last parameter, **IRC**, controls the recession of interflow storage only if this storage is active (see **INTFW** above).

Table 2.3 Basin Outflow Parameters

Parameter	Range	Default
LSUR ¹ Length of Overland Flow Plane [ft.]	1.0 - 2,500.0	None ¹
SLSUR ¹ Overland Flow Plane Slope [ft./ft.]	.001 - 1.0	None ¹
NSUR ¹ Overland Flow Manning's Friction Factor	.001 - 1.0	0.1 ¹
KVARY AGW Recession Parameter [1/in.]	0.0 - 1,000.0	0.9
AGWRC AGW Recession Rate [1/day]	0.001 - 0.9	0.9
GWVS Index to GW Slope	0.0 - 100.0	0.0
IRC Interflow Recession Parameter [1/day]	0.0 - 1.0	0.9
¹ GIS value available. Sources: HSPF Manual and FHM Project.		

Initial Storages

The initial storages of the basins define the amount of water each of the surface water storages will have at the beginning of the simulation. The volume of water is related to inches over the basin area. The first three storages, interception (**UZS**), surface detention (**SURS**), and upper zone (**UZS**), are typically dry unless the simulation is started directly after a storm event. These storages are typically small and dry from evaporation quickly. If there is wet antecedent condition then these storages must be estimated. The initial interception storage (**CEPS**) should however, be less than the capacity (**CEPSC**). If surface detention storage (**SURS**) is defined then the basin will discharge at the beginning of the simulation. The last three storages, interflow (**IFWS**), lower zone (**LZS**), and active ground water (**AGWS**), are typically much larger and will need to be estimated for the start of a simulation. The initial storages can be defined from previous simulations, if the simulations are sequential. To estimate these initial storages, see Part I for technical details. Initial lower zone storage is the most important for effecting runoff/infiltration response. An estimate for **LZS** is the moisture content of the vadoze zone. The integrated simulation automatically adjusts the initial storages within the integration loop to conserve mass. The initial storages primarily effect the water budget in the beginning of the simulation. However, the model may be sensitive to the initial values **LZS**, **IFWS**, and **AGWS** for several months or, in some cases, years (Baudean, 1995). To reduce the sensitivity of selection of initial conditions, longer simulation (multiple years) is required for reasonable calibrations. Table 2.4 describes each of the initial storages and lists the ranges permissible in the surface water model HSPF.

Table 2.4 Basin Initial Storages, Ranges and Defaults

Parameter	Range	Default
CEPS Initial Interception Storage [in.]	0.0 - 1.0	0.0
SURS Initial Surface Detention Storage [in.]	0.0 - 10.0	0.0
UZS Initial Upper Zone Storage [in.]	0.0 - 10.0	0.1
IFWS Initial Interflow Storage [in.]	0.0 - 100.0	0.0
LZS Initial Lower Zone Storage [in.]	0.0 - 100.0	LZSN
AGWS Initial Active Ground Water Storage [in.]	0.0 - 100.0	0.0
Sources: HSPF Manual and FHM Project.		

Evapotranspiration Parameters

The evapotranspiration parameters in the surface water component limit the available or remaining PET for different parts of the water budget, specifically baseflow, active ground water, and lower zone (see Table 2.5). For details on evapotranspiration in the surface water see Part I. Recall, HSPF uses a hierarchal allotment of ET from the various storages in the basin. If there is remaining PET it will be removed from the next available storage according to the potential of particular storage. The basin ET parameters can only be defined from model calibration. Part IV contains information on values found for West Central Florida.

Table 2.5 Basin Evapotranspiration Parameters

Parameter	Range	Default
BASETP Fraction of PET available for Baseflow ET	0.0 - 1.0	None
AGWETP Fraction of PET available for AGWET ET	0.0 - 1.0	None
LZETP Fraction of PET available for LZET ET	0.0 - 1.0	None

Reach Parameters

HSPF represents reaches as simplistic reservoirs with a predefined storage/discharge routing relationship. This is referred to as a reach F-Table in HSPF. The F-Table contains a user defined tabulation of reservoir stage to the reservoir surface area, storage and discharge. Hydraulic and F-Table parameters must be defined for every reach modeled in HSPF.

Hydraulic Parameters

The reach hydraulic characteristics required by HSPF as defined in FHM include: the length, K_s , and initial volume (see Table 2.6). The reach length is the overall length of the reach

in miles. The reach weighting factor, K_s , which defines the degree of implicitness in the numerical solution, can range from 0 to 0.99. A value of $K_s = 0.5$ is typically used which represents a central - difference in time solution. The initial volume is the volume of the reach at the start of the simulation. The initial volume of the reach is specified in acre-feet. If the current simulation was a continuation of another run then the initial volume would be the ending volume from the previous simulation. Otherwise, water balance problems would result. HSPF F-Tables must be constructed with the relative stage of the channel (depth to bed). A stage correction variable is allowed, **STCOR**, to convert the relative stage to absolute elevations (e.g., NGVD). **STCOR** values must be defined for integrated simulation. **STCOR** values are usually defined by the GIS (see Part II).

Table 2.6 Reach Hydraulic Parameters and Ranges

Parameter	Range	Default
LEN ¹ Reach Length [miles]	0.0 - no limit	None
KS Weighting factor for Hydraulic Routing	0.0 - 0.99	0.5
VOLUME Initial Volume of the Reach [ac.-ft.]	0.0 - no limit	None
STCOR Correction to Reach Stage. [ft.]	no limit	None
¹ GIS value available. Sources: HSPF Manual and FHM Project		

Rating (F-Tables)

The F-Table defines the non-linear relationship between stage, storage, discharge, and surface area for the range of storage volumes required during the simulation. Table 2.7 lists the F-Table variable descriptions and ranges. The table must be defined to include the extremes (high and low storage) for the simulation time period. Typically, the F-Table contains entries well above the measured extremes if the model is not calibrated. During calibration, if the model yields too much runoff, the routing tabulation will be exceeded and an HSPF error will result. For this reason, the highest entry should always be much greater than the user expected values. There are currently five methods to define the F-Table for HSPF reaches: GIS defined table, trapezoidal approximation using a Manning's formulation, weir controlled reservoir, orifice controlled reservoir, and direct user input. The first option, *GIS computed hydraulic parameters*, utilizes the GIS results stored in the characteristic file DAVDCHAR.DAT. The GIS defined table (see Part II) develops the stage, storage, and volume relationship from the digital map data but excludes the discharge approximation. The discharges are then added to the table manually, from field measurements or, optionally, from utilities provided in the pre-processor. Using the pre-processor the discharges can be added to the GIS derived table using the weir, trapezoidal, or orifice utilities or by user specified values.

The trapezoidal approximation is adequate for prismatic man-made reaches and natural stream sections with similar conveyance characteristics throughout the reach. The input

Table 2.7 Reach F-Table Entries¹

Parameter	Range	Default
DEPTH Reach Depth for Given Record [ft.]	0.0 - no limit	None
AREA Surface Area of Reach At Given Depth [ac.]	0.0 - no limit	None
VOLUME Storage of Reach at Given Depth [ac.-ft.]	0.0 - no limit	None
DISCHARGE Reach Discharge at Given Depth [cfs]	0.0 - no limit	None
Sources: HSPF Manual and FHM Project		

¹ Entries must be provided that bracket the expected ranges resulting from calculated inflows from the model.

requirements for the trapezoidal approximation include: bottom width in feet, side slope in feet/feet, maximum depth in feet, reach slope in feet per feet, and reach Manning's n friction factor. A table will be generated using 11 increments from zero to the maximum depth entered. Many typical reservoir outfall structures are reasonably represented by a weir and/or orifice (used predominately in storm water treatment ponds). The discharge from these structures can be defined with standard empirical hydraulic relationships. The required input data for the weir includes the weir invert in feet, weir length in feet, and a coefficient of discharge. The weir invert defines the reach stage at which the discharge begins (from the reach bottom). A similar window is used to enter the orifice data: orifice invert again in feet, orifice diameter in feet, and coefficient of discharge.

An option is available to define a linearly interpolated relationship for the stage-storage rating. To change the stage, volume, and area relationship of the reach reservoir, the option box should be checked. If the option box is selected, the reservoir maximum depth in feet, area at minimum depth in acres, and area at maximum depth in acres must be defined. The various stage, volume, and surface area values are defined by interpolation and eleven entries are provided up to the user defined maximum depth. The stage above invert (either the weir or orifice) determines the discharge using the standard discharge relationships while stages below the invert result in no discharge.

Advanced Options

The advanced user may want to modify the HSPF basin and reach parameters manually, which can greatly speed up the calibration process. Three separate files are used to describe the surface water system: *.INF, *.INS, and *.INR (examples of these files are shown in Appendix C.1-C.3, respectively). These files are created automatically by the HSPF pre-processor. It is highly recommended that the advanced user first use the pre-processor, then when appropriate, the files may be modified. Care must be used for both how and when files are modified (see detailed description below).

The *.INF file contains general information describing both the basins and the reaches. Comments are used to define entries in the file (the comments must be present for the file to be properly formatted). The numeric records of the *.INF file are read in free format. First the number of basins and reaches are entered along with the rainfall multiplier (used with design

storms) and the number of diversions. The basin areas and the basin routing information for each basin are entered in tabular format. The first column defines the basin area in acres. An additional column defines the area outside the grid (also in acres) for area correction in integrated simulations. The route flag must be set to one (basin to basin routing is not appropriate for large basins and therefore not permissible in FHM). The next section defines the reach routing information. The reaches are defined in ascending order along with the receiving reach number in the second column. The diversion routing is defined next. Again diversions are defined in ascending order followed by the reach number which will receive the diversion flows. The last two sections provide the data for the rain and evapotranspiration influences for multiple stations. First the number of stations for rainfall is entered followed by the factors for each basin and each reach respectively. The row number represents the basin or reach number and the column number defines the station number. Note that ten columns are always required. The ET influences are entered in the same manner (number of stations, basin factors, and reach factors). The factors should add to 1.0 for each basin and reach for both rainfall and ET influences.

The basin and reach data sets are standard HSPF formats. The basin simulation is simulated first which creates plot files that contain the basin discharge hydrographs. These basin discharges are used as input for the reach simulation. The examples included in Appendix C are for the NE Hillsborough model domain discussed in Part IV. These data files may be modified by the advanced user with no further pre-processing. Any modifications to these files must be performed using the formats required by HSPF (see HSPF documentation).

The parameters in the *.INF file are used by the pre-processor and not the model. To utilize modified contents of the *.INF file in a simulation, pre-processing is required (simply load the data into the pre-processor and exit; all changes will be accepted and utilized in the model data sets). The contents of the *.INF file will be used to generate the basin and reach data sets. If modifications are made to the *.INS or *.INR files, pre-processing is required only if integrated simulations will be run. Again, simply loading the data into the pre-processor and exiting will make the appropriate *.ICS and *.ICR data sets for the integrated simulation (from the modified data in the *.INS and *.INR files). Modifying the *.ICS or *.ICR files is not recommended because the contents will be overwritten with the contents of the *.INS and *.INR if the user forgets and returns to the pre-processor.

Ground Water Data

The ground water data pre-processing, for the most part, encompasses all standard MODFLOW applications. All available packages, drains, recharge, wells, etc. are available for integrated modeling. Please refer to the MODFLOW manual for details on data requirements and file formats. FHM provides a groundwater pre-processor to facilitate development of MODFLOW input files for both groundwater only and integrated simulations. The sections below include brief descriptions of the ground water pre-processing and FHM data requirements. Table 2.8 lists the input filenames and descriptions for groundwater simulation in FHM. **MODFLOW packages created by other pre-processors can be used directly in a simulation, provided the reach number is added to the right hand side of the river package for an integrated**

simulation. However, externally created packages must conform to the file formats and naming conventions as provided in Table 2.8 and in Appendices A and C.

Table 2.8 Input Data Files Used in the FHM Integrated Model - Ground Water

Filename	(Temporary Filename) ² Description
Model Input	
*.BAS	(MODBAS.INP) MODFLOW basic package input
*.BCF	(MODBCF.INP) MODFLOW block centered flow package input
*.DRN	(MODBCF.INP) MODFLOW drain package input
*.ETA	(MODEVA.INP) MODFLOW evapotranspiration package arrays
*.EVT	(MODEVT.INP) MODFLOW evapotranspiration package input excluding arrays
*.GHB	(MODGHB.INP) MODFLOW general head boundary package input
*.ICP	Integration control package (for time variable point data)
*.IHD	(MODHD.DAT) Initial aquifer head for all layers
*.Lxx	(MODLxx.INP) MODFLOW ibound and BCF arrays, LAYER xx input
*.NAM	(MODNAM.INP) Names file for MODFLOW input
*.OC	(MODOC.INP) MODFLOW output control
*.RCA	MODFLOW Recharge package arrays (ground water only)
*.RCH	(MODRCH.INP) MODFLOW recharge package input excluding array data
*.RIV	(MODRIV.INP) MODFLOW river package input
*.SIP	(MODSIP.INP) MODFLOW sip package input
*.STR	(MODSTR.INP) MODFLOW stream package input
*.WEL	(MODWEL.INP) MODFLOW well package input
Integrated Temporary Transfer	
RUN.MOD	Run modifications file for integrated loop
RUNB.DAT	Contains ending surface water conditions for current week

¹ All files are ASCII unless otherwise indicated.

² Filenames in “()” are temporary files used only for integrated simulations

Simulation Titles

Two title strings are available to the user so that the input data and related output can be identified. Type within the given space (two lines of 80 characters) to define the header titles for the simulation.

Domain Parameters

The domain parameters set up the basic conceptualization for ground water simulation: number of layers (**NLAY**), number of rows (**NROWS**), number of columns (**NCOL**), and the grid spacing (**DELR/DELC**) in feet. The number of layers defines the number of hydrostratigraphic units for the MODFLOW simulation. The number of rows and columns define the size of the grid network. Variable grids are not allowed in version 3.0 FHM, therefore, only one grid dimension is prompted. The grid spacing is defined in FHM in units of feet. If the GIS analysis is available then all parameters can be defined using the GIS results. Note that in order to use any GIS results it is important that the GIS number of rows and columns be used. If the **NROW** and **NCOL** values specified by the user conflict with the GIS results, errors will occur in utilizing the GIS data.

Simulation Type

There are two types of model simulations using MODFLOW, steady-state and transient. The steady-state simulation is a hypothetical modeling procedure that predicts model aquifer heads keeping all stresses constant until the aquifer heads stop changing (model reaches steady state). In reality, in the prototype system steady-state is never achieved. Steady-state simulations are used to approximate the initial heads used for the transient simulation. With steady-state results, transient simulations can start from a viable numerical solution. Transient simulation allows for varying stresses and the effect on the model domain with time. The integrated simulation must be transient.

Typical calibration of an integrated model first involves generating a reasonable steady-state solution, followed by a transient groundwater only solution with estimated recharge rates. The final step involves calibrating the transient integrated application. The data sets are built sequentially through the pre-processor. Recall for MODFLOW, temporal variation is provided by "stress period" (see following section). Input data (e.g., well pumping) can be input at any stress period. For the integrated model, MODFLOW execution will be broken up into typically smaller stress periods defined by the looping time step. The appropriate stress period data will be extracted for use by the current loop (see Part I). In version 3.0 FHM, the looping stress period is fixed weekly and MODFLOW time steps are daily.

Stress Period Data

Stress periods in MODFLOW are blocks of time that can be considered with constant stresses or external constraints (i.e., well pumping, recharge, river stages, etc.). The user has

control over stress periods and time steps in the ground water only simulation. The number of stress periods is prompted first in the pre-processor. The next window will prompt for the stress period data which include the stress period length (typically days, weeks, or months), number of time steps in the stress period, and time step multiplier for the stress period. The number of time steps defines the number of times in the period that the model will attempt to numerically close given the current stresses. The time step multiplier allows the user to have a logarithmic valuable time step within the given stress period. Variable time steps are highly desirable when introducing large stresses instantaneously.

Layer Definition

Each hydrostratigraphic layer must be a defined layer type (**LAYCON**). There are four aquifer types within MODFLOW: confined (0), unconfined (1), confined/unconfined with constant transmissivity (2), and confined/unconfined with variable transmissivity (3). The confined/unconfined aquifer type allows the model to automatically switch the layer type dependant on the simulated aquifer head and the elevation of the user defined top of aquifer (if the aquifer head is above the top then the aquifer type is confined). For the integrated simulation of FHM, a layer type of 3 must be used for the first layer. If GIS data are available, the layer types are automatically initialized with GIS values (stored in LAYCHAR.DAT). Each layer type has different data requirements which are described below and summarized in Table 2.9.

Layer Parameters

The layer parameters vary depending on the defined layer type. All parameters are an array of numbers representing the value for each cell in the grid. The array may be defined using the GIS data if it has been processed using HydroGIS (see Part II). The GIS data is stored in the layer characteristic files LYXXCHAR.DAT, where xx is the layer number. Other array definition methods include setting the array to one value, setting a block to one value, defining a multiplier for the array, substituting one value for another, and adding or subtracting a value from the array. Another option allows the array to be displayed to the screen.

For each layer, the user is prompted for the active area of the grid (**IBOUND**) and the starting heads (**SHEAD**). The **IBOUND** array defines for the layer which cells are active, inactive, and constant head. The active cells are denoted with **IBOUND** values greater than zero. The cells with the **IBOUND** of less than zero are labeled constant head. Any fluxes into or out of constant head cells (recharge, wells, etc.) are not entered into the ground water budget. Cells with a zero **IBOUND** are labeled as inactive and will not be entered into the water budget. The **IBOUND** array for each layer is developed in the pre-processor. The **IBOUND** array can be defined using GIS data if the data is available. The initial aquifer heads (**SHEAD**) are also prompted for in the pre-processor. For each layer, starting heads for the simulation must be defined. For a steady-state simulation the storage coefficients (factors) are not necessary (storage, coefficient are ignored in steady-state). If the user changes the simulation type from steady state to transient then the storage coefficients will be prompted for by the pre-processor.

Table 2.9 Layer Type and Data Requirements for MODFLOW

LAYER TYPE (LAYCON)	AQUIFER TYPE	STEADY STATE SIMULATION	TRANSIENT SIMULATION
0	Confined	TRAN - Transmissivity (ft ² /day) VCONT - Leakage (1/day)	SF1 - Storage Coefficient (ft/ft) TRAN - Transmissivity (ft ² /day) VCONT - Leakage (1/day)
1	Unconfined	HY - Hydraulic Conductivity (ft/day) BOT - Layer Bottom (ft) VCONT - Leakage (1/day)	SF1 - Specific Yield (ft ³ /ft ³) HY - Hydraulic Conductivity (ft/day) BOT - Layer Bottom (ft) VCONT - Leakage (1/day)
2	Confined/Unconfined (Fixed Transmissivity)	TRAN - Transmissivity (ft ² /day) VCONT - Leakage (1/day) TOP - Layer Top (ft)	SF1 - Storage Coefficient (ft/ft) TRAN - Transmissivity (ft ² /day) VCONT - Leakage (1/day) SF2 - Specific Yield (ft ³ /ft ³) TOP - Layer Top (ft)
3	Confined/Unconfined (Variable Transmissivity)	HY - Hydraulic Conductivity (ft/day) BOT - Layer Bottom (ft) VCONT - Leakage (1/day) TOP - Layer Top (ft)	SF1 - Storage Coefficient (ft/ft) HY - Hydraulic Conductivity (ft/day) BOT - Layer Bottom (ft) VCONT - Leakage (1/day) SF2 - Specific Yield (ft ³ /ft ³) TOP - Layer Top (ft)

Layer Type 0: Confined Aquifer

Layer type (**LAYCON**) 0 is a confined aquifer. The first input parameter prompted by the pre-processor for this layer type is the storage factor, denoted in the MODFLOW manual as **SF1**. This will not occur if the simulation is steady state. The storage factor for a confined aquifer is the specific storage in units of feet/feet. The second parameter is the transmissivity array (**TRAN**) in units of feet²/day. If this is not the last layer then the vertical conductance is also prompted. The vertical conductance defines the leakance between the aquifers and is defined in units of 1/day (or feet/day/feet). This layer type may be used to represent an unconfined aquifer if the saturated thickness is very large compared to the expected draw down (see MODFLOW manual).

Layer Type 1: Unconfined Aquifer

This layer type represents an unconfined aquifer. The first parameter is the storage factor (Again, only required if the simulation type is transient). The storage factor for an unconfined aquifer is the specific yield of the soil. The units of the specific yield are feet³/feet³. The next parameter required is the hydraulic conductivity of the aquifer media in feet/day. The third parameter is the elevation of the aquifer bottom in feet using the absolute datum (e.g., NGVD). The aquifer bottom and aquifer head will be used to calculate the saturated thickness of the aquifer throughout the simulation. As with all layer types, if this is not the last layer then the user will be prompted for the vertical conductance in units of 1/day (or feet/day/feet).

Layer Type 2: Convertible, Fixed Transmissivity

The next layer type allowed in MODFLOW is that of a confined/unconfined aquifer with a fixed transmissivity (**LAYCON**=2). The elevation of the aquifer head compared to the defined elevation of the aquifer top determines in what mode the aquifer is functioning. The first parameter prompted by the pre-processor is the confined storage factor. The confined storage factor is the specific storage of the aquifer in feet/feet. The next parameter, aquifer transmissivity, is defined in units of feet²/day. The transmissivity will be used for both confined and unconfined aquifer types. As with all layer types, if this is not the last layer then the user will be prompted for the vertical conductance in units of 1/day (or feet/day/feet). The fourth parameter is the unconfined storage factor in units of feet³/feet³. The unconfined storage factor is the specific yield of the aquifer media. The last parameter required by MODFLOW is the elevation of aquifer top (top) in feet from the datum.

Layer Type 3: Convertible, Variable Transmissivity

The last layer type, is also a confined/unconfined convertible type. This layer type differs from the previous layer type (**LAYCON**=2) because the transmissivity of the layer varies with the saturated thickness. The first parameter required for this layer type is the confined storage factor or storage coefficient. The confined storage factor (**SF1**) is used when the aquifer head is above the aquifer top. The storage factor is required in units of feet/feet. The next parameter is the aquifer hydraulic conductivity (**HYC**). The aquifer hydraulic conductivity is used to calculate the transmissivity of the aquifer. When the aquifer head is above the aquifer top the thickness used is the distance between the top and bottom. When the aquifer head is below the top then the thickness used is the distance between the bottom and the aquifer head. The hydraulic

conductivity is required in units of feet/day. The third parameter required for this layer type is the aquifer bottom (**BOT**). The aquifer bottom should be defined in units of feet using the absolute datum. The bottom is used to define the saturated thickness as outlined above. As with all layer types, if this is not the last layer then the user will be prompted for the vertical conductance (**VCONT**) in units of 1/day (or feet/day/feet). The next parameter prompted by the pre-processor is the storage factor for the unconfined case. The specific yield is the water released from the unsaturated zone when the water table fluctuates. The unconfined storage factor (**SF2**) is the specific yield of the soil. The unconfined storage factor is required in units of feet³/feet³. The last parameter required for this layer type is the elevation of the aquifer top (**TOP**). The aquifer top is expected in units of feet (absolute datum). The top elevation must be defined by mean surface topography for the grid. The top elevation is used to determine if the aquifer should operate as confined or unconfined.

Well Package

The MODFLOW well package is used to simulate the effects of withdrawal or injection wells. Wells can also be utilized to represent constant flux boundaries. The data requirements include the well location and pumping rate. The location is defined by specifying the layer (**LAY**), row (**ROW**), and column (**COL**) of the cell in which the well is located. The pumping rate is the quantity of water withdrawn or injected in units of cubic feet per day. The sign of the rate defines the direction: withdrawal wells are defined with negative values, while positive values are injection wells. Every well record defines one well. There may be more than one well defined in a cell. The well records are entered for each stress period. The data for each stress period is preceded with the number of records expected for the stress period. The first record of the well package includes the maximum number of wells expected in all stress periods and the cell by cell flow terms flag. See the MODFLOW manual for more information.

The pre-processor allows the manipulation of the well data using three different processes: apply GIS data to all parameters, manually add or modify values for individual parameters, or completely exclude the well package. The first option uses the data stored in the WELLCHAR.DAT and PUYCHAR.DAT data files (these files are produced with HydroGIS, refer to Part II, Chapter 3). The WELLCHAR.DAT file contains the well location data specific to the grid and the unique well ID that is used as a reference to match with the pumping data. The PUYCHAR.DAT contains the pumping rates defined for each stress period for existing wells only. Proposed wells and boundary flux “wells” are not included in this file. The “YY” refers to a two-digit, sequential file number starting with “01”. Up to 20 stress periods are stored in each file. More files are used as dictated by the number of stress periods. Refer to Appendix B of Part II for the file format for PUYCHAR.DAT. The first column in the PUYCHAR.DAT is assumed to be the first stress period in the simulation. There may be more records in the WELLCHAR.DAT than in the PUYCHAR.DAT because some wells penetrate multiple layers. In this case a well will have more than one entry in the WELLCHAR.DAT file (one for every layer) yet will only have one metered flow rate recorded in the PUYCHAR.DAT. The second option allows the user to modify, add, and delete wells. If a package currently exists, this method prompts the user for the stress period to modify. If the package is being created, the user will be prompted for each stress period sequentially. The user will be allowed to modify, add, or delete

the wells for the specified stress period. If there are more than 900 wells in the package then the wells are displayed in scrollable blocks of 900 at a time. To go to the next block, the user clicks on the ok button (this verifies all changes made on that particular block). If a well is added it will be added to the package at the end of the current block. Excluding the well package will only change the **IUNIT** array in the basic package, the well file will not be deleted.

Drain Package

Drains in MODFLOW allow water to be extracted from the aquifer but, unlike rivers, do not allow for water to re-enter the aquifer. The drain acts as a head dependant flux. The flux in a drain is dependant on the aquifer head and the specified conductance. The data requirements of a drain include the location, conductance, and the drain elevation. The location defines the layer, row, and column of the cell in which the drain is located. The conductance of the drain is defined in units of feet squared per day. The stage is the elevation of the drain in feet (absolute datum). Drains cannot be routed to the surface water reaches. The water is lost in the integrated water balance. If drains are a significant component in the water balance, then river cells should be used to represent the drains. If the river stage is the same as the river bottom then the river will act exactly as a drain.

The pre-processor allows the manipulation of the drain data using three different processes: apply GIS data to all parameters, manually add or modify values for individual parameters, or completely exclude the drain package. The first option uses the data stored in the DRNCHAR.DAT. This file is not yet supported by HydroGIS. The DRNCHAR.DAT file contains the drain location data specific to the grid and the drain conductance and stage. The second option allows the user to modify, add and delete drains. If a package currently exists, this method prompts the user for the stress period to modify first. If the package is being created the user will be prompted for each stress period sequentially. The user will be allowed to modify, add or delete the drains for the specified stress period. If there are more than 900 drains in the package then the drains are displayed in scrollable blocks of 900 at a time. To go to the next block, the user clicks on the ok button. This verifies all changes made on that particular block. If a drain is added it will be added to the package at the end of the current block. Excluding the drain package will only change the **IUNIT** array in the basic package; the drain file will not be deleted.

River Package

River cells in MODFLOW (RIV package) allow water to be removed or added to the aquifer from FHM reach types (see Part I). River cells represent segments of losing and gaining streams. The river cell acts as a head dependant flux. The flux in a river is dependant on the aquifer head, river stage, and the specified river conductance. The data requirements of each river segment in a cell include the location, river conductance, river stage, and river bed elevation. The location is defined by the layer, row and column of the cell in which the river is located. The conductance of the river is defined in units of feet²/day. The stage and the river bed bottom of the river are defined in units of feet (absolute datum). In the integrated model river fluxes are

routed to associated HSPF reaches. Therefore, an additional data element is required for each river cell. The HSPF reach number is the integer identification number assigned to the reach in the HSPF simulation. The 10 character entry is added at the end of the standard MODFLOW river package input dataset by the pre-processor. The HSPF reach number is positive for fully dynamic reaches. Recall, dynamic reaches have variable stages calculated by HSPF and baseflow calculated by MODFLOW. Dynamic reaches are only used in the integrated simulation. Negative reach numbers indicate static reaches where MODFLOW calculated baseflow will be routed to HSPF but, the river stage is held constant (see Part I). The river elevation data i.e., river stage and bed bottom, should be adjusted to reflect the shift from real elevation to grid relative elevation (see Part I).

The pre-processor allows the manipulation of the river data using three different processes: apply GIS data to all parameters, manually add or modify values for individual parameters, or completely exclude the river package. The GIS option uses the data stored in the RIV2CHAR.DAT. This file is produced with HydroGIS (see Part II). The RIV2CHAR.DAT file contains the location data specific to the grid, river conductance, river stage, river bed bottom elevation and HSPF reach number. The second option allows the user to manually modify, add and delete river cells. If a package currently exists, this method prompts the user for the stress period to modify first. If the package is being created the user will be prompted for each stress period sequentially. The user will be allowed to modify, add or delete the river data for the specified stress period. If there are more than 900 river cells in the package then the data are displayed in scrollable blocks 900 records at a time. To go to the next block click on the ok button this verifies all changes made on that particular block. If a river cell is added it will be added to the package at the end of the current block. Excluding the river package will only change the **IUNIT** array in the basic package; the river file will not be deleted.

General Head Boundary Package

General head boundaries in MODFLOW allow water to enter and exit the aquifer. The general head boundary (GHB) is a head dependant flux condition. The flux in a GHB is dependant on the aquifer head and the specified conductance and GHB stage. The data requirements of a GHB include the location, conductance, and the GHB elevation. The location defines the layer, row and column of the cell in which the GHB is located. The conductance is defined in units of feet²/day. The stage is the elevation of the aquifer or the boundary head. The stage is defined in feet (absolute datum). GHB fluxes typically represent the quantity of water moving in or out of the aquifer through the boundaries.

The pre-processor allows the manipulation of the GHB data using four different processes: apply GIS data to all parameters, apply GIS data to all parameters and include large-scale head results, manually add or modify values for individual parameters, or completely exclude the GHB package. Both GIS options use the data stored in the GHBCHAR.DAT, produced with HydroGIS. The GHBCHAR.DAT file contains the GHB location data specific to the grid and the GHB conductance and stage. The second option utilizes the data stored in both the GHBCHAR.DAT and the GHBDC.DAT. The GHBCHAR.DAT supplies location data specific to the grid and the GHB conductance. The GHBDC.DAT combines the large-scale simulation output providing the GHB stage. The large-scale output utilized is the binary head file,

which contains the aquifer heads for each layer and for each stress period. The GHBDCHAR.DAT file contains the inverse distances to the large-scale cell nodes from the GHB location (see Part II). Using inverse distance interpolation, the pre-processor determines the large-scale heads for each GHB. The third option allows the user to modify, add and delete GHBs. If a package currently exists, this method prompts the user for the stress period to modify first. If the package is being created the user will be prompted for each stress period sequentially. The user will be allowed to modify, add or delete the GHBs for the specified stress period. If there are more than 900 GHBs in the package then the GHBs are displayed in scrollable blocks 900 at a time. To go to the next block, the user clicks on the ok button. This verifies all changes made in that particular block. If a GHB is added it will be added to the package at the end of the current block. Excluding the GHB package will only change the IUNIT array in the basic package. The IUNIT value is set to zero which is an “off” flag. The GHB file will not be deleted.

Recharge Package

The recharge package defines the amount of water that reaches the aquifer by means of percolation through the unsaturated zone. The recharge data is supplied to the model in array format for each stress period. The recharge rate must be entered in units of feet/day. Recharge can be specified as net recharge (actual recharge minus ground water ET). Recharge specified as a positive number is water that will enter the aquifer while negative recharge is water lost by the aquifer (by ground water ET). Recharge should only be negative when using net recharge. The integrated model will create a recharge package based on the output from the surface water model and the basin array provided in the integrated pre-processing (see integrated data below). Therefore, no recharge package is necessary for integrated simulations. If a recharge package does exist it will be ignored.

The recharge package can be created or modified for ground water only simulations using four different procedures in the pre-processor: apply GIS data to all parameters, manually add or modify values for individual parameters, define the recharge rate from HSPF output, or completely exclude the recharge package. The first method defines the recharge package from the GIS data stored in the RCETCHAR.DAT. The GIS data stored in the RCETCHAR.DAT is the annual total recharge for each grid cell in inches. This total recharge is then distributed to each stress period in the simulation using a multiplier for the stress period. The user is allowed to modify the multiplier to represent the annual fluctuation in the recharge rate. The second method allows the user to manually modify the recharge package. Note that manual creation is not yet supported by the pre-processor. During the manual modification process the user is prompted for the stress period to modify. The user is allowed to modify the recharge array for the specified stress period. The next method allows the user to create a recharge package based on the monthly output of the surface water only simulation. Stress periods in the ground water model must be monthly for this method and the first month in the HSPF output is assumed to be the first month in the ground water only simulation. This method also requires the basin array data in order to distribute the recharge derived for each basin to the appropriate ground water cells that underlie each basin. This information may be obtained from either the integrated input or the RCETCHAR.DAT. The fourth option removes the recharge package from the simulation.

Excluding the recharge package will only change the **IUNIT** array in the basic package. The recharge file will not be deleted.

Evapotranspiration Package

The MODFLOW evapotranspiration package allows the ground water model to simulate the water lost to the atmosphere. The ET rate is specified in array format for each stress period, but it is modified by the aquifer elevation. Two additional arrays are required in the MODFLOW ET package: ET surface and the ET extinction depth. If the aquifer head is at or above the ET surface then the actual ET rate used by the model is the rate specified by the user. If the aquifer head is below the extinction depth then the actual ET rate used by the model is zero (no ground water lost to ET for this case). If the aquifer head is between the ET surface and the extinction depth then the ET rate used in the model is an interpolated linear value of the specified rate. MODFLOW requires that the ET surface, ET rate and ET extinction depth be specified for each stress period. In the integrated simulations, an ET package is modified using the data from the surface water component. The integration codes only modify the ET rate in an existing ET package, therefore, the ET package must be created.

In the pre-processor of FHM, the ET package can be created or modified using four different methods: apply GIS data to all parameters, manually add or modify values for individual parameters, define the maximum ET rate from HSPF output, or completely exclude the ET package. The first option uses the GIS data stored in the RCETCHAR.DAT file. The ET surface and the ET extinction depth are used directly from the GIS data. Manual modification of this data is allowed in the pre-processor. The rate stored in the RCETCHAR.DAT file is the annual total ET. The ET is distributed to each stress period using factors of the annual ET specified in the GIS data. The user is allowed to modify the multiplier to represent the annual fluctuation in the ET rate. The second method allows the user to manually modify the ET package. Note that manual creation is not yet supported by the pre-processor. During the manual modification process, the user is prompted for the stress period and parameter (i.e., surface, rate, or extinction depth) to modify. The user is allowed to modify the selected array for the specified stress period. The next method allows the user to create an ET package based on the monthly output of the surface water only simulation. Stress periods in the ground water model must be monthly for this method. This method also requires the basin array data in order to distribute the remaining ET derived for each basin to the appropriate ground water cells that underlie each basin. This data may be obtained from either the integrated input data or the RCETCHAR.DAT. The fourth option removes the ET package from the simulation. Excluding the ET package will only change the **IUNIT** array in the basic package, the ET file will not be deleted.

Strongly Implicit Procedure

The solution package used in FHM by default is the strongly implicit procedure. The seven parameters are predefined using default values. If the model is having difficulty in closing to the head closure criteria, the solution parameters may need to be modified. If necessary these

parameters may be modified within the pre-processor. See the MODFLOW manual for parameter definition.

Output Control Package

The output control package defines the output generated by the ground water component of FHM. The output control package is created by default. No user modification is allowed at this time.

Integration Data

To complete the data requirements for integrated simulations a separate integrated data pre-processor was developed. The pre-processor prompts for data that is not supplied in the surface water or ground water pre-processors. This information includes: the basin/grid assignment, field capacity, and plant ET coefficient. The integrated data is supplied in array format using a grid identical to the ground water grid.

Basin Array

The basin array is used in FHM integration routines. The basin array provides the link between the surface water basins and the ground water grid. The surface water model determines the recharge to the aquifer and the remaining potential evapotranspiration. Using the basin array defined in the integration pre-processor, the water budget terms are passed to the appropriate cells. The basin array is simply the integer of the HSPF basin number to each grid. Differences in areas between the basins as defined HSPF in the surface water model and basins defined by the integration basin array are corrected; care should be used to maintain similar areas.

The integration pre-processor allows the user to define the basin array using four different methods; use GIS data, define the entire array as one value, define a block with one value, and substitute one value for another. Array display is also available during the modification process. The GIS data is obtained from the RCETCHAR.DAT created in the HydroGIS procedures (see Part II).

Field Capacity Array

The soil field capacity specific retention is used during the integration to correct the water balance between the surface water component and the ground water component. In the integration, the soil porosity is assumed to be equal to the field capacity plus the specific yield.

The integration pre-processor allows the user to define the basin array using five different methods; using GIS data, define the entire array as one value, define a block with one value, apply a multiplier to the array and substitute one value for another. Array display is also available during the modification process. The GIS data is obtained from the RCETCHAR.DAT created in the HydroGIS procedures (see Part II).

Plant ET Coefficient

The plant ET coefficient is used in the integration to modify the remaining potential ET after all surface water ET fluxes are determined. The plant ET coefficient limits the plant ET in the ground water based on the vegetative land cover. Plants that transpire very little will require a plant ET coefficient much less than one. Plants that readily transpire at the potential given the proximity of the water table within the root zone water will have a plant ET coefficient close to one. Urban areas may obviously use plant coefficients near zero. The limits of the plant ET coefficient are between 0.0 and 1.0.

The integration pre-processor allows the user to define the plant ET coefficient array using five different methods; using GIS data, define the entire array one value, define a block with one value, apply a multiplier to the array (not applicable for basin array), and substitute one value for another. Array display is also available during the modification process. The GIS data is obtained from the RCETCHAR.DAT created in the HydroGIS procedures.

Reach Baseflow Initialization

The integrated simulation process is basically a loop (i.e., integration timestep) simulating the surface water component followed by the ground water component. The baseflow computed by the ground water model is used in the following integration timestep. During the first integration timestep, baseflow is missing because it has not been computed yet. The ASCII file HSPFBF0.DAT is used to initialize the baseflow in the reaches during the first integration timestep. One value is read for each reach and used throughout the integration timestep. The file is free format and contains one line for each HSPF reach consisting of the reach number (in consecutive order) and the average flow in cfs expected for the first integration timestep. Note that this file is not necessary and only improves the discharge hydrograph at and around the start of the simulation.

CHAPTER 3. MODEL SIMULATION AND TROUBLESHOOTING

With FHM, in either surface, ground water or integrated simulations, output is processed by support codes to produce files for water budget assessment. This section will describe the simulation and output produced, and give a brief description of common simulation problems and potential corrections.

Surface Water Simulation

The surface water component of FHM, for both the surface water only and the integrated simulation, utilizes off-the-shelf HSPF supported by the USEPA. The simulation is intended to be limited to basin and stream water budget analysis (actually the advanced user can modify input to add the additional data required for water quality simulations). Basins are simulated using the pervious land segment module and streams and lakes are simulated using the reach reservoir routing module. Input files required for surface water simulation are summarized in the previous section in Table 2.1. Output file names and descriptions are listed in Table 3.1. The HSPF model has adequate error checking for the intended surface water application. FHM adds additional error checks for the integrated model. A brief description of input and output files, problem solving and overall quality control is presented below for the surface water simulation.

Simulation Description

The surface water simulation is divided into two separate HSPF runs, one for the basin water balance, the second for the reach water balance. The HSPF basin input file, which contains the PERLND data, is named *.INS. The reach simulation input, which contains the RCHRES information, is named *.INR. The "*" refers to the eight character user defined run name. The pre-processors of FHM store integrated input data in *.ICS and *.ICR for the basin and reach input, respectively. Because FHM pre-processors only read the user defined data from the *.INS and *.INR files, any modifications manually made to the *.ICS or *.ICR will be lost if the data set files are read into the pre-processor. Another important input file for the surface water component is the *.INF data file. The *.INF contains the basin areas, basin routing, reach routing, and diversion routing information. The *.INF file also contains the Thiessen polygon station fractions for both rainfall and evapotranspiration data. Both simulations are performed using an hourly time step which requires that the input data be supplied in hourly format. The simulation input is comprised of a rainfall data file *.RAN, an ET data file *.EVT, and an optional diversion data file *.OFD. The basin discharges are transferred via standard HSPF plot files to the reach simulation. Plot files are produced containing the discharge hydrographs for each basin and reach in both simulations. Output hydrographs are available in both hourly and daily average increments for analysis and comparison in the post-processor of FHM. The daily files are produced from the hourly output. The hydrograph files for basins are named *.S81-

Table 3.1 Output Data Files Used in FHM for Surface Water

Filename	Description
Basin Data	
*.EBM	Surface water only balance output from HSPF for subbasins (monthly output)
*.EBS	Surface water only balance output from HSPF for subbasins (daily output)
*.EBY	Surface water only balance output from HSPF for Subbasins (yearly output)
*.S81	Subbasin discharge (S81-S85) (HSPF plot file format, hourly)
*.S91	Subbasin discharge (S91-S95) (HSPF plot file format, daily average)
Reach Data	
*.EBR	Surface water only balance output from HSPF for reaches (daily output)
*.R81	Reach discharge (R81-R85) (HSPF plot file format, hourly)
*.R91	Reach discharge (R91-R95) (HSPF plot file format, daily average)
Integrated Data	
*.IBM	Integrated balance output from HSPF for subbasins - deleted weekly (Monthly output)
*.IBR	Integrated balance output from HSPF for reaches (daily output)
*.IBS	Integrated balance output from HSPF for subbasins - deleted weekly (daily output)
*.IBY	Integrated balance output from HSPF for subbasins (yearly output)
Temporary Output	
*.BAL	Temporary HSPF balance file (used in integration daily)
*.LIS	HSPF error file (echo of user control input)

¹ All files are ASCII unless otherwise indicated.

*.S85 for the hourly interval and *.S91-*.S95 for the daily interval. The reach hydrographs are named *.R81-*.R85 for the hourly interval and *.R91-*.R95 for the daily interval. Recall the plot file format contains 10 columns of data per plot file, therefore up to 5 separate files are required each for the 50 basins and 50 reaches limitation.

The water budget at the completion of the simulations is condensed into a set of tabular files which are easier to use than the standard HSPF output. The basin water balance is stored in the *.EBS for the daily interval, *.EBM for the monthly water balance, and *.EBY for annual

intervals. The reach water balance is stored on a daily interval in the *.EBR file. An excerpt of the basin balance table and an excerpt of the reach balance table are shown in Appendix B (Tables B.1 and B.2, respectively). The output files can be readily imported into a spreadsheet or graphing package where advanced data analysis can be performed. As a rapid assessment tool, the post-processor of FHM provides for graphs of any HSPF storage or flux variable.

Common Simulation Errors

Two files are created during the simulation that contain messages of potential errors and warnings in the simulation: ERROR.DAT and WARNING.DAT. The file ERROR.DAT is used to store fatal errors that occurred in the simulation. The file WARNING.DAT is used to store the messages related to non-fatal warnings as defined by HSPF.

Common simulation errors that occur in the surface water component of FHM are F-Table extrapolation (flooded reaches) and reaches going dry. The first error, F-Table extrapolation, is a common problem that is easily corrected by increasing the storage or the discharge for the specified reach. HSPF will extrapolate the F-Table internally but, if the required extrapolation is too large then the simulation is halted with the error. The F-Table should represent the stage, area, storage, and discharge relationship for the expected range of flows (high and low). Temporarily modifying the F-Table to allow several orders of magnitude addition storage volume will usually allow the simulation to complete successfully. A follow up review of the water budget output (e.g., *.EBS file) can identify errors. F-Table extrapolation errors may also be caused by erroneously high basin discharges or diversion flows which cause the reach to flood past the normal range previously defined in the F-Table. Wetlands surrounding streams may store large volumes of water that need to be taken into account when developing the reach F-Table.

The second common problem is HSPF reaches going dry. When using diversions which withdraw (i.e., pump or divert) water from the reaches it is possible to create a dry HSPF reach. When the reach is dry and the diversion continues from the dry reach, the water balance will be flawed. The error file contains messages which indicate the time when withdrawal from the reach was attempted while the reach was dry. If the reach becomes dry without withdrawals, as seen for ephemeral streams, an error message is not printed nor is one necessary. It is incumbent upon the user to interpret the error messages and the effect the errors have upon the results.

Ground Water Simulation

The ground water only simulation and the ground water component of the integrated model use the USGS supported MODFLOW. MODFLOW is a popular ground water model that uses a finite difference grid to simulate the flow within the saturated zone. The pre-processor and interface of FHM allow the full implementation of the MODFLOW model. However, numerous input and output files must be written to allow integration of the models, required water budget compilation, and error checking. Input files required for the ground water modeling portion of FHM were listed in Table 2.8 for ground water only and integrated simulations within FHM, respectively. Output file names and descriptions for the ground water portion of FHM for ground water only and integrated simulations are summarized in Table 3.2.

Table 3.2 Output Data Files Used in FHM for Ground Water

Filename	Description
Ground Water Only and Integrated	
*.CDR	Output river fluxes, totals
*.HD	Output heads from MODFLOW (binary)
*.OUT	ASCII output from MODFLOW
Ground Water Only	
*.EBG	Output water balance from MODFLOW (ground water only)
Integrated Only	
*.IBG	Output water balance from MODFLOW (integrated)
Temporary Transfer	
*.B91	Output baseflow hydrographs from MODFLOW used by HSPF (plot file format, daily average)
*.CBR	Output cell by cell river fluxes
*.OHD	MODFLOW output heads (binary)

¹ All files are ASCII unless otherwise indicated.

Simulation Description

FHM uses standard MODFLOW input file structures. The basic package, input file *.BAS, contains the basic information for the simulation except all array data stored in separate layer data files. The array headers are in the basic package however, different unit numbers are defined to reference separate “array” files (or layer files). The IBOUND array is stored in the layer files named *.Lxx where xx is the layer number. The layer files use unit numbers 40 plus the layer number (i.e., layer one is unit 41, layer two is 42, etc.). The initial head for all layers is stored in unit 40. The block centered flow package input file, *.BCF, contains the array headers for all required aquifer parameters. As with the basic package array, the BCF package array data is also stored in the layer files referenced above. The recharge (*.RCH) and evapotranspiration (*.EVT) packages are similar in that the array data is also stored in separate files, *.RCA and *.ETA respectively. The river package has an additional column of data which defines the reach to accumulate flows. The post-processing codes will accumulate the flows for output in the *.CBD file.

The only variation from standard MODFLOW applications is the additional post-processing of the model output. Every water balance block in the output file is condensed into a tabular

format, named *.EBG for ground water only or *.IBG for integrated simulations. The tabular format is easy to pull into a spreadsheet program for graphical or statistical analysis. An example of the file is shown in Appendix B. Another file is created for baseflow accumulations. As discussed in the river package pre-processing, the river package contains a river id number. This number is used to accumulate the baseflow from the ground water model for transfer to HSPF. Contained in the *.CDR file for each river id number are baseflow rates for dynamic gaining, dynamic losing, static gaining, static losing, and total categories. The dynamic and static designation are only meaningful for integrated simulations.

Common Simulation Errors

Common errors found in ground water only simulations include cells going dry, baseflow flux problems, and head closure problems. Cells that go dry are basically cells where the aquifer head falls below the aquifer bottom. This condition is an error (unless the measured data shows the entire aquifer has gone dry for the entire cell area). This error can be caused by many factors: leakance too high, bed bottom is inappropriately too high, river gaining flux too high, incorrect boundary conditions, or incorrect well pumpage. River cells may have baseflow problems which do not show up with error messages. A given reach segment should generally be either gaining or losing (the reach segment should not have dramatic gaining portions and dramatic losing portions; this creates a flow through system which is not real). There should not be high gaining baseflows and high losing baseflows in the same reach. Lastly, there are potential head closure problems that exist in any iterative solver. To correct head closure problems, increase the maximum allowable iterations, decrease the closure criteria, or decrease the acceleration factor. See the MODFLOW documentation for details.

Integrated Simulation

The integrated model creates additional constraints on the water budget calibration; most notably, the influx to the ground water system is completely constrained by outflows from the surface water domain. Typically, the two components are applied individually and calibration is attempted separately before integrated simulation is begun. The integrated simulation is similar to the individual applications described above; the differences will be described in the next section. Table 3.3 lists the input and output files exclusive to integration in FHM.

Simulation Description

The surface water component in the integrated simulation is very similar to the surface water only simulation. Hourly rainfall, evapotranspiration, and diversion data are used as input to drive the model. The surface water component is again divided into two separate simulations,

Table 3.3 Input and Output Data Files Used in FHM for Integration

Filename	(Temporary Filename) ² Description
Model Input	
*.ET	(ETMODEL.DAT) Integration data: basin number, plant ET coefficient, and field capacity
Model Output	
*.IBI	Integration data: LZS , LZSN (old & new), additional recharge and error recharge

¹ All files are ASCII unless otherwise indicated.

one for basin simulations and the second for the reach routing simulations. The main differences between the surface water only and the surface water component of the integrated simulation are the baseflow computations and the constraints on the lower zone. First, the surface water component in the integrated simulation has in effect turned off all calculations of active ground water (deep fraction, **DEEPPFR**, is set to 1.0, and initial active ground water storage, **AGWS**, is set to 0.0). All percolated water will be sent to inactive ground water inflow (**IGWI**) which will be sent to MODFLOW as recharge. The baseflow is read in from the results of the ground water model using HSPF plot files, named *.BF1-*.BF5. The lower zone is updated by the ground water derived depth to water table and soil properties and the *.INS file is modified.

Four arrays of data are saved for use in the ground water simulation: basin recharge (**IGWI**), basin potential ET (**PET**), basin total actual ET (**TAET**), and reach stages (**STAGE**). The recharge, potential and actual ET rates are summed for the week and passed to MODFLOW. The reach stages are averaged for the week and passed to the ground water component. The data required by the ground water component and the data required to initialize the subsequent surface water simulation are extracted from the surface water simulation output and stored in a temporary file RUNB.DAT for transfer to the ground water model. The resulting water balance for the surface water simulation is extracted and stored in the *.IBS for the basin water budget and *.IBR for the reach water balance. Hydrograph plots files are also produced, *.S91-*.S95 for daily average basin hydrographs and *.R91-*.R95 for daily average reach hydrographs.

For the first integration loop, the ground water component is initialized using the user defined initial aquifer head from the *.IHD file. The aquifer heads should be the result of steady state simulation to eliminate numerical solution transients. For subsequent loops, the initial heads are derived from the heads of the previous loop. The water budget results of the ground water component of the integrated simulation are extracted and stored in the *.IBG file. Hydrograph plots of the baseflows for each HSPF reach are averaged for daily values and stored in the *.B91-*.B95 files (10 columns for each file). The heads are archived and stored in binary format in the *.HD file. Because the archive head file is in binary format, the post-processor must be used to create xyz files for plotting surface contours or well hydrograph files (*.WP1-*.WP5) for plotting

the simulated aquifer head with time. Integration output is created which produces a time series of the lower zone storage, lower zone storage ratio, additional recharge, and error recharge. An example of the *.IBI file format is shown in Appendix B.

Common Simulation Errors

The integrated model is susceptible to the same errors as in the surface water only and ground water only simulations outlined above. These errors include the F-Table extrapolation, head closure errors etc. In the integrated simulations, an additional river flux may cause the HSPF reaches to go dry. The additional flux is the MODFLOW baseflow. In the surface water only simulations the baseflow calculated in HSPF is always positive. In the integrated simulations the baseflow can be positive or negative. In converting from surface water only to integrated the simulation may produce errors due to the externally applied additional stress on the reach. Errors in the simulated water balance for hydrography can occur when pumping withdrawals from the reach exceed the available reach volume. When the simulated baseflow from MODFLOW is negative (i.e., reach loses water to ground water), an error can occur if simulated baseflow exceeds the available reach volume. Another possible problem in integrated simulation is related to the surface water/ground water interaction. Additional recharge is simply a correction to the water balance due to high or low unsaturated zone moisture. Additional recharge should become smaller for longer simulation times. However, significant error recharge is an indication of problems in the simulation results. If error recharge for a basin is consistently negative, the water table is above land surface. In this case the lower zone storage for that cell is zero (saturated soil). Since HSPF limits the allowable **LZS** to 0.01 inches, the model must remove that water from the ground water model in order to maintain the allowable limit. If error recharge term is positive, **LZS** was above the HSPF limit of 100.0 inches and the water was artificially returned to the ground water system. Error recharge should be near zero for any simulation. Another problem (not a fatal error) with the integrated model is stage and baseflow oscillations. During low flow baseflow dominated periods, reach discharges and baseflow may show signs of oscillation with frequency of the integration time step. When the stage in HSPF is high it causes the baseflow to be negative (losing reach). When the negative baseflows are used in HSPF (subsequent loop) it causes the stages to be low. The low stages cause the baseflow to be positive which will cause the stages in HSPF to be high again. There are many ways to correct this problem: reduce the reach bed conductance, increase reach storage, or decrease the integration time step (not available in version 3.0 FHM). The above errors do not cause the simulation to terminate. The errors are documented in the ERROR.DAT file. It is incumbent upon the user to determine whether the error warrants further investigation.

CHAPTER 4. MODEL POST-PROCESSING

The output post-processor of FHM enables the user to view or analyze the output from the various simulations: surface water only, ground water only, or integrated simulations. The output processor enables the user to view the output and input data in graphical format. The graphs can plot two series which allows the user to compare the simulated output with other simulated output or with observed data. Also available is a second graph across the top of the screen for comparison with input hydrologic conditions. The second graph uses the same X-axis but a different Y-axis. This allows comparison of model output with the timing and magnitude of input rainfall or diversion data. The Y-axis may be plotted linearly (the default) or logarithmically. The scale is set automatically to the range of data. The X-axis limits, or start and stop times, can be selected by the user from the available range of data. Plotting a second series or input data may, however, decrease the allowable time-frame of the graphed data due to memory limitations of the post-processor. If an error is encountered trying to display two plots, reduce the display period (results may have to be viewed sequentially).

In addition to the graphical view of the data, a summary analysis is available. The summary will reduce the selected time series into statistics such as the maximum, average, minimum, and total. The output processor is menu based. Menu selections that are shown in grey are not available. For instance, if a surface water only simulation is post-processed, then ground water options will be disabled.

Surface Water Post-Processing

For surface water only simulations there are three options for analyzing and displaying the output results. The three options provide assessment of *input hydrologic conditions (time series)*, *surface water basin conditions*, and *reach conditions*. These options are summarized in the flowcharts shown in Figures 4.1 - 4.3.

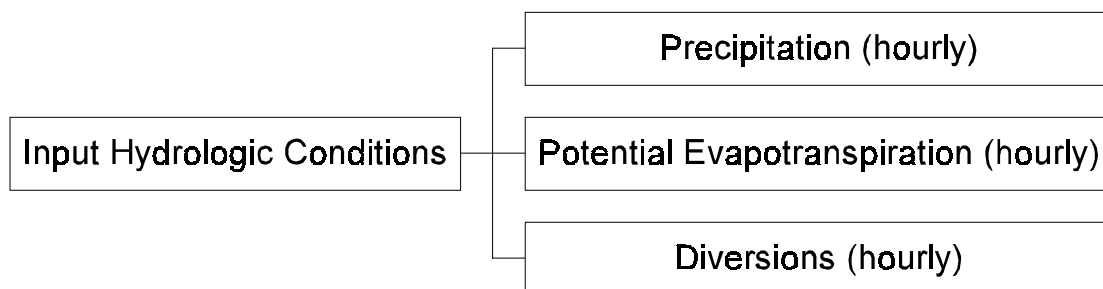


Figure 4.1 Output Display Options: Time Series Review

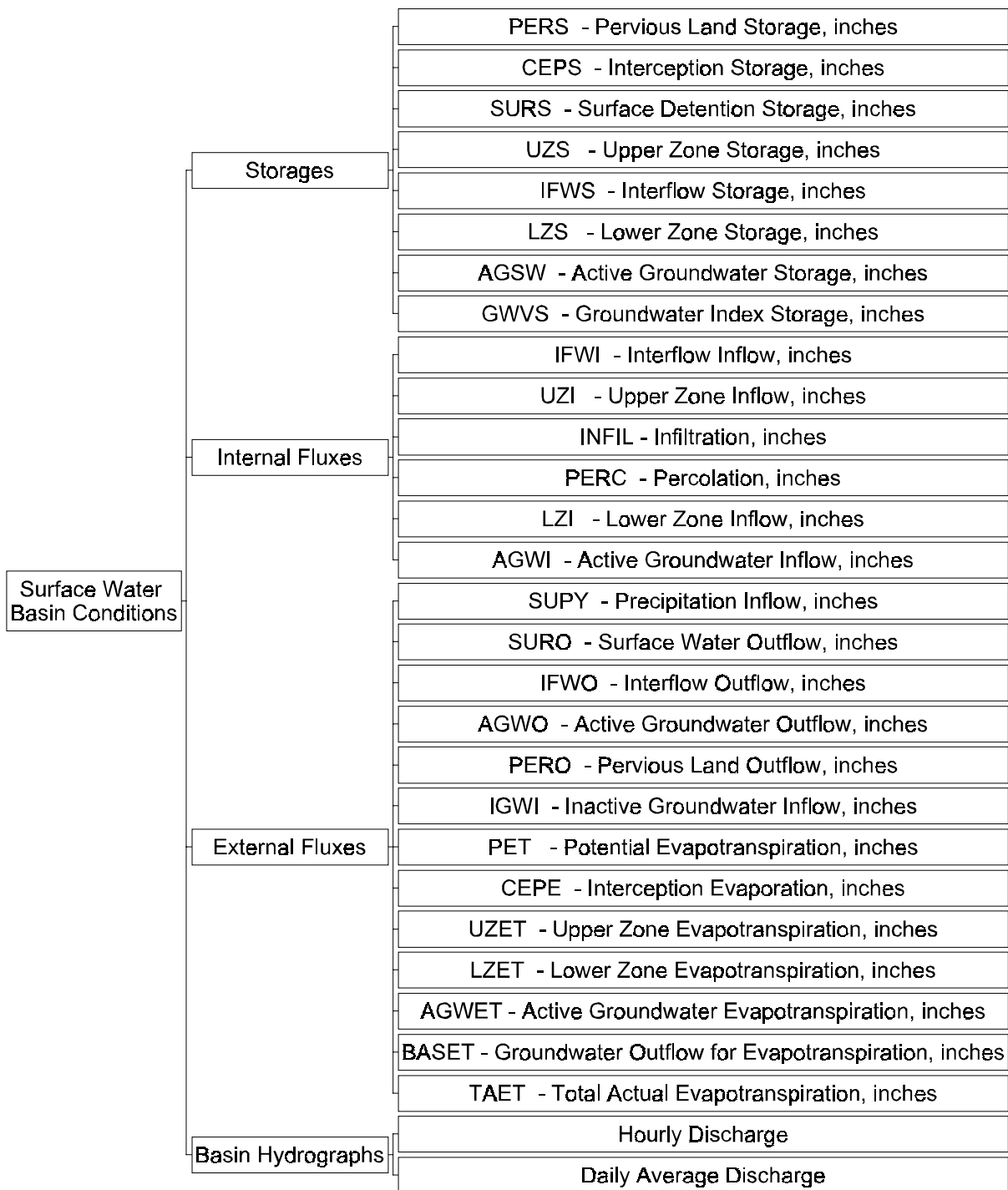


Figure 4.2 Output Display Options for Surface Water Basins

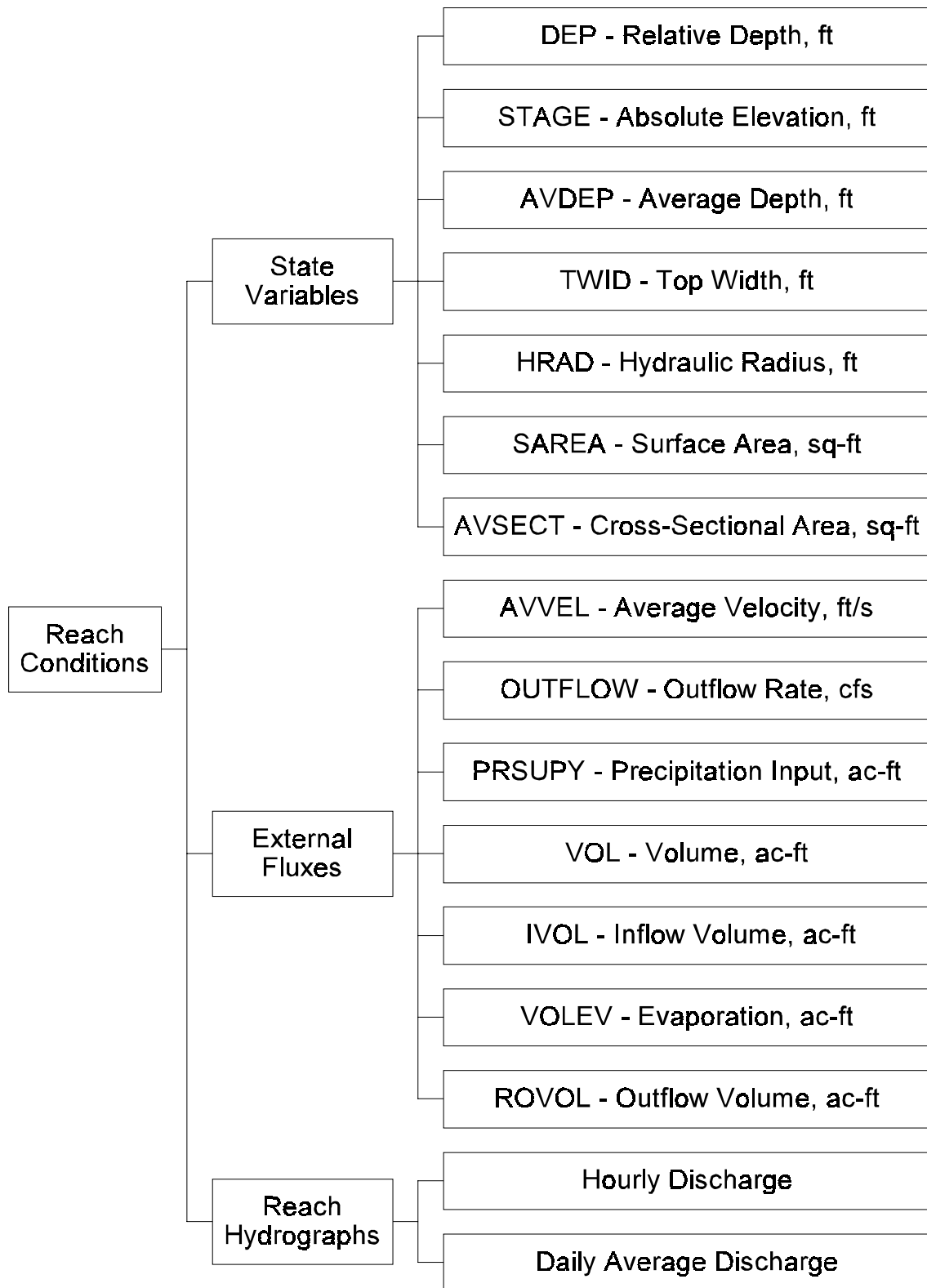


Figure 4.3 Output Display Options for Surface Water Reaches

Input Hydrologic Conditions

The first option, *input hydrologic conditions*, allows the user to summarize or graph data from the available time series input files containing the hourly rainfall (*.RAN), evapotranspiration (*.EVT), and surface water diversions (*.OFD) which were used for model simulation. The data may be plotted with time, or summarized which will compute the maximum, minimum, average, and total of the selected time series. Options allow the user to select the station (10 stations are available in each file) and time interval (start and stop) to process.

Subbasins

The second option, *surface water basin conditions*, enables the user to summarize or graph data from the water balance files containing the daily (*.EBS), monthly (*.EBM), and annual (*.EBY) collated data which include basin storages, internal basin fluxes and external basin fluxes. The output results from the files for hourly basin hydrographs (*.S81 - *.S85) and daily average basin hydrographs (*.S91 - *.S95) may also be summarized or graphed.

Reaches

Selecting *reach conditions* allows the user to summarize or graph data from the reach water balance contained in file *.EBR. This file also contains daily collated reach state variables and external reach fluxes. The files for hourly reach hydrographs (*.R81 - *.R85) and daily average reach hydrographs (*.R91 - *.R95) may also be summarized or graphed.

Ground Water Post-Processing

The *ground water conditions* option enables the user to display ground water balance terms, baseflow rates, and aquifer heads. As before, the post-processor allows data to be presented in summary or graphical format. The options for ground water output summaries are shown in Figure 4.4.

Water Budget

The ground water balance information is obtained from the *.EBG and *.IBG files for ground water only or integrated simulations, respectively. The balance data is divided into both inflows and outflows. The time increment for summaries is controlled by the output control package in MODFLOW. MODFLOW can create the budget data down to every time step if requested. By default the water budget data will be produced at the end of every stress period (every integration time step in the requested run).

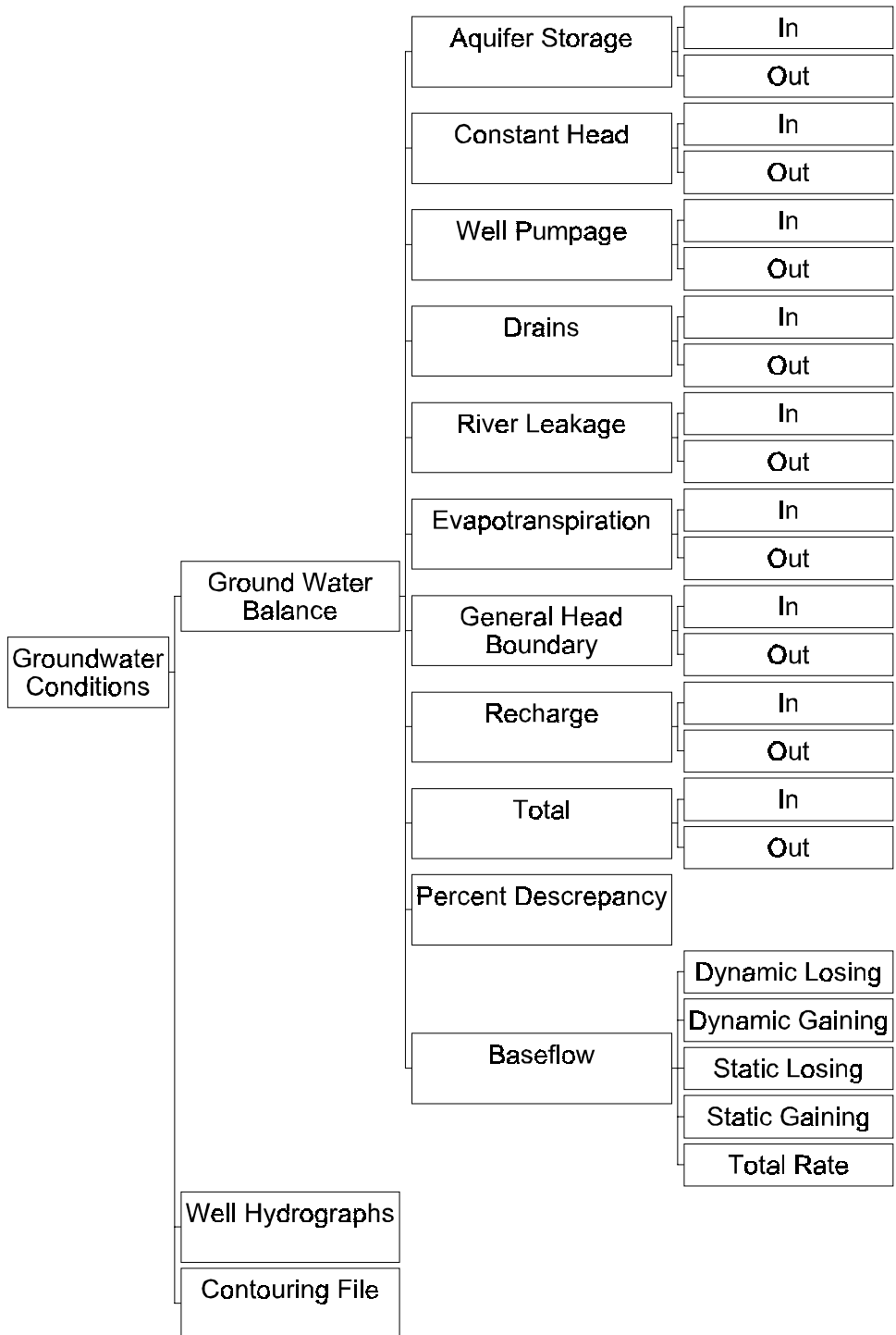


Figure 4.4 Output Display Options for Ground Water System

Baseflow Hydrographs

Baseflow data from the *.CDR file can be summarized or graphed versus the stress period used in the simulation. Reach baseflow data from the *.CDR file is available for each dynamic or static reach segment and includes the rate of gain or loss of baseflow and the total net baseflow rate. The time interval of the *.CDR file is every stress period.

Aquifer Hydrographs and Surface Plots

The aquifer heads are stored in a MODFLOW binary file. The interval at which the heads are recorded can be controlled by the MODFLOW output control package. By default, the interval is once per stress period. This binary file can be processed into ASCII data files for well hydrographs or surface contour plots by the post-processor.

Aquifer heads for a particular cell and layer (i, j, k) may be graphed for the simulation time. The post-processor allows a list of up to 50 wells to be specified. Options enable the user to add, delete or modify this list. The well list is stored in ASCII file named *.WHP. Each well has a layer, row, and column defined to specify the well location and a user name to identify the well. The process option extracts the data from the binary file and is necessary whenever the well list is modified or after model simulation. The ASCII files created are named *.WP1-*.WP5. The well hydrograph files are in HSPF plot file format which allows 10 columns of data each (see Appendix A).

A head contouring file may be created in an “x, y, z” format (*.XYZ) and can be found in the working project directory. This file will be created for a specified layer and stress period. The *.XYZ file can be used in many graphing packages (e.g., Surfer, QuattroPro, etc.) to produce surface plots or contour plots. The x-y values represent real world, grid cell center coordinates based on the map projection and units of the ground water grid. The *.XYZ file can be plotted using ARC/INFO.

Integrated Post-Processing

An integrated model simulation contains most of the output format previously described for the surface water and ground water only simulations. Additional options are included for reach water budget outlining the integrated baseflow fluxes. The files used as input to the post-processor have changed and are outlined below.

Surface Water Budget

The surface water budget is divided into three major components. The *input parameters options* allows graphing of all time series used as model input. The basins water budget defines all basin storages and fluxes. The reach water budget includes all reach storages and fluxes. Summary and graphing options are available for *surface water basin input conditions*, as before. The input parameters are stored in the same files as the surface water only simulation (rainfall, *.RAN, evapotranspiration, *.EVT, and diversions, *.OFD). The surface water basin conditions

are in the *.IBS file containing the daily collated basin storages, internal basin fluxes and external basin fluxes. The daily average basin discharge hydrographs are stored in files *.S91 - *.S95.

Hourly hydrographs are not available for integrated simulations. The reach conditions utilize the data in the *.IBR file containing daily collated reach state variables and external reach fluxes. The additional baseflow external fluxes are available as a result of the integration and are retrieved from the *.CDR file. The daily average reach hydrographs stored in the *.R91 - *.R95 files can also be presented in summary or graphical format (hourly hydrographs are not available). All of these options are similar to what has been described for surface water only simulation post-processing.

Ground Water Budget

Post-processing the groundwater conditions enables the user to display or summarize ground water balance terms, baseflow rates, and aquifer heads. The ground water balance information is derived from data stored in the *.IBG file. Baseflow data from the *.CDR file can be summarized or graphed versus the stress period used in the simulation. Reach baseflow data from the *.CDR file is available for each dynamic or static reach segment and includes the rate of gain or loss of baseflow and the total net baseflow rate. The time interval of the *.CDR file is the integration time step. The aquifer heads are stored in a MODFLOW binary file. The heads are recorded every integration time step. This binary file can be processed into ASCII data files for well hydrographs or surface contour plots by the post-processor. Aquifer heads for a particular cell and layer (i, j, k) may be graphed versus the simulation time (see ground water only post-processing). A head contouring file may be created in an "x, y, z" format (*.XYZ) and can be found in the working project directory. This file will be created for a specified layer and integration time step. The *.XYZ can be used in many graphing packages (e.g., Surfer, QuattroPro, etc.) to produce surface plots or contour plots. The *.XYZ file can also be plotted using HydroGIS (see Part II).

Integrated Water Budget

The integrated water balance is summarized in the *.IBI file. This file contains the lower zone storage nominal capacity (**LZSN**), lower zone storage (**LZS**), and lower zone ratio (**LZRAT**) before and after update for each integration loop. Also available is the additional recharge and error recharge components of the integration water balance. Analysis of this file by the post-processor is not available in Version 3.0 FHM.

REFERENCES

- Baudean, Jodi Ann (1996). "Factors That Affect Calibration of a Comprehensive Surface Water Model of West Central Florida." Masters Thesis, University of South Florida, Tampa, FL.
- Bicknell, B., J. C. Imhoff, J. L. Kittle, Jr., A. S. Donigian, Jr., and R. C. Johanson (1993). *Hydrological Simulation Program--FORTRAN (HSPF): User's Manual for Release 10*. U.S. Environmental Protection Agency, Athens, Georgia.
- McDonald, M. G., and Harbaugh, A. W. (1984). *A Modular Three-Dimensional Finite-Difference Ground-Water Flow Model*. U.S. Geological Survey, Reston, Virginia.
- Viessman, Warren., and Lewis, Gary (1996). *Introduction to Hydrology*. Harper Collins College Publishers, New York, New York.

APPENDIX A. HSPF PLOT FILE FORMAT

The ASCII file format for a PLTGEN file is shown below.

The file format is used by HSPF and by the integrated FHM model. All time series data must conform to this format.

```

SWFWMD District 01/01/1989-12/31/1989          27-DEC-1995:18:01:48.00
 1988 11 1 1 0 1989 12 31 24 0
 3 blank_line
 4 blank_line
 5 blank_line
 6 blank_line
 7 blank_line
 8 blank_line
 9 blank_line
10 blank_line
11 blank_line
1048 Brooksville
3186 Fort Meyers
4797 Lakeland
5076 Lisbon
6628 Orlando
6880 Parrish
7851 Saint Leo
7886 Saint Petersburg
8788 Tampa
9176 Venice
22 blank_line
23 blank_line
24 blank_line
25 blank_line
 1988 11 1 1 0 0.00 0.00 0.00 -9999.00 0.01 0.00 0.00 0.00 0.00 0.00
 1988 11 1 2 0 0.00 0.00 0.00 -9999.00 0.00 0.00 0.00 0.00 0.00 0.00
 1988 11 1 3 0 0.00 0.00 0.00 -9999.00 0.00 0.00 0.00 0.00 0.00 0.00
 1988 11 1 4 0 0.00 0.00 0.00 -9999.00 0.00 0.00 0.00 0.00 0.00 0.00
 1988 11 1 5 0 0.00 0.00 0.00 -9999.00 0.00 0.00 0.00 0.00 0.00 0.00
 1988 11 1 6 0 0.00 0.00 0.00 -9999.00 0.00 0.00 0.00 0.00 0.00 0.00
 1988 11 1 7 0 0.00 0.00 0.00 -9999.00 0.00 0.00 0.00 0.00 0.00 0.00
 1988 11 1 8 0 0.00 0.00 0.00 -9999.00 0.00 0.00 0.00 0.00 0.00 0.00
 1988 11 1 9 0 0.00 0.00 0.00 -9999.00 0.00 0.00 0.00 0.00 0.00 0.00
 1988 11 1 10 0 0.00 0.00 0.10 -9999.00 0.00 0.00 0.00 0.00 0.00 0.00
 1988 11 1 11 0 0.00 0.00 0.00 -9999.00 0.00 0.00 0.00 0.00 0.00 0.00
 1988 11 1 12 0 0.00 0.00 0.00 -9999.00 0.00 0.00 0.00 0.00 0.00 0.00
 1988 11 1 13 0 0.00 0.00 0.00 -9999.00 0.00 0.00 0.00 0.00 0.00 0.00
 1988 11 1 14 0 0.00 0.00 0.00 -9999.00 0.00 0.00 0.00 0.00 0.00 0.00
 1988 11 1 15 0 0.00 0.00 0.00 -9999.00 0.00 0.00 0.00 0.00 0.00 0.00
 1988 11 1 16 0 0.00 0.00 0.00 -9999.00 0.00 0.00 0.00 0.00 0.00 0.00
 1988 11 1 17 0 0.00 0.00 0.00 -9999.00 0.00 0.00 0.00 0.00 0.00 0.00

      1          2          3          4          5          6          7          8          9          1          1          1          1          1          1
123456789012345678901234567890123456789012345678901234567890123456789012345678901234567890123456789012345678901234567
LABL YEAR MO DA HR MN VALUE1 VALUE2 VALUE3 VALUE4 VALUES VALUE6 VALUE7 VALUE8 VALUE9 VALUE10

```

APPENDIX B. WATER BALANCE FILE FORMATS

Appendix B.1 Subbasin Water Budget Output

FHM Integrated Water Balance for Run - NEHINT Subbasins

SUB DATE <-----STORAGES-----><-----OUTFLOWS AND INFLOWS----->																	
NUM	YR	MN	DY	PERS (in)	CEPS (in)	SURS (in)	UZS (in)	IFWS (in)	LZS (in)	AGWS (in)	GWVS (in)	SUPY (in)	SURO (in)	IFWO (in)	AGWO (in)	PERO (in)	IGWI (in)
1	89	1	1	10.794	0.000	0.000	0.016	0.000	10.779	0.000	0.145	0.000	0.000	0.000	0.000	0.000	0.000
1	89	1	2	10.790	0.000	0.000	0.013	0.000	10.777	0.000	0.140	0.000	0.000	0.000	0.000	0.000	0.000
1	89	1	3	10.787	0.000	0.000	0.012	0.000	10.776	0.000	0.136	0.000	0.000	0.000	0.000	0.000	0.000
1	89	1	4	10.784	0.000	0.000	0.009	0.000	10.774	0.000	0.132	0.000	0.000	0.000	0.000	0.000	0.000
1	89	1	5	10.780	0.000	0.000	0.007	0.000	10.773	0.000	0.128	0.000	0.000	0.000	0.000	0.000	0.000
1	89	1	6	10.778	0.000	0.000	0.006	0.000	10.772	0.000	0.124	0.000	0.000	0.000	0.000	0.000	0.000
1	89	1	7	10.775	0.000	0.000	0.005	0.000	10.770	0.000	0.120	0.000	0.000	0.000	0.000	0.000	0.000
1	89	1	8	10.835	0.000	0.000	0.004	0.000	10.831	0.000	0.145	0.000	0.000	0.000	0.000	0.000	0.000
1	89	1	9	10.830	0.000	0.000	0.004	0.000	10.827	0.000	0.140	0.000	0.000	0.000	0.000	0.000	0.000
1	89	1	10	10.826	0.000	0.000	0.003	0.000	10.823	0.000	0.136	0.000	0.000	0.000	0.000	0.000	0.000
1	89	1	11	10.820	0.000	0.000	0.002	0.000	10.818	0.000	0.132	0.000	0.000	0.000	0.000	0.000	0.000
1	89	1	12	10.816	0.000	0.000	0.002	0.000	10.814	0.000	0.128	0.000	0.000	0.000	0.000	0.000	0.000
1	89	1	13	10.811	0.000	0.000	0.002	0.000	10.810	0.000	0.124	0.000	0.000	0.000	0.000	0.000	0.000
1	89	1	14	10.806	0.000	0.000	0.001	0.000	10.804	0.000	0.120	0.000	0.000	0.000	0.000	0.000	0.000
1	89	1	15	10.861	0.000	0.000	0.001	0.000	10.860	0.000	0.145	0.000	0.000	0.000	0.000	0.000	0.000
1	89	1	16	10.985	0.000	0.000	0.056	0.000	10.929	0.000	0.140	0.200	0.000	0.000	0.000	0.000	0.042
1	89	1	17	10.978	0.000	0.000	0.051	0.000	10.927	0.000	0.136	0.000	0.000	0.000	0.000	0.000	0.000
1	89	1	18	10.964	0.000	0.000	0.042	0.000	10.922	0.000	0.132	0.000	0.000	0.000	0.000	0.000	0.000
1	89	1	19	10.953	0.000	0.000	0.035	0.000	10.918	0.000	0.128	0.000	0.000	0.000	0.000	0.000	0.000
1	89	1	20	11.264	0.021	0.001	0.251	0.000	10.990	0.000	0.124	0.400	0.000	0.000	0.000	0.000	0.045
1	89	1	21	12.076	0.020	0.078	0.590	0.000	11.389	0.000	0.120	1.200	0.055	0.000	0.000	0.055	0.255
1	89	1	22	12.499	0.000	0.000	0.570	0.000	11.929	0.000	0.145	2.200	1.211	0.000	0.000	1.211	0.458
1	89	1	23	12.404	0.000	0.000	0.455	0.000	11.949	0.000	0.140	0.000	0.000	0.000	0.000	0.000	0.019

Table Continued

<-----EVAPOTRANSPIRATION-----><-----INTERNAL FLUXES----->												
PET (in)	CEPE (in)	UZET (in)	LZET (in)	AGWET (in)	BASET (in)	TAET (in)	IFWI (in)	UZI (in)	INFIL (in)	PERC (in)	LZI (in)	AGWI (in)
0.098	0.000	0.003	0.001	0.000	0.000	0.005	0.000	0.000	0.000	0.000	0.000	0.000
0.084	0.000	0.002	0.001	0.000	0.000	0.004	0.000	0.000	0.000	0.000	0.000	0.000
0.063	0.000	0.002	0.001	0.000	0.000	0.003	0.000	0.000	0.000	0.000	0.000	0.000
0.105	0.000	0.002	0.001	0.000	0.000	0.004	0.000	0.000	0.000	0.000	0.000	0.000
0.133	0.000	0.002	0.001	0.000	0.000	0.004	0.000	0.000	0.000	0.000	0.000	0.000
0.077	0.000	0.001	0.001	0.000	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000
0.077	0.000	0.001	0.001	0.000	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000
0.091	0.000	0.001	0.004	0.000	0.000	0.005	0.000	0.000	0.000	0.000	0.000	0.000
0.084	0.000	0.001	0.004	0.000	0.000	0.005	0.000	0.000	0.000	0.000	0.000	0.000
0.077	0.000	0.001	0.004	0.000	0.000	0.004	0.000	0.000	0.000	0.000	0.000	0.000
0.105	0.000	0.001	0.005	0.000	0.000	0.005	0.000	0.000	0.000	0.000	0.000	0.000
0.084	0.000	0.000	0.004	0.000	0.000	0.004	0.000	0.000	0.000	0.000	0.000	0.000
0.084	0.000	0.000	0.004	0.000	0.000	0.004	0.000	0.000	0.000	0.000	0.000	0.000
0.119	0.000	0.000	0.005	0.000	0.000	0.006	0.000	0.000	0.000	0.000	0.000	0.000
0.126	0.000	0.000	0.006	0.000	0.000	0.006	0.000	0.000	0.000	0.000	0.000	0.000
0.084	0.028	0.003	0.003	0.000	0.000	0.034	0.000	0.058	0.113	0.000	0.071	0.000
0.049	0.000	0.005	0.002	0.000	0.000	0.008	0.000	0.000	0.000	0.000	0.000	0.000
0.098	0.000	0.009	0.004	0.000	0.000	0.014	0.000	0.000	0.000	0.000	0.000	0.000
0.091	0.000	0.007	0.004	0.000	0.000	0.011	0.000	0.000	0.000	0.000	0.000	0.000
0.112	0.031	0.010	0.003	0.000	0.000	0.044	0.000	0.227	0.121	0.000	0.076	0.000
0.077	0.077	0.000	0.000	0.000	0.000	0.077	0.000	0.357	0.636	0.018	0.399	0.000
0.077	0.062	0.015	0.000	0.000	0.000	0.077	0.000	0.093	0.932	0.098	0.572	0.000
0.077	0.000	0.076	0.000	0.000	0.000	0.076	0.000	0.000	0.000	0.039	0.020	0.000

Appendix B.2 Reach Water Budget Output

FHM Integrated Water Balance for Run - NEHINT - Reaches

FHM Integrated Water Balance for Run - NEHINT - Reaches																	
-----STATE VARIABLES-----																	
RCH	DATE	VOL	DEP	STAGE	AVDEP	TWID	HRAD	SAREA	AVVEL	AVSECT	OUTFLOW	INFLOW	PRECIP	EVAP	OUTFLOW		
NUM	YR	MN	DY	AC-FT	FT	FT	FT	ACRES	FT/S	FT2	FT3/S	IVOL	PRSUPY	VOLEV	ROVOL		
												AC-FT	AC-FT	AC-FT	AC-FT		
1	89	1	1	2.04	0.29	0.29	0.12	8.20	0.12	17.04	1.81	0.98	1.78	9.3240E-01	0.0000E+00	1.5480E-01	8.7350E+00
1	89	1	2	0.75	0.11	0.11	0.05	7.73	0.05	16.08	1.81	0.36	0.66	9.3240E-01	0.0000E+00	1.1510E-01	2.1080E+00
1	89	1	3	0.54	0.08	0.08	0.03	7.65	0.03	15.91	1.81	0.26	0.47	9.3240E-01	0.0000E+00	8.3850E-02	1.0640E+00
1	89	1	4	0.47	0.07	0.07	0.03	7.63	0.03	15.86	1.81	0.23	0.41	9.3240E-01	0.0000E+00	1.3890E-01	8.5800E-01
1	89	1	5	0.44	0.07	0.07	0.03	7.62	0.03	15.84	1.81	0.21	0.39	9.3240E-01	0.0000E+00	1.7560E-01	7.8570E-01
1	89	1	6	0.47	0.07	0.07	0.03	7.63	0.03	15.87	1.81	0.23	0.41	9.3240E-01	0.0000E+00	1.0170E-01	8.0060E-01
1	89	1	7	0.48	0.07	0.07	0.03	7.63	0.03	15.87	1.81	0.23	0.42	9.3240E-01	0.0000E+00	1.0180E-01	8.2530E-01
1	89	1	8	0.27	0.04	0.04	0.02	7.55	0.02	15.71	1.81	0.13	0.24	5.0760E-01	0.0000E+00	1.1950E-01	5.9780E-01
1	89	1	9	0.23	0.03	0.03	0.01	7.54	0.01	15.68	1.81	0.11	0.20	4.9880E-01	0.0000E+00	1.0980E-01	4.2590E-01
1	89	1	10	0.23	0.03	0.03	0.01	7.54	0.01	15.67	1.81	0.11	0.20	4.9000E-01	0.0000E+00	1.0050E-01	3.9580E-01
1	89	1	11	0.20	0.03	0.03	0.01	7.53	0.01	15.65	1.81	0.10	0.18	4.8130E-01	0.0000E+00	1.3700E-01	3.6700E-01
1	89	1	12	0.21	0.03	0.03	0.01	7.53	0.01	15.66	1.81	0.10	0.18	4.7260E-01	0.0000E+00	1.0960E-01	3.5820E-01
1	89	1	13	0.21	0.03	0.03	0.01	7.53	0.01	15.66	1.81	0.10	0.18	4.6400E-01	0.0000E+00	1.0950E-01	3.5770E-01
1	89	1	14	0.18	0.03	0.03	0.01	7.52	0.01	15.63	1.81	0.09	0.16	4.5530E-01	0.0000E+00	1.5510E-01	3.2660E-01
1	89	1	15	0.21	0.03	0.03	0.01	7.53	0.01	15.66	1.81	0.10	0.18	5.4130E-01	0.0000E+00	1.6430E-01	3.4540E-01
1	89	1	16	0.34	0.05	0.05	0.02	7.58	0.02	15.76	1.81	0.16	0.29	5.3530E-01	2.6190E-01	1.1020E-01	5.6300E-01
1	89	1	17	0.28	0.04	0.04	0.02	7.56	0.02	15.71	1.81	0.13	0.24	5.2540E-01	0.0000E+00	6.4210E-02	5.1740E-01
1	89	1	18	0.24	0.04	0.04	0.02	7.54	0.01	15.68	1.81	0.11	0.20	5.1750E-01	0.0000E+00	1.2810E-01	4.3360E-01
1	89	1	19	0.23	0.03	0.03	0.01	7.54	0.01	15.67	1.81	0.11	0.20	5.0950E-01	0.0000E+00	1.1880E-01	3.9800E-01
1	89	1	20	0.56	0.08	0.08	0.04	7.66	0.04	15.93	1.81	0.27	0.49	5.2890E-01	5.2340E-01	1.4690E-01	5.6890E-01
1	89	1	21	29.67	2.94	2.94	0.95	14.95	0.85	31.09	2.35	14.27	33.46	3.9930E+01	1.9010E+00	1.1860E-01	1.2610E+01
1	89	1	22	687.58	6.05	6.05	13.94	23.72	6.41	49.31	0.38	330.72	125.05	8.6700E+02	7.2580E+00	2.9570E-01	2.1610E+02
1	89	1	23	447.88	5.79	5.79	9.29	23.19	5.16	48.21	0.52	215.42	111.18	2.1380E-01	0.0000E+00	3.1520E-01	2.3960E+02
1	89	1	24	253.23	5.49	5.49	5.58	21.82	3.69	45.37	0.71	121.80	86.04	2.2260E-01	0.0000E+00	3.2750E-01	1.9450E+02
1	89	1	25	105.03	4.55	4.55	2.65	19.05	2.07	39.60	1.16	50.52	58.44	2.3130E-01	0.0000E+00	3.0650E-01	1.4810E+02
1	89	1	26	16.89	1.90	1.90	0.66	12.31	0.60	25.58	2.30	8.12	18.70	2.4000E-01	0.0000E+00	4.0910E-01	8.7970E+01
1	89	1	27	2.62	0.37	0.37	0.15	8.39	0.14	17.45	1.81	1.26	2.28	2.4870E-01	0.0000E+00	1.4360E-01	1.4370E+01
1	89	1	28	0.52	0.08	0.08	0.03	7.65	0.03	15.90	1.81	0.25	0.45	2.5730E-01	0.0000E+00	1.4440E-01	2.2120E+00

Appendix B.3 Ground Water Balance

Integrated Ground Water Balance for Run - NEHINT

Loop Time No. Step	Sim. Time	Aquifer Storage		Constant Head		Well Pumpage		Drains		Rivers Leakage		Evapotranspiration		
		IN	OUT	IN	OUT	IN	OUT	IN	OUT	IN	OUT	IN	OUT	
1	7	7.00	0.25526E+09	0.61088E+07	0.00000E+00	0.00000E+00	0.00000E+00	0.69250E+08	0.00000E+00	0.00000E+00	0.10109E+07	0.78976E+08	0.00000E+00	0.38572E+08
2	7	7.00	0.23806E+09	0.47582E+07	0.00000E+00	0.00000E+00	0.00000E+00	0.69250E+08	0.00000E+00	0.00000E+00	0.10007E+07	0.78531E+08	0.00000E+00	0.37392E+08
3	7	7.00	0.18533E+08	0.17236E+09	0.00000E+00	0.00000E+00	0.00000E+00	0.69250E+08	0.00000E+00	0.00000E+00	0.10452E+07	0.78961E+08	0.00000E+00	0.30057E+08
4	7	7.00	0.30554E+07	0.27425E+09	0.00000E+00	0.00000E+00	0.00000E+00	0.69250E+08	0.00000E+00	0.00000E+00	0.18112E+07	0.72506E+08	0.00000E+00	0.89178E+07
5	7	7.00	0.26192E+09	0.36611E+07	0.00000E+00	0.00000E+00	0.00000E+00	0.80462E+08	0.00000E+00	0.00000E+00	0.10993E+07	0.76957E+08	0.00000E+00	0.30039E+08
6	7	7.00	0.25969E+09	0.23684E+07	0.00000E+00	0.00000E+00	0.00000E+00	0.80462E+08	0.00000E+00	0.00000E+00	0.98007E+06	0.77708E+08	0.00000E+00	0.42434E+08
7	7	7.00	0.26222E+09	0.19949E+07	0.00000E+00	0.00000E+00	0.00000E+00	0.80462E+08	0.00000E+00	0.00000E+00	0.98454E+06	0.77135E+08	0.00000E+00	0.47364E+08
8	7	7.00	0.21572E+09	0.42820E+07	0.00000E+00	0.00000E+00	0.00000E+00	0.80462E+08	0.00000E+00	0.00000E+00	0.98857E+06	0.76543E+08	0.00000E+00	0.33147E+08
9	7	7.00	0.52150E+08	0.89654E+08	0.00000E+00	0.00000E+00	0.00000E+00	0.76773E+08	0.00000E+00	0.00000E+00	0.10002E+07	0.76453E+08	0.00000E+00	0.24129E+08
10	7	7.00	0.22149E+09	0.45183E+07	0.00000E+00	0.00000E+00	0.00000E+00	0.76773E+08	0.00000E+00	0.00000E+00	0.99213E+06	0.75664E+08	0.00000E+00	0.11916E+08
11	7	7.00	0.25364E+09	0.14256E+07	0.00000E+00	0.00000E+00	0.00000E+00	0.76773E+08	0.00000E+00	0.00000E+00	0.99778E+06	0.74879E+08	0.00000E+00	0.33185E+08
12	7	7.00	0.19922E+09	0.39480E+07	0.00000E+00	0.00000E+00	0.00000E+00	0.76773E+08	0.00000E+00	0.00000E+00	0.10012E+07	0.74391E+08	0.00000E+00	0.29611E+08
13	7	7.00	0.18637E+09	0.35202E+07	0.00000E+00	0.00000E+00	0.00000E+00	0.76773E+08	0.00000E+00	0.00000E+00	0.10138E+07	0.73804E+08	0.00000E+00	0.21384E+08
14	7	7.00	0.11414E+09	0.20180E+08	0.00000E+00	0.00000E+00	0.00000E+00	0.86536E+08	0.00000E+00	0.00000E+00	0.10547E+07	0.72707E+08	0.00000E+00	0.19337E+08
15	7	7.00	0.17247E+09	0.50019E+07	0.00000E+00	0.00000E+00	0.00000E+00	0.86536E+08	0.00000E+00	0.00000E+00	0.10065E+07	0.72824E+08	0.00000E+00	0.17738E+08
16	7	7.00	0.21846E+09	0.28134E+07	0.00000E+00	0.00000E+00	0.00000E+00	0.86536E+08	0.00000E+00	0.00000E+00	0.10118E+07	0.72194E+08	0.00000E+00	0.11995E+08
17	7	7.00	0.21606E+09	0.10197E+07	0.00000E+00	0.00000E+00	0.00000E+00	0.86536E+08	0.00000E+00	0.00000E+00	0.10174E+07	0.71585E+08	0.00000E+00	0.32498E+08
18	7	7.00	0.15534E+09	0.56585E+07	0.00000E+00	0.00000E+00	0.00000E+00	0.88696E+08	0.00000E+00	0.00000E+00	0.10329E+07	0.70381E+08	0.00000E+00	0.19855E+08
19	7	7.00	0.27171E+09	0.32335E+06	0.00000E+00	0.00000E+00	0.00000E+00	0.88696E+08	0.00000E+00	0.00000E+00	0.10398E+07	0.69619E+08	0.00000E+00	0.42577E+08
20	7	7.00	0.23967E+09	0.37440E+06	0.00000E+00	0.00000E+00	0.00000E+00	0.88696E+08	0.00000E+00	0.00000E+00	0.10658E+07	0.69033E+08	0.00000E+00	0.39655E+08
21	7	7.00	0.25353E+09	0.33029E+06	0.00000E+00	0.00000E+00	0.00000E+00	0.88696E+08	0.00000E+00	0.00000E+00	0.10954E+07	0.68426E+08	0.00000E+00	0.45194E+08
22	7	7.00	0.24603E+09	0.31045E+06	0.00000E+00	0.00000E+00	0.00000E+00	0.88696E+08	0.00000E+00	0.00000E+00	0.11277E+07	0.67854E+08	0.00000E+00	0.47019E+08
23	7	7.00	0.10739E+09	0.48142E+08	0.00000E+00	0.00000E+00	0.00000E+00	0.54897E+08	0.00000E+00	0.00000E+00	0.11670E+07	0.67544E+08	0.00000E+00	0.12931E+08

Table Continued

<General Head Boundary>		Recharge		Total		<Pct.>	
IN	OUT	IN	OUT	IN	OUT	IN	OUT
0.33497E+08	0.96840E+08	0.00000E+00	0.55758E+05	0.28976E+09	0.28980E+09	-0.010	
0.34082E+08	0.96309E+08	0.13680E+08	0.63943E+06	0.28682E+09	0.28688E+09	-0.020	
0.33470E+08	0.96846E+08	0.39442E+09	0.00000E+00	0.44747E+09	0.44748E+09	0.000	
0.32770E+08	0.97853E+08	0.48515E+09	0.00000E+00	0.52278E+09	0.52277E+09	0.000	
0.30303E+08	0.96961E+08	0.67637E+06	0.59574E+07	0.29400E+09	0.29404E+09	-0.010	
0.31296E+08	0.95105E+08	0.68232E+07	0.73550E+06	0.29879E+09	0.29881E+09	-0.010	
0.31800E+08	0.94101E+08	0.66770E+07	0.64827E+06	0.30168E+09	0.30171E+09	-0.010	
0.32177E+08	0.93432E+08	0.38939E+08	0.00000E+00	0.28783E+09	0.28787E+09	-0.010	
0.26729E+08	0.11102E+09	0.29813E+09	0.00000E+00	0.37801E+09	0.37803E+09	-0.010	
0.28286E+08	0.10578E+09	0.24219E+08	0.36601E+06	0.27499E+09	0.27502E+09	-0.010	
0.28873E+08	0.10433E+09	0.75232E+07	0.46830E+06	0.29103E+09	0.29106E+09	-0.010	
0.29220E+08	0.10352E+09	0.58778E+08	0.00000E+00	0.28822E+09	0.28824E+09	-0.010	
0.29554E+08	0.10278E+09	0.61377E+08	0.82088E+05	0.27831E+09	0.27835E+09	-0.010	
0.30056E+08	0.10504E+09	0.15852E+09	0.00000E+00	0.30377E+09	0.30380E+09	-0.010	
0.31010E+08	0.10321E+09	0.80798E+08	0.00000E+00	0.28528E+09	0.28531E+09	-0.010	
0.31503E+08	0.10225E+09	0.24898E+08	0.10874E+06	0.27588E+09	0.27590E+09	-0.010	
0.31917E+08	0.10151E+09	0.44191E+08	0.59222E+05	0.29318E+09	0.29320E+09	-0.010	
0.24536E+08	0.11324E+09	0.11688E+09	0.00000E+00	0.29779E+09	0.29783E+09	-0.010	
0.25731E+08	0.10904E+09	0.12190E+08	0.44735E+06	0.31067E+09	0.31070E+09	-0.010	
0.26142E+08	0.10776E+09	0.38679E+08	0.66226E+05	0.30556E+09	0.30558E+09	-0.010	
0.26495E+08	0.10677E+09	0.28399E+08	0.12641E+06	0.30952E+09	0.30954E+09	-0.010	
0.26829E+08	0.10589E+09	0.35871E+08	0.10867E+06	0.30985E+09	0.30988E+09	-0.010	

Appendix B.4 Integrated Water Balance

Integrated Water Balance Report

loop	Basin	LZSN	LZSN	LZS	LZS	LZS	Change	LZRAT	LZRAT	Add	Error		
count	num	old	new	old	start	old	end	new	in LZS	old	new	Recharge	Recharge
1	1	60.00000	11.92486	10.78000	10.78000	10.78000	.00000	.17967	.90399	.00000	.00000	.00000	.00000
1	2	60.00000	15.28465	13.49000	13.49000	13.49008	.00008	.22483	.88259	.00000	.00000	.00000	.00000
1	3	60.00000	18.29207	16.51000	16.51000	16.51003	.00003	.27517	.90258	.00000	.00000	.00000	.00000
1	4	60.00000	4.38274	3.96000	3.96000	3.96000	.00000	.06600	.90354	.00000	.00000	.00000	.00000
1	5	60.00000	4.01280	3.63000	3.63000	3.63000	.00000	.06050	.90461	.00000	.00000	.00000	.00000
1	6	60.00000	7.36628	6.53000	6.53000	6.53007	.00007	.10883	.88648	.00000	.00000	.00000	.00000
1	7	55.00000	2.82710	2.37000	2.37000	2.37025	.00025	.04309	.83840	.00000	.00000	.00000	.00000
1	8	55.00000	3.61136	3.33000	3.33000	3.33000	.00000	.06055	.92209	.00000	.00000	.00000	.00000
1	9	55.00000	5.13205	4.74000	4.74000	4.74000	.00000	.08618	.92361	.00000	.00000	.00000	.00000
1	10	55.00000	5.43616	5.02000	5.02000	5.02000	.00000	.09127	.92345	.00000	.00000	.00000	.00000
1	11	55.00000	14.25776	13.12000	13.12000	13.12005	.00005	.23855	.92020	.00000	.00000	.00000	.00000
1	12	50.00000	3.84754	3.74000	3.74000	3.74005	.00005	.07480	.97206	.00000	.00000	.00000	.00000
1	13	50.00000	7.24463	7.15000	7.15000	7.15006	.00006	.14300	.98695	.00000	.00000	.00000	.00000
1	14	55.00000	15.07910	13.92000	13.92000	13.92000	.00000	.25309	.92313	.00000	.00000	.00000	.00000
1	15	55.00000	15.15716	13.99000	13.99000	13.99000	.00000	.25436	.92300	.00000	.00000	.00000	.00000
1	16	50.00000	36.36833	34.70000	34.70000	34.70000	.00000	.69400	.95413	.00000	.00000	.00000	.00000
1	17	55.00000	4.30751	3.66000	3.66000	3.66014	.00014	.06655	.84971	.00000	.00000	.00000	.00000
1	18	50.00000	11.09089	10.30000	10.30000	10.30013	.00013	.20600	.92870	.00000	.00000	.00000	.00000
1	19	50.00000	17.13980	16.35000	16.35000	16.35000	.00000	.32700	.95392	.00000	.00000	.00000	.00000
1	20	50.00000	17.20914	16.42000	16.42000	16.42000	.00000	.32840	.95414	.00000	.00000	.00000	.00000
1	21	50.00000	23.58432	22.50000	22.50000	22.50000	.00000	.45000	.95402	.00000	.00000	.00000	.00000
1	22	50.00000	11.49579	11.50000	11.50000	11.50000	.00000	.23000	1.00037	.00000	.00000	.00000	.00000
1	23	50.00000	12.65562	12.39000	12.39000	12.39010	.00010	.24780	.97902	.00000	.00000	.00000	.00000
1	24	50.00000	31.54688	31.55000	31.55000	31.55000	.00000	.63100	1.00010	.00000	.00000	.00000	.00000

APPENDIX C. FHM INPUT DATA FILES

Appendix C.1 Surface Water Information File (*.INF)

SUBBASINS	REACHES	rain (in)	INFLOWS
24	22	1.000	7
Basin #	Basin area	Area Outside Grid	Route Flg Route To
1	8587.130	0.000	1 1
2	23175.520	0.000	1 2
3	21328.381	0.000	1 6
4	4734.830	0.000	1 4
5	5255.440	0.000	1 8
6	8823.300	0.000	1 10
7	7372.500	0.000	1 13
8	5187.080	0.000	1 14
9	5863.080	0.000	1 17
10	6353.430	0.000	1 19
11	13217.870	0.000	1 12
12	60910.922	24359.523	1 0
13	10219.460	0.000	1 0
14	17819.859	5038.595	1 16
15	5546.720	0.000	1 18
16	3230.070	0.000	1 0
17	11855.000	59.503	1 21
18	19425.961	0.000	1 0
19	6830.510	0.000	1 0
20	13301.910	0.000	1 0
21	10724.070	5071.395	1 0
22	9971.680	0.000	1 0
23	24045.000	0.858	1 0
24	6469.910	0.000	1 0

Reach number	Route To
1	5
2	3
3	5
4	5
5	9
6	7
7	9
8	9
9	11
10	11
11	22
12	15
13	15
14	15
15	17
16	17
17	20
18	20
19	20
20	22
21	22
22	0

Diversion inflow number	Route To
1	0
2	0
3	0
4	0
5	0
6	0
7	0

Number of Rain Stations
10

Basin Rain Influence

1	-9999	-9999	1	-9999	-9999	-9999	-9999	-9999	-9999	-9999
2	-9999	-9999	1	-9999	-9999	-9999	-9999	-9999	-9999	-9999
3	-9999	-9999	1	-9999	-9999	-9999	-9999	-9999	-9999	-9999
4	-9999	-9999	1	-9999	-9999	-9999	-9999	-9999	-9999	-9999
5	-9999	-9999	.8	-9999	-9999	-9999	.2	-9999	-9999	-9999
6	-9999	-9999	.3	-9999	-9999	-9999	.7	-9999	-9999	-9999
7	-9999	-9999	-9999	-9999	-9999	-9999	1	-9999	-9999	-9999
8	-9999	-9999	-9999	-9999	-9999	-9999	1	-9999	-9999	-9999
9	-9999	-9999	.3	-9999	-9999	-9999	.7	-9999	-9999	-9999
10	-9999	-9999	.3	-9999	-9999	-9999	.7	-9999	-9999	-9999
11	-9999	-9999	.75	-9999	-9999	-9999	.25	-9999	-9999	-9999
12	-9999	-9999	.69	-9999	-9999	-9999	.31	-9999	-9999	-9999
13	-9999	-9999	-9999	-9999	-9999	-9999	1	-9999	-9999	-9999
14	-9999	-9999	-9999	-9999	-9999	-9999	1	-9999	-9999	-9999
15	-9999	-9999	-9999	-9999	-9999	-9999	1	-9999	-9999	-9999
16	-9999	-9999	-9999	-9999	-9999	-9999	1	-9999	-9999	-9999
17	-9999	-9999	-9999	-9999	-9999	-9999	1	-9999	-9999	-9999
18	-9999	-9999	.36	-9999	-9999	-9999	.64	-9999	-9999	-9999
19	-9999	-9999	.67	-9999	-9999	-9999	.15	-9999	.18	-9999
20	-9999	-9999	1	-9999	-9999	-9999	-9999	-9999	-9999	-9999
21	-9999	-9999	.16	-9999	-9999	-9999	-9999	-9999	.84	-9999
22	-9999	-9999	1	-9999	-9999	-9999	-9999	-9999	-9999	-9999

Appendix C.2 Basin Simulation Data File (*.INS)

```

RUN 1
GLOBAL 2
HSPF VERSION 10.1 3
***START AND END TIME FOR THE RUN 4
****/**/** **:** 5
START 1989 1 1 0 0 END 1989 12 31 24 0 6
RUN INTERP OUTPUT LEVEL 4 7
RESUME 0 RUN 1 8
END GLOBAL 9
FILES 10
<FILE> <UN#>***<---FILE NAME-----> 11
INFO 23 C:\FHM\HSPINF.DA 12
ERROR 24 C:\FHM\HSPERR.DA 13
WARN 25 C:\FHM\HSPWRN.DA 14
MESSU 22 NEHINT.lis 15
1 NEHINT.bal 16
40 NEHINT.ran 17
96 NEHINT.etd 18
81 NEHINT.s81 19
82 NEHINT.s82 20
83 NEHINT.s83 21
END FILES 22
OPN SEQUENCE 23
INGRP INDELT 01:00 24
MUTSIN 1 END ACTIVITY
COPY 1 PRINT-INFO
MUTSIN 2 ## - ## ATMP SNOW PWAT *** PIVL PYR
COPY 2 1 3 1 12
PERLND 1 2 3 1 12
PERLND 2 3 3 1 12
PERLND 3 4 3 1 12
PERLND 4 5 3 1 12
PERLND 5 6 3 1 12
PERLND 6 7 3 1 12
PERLND 7 8 3 1 12
PERLND 8 9 3 1 12
PERLND 9 10 3 1 12
PERLND 10 11 3 1 12
PERLND 11 12 3 1 12
PERLND 12 13 3 1 12
PERLND 13 14 3 1 12
PERLND 14 15 3 1 12
PERLND 15 16 3 1 12
PERLND 16 17 3 1 12
PERLND 17 18 3 1 12
PERLND 18 19 3 1 12
PERLND 19 20 3 1 12
PERLND 20 21 3 1 12
PERLND 21 22 3 1 12
PERLND 22 23 3 1 12
PERLND 23 24 3 1 12
PLTGEN 1 END PRINT-INFO
PLTGEN 2 GEN-INFO
PLTGEN 3 ##
*** 1 SUBBASIN - 1 1 1 1 1 1 1 1 1 1
2 SUBBASIN - 2 1 1 1 1 1
3 SUBBASIN - 3 1 1 1 1 1
4 SUBBASIN - 4 1 1 1 1 1
5 SUBBASIN - 5 1 1 1 1 1

```

6	SUBBASIN - 6	1	1	1	1	1	1	1	1
7	SUBBASIN - 7	1	1	1	1	1	1	1	1
8	SUBBASIN - 8	1	1	1	1	1	1	1	1
9	SUBBASIN - 9	1	1	1	1	1	1	1	1
10	SUBBASIN - 10	1	1	1	1	1	1	1	1
11	SUBBASIN - 11	1	1	1	1	1	1	1	1
12	SUBBASIN - 12	1	1	1	1	1	1	1	1
13	SUBBASIN - 13	1	1	1	1	1	1	1	1
14	SUBBASIN - 14	1	1	1	1	1	1	1	1
15	SUBBASIN - 15	1	1	1	1	1	1	1	1
16	SUBBASIN - 16	1	1	1	1	1	1	1	1
17	SUBBASIN - 17	1	1	1	1	1	1	1	1
18	SUBBASIN - 18	1	1	1	1	1	1	1	1
19	SUBBASIN - 19	1	1	1	1	1	1	1	1
20	SUBBASIN - 20	1	1	1	1	1	1	1	1
21	SUBBASIN - 21	1	1	1	1	1	1	1	1
22	SUBBASIN - 22	1	1	1	1	1	1	1	1
23	SUBBASIN - 23	1	1	1	1	1	1	1	1
24	SUBBASIN - 24	1	1	1	1	1	1	1	1

END GEN-INFO

PWAT-PARM1

##	CSNO	RTOP	UZPG	VCS	VUZ	VNN	VIFW	VIRC	VLE	***
1	0	0	0	1	0	0	0	0	1	
2	0	0	0	1	0	0	0	0	1	
3	0	0	0	1	0	0	0	0	1	
4	0	0	0	1	0	0	0	0	1	
5	0	0	0	1	0	0	0	0	1	
6	0	0	0	1	0	0	0	0	1	
7	0	0	0	1	0	0	0	0	1	
8	0	0	0	1	0	0	0	0	1	
9	0	0	0	1	0	0	0	0	1	
10	0	0	0	1	0	0	0	0	1	
11	0	0	0	1	0	0	0	0	1	
12	0	0	0	1	0	0	0	0	1	
13	0	0	0	1	0	0	0	0	1	
14	0	0	0	1	0	0	0	0	1	
15	0	0	0	1	0	0	0	0	1	
16	0	0	0	1	0	0	0	0	1	
17	0	0	0	1	0	0	0	0	1	
18	0	0	0	1	0	0	0	0	1	
19	0	0	0	1	0	0	0	0	1	
20	0	0	0	1	0	0	0	0	1	
21	0	0	0	1	0	0	0	0	1	
22	0	0	0	1	0	0	0	0	1	
23	0	0	0	1	0	0	0	0	1	
24	0	0	0	1	0	0	0	0	1	

END PWAT-PARM1

PWAT-PARM2

##	***FOREST	LZSN	INFILT	LSUR	SLSUR	KVARY	AGWRC
1		11.920	0.078	1591.0	0.0030	1.0000	0.9980
2		15.280	0.083	2039.0	0.0068	1.0000	0.9980
3		18.290	0.082	1884.0	0.0077	1.0000	0.9980
4		4.380	0.078	2951.0	0.0023	1.0000	0.9980
5		4.010	0.071	2767.0	0.0027	1.0000	0.9980
6		7.370	0.042	2596.0	0.0029	1.0000	0.9980
7		2.830	0.044	1974.0	0.0028	1.0000	0.9980
8		3.610	0.044	4952.0	0.0028	1.0000	0.9980
9		5.130	0.045	2369.0	0.0026	1.0000	0.9980
10		5.440	0.044	1181.0	0.0028	1.0000	0.9980
11		14.260	0.049	1483.0	0.0042	1.0000	0.9980
12		3.850	0.040	1898.0	0.0026	1.0000	0.9970
13		7.240	0.040	1379.0	0.0043	1.0000	0.9970
14		15.080	0.050	2379.0	0.0107	1.0000	0.9980
15		15.160	0.048	1686.0	0.0056	1.0000	0.9980
16		36.370	0.060	1734.0	0.0087	1.0000	0.9900

17	4.310	0.047	2876.0	0.0032	1.0000	0.9980
18	11.090	0.053	1544.0	0.0030	1.0000	0.9990
19	17.140	0.053	1912.0	0.0032	1.0000	0.9990
20	17.210	0.055	1659.0	0.0042	1.0000	0.9990
21	23.580	0.055	2075.0	0.0084	1.0000	0.9990
22	11.500	0.046	2130.0	0.0043	1.0000	0.9960
23	12.660	0.046	1809.0	0.0072	1.0000	0.9960
24	31.550	0.055	2871.0	0.0172	1.0000	0.9980

END PWAT-PARM2

PWAT-PARM3

##	***PETMAX	PETMIN	INFEXP	INFILD	DEEPPR	BASETP	AGWETP
1			2.000	2.000	1.000	0.000	0.040
2			2.000	2.000	1.000	0.000	0.040
3			2.000	2.000	1.000	0.000	0.040
4			2.000	2.000	1.000	0.000	0.040
5			2.000	2.000	1.000	0.000	0.040
6			2.000	2.000	1.000	0.000	0.040
7			2.000	2.000	1.000	0.000	0.040
8			2.000	2.000	1.000	0.000	0.040
9			2.000	2.000	1.000	0.000	0.040
10			2.000	2.000	1.000	0.000	0.040
11			2.000	2.000	1.000	0.000	0.040
12			2.000	2.000	1.000	0.000	0.070
13			2.000	2.000	1.000	0.000	0.070
14			2.000	2.000	1.000	0.000	0.040
15			2.000	2.000	1.000	0.000	0.040
16			2.000	2.000	1.000	0.000	0.040
17			2.000	2.000	1.000	0.000	0.040
18			2.000	2.000	1.000	0.000	0.040
19			2.000	2.000	1.000	0.000	0.040
20			2.000	2.000	1.000	0.000	0.040
21			2.000	2.000	1.000	0.000	0.040
22			2.000	2.000	1.000	0.000	0.040
23			2.000	2.000	1.000	0.000	0.040
24			2.000	2.000	1.000	0.000	0.070

END PWAT-PARM3

PWAT-PARM4

##	***CEPSC	UZSN	NSUR	INTFW	IRC	LZETP
1	0.090	0.247	0.25000	0.000	0.900	0.700
2	0.090	0.247	0.25000	0.000	0.900	0.700
3	0.090	0.247	0.25000	0.000	0.900	0.700
4	0.090	0.247	0.25000	0.000	0.900	0.700
5	0.090	0.247	0.25000	0.000	0.900	0.700
6	0.090	0.247	0.25000	0.000	0.900	0.700
7	0.110	0.400	0.25000	0.000	0.900	0.700
8	0.110	0.400	0.25000	0.000	0.900	0.700
9	0.110	0.400	0.25000	0.000	0.900	0.700
10	0.110	0.400	0.25000	0.000	0.900	0.700
11	0.110	0.400	0.25000	0.000	0.900	0.700
12	0.120	1.750	0.16500	0.000	0.900	0.700
13	0.120	1.750	0.16500	0.000	0.900	0.700
14	0.110	0.400	0.25000	0.000	0.900	0.700
15	0.110	0.400	0.25000	0.000	0.900	0.700
16	0.100	0.595	0.25000	0.000	0.900	0.700
17	0.110	0.400	0.25000	0.000	0.900	0.700
18	0.100	0.450	0.25000	0.000	0.900	0.700
19	0.100	0.450	0.25000	0.000	0.900	0.700
20	0.100	0.450	0.25000	0.000	0.900	0.700
21	0.100	0.450	0.25000	0.000	0.900	0.700
22	0.100	0.388	0.23000	0.000	0.900	0.700
23	0.100	0.388	0.23000	0.000	0.900	0.700
24	0.100	1.500	0.12600	0.000	0.900	0.900

END PWAT-PARM4

MON-INTERCEP

##	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC***
----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	--------

```

1 0.02 0.03 0.05 0.10 0.10 0.10 0.10 0.10 0.10 0.10 0.05 0.03
2 0.02 0.03 0.05 0.10 0.10 0.10 0.10 0.10 0.10 0.10 0.05 0.03
3 0.02 0.03 0.05 0.10 0.10 0.10 0.10 0.10 0.10 0.10 0.05 0.03
4 0.02 0.03 0.05 0.10 0.10 0.10 0.10 0.10 0.10 0.10 0.05 0.03
5 0.02 0.03 0.05 0.10 0.10 0.10 0.10 0.10 0.10 0.10 0.05 0.03
6 0.02 0.03 0.05 0.10 0.10 0.10 0.10 0.10 0.10 0.10 0.05 0.03
7 0.02 0.03 0.05 0.10 0.10 0.10 0.10 0.10 0.10 0.10 0.05 0.03
8 0.02 0.03 0.05 0.10 0.10 0.10 0.10 0.10 0.10 0.10 0.05 0.03
9 0.02 0.03 0.05 0.10 0.10 0.10 0.10 0.10 0.10 0.10 0.05 0.03
10 0.02 0.03 0.05 0.10 0.10 0.10 0.10 0.10 0.10 0.10 0.05 0.03
11 0.02 0.03 0.05 0.10 0.10 0.10 0.10 0.10 0.10 0.10 0.05 0.03
12 0.02 0.03 0.05 0.10 0.10 0.10 0.10 0.10 0.10 0.10 0.05 0.03
13 0.02 0.03 0.05 0.10 0.10 0.10 0.10 0.10 0.10 0.10 0.05 0.03
14 0.02 0.03 0.05 0.10 0.10 0.10 0.10 0.10 0.10 0.10 0.05 0.03
15 0.02 0.03 0.05 0.10 0.10 0.10 0.10 0.10 0.10 0.10 0.05 0.03
16 0.02 0.03 0.05 0.10 0.10 0.10 0.10 0.10 0.10 0.10 0.05 0.03
17 0.02 0.03 0.05 0.10 0.10 0.10 0.10 0.10 0.10 0.10 0.05 0.03
18 0.02 0.03 0.05 0.10 0.10 0.10 0.10 0.10 0.10 0.10 0.05 0.03
19 0.02 0.03 0.05 0.10 0.10 0.10 0.10 0.10 0.10 0.10 0.05 0.03
20 0.02 0.03 0.05 0.10 0.10 0.10 0.10 0.10 0.10 0.10 0.05 0.03
21 0.02 0.03 0.05 0.10 0.10 0.10 0.10 0.10 0.10 0.10 0.05 0.03
22 0.02 0.03 0.05 0.10 0.10 0.10 0.10 0.10 0.10 0.10 0.05 0.03
23 0.02 0.03 0.05 0.10 0.10 0.10 0.10 0.10 0.10 0.10 0.05 0.03
24 0.02 0.03 0.05 0.10 0.10 0.10 0.10 0.10 0.10 0.10 0.05 0.03
END MON-INTERCEP
MON-LZETPARM
## JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC***
1 0.03 0.03 0.17 0.30 0.41 0.43 0.43 0.49 0.49 0.37 0.25 0.12
2 0.03 0.03 0.17 0.30 0.41 0.43 0.43 0.49 0.49 0.37 0.25 0.12
3 0.03 0.03 0.17 0.30 0.41 0.43 0.43 0.49 0.49 0.37 0.25 0.12
4 0.03 0.03 0.17 0.30 0.41 0.43 0.43 0.49 0.49 0.37 0.25 0.12
5 0.03 0.03 0.17 0.30 0.41 0.43 0.43 0.49 0.49 0.37 0.25 0.12
6 0.03 0.03 0.17 0.30 0.41 0.43 0.43 0.49 0.49 0.37 0.25 0.12
7 0.03 0.03 0.15 0.27 0.37 0.39 0.39 0.45 0.45 0.34 0.22 0.11
8 0.03 0.03 0.15 0.27 0.37 0.39 0.39 0.45 0.45 0.34 0.22 0.11
9 0.03 0.03 0.15 0.27 0.37 0.39 0.39 0.45 0.45 0.34 0.22 0.11
10 0.03 0.03 0.15 0.27 0.37 0.39 0.39 0.45 0.45 0.34 0.22 0.11
11 0.03 0.03 0.15 0.27 0.37 0.39 0.39 0.45 0.45 0.34 0.22 0.11
12 0.02 0.02 0.08 0.14 0.18 0.18 0.18 0.21 0.21 0.16 0.11 0.05
13 0.02 0.02 0.08 0.14 0.18 0.18 0.18 0.21 0.21 0.16 0.11 0.05
14 0.03 0.03 0.15 0.27 0.37 0.39 0.39 0.45 0.45 0.34 0.22 0.11
15 0.03 0.03 0.15 0.27 0.37 0.39 0.39 0.45 0.45 0.34 0.22 0.11
16 0.03 0.03 0.17 0.30 0.41 0.43 0.43 0.49 0.49 0.37 0.25 0.12
17 0.03 0.03 0.15 0.27 0.37 0.39 0.39 0.45 0.45 0.34 0.22 0.11
18 0.03 0.03 0.15 0.27 0.37 0.39 0.39 0.45 0.45 0.34 0.22 0.11
19 0.03 0.03 0.15 0.27 0.37 0.39 0.39 0.45 0.45 0.34 0.22 0.11
20 0.03 0.03 0.15 0.27 0.37 0.39 0.39 0.45 0.45 0.34 0.22 0.11
21 0.03 0.03 0.15 0.27 0.37 0.39 0.39 0.45 0.45 0.34 0.22 0.11
22 0.03 0.03 0.15 0.27 0.37 0.39 0.39 0.45 0.45 0.34 0.22 0.11
23 0.03 0.03 0.15 0.27 0.37 0.39 0.39 0.45 0.45 0.34 0.22 0.11
24 0.03 0.03 0.15 0.27 0.37 0.39 0.39 0.45 0.45 0.34 0.22 0.11
END MON-LZETPARM
PWAT-STATE1
## *** CEPS SURS UZS IFWS LZS AGWS GWVS
1 0.000 0.000 0.019 0.000 10.780 0.000 0.149
2 0.000 0.000 0.019 0.000 13.490 0.000 0.149
3 0.000 0.000 0.019 0.000 16.510 0.000 0.149
4 0.000 0.000 0.019 0.000 3.960 0.000 0.149
5 0.000 0.000 0.019 0.000 3.630 0.000 0.149
6 0.000 0.000 0.019 0.000 6.530 0.000 0.149
7 0.000 0.000 0.109 0.000 2.900 0.000 0.297
8 0.000 0.000 0.109 0.000 3.700 0.000 0.297
9 0.000 0.000 0.109 0.000 5.300 0.000 0.297
10 0.000 0.000 0.109 0.000 5.020 0.000 0.297
11 0.000 0.000 0.109 0.000 14.700 0.000 0.297

```

```

12 0.000 0.000 3.500 0.000 5.770 0.000 0.100
13 0.000 0.000 3.500 0.000 10.870 0.000 0.100
14 0.000 0.000 0.109 0.000 15.800 0.000 0.297
15 0.000 0.000 0.109 0.000 13.990 0.000 0.297
16 0.000 0.000 0.285 0.000 33.100 0.000 0.134
17 0.000 0.000 0.109 0.000 3.660 0.000 0.297
18 0.000 0.000 0.150 0.000 10.400 0.000 0.100
19 0.000 0.000 0.150 0.000 16.000 0.000 0.100
20 0.000 0.000 0.150 0.000 16.400 0.000 0.100
21 0.000 0.000 0.150 0.000 22.500 0.000 0.100
22 0.000 0.000 0.117 0.000 10.560 0.000 0.189
23 0.000 0.000 0.117 0.000 11.630 0.000 0.189
24 0.000 0.000 2.250 0.000 35.620 0.000 0.100
END PWAT-STATE1
END PERLND
COPY
TIMESERIES
## NPT NMN ***
1 10
2 10
END TIMESERIES
END COPY
PLTGEN
PLOTINFO
## FILE NPT NMN LABEL PYR PIVL ***
1 81 10 12 1
2 82 10 12 1
3 83 4 12 1
END PLOTINFO
GEN-LABELS
## <- TITLE > *** <- Y AXIS ->
1 CFS
2 CFS
3 CFS
END GEN-LABELS
SCALING
## YMIN YMAX IVLIN ***
1 1500. 4.
2 1500. 4.
3 1500. 4.
END SCALING
CURV-DATA
*** <-CURVE LABEL--> LINE INTG COL TRAN ***
***## ## TYPE EQV CODE CODE ***
1 3 column 1data 1 1 1 AVER
END CURV-DATA
CURV-DATA
*** <-CURVE LABEL--> LINE INTG COL TRAN ***
***## ## TYPE EQV CODE CODE ***
1 3 column 2data 1 2 2 AVER
END CURV-DATA
CURV-DATA
*** <-CURVE LABEL--> LINE INTG COL TRAN ***
***## ## TYPE EQV CODE CODE ***
1 3 column 3data 1 3 3 AVER
END CURV-DATA
CURV-DATA
*** <-CURVE LABEL--> LINE INTG COL TRAN ***
***## ## TYPE EQV CODE CODE ***
1 3 column 4data 1 4 4 AVER
END CURV-DATA
CURV-DATA
*** <-CURVE LABEL--> LINE INTG COL TRAN ***
***## ## TYPE EQV CODE CODE ***
1 3 column 5data 1 5 5 AVER

```

```

END CURV-DATA
CURV-DATA
***          <-CURVE LABEL--> LINE INTG COL TRAN ***
***## ##          TYPE EQV CODE CODE ***
1 3 column 6data 1 6 6 AVER
END CURV-DATA
CURV-DATA
***          <-CURVE LABEL--> LINE INTG COL TRAN ***
***## ##          TYPE EQV CODE CODE ***
1 3 column 7data 1 7 7 AVER
END CURV-DATA
CURV-DATA
***          <-CURVE LABEL--> LINE INTG COL TRAN ***
***## ##          TYPE EQV CODE CODE ***
1 3 column 8data 1 8 8 AVER
END CURV-DATA
CURV-DATA
***          <-CURVE LABEL--> LINE INTG COL TRAN ***
***## ##          TYPE EQV CODE CODE ***
1 3 column 9data 1 9 9 AVER
END CURV-DATA
CURV-DATA
***          <-CURVE LABEL--> LINE INTG COL TRAN ***
***## ##          TYPE EQV CODE CODE ***
1 3 column 10data 1 10 10 AVER
END CURV-DATA
END PLTGEN
MUTSIN
MUTSINFO
## MLF NPT NMN NLI ***
1 40 10 25 1
2 96 10 25 1
END MUTSINFO
END MUTSIN
NETWORK
<-VOLUME-> <-GRP> <-MEMBER->< MULT >TRAN <-TARGET-VOLS> <-GRP> <-MEMBER-> ***
<-NAME> ## <-NAME> # #<-FACTOR->STRG <-NAME> ## # <-NAME> # # ***
MUTSIN 1 OUTPUT MEAN 1 COPY 1 INPUT MEAN 1
MUTSIN 1 OUTPUT MEAN 2 COPY 1 INPUT MEAN 2
MUTSIN 1 OUTPUT MEAN 3 COPY 1 INPUT MEAN 3
MUTSIN 1 OUTPUT MEAN 4 COPY 1 INPUT MEAN 4
MUTSIN 1 OUTPUT MEAN 5 COPY 1 INPUT MEAN 5
MUTSIN 1 OUTPUT MEAN 6 COPY 1 INPUT MEAN 6
MUTSIN 1 OUTPUT MEAN 7 COPY 1 INPUT MEAN 7
MUTSIN 1 OUTPUT MEAN 8 COPY 1 INPUT MEAN 8
MUTSIN 1 OUTPUT MEAN 9 COPY 1 INPUT MEAN 9
MUTSIN 1 OUTPUT MEAN 10 COPY 1 INPUT MEAN 10
MUTSIN 2 OUTPUT MEAN 1 0.700000 COPY 2 INPUT MEAN 1
MUTSIN 2 OUTPUT MEAN 2 0.700000 COPY 2 INPUT MEAN 2
MUTSIN 2 OUTPUT MEAN 3 0.700000 COPY 2 INPUT MEAN 3
MUTSIN 2 OUTPUT MEAN 4 0.700000 COPY 2 INPUT MEAN 4
MUTSIN 2 OUTPUT MEAN 5 0.700000 COPY 2 INPUT MEAN 5
MUTSIN 2 OUTPUT MEAN 6 0.700000 COPY 2 INPUT MEAN 6
MUTSIN 2 OUTPUT MEAN 7 0.700000 COPY 2 INPUT MEAN 7
MUTSIN 2 OUTPUT MEAN 8 0.700000 COPY 2 INPUT MEAN 8
MUTSIN 2 OUTPUT MEAN 9 0.700000 COPY 2 INPUT MEAN 9
MUTSIN 2 OUTPUT MEAN 10 0.700000 COPY 2 INPUT MEAN 10
COPY 1 OUTPUT MEAN 3 PERLND 1 EXTNL PREC
COPY 1 OUTPUT MEAN 3 PERLND 2 EXTNL PREC
COPY 1 OUTPUT MEAN 3 PERLND 3 EXTNL PREC
COPY 1 OUTPUT MEAN 3 PERLND 4 EXTNL PREC
COPY 1 OUTPUT MEAN 3 0.800000 PERLND 5 EXTNL PREC
COPY 1 OUTPUT MEAN 7 0.200000 PERLND 5 EXTNL PREC
COPY 1 OUTPUT MEAN 3 0.300000 PERLND 6 EXTNL PREC
COPY 1 OUTPUT MEAN 7 0.700000 PERLND 6 EXTNL PREC

```

```

COPY 1 OUTPUT MEAN 7 PERLND 7 EXTNL PREC
COPY 1 OUTPUT MEAN 7 PERLND 8 EXTNL PREC
COPY 1 OUTPUT MEAN 3 0.300000 PERLND 9 EXTNL PREC
COPY 1 OUTPUT MEAN 7 0.700000 PERLND 9 EXTNL PREC
COPY 1 OUTPUT MEAN 3 0.300000 PERLND 10 EXTNL PREC
COPY 1 OUTPUT MEAN 7 0.700000 PERLND 10 EXTNL PREC
COPY 1 OUTPUT MEAN 3 0.750000 PERLND 11 EXTNL PREC
COPY 1 OUTPUT MEAN 7 0.250000 PERLND 11 EXTNL PREC
COPY 1 OUTPUT MEAN 3 0.690000 PERLND 12 EXTNL PREC
COPY 1 OUTPUT MEAN 7 0.310000 PERLND 12 EXTNL PREC
COPY 1 OUTPUT MEAN 7 PERLND 13 EXTNL PREC
COPY 1 OUTPUT MEAN 7 PERLND 14 EXTNL PREC
COPY 1 OUTPUT MEAN 7 PERLND 15 EXTNL PREC
COPY 1 OUTPUT MEAN 7 PERLND 16 EXTNL PREC
COPY 1 OUTPUT MEAN 7 PERLND 17 EXTNL PREC
COPY 1 OUTPUT MEAN 3 0.360000 PERLND 18 EXTNL PREC
COPY 1 OUTPUT MEAN 7 0.640000 PERLND 18 EXTNL PREC
COPY 1 OUTPUT MEAN 3 0.670000 PERLND 19 EXTNL PREC
COPY 1 OUTPUT MEAN 7 0.150000 PERLND 19 EXTNL PREC
COPY 1 OUTPUT MEAN 9 0.180000 PERLND 19 EXTNL PREC
COPY 1 OUTPUT MEAN 3 PERLND 20 EXTNL PREC
COPY 1 OUTPUT MEAN 3 0.160000 PERLND 21 EXTNL PREC
COPY 1 OUTPUT MEAN 9 0.840000 PERLND 21 EXTNL PREC
COPY 1 OUTPUT MEAN 3 PERLND 22 EXTNL PREC
COPY 1 OUTPUT MEAN 3 PERLND 23 EXTNL PREC
COPY 1 OUTPUT MEAN 3 PERLND 24 EXTNL PREC
COPY 2 OUTPUT MEAN 6 PERLND 1 EXTNL PETINP
COPY 2 OUTPUT MEAN 6 PERLND 2 EXTNL PETINP
COPY 2 OUTPUT MEAN 6 PERLND 3 EXTNL PETINP
COPY 2 OUTPUT MEAN 6 PERLND 4 EXTNL PETINP
COPY 2 OUTPUT MEAN 6 PERLND 5 EXTNL PETINP
COPY 2 OUTPUT MEAN 6 PERLND 6 EXTNL PETINP
COPY 2 OUTPUT MEAN 6 PERLND 7 EXTNL PETINP
COPY 2 OUTPUT MEAN 6 PERLND 8 EXTNL PETINP
COPY 2 OUTPUT MEAN 6 PERLND 9 EXTNL PETINP
COPY 2 OUTPUT MEAN 6 PERLND 10 EXTNL PETINP
COPY 2 OUTPUT MEAN 6 PERLND 11 EXTNL PETINP
COPY 2 OUTPUT MEAN 6 PERLND 12 EXTNL PETINP
COPY 2 OUTPUT MEAN 6 0.930000 PERLND 13 EXTNL PETINP
COPY 2 OUTPUT MEAN 8 0.070000 PERLND 13 EXTNL PETINP
COPY 2 OUTPUT MEAN 6 0.500000 PERLND 14 EXTNL PETINP
COPY 2 OUTPUT MEAN 8 0.500000 PERLND 14 EXTNL PETINP
COPY 2 OUTPUT MEAN 6 PERLND 15 EXTNL PETINP
COPY 2 OUTPUT MEAN 6 0.340000 PERLND 16 EXTNL PETINP
COPY 2 OUTPUT MEAN 8 0.660000 PERLND 16 EXTNL PETINP
COPY 2 OUTPUT MEAN 6 PERLND 17 EXTNL PETINP
COPY 2 OUTPUT MEAN 6 PERLND 18 EXTNL PETINP
COPY 2 OUTPUT MEAN 6 PERLND 19 EXTNL PETINP
COPY 2 OUTPUT MEAN 6 PERLND 20 EXTNL PETINP
COPY 2 OUTPUT MEAN 6 PERLND 21 EXTNL PETINP
COPY 2 OUTPUT MEAN 6 PERLND 22 EXTNL PETINP
COPY 2 OUTPUT MEAN 6 PERLND 23 EXTNL PETINP
COPY 2 OUTPUT MEAN 6 PERLND 24 EXTNL PETINP
PERLND 1 PWATER PERO 8658.66 PLTGEN 1 INPUT MEAN 1
PERLND 2 PWATER PERO 23368.57 PLTGEN 1 INPUT MEAN 2
PERLND 3 PWATER PERO 21506.05 PLTGEN 1 INPUT MEAN 3
PERLND 4 PWATER PERO 4774.27 PLTGEN 1 INPUT MEAN 4
PERLND 5 PWATER PERO 5299.22 PLTGEN 1 INPUT MEAN 5
PERLND 6 PWATER PERO 8896.80 PLTGEN 1 INPUT MEAN 6
PERLND 7 PWATER PERO 7433.91 PLTGEN 1 INPUT MEAN 7
PERLND 8 PWATER PERO 5230.29 PLTGEN 1 INPUT MEAN 8
PERLND 9 PWATER PERO 5911.92 PLTGEN 1 INPUT MEAN 9
PERLND 10 PWATER PERO 6406.35 PLTGEN 1 INPUT MEAN 10
PERLND 11 PWATER PERO 13327.97 PLTGEN 2 INPUT MEAN 1
PERLND 12 PWATER PERO 61418.31 PLTGEN 2 INPUT MEAN 2

```

PERLND	13	PWATER	PERO	10304.59	PLTGEN	2	INPUT	MEAN	3
PERLND	14	PWATER	PERO	17968.30	PLTGEN	2	INPUT	MEAN	4
PERLND	15	PWATER	PERO	5592.92	PLTGEN	2	INPUT	MEAN	5
PERLND	16	PWATER	PERO	3256.98	PLTGEN	2	INPUT	MEAN	6
PERLND	17	PWATER	PERO	11953.75	PLTGEN	2	INPUT	MEAN	7
PERLND	18	PWATER	PERO	19587.78	PLTGEN	2	INPUT	MEAN	8
PERLND	19	PWATER	PERO	6887.41	PLTGEN	2	INPUT	MEAN	9
PERLND	20	PWATER	PERO	13412.71	PLTGEN	2	INPUT	MEAN	10
PERLND	21	PWATER	PERO	10813.40	PLTGEN	3	INPUT	MEAN	1
PERLND	22	PWATER	PERO	10054.74	PLTGEN	3	INPUT	MEAN	2
PERLND	23	PWATER	PERO	24245.29	PLTGEN	3	INPUT	MEAN	3
PERLND	24	PWATER	PERO	6523.80	PLTGEN	3	INPUT	MEAN	4
END NETWORK									
END RUN									

Appendix C.3 Reach Simulation Data File (*.INR)

```

RUN
GLOBAL
HSPF VERSION 10.1
***START AND END TIME FOR THE RUN
****/**/** **:**
START 1989 1 1 0 0 END 1989 12 31 24 0
RUN INTERP OUTPUT LEVEL 4
RESUME 0 RUN 1
END GLOBAL
FILES
<FILE> <UN#>***<---FILE NAME----->
INFO 23 C:\FHM\HSPINF.DA
ERROR 24 C:\FHM\HSPERR.DA
WARN 25 C:\FHM\HSPWRN.DA
MESSU 22 NEHINT.lis
1 NEHINT.bal
40 NEHINT.ran
97 NEHINT.ofd
96 NEHINT.etd
91 NEHINT.s81
92 NEHINT.s82
93 NEHINT.s83
81 NEHINT.r81
82 NEHINT.r82
83 NEHINT.r83
END FILES
OPN SEQUENCE
INGRP INDELT 01:00
MUTSIN 1
COPY 1
MUTSIN 2
COPY 2
MUTSIN 3
MUTSIN 4
MUTSIN 5
MUTSIN 6
RCHRES 1
RCHRES 2
RCHRES 3
RCHRES 4
RCHRES 5
RCHRES 6
RCHRES 7
RCHRES 8
RCHRES 9
RCHRES 10
RCHRES 11
RCHRES 12
RCHRES 13
RCHRES 14
RCHRES 15
RCHRES 16
RCHRES 17
RCHRES 18
RCHRES 19
RCHRES 20
RCHRES 21
RCHRES 22
PLTGEN 1
PLTGEN 2

```

```

PLTGEN 3
END INGRP
END OPN SEQUENCE
RCHRES
ACTIVITY
## HYPG ***
1 1
2 1
3 1
4 1
5 1
6 1
7 1
8 1
9 1
10 1
11 1
12 1
13 1
14 1
15 1
16 1
17 1
18 1
19 1
20 1
21 1
22 1
END ACTIVITY
PRINT-INFO
## HYDR ***
1 3
2 3
3 3
4 3
5 3
6 3
7 3
8 3
9 3
10 3
11 3
12 3
13 3
14 3
15 3
16 3
17 3
18 3
19 3
20 3
21 3
22 3
END PRINT-INFO
GEN-INFO
##
***
USER T-SERIES ENGL METR LKFG ***
IN OUT ***
1 REACH - 1 1 1 1 1 1
2 REACH - 2 1 1 1 1 1
3 REACH - 3 1 1 1 1 1

```

```

4 REACH - 4 1 1 1 1 1
5 REACH - 5 1 1 1 1 1
6 REACH - 6 1 1 1 1 1
7 REACH - 7 1 1 1 1 1
8 REACH - 8 1 1 1 1 1
9 REACH - 9 1 1 1 1 1
10 REACH - 10 1 1 1 1 1
11 REACH - 11 1 1 1 1 1
12 REACH - 12 1 1 1 1 1
13 REACH - 13 1 1 1 1 1
14 REACH - 14 1 1 1 1 1
15 REACH - 15 1 1 1 1 1
16 REACH - 16 1 1 1 1 1
17 REACH - 17 1 1 1 1 1
18 REACH - 18 1 1 1 1 1
19 REACH - 19 1 1 1 1 1
20 REACH - 20 1 1 1 1 1
21 REACH - 21 1 1 1 1 1
22 REACH - 22 1 1 1 1 1
END GEN-INFO
HYDR-PARM1
## VC A1 A2 A3 ODFVFG FOR EACH ODGTFG FOR EACH *** FUNCT FOR EACH
*** FG FG FG FG POSSIBLE EXIT POSSIBLE EXIT *** POSSIBLE EXIT
*** 1 2 3 1 2 3 4 5 ***
1 1 1 4
2 1 1 4
3 1 1 4
4 1 1 4
5 1 1 4
6 1 1 4
7 1 1 4
8 1 1 4
9 1 1 4
10 1 1 4
11 1 1 4
12 1 1 4
13 1 1 4
14 1 1 4
15 1 1 4
16 1 1 4
17 1 1 4
18 1 1 4
19 1 1 4
20 1 1 4
21 1 1 4
22 1 1 4
END HYDR-PARM1
HYDR-PARM2
## DSN FTBN LEN DELTH STCOR KS ***
1 10.1715E+02 0.00 0.00 0.500
2 20.3801E+02 0.00 0.00 0.500
3 30.2430E+01 0.00 97.00 0.500
4 40.2980E+01 0.00 0.00 0.500
5 50.2400E+01 0.00 87.00 0.500
6 60.3785E+02 0.00 0.00 0.500
7 70.1450E+01 0.00 84.00 0.500
8 80.1580E+01 0.00 0.00 0.500
9 90.2040E+01 0.00 71.20 0.500
10 100.7550E+01 0.00 0.00 0.500
11 110.4550E+01 0.00 74.00 0.500
12 120.1874E+02 0.00 0.00 0.500
13 130.6100E+01 0.00 0.00 0.500
14 140.2430E+00 0.00 0.00 0.500
15 150.4470E+01 0.00 70.00 0.500
16 160.2080E+01 0.00 0.00 0.500

```

```

17 170.2410E+01 0.00 51.30 0.500
18 180.8240E+01 0.00 0.00 0.500
19 190.1731E+02 0.00 0.00 0.500
20 200.3110E+01 0.00 50.00 0.500
21 210.4170E+01 0.00 0.00 0.500
22 220.1470E+01 0.00 33.28 0.500
END HYDR-PARM2
HYDR-INIT
## VOL INITIAL VALUE OF COLIND *** INITIAL VALUE OF OUTDGT
*** (AC-FT) FOR EACH POSSIBLE EXIT *** FOR EACH POSSIBLE EXIT
*** EX1 EX2 EX3 EX4 EX5 *** EX1 EX2 EX3 EX4 EX5
1 14.00
2 34.00
3 3.30
4 3.90
5 3.60
6 31.40
7 3.20
8 17.80
9 10.00
10 4.44
11 13.20
12 40.00
13 15.00
14 15.00
15 7.20
16 20.00
17 26.40
18 20.00
19 20.00
20 38.40
21 20.00
22 26.40
END HYDR-INIT
END RCHRES
FTABLES
*****
FTABLE 1
ROWS COLS ***
11 4
*** DEPTH AREA VOLUME DISCH FLO-THRU ***
*** (FT) (ACRES) (AC-FT) (CFS) (MIN) ***
0.0000E+000.1549E+020.0000E+000.0000E+00
0.7000E+000.1920E+020.5220E+010.4542E+01
0.1300E+010.2238E+020.1061E+020.1102E+02
0.2000E+010.2609E+020.1796E+020.2001E+02
0.2600E+010.2927E+020.2517E+020.2853E+02
0.3300E+010.3298E+020.3466E+020.3895E+02
0.4000E+010.3669E+020.4528E+020.4972E+02
0.4600E+010.3986E+020.1106E+030.5925E+02
0.5300E+010.4357E+020.1361E+030.7091E+02
0.5900E+010.4930E+020.5262E+030.1213E+03
0.6600E+010.4930E+020.1278E+040.1388E+03
END FTABLE 1
*****
FTABLE 2
ROWS COLS ***
11 4
*** DEPTH AREA VOLUME DISCH FLO-THRU ***
*** (FT) (ACRES) (AC-FT) (CFS) (MIN) ***
0.0000E+000.3487E+020.0000E+000.0000E+00
0.7000E+000.4452E+020.1611E+020.6938E+01
0.1300E+010.5279E+020.3283E+020.1683E+02
0.2000E+010.6244E+020.5571E+020.3057E+02
0.2600E+010.7071E+020.7822E+020.4359E+02

```

```

0.3300E+010.8036E+020.1079E+030.5950E+02
0.4000E+010.9002E+020.1412E+030.5194E+02
0.4600E+010.9829E+020.3452E+030.9056E+02
0.5300E+010.1079E+030.4254E+030.1620E+03
0.5900E+010.1200E+030.1444E+040.1854E+03
0.6600E+010.1200E+030.3209E+040.2122E+03
END FTABLE 2

```

```

*****
FTABLE 3
ROWS COLS ***
11 4

```

```

*** DEPTH AREA VOLUME DISCH
*** (FT) (ACRES) (AC-FT) (CFS)
0.0000E+000.5604E+010.0000E+000.0000E+00
0.1100E+010.6742E+010.3973E+010.2683E+02
0.2300E+010.7985E+010.9143E+010.9429E+02
0.3400E+010.9124E+010.1465E+020.1824E+03
0.4500E+010.1026E+020.2089E+020.2927E+03
0.5600E+010.1140E+020.2786E+020.4409E+03
0.6800E+010.1264E+020.3630E+020.6763E+03
0.7900E+010.1378E+020.8961E+020.1191E+04
0.9000E+010.1492E+020.1081E+030.2014E+04
0.1020E+020.1548E+020.3886E+030.3336E+04
0.1130E+020.1548E+020.9083E+030.4550E+04
END FTABLE 3

```

```

*****
FTABLE 4
ROWS COLS ***
11 4

```

```

*** DEPTH AREA VOLUME DISCH
*** (FT) (ACRES) (AC-FT) (CFS)
0.0000E+000.1447E+010.0000E+000.0000E+00
0.2000E+000.1881E+010.6660E+000.1274E+01
0.4000E+000.2316E+010.1504E+010.2549E+01
0.6000E+000.2750E+010.2518E+010.4374E+01
0.9000E+000.3401E+010.4364E+010.7939E+01
0.1100E+010.3835E+010.1162E+020.1058E+02
0.1300E+010.4269E+010.1486E+020.1350E+02
0.1500E+010.4703E+010.1845E+020.1642E+02
0.1700E+010.5138E+010.2239E+020.1966E+02
0.1900E+010.5400E+010.1404E+030.3433E+02
0.2200E+010.5400E+010.4199E+030.4194E+02
END FTABLE 4

```

```

*****
FTABLE 5
ROWS COLS ***
11 4

```

```

*** DEPTH AREA VOLUME DISCH
*** (FT) (ACRES) (AC-FT) (CFS)
0.0000E+000.5534E+010.0000E+000.0000E+00
0.1100E+010.6658E+010.3924E+010.3105E+02
0.2300E+010.7885E+010.9029E+010.1078E+03
0.3400E+010.9010E+010.1447E+020.2085E+03
0.4500E+010.1014E+020.2063E+020.3346E+03
0.5600E+010.1126E+020.2751E+020.5038E+03
0.6800E+010.1249E+020.3585E+020.7730E+03
0.7900E+010.1361E+020.8849E+020.1361E+04
0.9000E+010.1474E+020.1067E+030.2302E+04
0.1020E+020.1512E+020.3832E+030.3812E+04
0.1130E+020.1512E+020.8938E+030.5200E+04
END FTABLE 5

```

```

*****
FTABLE 6
ROWS COLS ***
11 4

```

```

*** DEPTH AREA VOLUME DISCH
*** (FT) (ACRES) (AC-FT) (CFS)
0.0000E+000.2421E+020.0000E+000.0000E+00
0.7000E+000.3112E+020.1116E+020.7417E+01
0.1300E+010.3705E+020.2280E+020.1800E+02
0.2000E+010.4397E+020.3880E+020.3268E+02
0.2600E+010.4990E+020.5459E+020.4658E+02
0.3300E+010.5682E+020.7543E+020.6361E+02
0.4000E+010.7882E+020.1028E+030.8120E+02
0.4600E+010.1029E+030.2793E+030.1451E+03
0.5300E+010.1309E+030.3976E+030.1738E+03
0.5900E+010.1422E+030.1293E+040.1982E+03
0.6600E+010.1422E+030.2233E+040.2268E+03
END FTABLE 6

```

```

*****
FTABLE 7
ROWS COLS ***
11 4

```

```

*** DEPTH AREA VOLUME DISCH
*** (FT) (ACRES) (AC-FT) (CFS)
0.0000E+000.3330E+010.0000E+000.0000E+00
0.4000E+000.4053E+010.2538E+010.1094E+02
0.8000E+000.4776E+010.5573E+010.2188E+02
0.1200E+010.5499E+010.9106E+010.4815E+02
0.1500E+010.6042E+010.1208E+020.6784E+02
0.1900E+010.6765E+010.1648E+020.1053E+03
0.2300E+010.7488E+010.2138E+020.1466E+03
0.2700E+010.8211E+010.5356E+020.2000E+03
0.3100E+010.8934E+010.6535E+020.2574E+03
0.3500E+010.2620E+020.2446E+030.3278E+03
0.3800E+010.2620E+020.4846E+030.3839E+03
END FTABLE 7

```

```

*****
FTABLE 8
ROWS COLS ***
11 4

```

```

*** DEPTH AREA VOLUME DISCH
*** (FT) (ACRES) (AC-FT) (CFS)
0.0000E+000.8257E+010.0000E+000.0000E+00
0.2000E+000.1561E+020.4774E+010.1562E+01
0.4000E+000.2296E+020.1249E+020.3122E+01
0.6000E+000.3032E+020.2314E+020.5358E+01
0.9000E+000.4135E+020.4464E+020.9720E+01
0.1100E+010.4870E+020.1253E+030.1296E+02
0.1300E+010.5605E+020.1672E+030.1654E+02
0.1500E+010.6341E+020.2150E+030.2010E+02
0.1700E+010.7076E+020.2687E+030.2407E+02
0.1900E+010.3030E+020.9329E+030.4205E+02
0.2200E+010.3030E+020.2206E+040.5137E+02
END FTABLE 8

```

```

*****
FTABLE 9
ROWS COLS ***
11 4

```

```

*** DEPTH AREA VOLUME DISCH
*** (FT) (ACRES) (AC-FT) (CFS)
0.0000E+000.1015E+020.0000E+000.0000E+00
0.1100E+010.1173E+020.2406E+020.3881E+02
0.2300E+010.1345E+020.5428E+020.1347E+03
0.3400E+010.1503E+020.8561E+020.2606E+03
0.4500E+010.1661E+020.9031E+020.4182E+03
0.5600E+010.1819E+020.1111E+030.6298E+03
0.6800E+010.1991E+020.1431E+030.9662E+03
0.7900E+010.2149E+020.1750E+030.1701E+04
0.9000E+010.2307E+020.2093E+030.2877E+04

```

```

FLO-THRU ***
(MIN) ***

```

```

FLO-THRU ***
(MIN) ***

```

```

FLO-THRU ***
(MIN) ***

```

```

FLO-THRU ***
(MIN) ***

```

0.1020E+020.5850E+020.9859E+030.4765E+04
0.1130E+020.5850E+020.2256E+040.6500E+04
END FTABLE 9

FTABLE 10
ROWS COLS ***

DEPTH (FT)	AREA (ACRES)	VOLUME (AC-FT)	DISCH (CFS)	FLO-THRU (MIN)
0.0000E+000	0.3156E+010	0.0000E+000	0.0000E+00	
0.2000E+000	0.4102E+010	0.1452E+010	0.1301E+01	
0.4000E+000	0.5049E+010	0.3282E+010	0.2602E+01	
0.6000E+000	0.5996E+010	0.5492E+010	0.4465E+01	
0.9000E+000	0.7416E+010	0.9514E+010	0.8103E+01	
0.1100E+010	0.8363E+010	0.2534E+020	0.1080E+02	
0.1300E+010	0.9309E+010	0.3241E+020	0.1378E+02	
0.1500E+010	0.1000E+020	0.4024E+020	0.1675E+02	
0.1700E+010	0.1000E+020	0.4882E+020	0.2006E+02	
0.1900E+010	0.1000E+020	0.1528E+030	0.2336E+02	
0.2200E+010	0.1000E+020	0.4545E+040	0.2854E+02	

END FTABLE 10

FTABLE 11
ROWS COLS ***

DEPTH (FT)	AREA (ACRES)	VOLUME (AC-FT)	DISCH (CFS)	FLO-THRU (MIN)
0.0000E+000	0.2259E+020	0.0000E+000	0.0000E+00	
0.1100E+010	0.2610E+020	0.5356E+020	0.1016E+03	
0.2300E+010	0.2994E+020	0.1208E+030	0.3585E+03	
0.3400E+010	0.3345E+020	0.1905E+030	0.7557E+03	
0.4500E+010	0.3697E+020	0.2680E+030	0.1316E+04	
0.5600E+010	0.4048E+020	0.7064E+030	0.2045E+04	
0.6800E+010	0.4432E+020	0.9099E+030	0.3096E+04	
0.7900E+010	0.4783E+020	0.1113E+040	0.4264E+04	
0.9000E+010	0.5135E+020	0.1331E+040	0.5000E+04	
0.1020E+020	0.5220E+020	0.3258E+040	0.5500E+04	
0.1130E+020	0.5220E+020	0.7345E+040	0.6000E+04	

END FTABLE 11

FTABLE 12
ROWS COLS ***

DEPTH (FT)	AREA (ACRES)	VOLUME (AC-FT)	DISCH (CFS)	FLO-THRU (MIN)
0.0000E+000	0.6332E+010	0.0000E+000	0.0000E+00	
0.2000E+000	0.8231E+010	0.1456E+010	0.1545E+01	
0.4000E+000	0.1013E+020	0.3292E+010	0.3186E+01	
0.6000E+000	0.1203E+020	0.5509E+010	0.5468E+01	
0.9000E+000	0.1488E+020	0.9545E+010	0.9924E+01	
0.1100E+010	0.1678E+020	0.2542E+020	0.1323E+02	
0.1300E+010	0.1868E+020	0.3251E+020	0.1688E+02	
0.1500E+010	0.2058E+020	0.4037E+020	0.2052E+02	
0.1700E+010	0.2248E+020	0.1959E+030	0.2457E+02	
0.1900E+010	0.2360E+020	0.3981E+030	0.4290E+02	
0.2200E+010	0.2360E+020	0.2088E+040	0.5250E+02	

END FTABLE 12

FTABLE 13
ROWS COLS ***

DEPTH (FT)	AREA (ACRES)	VOLUME (AC-FT)	DISCH (CFS)	FLO-THRU (MIN)
0.0000E+000	0.2950E+000	0.0000E+000	0.0000E+00	
0.2000E+000	0.3830E+000	0.2720E+000	0.1952E+01	

DEPTH (FT)	AREA (ACRES)	VOLUME (AC-FT)	DISCH (CFS)	FLO-THRU (MIN)
0.4000E+000	0.4710E+000	0.6120E+000	0.3903E+01	
0.6000E+000	0.5600E+000	0.1024E+010	0.6698E+01	
0.9000E+000	0.6400E+000	0.1776E+010	0.1215E+02	
0.1100E+010	0.6400E+000	0.4736E+010	0.1620E+02	
0.1300E+010	0.6400E+000	0.6048E+010	0.2067E+02	
0.1500E+010	0.6400E+000	0.7513E+010	0.2513E+02	
0.1700E+010	0.6400E+000	0.9112E+010	0.3009E+02	
0.1900E+010	0.6400E+000	0.1501E+030	0.5256E+02	
0.2200E+010	0.6400E+000	0.8393E+030	0.6422E+02	

END FTABLE 13

FTABLE 14
ROWS COLS ***

DEPTH (FT)	AREA (ACRES)	VOLUME (AC-FT)	DISCH (CFS)	FLO-THRU (MIN)
0.0000E+000	0.1181E+010	0.0000E+000	0.0000E+00	
0.2000E+000	0.1535E+010	0.2720E+000	0.1952E+01	
0.4000E+000	0.1889E+010	0.6140E+000	0.3903E+01	
0.6000E+000	0.2243E+010	0.1027E+010	0.6698E+01	
0.9000E+000	0.2774E+010	0.1780E+010	0.1215E+02	
0.1100E+010	0.3128E+010	0.4740E+010	0.1620E+02	
0.1300E+010	0.3482E+010	0.6062E+010	0.2067E+02	
0.1500E+010	0.3837E+010	0.7526E+010	0.2513E+02	
0.1700E+010	0.4191E+010	0.3653E+020	0.3009E+02	
0.1900E+010	0.1204E+020	0.7520E+020	0.5256E+02	
0.2200E+010	0.1204E+020	0.4204E+030	0.6422E+02	

END FTABLE 14

FTABLE 15
ROWS COLS ***

DEPTH (FT)	AREA (ACRES)	VOLUME (AC-FT)	DISCH (CFS)	FLO-THRU (MIN)
0.0000E+000	0.4875E+010	0.0000E+000	0.0000E+00	
0.4000E+000	0.6175E+010	0.2210E+010	0.9720E+01	
0.8000E+000	0.7475E+010	0.4940E+010	0.3040E+02	
0.1200E+010	0.8620E+010	0.5733E+010	0.6242E+02	
0.1500E+010	0.8620E+010	0.3510E+030	0.9220E+02	
0.1900E+010	0.8620E+010	0.4841E+030	0.1491E+03	
0.2300E+010	0.8620E+010	0.6339E+030	0.2202E+03	
0.2700E+010	0.8620E+010	0.8003E+030	0.3066E+03	
0.3100E+010	0.8620E+010	0.9833E+030	0.4090E+03	
0.3500E+010	0.8620E+010	0.1993E+040	0.5285E+03	
0.3800E+010	0.8620E+010	0.3786E+040	0.6364E+03	

END FTABLE 15

FTABLE 16
ROWS COLS ***

DEPTH (FT)	AREA (ACRES)	VOLUME (AC-FT)	DISCH (CFS)	FLO-THRU (MIN)
0.0000E+000	0.2648E+010	0.0000E+000	0.0000E+00	
0.4000E+000	0.3140E+010	0.8140E+000	0.4982E+01	
0.8000E+000	0.3631E+010	0.1786E+010	0.1319E+02	
0.1200E+010	0.4123E+010	0.2917E+010	0.2353E+02	
0.1500E+010	0.9916E+010	0.4739E+010	0.3208E+02	
0.1900E+010	0.1764E+020	0.1968E+020	0.4473E+02	
0.2300E+010	0.2536E+020	0.3598E+020	0.5802E+02	
0.2700E+010	0.3309E+020	0.5838E+020	0.7180E+02	
0.3100E+010	0.4081E+020	0.3476E+030	0.8595E+02	
0.3500E+010	0.5540E+020	0.8979E+030	0.1005E+03	
0.3800E+010	0.5540E+020	0.9895E+040	0.1116E+03	

```

FTABLE 17
ROWS COLS ***
11 4
*** DEPTH AREA VOLUME DISCH FLO-THRU ***
*** (FT) (ACRES) (AC-FT) (CFS) (MIN) ***
0.0000E+000.5473E+010.0000E+000.0000E+00
0.7000E+000.6687E+010.8468E+010.1446E+02
0.1300E+010.7727E+010.1707E+020.3767E+02
0.1500E+010.8333E+010.7135E+020.5000E+02
0.2000E+010.8940E+010.4588E+030.1164E+03
0.2300E+010.9460E+010.5491E+030.1770E+03
0.2600E+010.9980E+010.6394E+030.2561E+03
0.3300E+010.1119E+020.8752E+030.5278E+03
0.4000E+010.1241E+020.1138E+040.9495E+03
0.4600E+010.1340E+020.1385E+040.1457E+04
0.5900E+010.1340E+020.2670E+040.2500E+04
END FTABLE 17
*****
FTABLE 18
ROWS COLS ***
11 4
*** DEPTH AREA VOLUME DISCH FLO-THRU ***
*** (FT) (ACRES) (AC-FT) (CFS) (MIN) ***
0.0000E+000.7040E+010.0000E+000.0000E+00
0.2000E+000.8336E+010.1537E+010.1840E+01
0.4000E+000.9631E+010.3334E+010.3679E+01
0.6000E+000.1093E+020.5390E+010.6314E+01
0.9000E+000.1287E+020.8960E+010.1146E+02
0.1100E+010.1417E+020.2333E+020.1528E+02
0.1300E+010.1546E+020.2925E+020.1948E+02
0.1500E+010.1676E+020.3570E+020.2369E+02
0.1700E+010.1805E+020.4266E+020.2836E+02
0.1900E+010.2270E+020.2962E+030.3304E+02
0.2200E+010.2270E+020.5507E+030.4036E+02
END FTABLE 18
*****
FTABLE 19
ROWS COLS ***
11 4
*** DEPTH AREA VOLUME DISCH FLO-THRU ***
*** (FT) (ACRES) (AC-FT) (CFS) (MIN) ***
0.0000E+000.6948E+010.0000E+000.0000E+00
0.2000E+000.1143E+020.1838E+010.1952E+01
0.4000E+000.1592E+020.4573E+010.3903E+01
0.6000E+000.2040E+020.8205E+010.6698E+01
0.9000E+000.2713E+020.1533E+020.1215E+02
0.1100E+010.3161E+020.4242E+020.1620E+02
0.1300E+010.3610E+020.5596E+020.2067E+02
0.1500E+010.4058E+020.7129E+020.2513E+02
0.1700E+010.4150E+020.8842E+020.3009E+02
0.1900E+010.4150E+020.4998E+030.3504E+02
0.2200E+010.4150E+020.7450E+030.4281E+02
END FTABLE 19
*****
FTABLE 20
ROWS COLS ***
11 4
*** DEPTH AREA VOLUME DISCH FLO-THRU ***
*** (FT) (ACRES) (AC-FT) (CFS) (MIN) ***
0.0000E+000.7154E+010.0000E+000.0000E+00
0.7000E+000.8735E+010.1112E+020.1735E+02
0.1300E+010.1009E+020.2242E+020.4520E+02
0.2000E+010.1167E+020.3765E+020.1397E+03
0.2600E+010.1303E+020.1049E+030.3073E+03
0.3300E+010.1461E+020.1436E+030.6334E+03

```

```

0.4000E+010.1619E+020.1868E+030.1139E+04
0.4600E+010.1755E+020.2272E+030.1748E+04
0.5300E+010.1760E+020.2786E+030.2640E+04
0.5900E+010.1760E+020.4451E+030.3000E+04
0.6600E+010.1760E+020.1055E+040.3600E+04
END FTABLE 20
*****
FTABLE 21
ROWS COLS ***
11 4
*** DEPTH AREA VOLUME DISCH FLO-THRU ***
*** (FT) (ACRES) (AC-FT) (CFS) (MIN) ***
0.0000E+000.2024E+010.0000E+000.0000E+00
0.2000E+000.2631E+010.4660E+000.1952E+01
0.4000E+000.3239E+010.1053E+010.3903E+01
0.6000E+000.3846E+010.1761E+010.6698E+01
0.9000E+000.4757E+010.3051E+010.1215E+02
0.1100E+010.5364E+010.8128E+010.1620E+02
0.1300E+010.5971E+010.1039E+020.2067E+02
0.1500E+010.6578E+010.1290E+020.2513E+02
0.1700E+010.7186E+010.1566E+020.3009E+02
0.1900E+010.1020E+020.1301E+030.3504E+02
0.2200E+010.1020E+020.7595E+040.4281E+02
END FTABLE 21
*****
FTABLE 22
ROWS COLS ***
11 4
*** DEPTH AREA VOLUME DISCH FLO-THRU ***
*** (FT) (ACRES) (AC-FT) (CFS) (MIN) ***
0.0000E+000.7320E+010.0000E+000.0000E+00
0.1100E+010.8459E+010.3471E+020.1111E+03
0.2300E+010.9702E+010.5872E+020.2901E+03
0.3400E+010.1084E+020.6175E+020.4824E+03
0.4500E+010.1198E+020.6514E+020.6947E+03
0.5600E+010.1312E+020.8585E+020.9233E+03
0.6800E+010.1436E+020.1106E+030.1202E+04
0.7900E+010.1550E+020.1352E+030.1494E+04
0.9000E+010.1664E+020.1617E+030.1870E+04
0.1020E+020.2380E+020.6911E+030.2361E+04
0.1130E+020.2380E+020.1515E+040.3033E+04
END FTABLE 22
END FTABLES
COPY
TIMESERIES
## NPT NMN ***
1 10
2 10
END TIMESERIES
END COPY
PLTGEN
PLOTINFO
## FILE NPT NMN LABL PYR PIVL ***
1 81 10 12 1
2 82 10 12 1
3 83 2 12 1
END PLOTINFO
GEN-LABELS
## <- TITLE > *** <- Y AXIS ->
1 CFS
2 CFS
3 CFS
END GEN-LABELS
SCALING
## YMIN YMAX IVLIN ***

```

```

1          1500.      4.
2          1500.      4.
3          1500.      4.
END SCALING
CURV-DATA
***<-CURVE LABEL--> LINE INTG COL TRAN ***
***## ## TYPE EQV CODE CODE ***
1 3 column 1data 1 1 1 AVER
END CURV-DATA
CURV-DATA
***<-CURVE LABEL--> LINE INTG COL TRAN ***
***## ## TYPE EQV CODE CODE ***
1 3 column 2data 1 2 2 AVER
END CURV-DATA
CURV-DATA
***<-CURVE LABEL--> LINE INTG COL TRAN ***
***## ## TYPE EQV CODE CODE ***
1 3 column 3data 1 3 3 AVER
END CURV-DATA
CURV-DATA
***<-CURVE LABEL--> LINE INTG COL TRAN ***
***## ## TYPE EQV CODE CODE ***
1 3 column 4data 1 4 4 AVER
END CURV-DATA
CURV-DATA
***<-CURVE LABEL--> LINE INTG COL TRAN ***
***## ## TYPE EQV CODE CODE ***
1 3 column 5data 1 5 5 AVER
END CURV-DATA
CURV-DATA
***<-CURVE LABEL--> LINE INTG COL TRAN ***
***## ## TYPE EQV CODE CODE ***
1 3 column 6data 1 6 6 AVER
END CURV-DATA
CURV-DATA
***<-CURVE LABEL--> LINE INTG COL TRAN ***
***## ## TYPE EQV CODE CODE ***
1 3 column 7data 1 7 7 AVER
END CURV-DATA
CURV-DATA
***<-CURVE LABEL--> LINE INTG COL TRAN ***
***## ## TYPE EQV CODE CODE ***
1 3 column 8data 1 8 8 AVER
END CURV-DATA
CURV-DATA
***<-CURVE LABEL--> LINE INTG COL TRAN ***
***## ## TYPE EQV CODE CODE ***
1 3 column 9data 1 9 9 AVER
END CURV-DATA
CURV-DATA
***<-CURVE LABEL--> LINE INTG COL TRAN ***
***## ## TYPE EQV CODE CODE ***
1 3 column 10data 1 10 10 AVER
END CURV-DATA
END PLTGEN
MUTSIN
MUTSINFO
## MLF NPT NMN NLI ***
1 40 10 25 1
2 96 10 25 1
3 97 7 25 1
4 91 10 25 1
5 92 10 25 1
6 93 4 25 1
END MUTSINFO

```

```

END MUTSIN
NETWORK
<-VOLUME-> <-GRP> <-MEMBER->< MULT >TRAN <-TARGET-VOLS> <-GRP> <-MEMBER-> ***
<NAME> ## <NAME> # #<-FACTOR->STRG <NAME> ## # <NAME> # # ***
MUTSIN 1 OUTPUT MEAN 1 COPY 1 INPUT MEAN 1
MUTSIN 1 OUTPUT MEAN 2 COPY 1 INPUT MEAN 2
MUTSIN 1 OUTPUT MEAN 3 COPY 1 INPUT MEAN 3
MUTSIN 1 OUTPUT MEAN 4 COPY 1 INPUT MEAN 4
MUTSIN 1 OUTPUT MEAN 5 COPY 1 INPUT MEAN 5
MUTSIN 1 OUTPUT MEAN 6 COPY 1 INPUT MEAN 6
MUTSIN 1 OUTPUT MEAN 7 COPY 1 INPUT MEAN 7
MUTSIN 1 OUTPUT MEAN 8 COPY 1 INPUT MEAN 8
MUTSIN 1 OUTPUT MEAN 9 COPY 1 INPUT MEAN 9
MUTSIN 1 OUTPUT MEAN 10 COPY 1 INPUT MEAN 10
MUTSIN 2 OUTPUT MEAN 1 0.700000 COPY 2 INPUT MEAN 1
MUTSIN 2 OUTPUT MEAN 2 0.700000 COPY 2 INPUT MEAN 2
MUTSIN 2 OUTPUT MEAN 3 0.700000 COPY 2 INPUT MEAN 3
MUTSIN 2 OUTPUT MEAN 4 0.700000 COPY 2 INPUT MEAN 4
MUTSIN 2 OUTPUT MEAN 5 0.700000 COPY 2 INPUT MEAN 5
MUTSIN 2 OUTPUT MEAN 6 0.700000 COPY 2 INPUT MEAN 6
MUTSIN 2 OUTPUT MEAN 7 0.700000 COPY 2 INPUT MEAN 7
MUTSIN 2 OUTPUT MEAN 8 0.700000 COPY 2 INPUT MEAN 8
MUTSIN 2 OUTPUT MEAN 9 0.700000 COPY 2 INPUT MEAN 9
MUTSIN 2 OUTPUT MEAN 10 0.700000 COPY 2 INPUT MEAN 10
COPY 1 OUTPUT MEAN 3 RCHRES 1 EXTNL PREC
COPY 1 OUTPUT MEAN 3 RCHRES 2 EXTNL PREC
COPY 1 OUTPUT MEAN 3 RCHRES 3 EXTNL PREC
COPY 1 OUTPUT MEAN 3 RCHRES 4 EXTNL PREC
COPY 1 OUTPUT MEAN 3 RCHRES 5 EXTNL PREC
COPY 1 OUTPUT MEAN 3 RCHRES 6 EXTNL PREC
COPY 1 OUTPUT MEAN 3 RCHRES 7 EXTNL PREC
COPY 1 OUTPUT MEAN 3 RCHRES 8 EXTNL PREC
COPY 1 OUTPUT MEAN 3 0.440000 RCHRES 9 EXTNL PREC
COPY 1 OUTPUT MEAN 7 0.560000 RCHRES 9 EXTNL PREC
COPY 1 OUTPUT MEAN 3 0.660000 RCHRES 10 EXTNL PREC
COPY 1 OUTPUT MEAN 7 0.340000 RCHRES 10 EXTNL PREC
COPY 1 OUTPUT MEAN 7 RCHRES 11 EXTNL PREC
COPY 1 OUTPUT MEAN 3 0.600000 RCHRES 12 EXTNL PREC
COPY 1 OUTPUT MEAN 7 0.400000 RCHRES 12 EXTNL PREC
COPY 1 OUTPUT MEAN 7 RCHRES 13 EXTNL PREC
COPY 1 OUTPUT MEAN 7 RCHRES 14 EXTNL PREC
COPY 1 OUTPUT MEAN 7 RCHRES 15 EXTNL PREC
COPY 1 OUTPUT MEAN 7 RCHRES 16 EXTNL PREC
COPY 1 OUTPUT MEAN 7 RCHRES 17 EXTNL PREC
COPY 1 OUTPUT MEAN 7 RCHRES 18 EXTNL PREC
COPY 1 OUTPUT MEAN 3 0.100000 RCHRES 19 EXTNL PREC
COPY 1 OUTPUT MEAN 7 0.900000 RCHRES 19 EXTNL PREC
COPY 1 OUTPUT MEAN 7 RCHRES 20 EXTNL PREC
COPY 1 OUTPUT MEAN 7 RCHRES 21 EXTNL PREC
COPY 1 OUTPUT MEAN 7 RCHRES 22 EXTNL PREC
COPY 2 OUTPUT MEAN 6 RCHRES 1 EXTNL POTEV
COPY 2 OUTPUT MEAN 6 RCHRES 2 EXTNL POTEV
COPY 2 OUTPUT MEAN 6 RCHRES 3 EXTNL POTEV
COPY 2 OUTPUT MEAN 6 RCHRES 4 EXTNL POTEV
COPY 2 OUTPUT MEAN 6 RCHRES 5 EXTNL POTEV
COPY 2 OUTPUT MEAN 6 RCHRES 6 EXTNL POTEV
COPY 2 OUTPUT MEAN 6 RCHRES 7 EXTNL POTEV
COPY 2 OUTPUT MEAN 6 RCHRES 8 EXTNL POTEV
COPY 2 OUTPUT MEAN 6 RCHRES 9 EXTNL POTEV
COPY 2 OUTPUT MEAN 6 RCHRES 10 EXTNL POTEV
COPY 2 OUTPUT MEAN 6 RCHRES 11 EXTNL POTEV
COPY 2 OUTPUT MEAN 6 RCHRES 12 EXTNL POTEV
COPY 2 OUTPUT MEAN 6 RCHRES 13 EXTNL POTEV
COPY 2 OUTPUT MEAN 6 RCHRES 14 EXTNL POTEV
COPY 2 OUTPUT MEAN 6 RCHRES 15 EXTNL POTEV

```

COPY	2	OUTPUT	MEAN	6		RCHRES	16	EXTNL	POTEV		END RUN
COPY	2	OUTPUT	MEAN	6		RCHRES	17	EXTNL	POTEV		
COPY	2	OUTPUT	MEAN	6		RCHRES	18	EXTNL	POTEV		
COPY	2	OUTPUT	MEAN	6		RCHRES	19	EXTNL	POTEV		
COPY	2	OUTPUT	MEAN	6		RCHRES	20	EXTNL	POTEV		
COPY	2	OUTPUT	MEAN	6		RCHRES	21	EXTNL	POTEV		
COPY	2	OUTPUT	MEAN	6		RCHRES	22	EXTNL	POTEV		
MUTSIN	4	OUTPUT	MEAN	1	0.082645	RCHRES	1	INFLOW	IVOL	1	
MUTSIN	4	OUTPUT	MEAN	2	0.082645	RCHRES	2	INFLOW	IVOL	1	
MUTSIN	4	OUTPUT	MEAN	4	0.082645	RCHRES	4	INFLOW	IVOL	1	
MUTSIN	4	OUTPUT	MEAN	3	0.082645	RCHRES	6	INFLOW	IVOL	1	
MUTSIN	4	OUTPUT	MEAN	5	0.082645	RCHRES	8	INFLOW	IVOL	1	
MUTSIN	4	OUTPUT	MEAN	6	0.082645	RCHRES	10	INFLOW	IVOL	1	
MUTSIN	5	OUTPUT	MEAN	1	0.082645	RCHRES	12	INFLOW	IVOL	1	
MUTSIN	4	OUTPUT	MEAN	7	0.082645	RCHRES	13	INFLOW	IVOL	1	
MUTSIN	4	OUTPUT	MEAN	8	0.082645	RCHRES	14	INFLOW	IVOL	1	
MUTSIN	5	OUTPUT	MEAN	4	0.082645	RCHRES	16	INFLOW	IVOL	1	
MUTSIN	4	OUTPUT	MEAN	9	0.082645	RCHRES	17	INFLOW	IVOL	1	
MUTSIN	5	OUTPUT	MEAN	5	0.082645	RCHRES	18	INFLOW	IVOL	1	
MUTSIN	4	OUTPUT	MEAN	10	0.082645	RCHRES	19	INFLOW	IVOL	1	
MUTSIN	5	OUTPUT	MEAN	7	0.082645	RCHRES	21	INFLOW	IVOL	1	
RCHRES	1	ROFLOW				RCHRES	5	INFLOW	IVOL		
RCHRES	2	ROFLOW				RCHRES	3	INFLOW	IVOL		
RCHRES	3	ROFLOW				RCHRES	5	INFLOW	IVOL		
RCHRES	4	ROFLOW				RCHRES	5	INFLOW	IVOL		
RCHRES	5	ROFLOW				RCHRES	9	INFLOW	IVOL		
RCHRES	6	ROFLOW				RCHRES	7	INFLOW	IVOL		
RCHRES	7	ROFLOW				RCHRES	9	INFLOW	IVOL		
RCHRES	8	ROFLOW				RCHRES	9	INFLOW	IVOL		
RCHRES	9	ROFLOW				RCHRES	11	INFLOW	IVOL		
RCHRES	10	ROFLOW				RCHRES	11	INFLOW	IVOL		
RCHRES	11	ROFLOW				RCHRES	22	INFLOW	IVOL		
RCHRES	12	ROFLOW				RCHRES	15	INFLOW	IVOL		
RCHRES	13	ROFLOW				RCHRES	15	INFLOW	IVOL		
RCHRES	14	ROFLOW				RCHRES	15	INFLOW	IVOL		
RCHRES	15	ROFLOW				RCHRES	17	INFLOW	IVOL		
RCHRES	16	ROFLOW				RCHRES	17	INFLOW	IVOL		
RCHRES	17	ROFLOW				RCHRES	20	INFLOW	IVOL		
RCHRES	18	ROFLOW				RCHRES	20	INFLOW	IVOL		
RCHRES	19	ROFLOW				RCHRES	20	INFLOW	IVOL		
RCHRES	20	ROFLOW				RCHRES	22	INFLOW	IVOL		
RCHRES	21	ROFLOW				RCHRES	22	INFLOW	IVOL		
RCHRES	1	HYDR	RO			PLTGEN	1	INPUT	MEAN	1	
RCHRES	2	HYDR	RO			PLTGEN	1	INPUT	MEAN	2	
RCHRES	3	HYDR	RO			PLTGEN	1	INPUT	MEAN	3	
RCHRES	4	HYDR	RO			PLTGEN	1	INPUT	MEAN	4	
RCHRES	5	HYDR	RO			PLTGEN	1	INPUT	MEAN	5	
RCHRES	6	HYDR	RO			PLTGEN	1	INPUT	MEAN	6	
RCHRES	7	HYDR	RO			PLTGEN	1	INPUT	MEAN	7	
RCHRES	8	HYDR	RO			PLTGEN	1	INPUT	MEAN	8	
RCHRES	9	HYDR	RO			PLTGEN	1	INPUT	MEAN	9	
RCHRES	10	HYDR	RO			PLTGEN	1	INPUT	MEAN	10	
RCHRES	11	HYDR	RO			PLTGEN	2	INPUT	MEAN	1	
RCHRES	12	HYDR	RO			PLTGEN	2	INPUT	MEAN	2	
RCHRES	13	HYDR	RO			PLTGEN	2	INPUT	MEAN	3	
RCHRES	14	HYDR	RO			PLTGEN	2	INPUT	MEAN	4	
RCHRES	15	HYDR	RO			PLTGEN	2	INPUT	MEAN	5	
RCHRES	16	HYDR	RO			PLTGEN	2	INPUT	MEAN	6	
RCHRES	17	HYDR	RO			PLTGEN	2	INPUT	MEAN	7	
RCHRES	18	HYDR	RO			PLTGEN	2	INPUT	MEAN	8	
RCHRES	19	HYDR	RO			PLTGEN	2	INPUT	MEAN	9	
RCHRES	20	HYDR	RO			PLTGEN	2	INPUT	MEAN	10	
RCHRES	21	HYDR	RO			PLTGEN	3	INPUT	MEAN	1	
RCHRES	22	HYDR	RO			PLTGEN	3	INPUT	MEAN	2	

END NETWORK