COMPARISON OF THE WIRSOS AND STATEMOD RIVER BASIN MODELS WITH RESPECT TO WYOMING MODELING REQUIREMENTS

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I, John P. Buyok, of Sheridan Wyoming hereby certify that this report was prepared by me or under my direct supervision and, to the best of my knowledge and belief, it accurately describes the referenced surface water models and their application to Wyoming water law.

Table of Contents

Tables

WIRSOS and StateMod River Basin Model Comparison

I. Introduction

For approximately the last 25 years, the State of Wyoming has maintained a proprietary river basin model for use in analyzing Wyoming river basins. The Wyoming Integrated River System Operating Study (WIRSOS) model was originally developed by Leonard Rice Consulting Water Engineers of Colorado for use in the Wind and Bighorn River Basin litigation between the State of Wyoming and the Shoshone and Arapahoe Indian Tribes. The purpose of the model was to determine reserved water rights of the Tribes. The model was specifically designed to incorporate Wyoming water law and allow modeling of Wyoming water rights throughout a river basin.

WIRSOS is a monthly streamflow model that uses average monthly flows in a water balance approach to estimate water use. Over the years, the WIRSOS model was modified and expanded to more accurately handle different operating situations such as exchanges of natural flow diversions for storage water, multiple reservoir supplies, etc. Originally, the model was developed for use on mainframe computers, which were the only computers at the time with the memory and storage capacity required to model a large river basin. As the capabilities of personal computers increased, the model was converted to allow operation on desktop machines. The model was also converted from the original FORTRAN IV/VMS language and operating system to different updated FORTRAN languages and operating systems as computer technology evolved. The utilities required to process the massive input and output files were also revised several times as computer technology changed.

Due to the complexity of the model, significant maintenance is required to ensure that the model operates as expected. Different situations are encountered in every new basin model that test model code and subroutines that may not have been used in that particular manner before. As a result, if the model is to be of maximum utility, someone familiar with the model code must be available at all times to modify code if computational anomalies arise with new uses.

In 2000, the Wyoming Water Development Commission (WWDC) began developing Basin Plans for each of the major Wyoming river basins. These plans are to be maintained, updated, and improved over time so that the data remains current and the methodology remains available for analyzing changes in each river basin. Therefore, the computer model that will eventually be used in these Basin Plans will need to be maintained scrupulously in order to ensure that it remains technologically up-to-date and is able to incorporate any changes in water law or operational scenarios into the future. The question faced by the WWDC was whether it would be more efficient to continue to maintain and improve the proprietary WIRSOS model for use in the Basin Plans or whether there were other public domain models available that could be used in place of WIRSOS so that maintenance costs to the State of Wyoming could be reduced.

The WWDC staff reviewed several computer models that were available from Federal and State agencies. Most of these had been developed to model a specific portion of a river basin operation and were therefore superior to the WIRSOS model in some ways but inferior in others. The one model reviewed that appeared to be as broad based as the WIRSOS model and also

flexible enough to handle most of Wyoming water law was the StateMod model developed by the State of Colorado. The StateMod model was developed for use in Colorado so the water laws, rules, and regulations in the StateMod model are those of Colorado. The water laws of Colorado and Wyoming are similar; therefore, the StateMod model has the potential to be applicable to Wyoming conditions.

The WWDC initiated an in-depth review of the StateMod model in 2002. The StateMod model can be used for either monthly or daily simulations. Since the WIRSOS model is strictly a monthly model, only the StateMod monthly data files and operations were reviewed for this report. A StateMod model of the Bear River Basin in southwestern Wyoming had been developed as an adjunct to the original Bear River Basin Plan. The WWDC contracted with John Buyok, who had done much of the maintenance on the WIRSOS model over the years, to 1) develop a parallel WIRSOS model of the Bear River Basin to compare with the Bear River StateMod model and 2) review and modify the existing Bear River Basin StateMod model to more closely match the WIRSOS model. Erin Wilson of Leonard Rice Engineers, Inc., who is an expert on the StateMod model and Linda Williams, who has worked with both models, were hired as subcontractors to help with the comparison. The two models were to use the same data and assumptions so that the two sets of model output could be compared. The purpose of the comparison was to determine if the StateMod model was capable of adequately modeling Wyoming laws and regulations. This report summarizes the comparison of the two models. Although StateMod has the capability of performing daily simulations and other specialized modeling options, evaluation of these capabilities was not included in this scope of work and are not discussed in this report.

II. General Model Comparison

The following table summarizes the general comparison of the WIRSOS and StateMod models. It highlights differences between the models and how they operate. The following sections of the report discuss comparisons of the various types of input and output from the two models in detail.

The WIRSOS model used for comparison is Version 5B (WIRSOS5B), which is the most up-to-date version available (circa 2001). The StateMod model that was used in the comparison is Version 9.96 (2001-8-31) that was available on the Colorado's Decision Support Systems (CDSS) website. In the spring of 2005, a new version of StateMod was posted on the CDSS website (Version 10.43, dated 2004/10/13). This report was revised to attempt to incorporate the changes in the new version of the model, but since most of the comparison work was done with the previous version, some changes may have been overlooked.

Model Operations and Features	WIRSOS	StateMod
Reservoirs		
Exchanges	X	X
Off-Channel	X	X
Flood Operation	Limited	Limited
Forecasting		X
Hydropower	Limited	Limited
Seepage		X
Reservoir-to-Reservoir Release		X
Storage Targets	Limited	X
Monthly Minimum Release	Yearly only in Res. File Monthly with Instream Flow File	X
Reservoir Storage Accounts	Only as Related to Reservoir Rights	X
One-Fill Limitation	Wyoming Definition	Colorado Definition
Out-of-Priority Storage	Only in Surplus Flow Conditions	X
Storage of Direct Flow Rights		X
Instream Flows		
Reach Definition	Define each node	X
Can be Tied to a Reservoir Supply		X
Diversions/Project Releases		
Yearly Demand Variance		X
Reservoir-to-Diversion Release	Senior and Junior Project Releases under Wyoming Law, Non-Project Releases	Various, Can release to diversion structure for all rights or to a specific water right?

Demand Met by Multiple Structures (Wyoming Supplemental Supply)		X
Direct Flow Right Exchanges		X
Demands Met by Wells	Only Alluvial as Estimated by a Direct Flow Diversion	X
Variable Efficiency Based on Consumptive Use, Soil Moisture, and Irrigation Type		X
Soil Moisture Accounting		X
Wyoming Surplus and Excess Water Diversions	Can be Approximated Using Multiple Rights or Using External Utility	Can be Approximated Using Multiple Rights
Imports/Exports	Defined as River Inflow, 100% CU Diversion	Defined as River Inflow or Negative Diversion, 100% CU Diversion
Direct Flow Rights Water Exchanges		X
General		
Virgin Flow Generator		X
Daily Timestep		X
Water Right Identification	Uses Wyoming Conventions	Uses Colorado Appropriation Date, or any numbering system where lower numbers represent more senior rights
Irrigated Acreage	Uses 1 cfs/70 acres, Used in Utilities	Acreage Entered in Diversion File, Variable as per Colorado law
Diversion, Instream Flow, and Reservoir Operation for a Subset of the Total Years of Model Operation		X
Futile Calls		Approximated by Allowing a Tributary to be Operated Independently of the Remainder of the Model

Input Files		
Input Data Checks	Limited Internal, Also External Data Checking Utilities	X
Input Data Preparation and Editing	Uses MS Access Databases that Import and Export Fortran Formatted Input Files	Uses a Proprietary GUI and External Utilities that Access CDSS Databases
Output		
Select Output	Limited Internal, Uses External Utilities	X
Graphical Output	Only with External Spreadsheets	With GUI

III. Input Data Processing

Because of the large quantities of data required to model entire river basins, external data handling and processing utilities have been developed for both the WIRSOS and StateMod models. The utilities developed by the State of Wyoming for the WIRSOS model are exclusive to the model primarily because they were developed prior to or concurrent with the development of water rights and streamflow databases used by the state. The utilities developed by the State of Colorado for the StateMod model are designed to interface with the existing Colorado state databases and extract and format data for the model. The available utilities for each model are discussed in general terms below. The limits on size of data files is also discussed.

A. WIRSOS Data Management Utilities

WIRSOS model data is managed using Microsoft Access databases. Access-format databases have been developed for each of the input files needed for operation of the WIRSOS model. Standard database formats are used whenever possible. Custom Visual Basic for Applications modules have been written for each database to allow output of files in the correct format for input to the WIRSOS model. Separate databases exist for each WIRSOS input file in order to avoid confusion in using the custom modules and import specification files.

New databases for WIRSOS input files are created using the data input form provided for each database. The data input form includes all of the required and optional data for each input file type. Data input should be done while referring to the WIRSOS User's Manual in order to ensure that data is entered in the correct format.

Databases can also be created by importing existing WIRSOS input files. Importing existing files requires the use of an IMPORT utility which reformats the files so that they can be imported as fixed-width text files into tables in the corresponding database. In some cases, it is possible to import the files without using the IMPORT utility, but formatting of the database fields is automatically handled if the IMPORT utility is used in conjunction with the Access data import specifications which are part of each database.

The WIRSOS input files require sorting in a particular manner in order for them to work within the model. Some of the files, such as the Station file are sorted on only one field, the station number. Some files, such as the Diversion file, are sorted on as many as five fields. The fields must be sorted correctly within the databases in order for the WIRSOS input files that are created from the database to be correctly sorted. Files that require sorting on more than one field are sorted by creating a query in the database Query folder that specifies the sort order. Each field that the data is sorted by is indexed when the database table is designed. File output macros and modules refer to the query rather than the database table in order to ensure that the database output files (WIRSOS input files) are correctly sorted.

Due to the precise formatting requirements of the WIRSOS model input files, custom Visual Basic for Applications modules have been written for each database to gather the required data from the database and create the associated WIRSOS input file. The modules are run and the required WIRSOS input file created by running the file output macros included under the Macro

folder of each database. The macros call on the modules in the correct order and create the required file.

B. StateMod Data Management Utilities

1. StateMod Graphical User Interface (GUI)

The StateMod GUI is a graphical user interface for the StateMod model that allows users to perform numerous tasks more easily, including visualizing data, modifying data files, and executing StateMod. The StateMod GUI operates on StateMod data sets described by a response file. The GUI stores most of the currently selected StateMod data set in memory at the time that a data set is selected. When data are edited, the changes are made to the copy of the data within memory. The GUI automatically detects when changes to data occur and notifies the user to allow changes to be saved before a model run is made or the GUI is closed.

To avoid complicated displays, not all of the information for a particular model data type (e.g., diversion structure) is shown in main display windows. For example, the diversion window shows the list of diversions and general information for the selected diversion. To see the direct flow demands, return flow, and water rights for the diversion, additional windows are provided and can be accessed by clicking on the appropriate button within the diversions interface.

2. StateMod Data Management Interface (DMI) Utilities

Because of the large amount of data stored in StateMod files, it is not generally practical to create a data set from scratch using the GUI. Instead, DMI utilities (data management interface utilities) are used to create baseline data sets, which are then run and modified using the GUI.

StateMod data files are typically created using DMI (Data Management Interface) programs. These programs query data from the State of Colorado HydroBase database and create StateMod-format input files. Baseline data sets for Colorado are typically distributed by the State of Colorado. These data sets can be modified by changing the DMI command files and rerunning the DMIs or can be modified using the StateMod GUI. Enhancements to the baseline data sets occur over time (e.g., extending the period, adding daily model options).

There are four current DMI utilities associated with StateMod. The Demand DMI processes diversion and demand time series data files for StateMod. The Makenet DMI creates StateMod river network files. The TSTool DMI views, manipulates, and formats time series data for StateMod. The Watright DMI processes Colorado water rights data for input to StateMod.

Currently, most of the DMI utilities are of limited use to Wyoming models because they are designed to extract data from the Colorado state databases. An update of the TSTool DMI is in the process of being completed, however, that will allow data to be imported from federal databases (e.g., USGS) and formatted for use in StateMod. This DMI is not yet available from the State of Colorado website.

C. Data Limits

Due to the large quantities of data required for each of the models, the number of each type of data (i.e., stations, structures, water rights) is limited. The maximum allowable number of each data type in WIRSOS is discussed in the User's Manual and can be found in the FORTRAN code listing. Quantities of each type can be changed by changing the FORTRAN code which controls the array size, but an increase in one type must generally be accompanied by a reduction in another due to compiler limitations.

The maximum number of each data type in StateMod can be determined by looking at the table generated in the log (*.log) file created by the data check module. If limits are exceeded, the StateMod code may also be modified to increase data array size (by request to the Colorado model administrator). Size limitations are not as stringent with the StateMod model because of the compiler used.

IV. Comparison of Specific Files

A. Model Control Files

WIRSOS	StateMod
Interactive Data Input	StateMod GUI v.5.06
Run Control File (Inp21)	(Graphical User Interface)
	DOS Command Line Options
	Response File (*.rsp)
	Control File (*.ctl)

The WIRSOS model can be run directly from Microsoft (MS) Windows Explorer by clicking on the executable file name or can also be run from an MS-DOS window. WIRSOS has an interactive starting routine in MS-DOS that allows the user to enter names of input and output files, modeling options, and model run identification data by typing it in at the keyboard. This starting routine can be bypassed by use of the Inp21 file, which contains the same information in a specific text format. Inp21 is a default file name used by the model, but the user can name the file anything that meets MS-DOS file name rules. In general, default input file names begin with the letters "Inp" and output file names begin with the letters "Tape".

The names of StateMod input and output files are included in the Response File (*.rsp) and options for model operation are included in the Control File (*.ctl). StateMod files are typically named using a descriptive project name with an extension that indicates the type of file. StateMod has a graphical user interface (GUI) that runs in MS Windows and allows the user to choose and view or edit input and output files as well as modeling options by pointing and clicking with a mouse or other pointing device. The model may also be run in a MS-DOS window with command line options.

Cautions

The current version of the StateMod GUI available from the CDSS website is sensitive to directory or folder structure and requires that all files be located in a specific sub-directory or sub-folder before the model can be operated. The GUI also does not allow creation of certain output files. In order to create some output files, the model must be run in an MS-DOS window so that DOS command line options can be used. If the command line options are used, the commands must be in lower case or the model does not operate correctly.

B. River Basin Network Files

WIRSOS	StateMod
Station File (Inp1)	River Network File (*.rin)
	River Station File (*.ris)

The WIRSOS station file defines the geometry of the river basin and the direction of flow through it. Each point of interest in the basin is assigned a node name, a node number and a stream order number. Nodes are numbered increasing in a downstream direction. Tributaries or branches in the network are denoted by a decreasing node number and a higher stream order number. The mainstem of the river basin is assigned a stream order of one (1) and tributaries are assigned higher numbers based on how many branches they are away from the main stem. Node numbers are six digit numbers and generally are assigned so that the first four digits indicate a specific stream reach and the last two numbers indicate the location of the node within the reach. The node numbering requirements are very strict because an error can result in flow being accounted for in the wrong direction through the basin.

The StateMod river network file also defines the geometry of the river basin. Nodes are assigned a node name, a node number, and a downstream node number. The node name has a suffix of _DIV, _ISF, or _FLO depending on whether it is a diversion node, an instream flow node, or a flow accounting node. This naming convention is not a requirement, except to allow Colorado's Data Management Interface (DMI) water right utility to be used. Node numbering requirements are not as strict as in the WIRSOS model because only one number is used for each node. Direction of flow is denoted by the downstream node number with branches in the network identified by having two nodes each with the same downstream node. The node at the downstream end of the network is identified by leaving the downstream node number blank.

The StateMod river station file does not have a direct equivalent in WIRSOS. The river station file identifies the nodes where streamflow stations are located and must have the same number and order of entries as the streamflow files.

Cautions

Although the StateMod numbering system is much more flexible in allowing nodes to be numbered in any order that the user wishes, care should be taken to create a numbering scheme that is consistent and easily remembered. The Bear River StateMod river network file that was used in this comparison had nodes that were numbered out of sequence. As a result, when other input files were modified to fix errors in the model, it was very easy to assign the wrong node number accidentally and create impossible situations that would make the model crash.

C. Streamflow Files

WIRSOS	StateMod
Runoff File (Inp2)	Streamflow File – Monthly (*.rim or *.xbm)
	Baseflow File (*.rib)
	Historic Streamflow File – Monthly (*.rih)

The WIRSOS runoff file contains the streamflow data required to run the model. Virgin flows are developed outside the model and the virgin flow gains are input at various nodes throughout the basin in an attempt to approximate virgin flows at each node in the model. The gains are accumulated downstream in order to calculate virgin flows at each node. The data is input in acre-feet per month for each inflow node from upstream to downstream and then year-by-year. All of the virgin flow data for one year is input before any data for the next year is input. The model can be operated on either a calendar year or water year (Oct. 1 - Sep. 30).

The StateMod model can be run using approximately the same streamflow file as is used by the WIRSOS model. In addition, virgin streamflow data can be entered as total streamflow at each inflow node instead of gain. Both the total virgin flow and the gains can be entered as either acre-feet or cubic feet per second (cfs) as long as the units are consistent throughout the model. StateMod can be operated on a calendar year, water year, or irrigation year (Nov. 1 – October 31). Streamflow data entered must have the same number and order of nodes as in the river station file. Streamflow data generated outside the current model is usually contained in a file with the .rim extension.

The StateMod model also includes a virgin flow generator. Historic streamflow data at gaging stations throughout the basin can be input in the historic streamflow file (*.rih). The baseflow module of StateMod can then be used with the other input data to generate virgin flow data at the inflow nodes required to operate the model. The baseflow file (*.rib) contains the data required to distribute virgin flows among the inflow nodes.

Cautions

The virgin flow data generated in the baseflow module of StateMod is only as good as all of the input data for the model. Since the virgin flow data is generated by calculating backwards from actual gaging data using the diversions, return flows, reservoir storage, etc. in the input files, if there are errors in any of the input data there can be large errors in the virgin flow data. The virgin flow data can look good even if there are errors because, in the simulation module, the model calculates forward through the same steps that it calculated backward in the baseflow module so the results can appear to match gaged data.

If virgin flow gains are developed outside the model, negative gains can be entered in the .rim file if necessary. Negative gains may be required in situations where there is a losing stream reach or, as was the case in the Bear River model, gains from a tributary in another state must be accounted for and the stream basin contains large reservoirs for which no storage records are available.

D. Instream Flow Files

WIRSOS	StateMod
Instream Flow Use File (Inp3)	Instream Flow Station File (*.ifs)
	Instream Flow Right File (*.ifr)
	Instream Flow Demand File – Annual (*.ifa)
	Instream Flow Demand File - Monthly(*.ifm)

The WIRSOS instream flow file contains the node location (station) of the instream flow, the permit number of the instream flow right, the priority date, and the monthly flow amount (cfs). Each entry in the file applies for a specific station, so if an instream flow is required for a flow reach, each station in the reach must have an entry.

The StateMod instream flow station file contains the station (node) ID for the instream flow, the instream flow name, and the upstream and downstream stations of the reach on which the instream flow is located. The instream flow can also be modeled as a point by only entering the upstream station.

The StateMod instream flow right file contains the instream flow right ID, the instream flow right name, the instream flow right structure ID (apparently the same as the station ID in the instream flow station file), the administration number (equivalent to the priority date in WIRSOS), the decreed amount in cfs, and a switch that indicates whether the right is to be modeled and, if so, for which portion of the period of record of the model it is to be modeled.

The StateMod instream flow demand file contains a lead record that indicates the beginning month and year of the data, the ending month and year of the data, the units in which the data is provided, and whether the data is in calendar year, water year, or irrigation year format. If the annual file is provided (*.ifa), the following records include the station ID for the instream flow and the instream flow demand for all twelve months. The same instream flow demand applies for all years of record of the model if the annual file is used. Instream flow demand can be varied from year to year by using the monthly file (*.ifm). The format is the same except the demands are repeated for each instream flow and each year of the modeled period.

Cautions

Instream flow right IDs in StateMod are not interchangeable with the Wyoming permit number because of the ID naming convention. Typically in StateMod the right ID is the station/node/structure ID plus .01, .02, etc. Wyoming permit numbers should be included in the water right name field.

Care should be taken when developing an administration number for StateMOD using the Wyoming priority date. In general, the format should be YYYY.MMDD with the year first and the month and day following after the decimal point. This format enables the user to avoid producing a warning message in the StateMod log files regarding administration numbers greater than 99999. StateMod assumes that an administration number of 99999 is a free water right (very junior); however, the model still processes the administration numbers in sequential order even if

they are greater than 99999. This caution is applicable to all files containing an administration number.

Since instream flow rates are input both in the StateMod rights file and the demand file, care should be taken to make sure that the amount in the right file encompasses the maximum amount in the demand file, otherwise the smaller amount governs.

E. Diversion Files

WIRSOS	StateMod
Diversion File (Inp4)	Direct Diversion Station File (*.dds)
	Direct Diversion Right File (*.ddr)
	Direct Flow Demand File – Annual (*.dda)
	Direct Flow Demand File –Monthly (*.ddm)
	Direct Flow Demand Overwrite (*.ddo)
	Historic Diversion Data – Monthly (*.ddh)

The diversion files are where most of the differences between the models appear. Wyoming diversions are administered strictly on a water right basis while Colorado's are administered more on a diversion structure basis. As a result, much of the diversion data in StateMod is entered by structure rather than by water right.

The WIRSOS diversion file contains data for each diversion water right indicating the location of the diversion, the reservoir and reservoir water rights from which the diversion right can draw, the diversion efficiency, the permit number, the priority date, the number of return flow locations as well as the percentage of return flow that accrues at each location and the return flow delay pattern, and average monthly diversion amounts for the water right in cfs. Flags can also be set in this file to model certain project rights and exchanges that are handled with a separate operational right file in StateMod.

The direct diversion station file in StateMOD contains data for each diversion in the system. Note that each diversion can have many associated water rights. Data included in the direct diversion station file includes the diversion station ID, the diversion name, the diversion station (node location), the physical diversion capacity in cfs, the type of demand data that is provided for the diversion, the user name, the system efficiency (either overall or month by month), and the number of return flow locations with the percentage of return flow that returns at each location and the return flow delay pattern. There are also switches to control whether the diversion is modeled and, if an operational right from a reservoir is associated with the diversion, what type of supply replacement is to be provided from the reservoir.

The direct diversion right file in StateMod contains the diversion right ID, the diversion right name, the diversion structure ID associated with the right, the administration number, and the decreed amount in cfs. There is also a switch to indicate whether the right is to be modeled and, if it is not in operation for the entire period of the model, when diversions begin or end.

The direct flow demand file, either annual or monthly, contains diversion data for each diversion structure in the diversion station file. The first record in the file indicates the beginning month and year of the data, the ending month and year of the data, the units in which the data is provided, and whether the data is in calendar year, water year, or irrigation year format. The records contain a demand station ID followed by twelve months of diversion data. If the file is an annual file (*.dda), the diversion records are repeated for each diversion station and the same data is used for all years of the simulation. If the file is a monthly file (*.ddm), the diversion records for each station are repeated for each year of the simulation.

The direct flow demand overwrite file contains the same data as the monthly direct flow demand file, except that data is provided for only some of the diversion structures in the model. The data for structures in the overwrite file replaces that in the monthly demand file. The overwrite file is used to evaluate different scenarios by changing demands at some structures without having to modify the entire monthly demand file.

The historic diversion data file contains data in the same format as the monthly direct flow demand file and consists of historic diversion data for each structure. The historic data is used in the generating baseflow or virgin flow data and is also used in the report module to provide comparisons between historic and simulated diversions.

Cautions

As in the case of instream flow rights, diversion water right IDs in StateMod are not interchangeable with the Wyoming permit number because of the ID naming convention. Typically in StateMod, the water right ID is the station/node/structure ID plus .01, .02, etc. Wyoming permit numbers should be included in the water right name field so that the diversion can be identified by the permit number, if necessary.

Neither the WIRSOS or StateMod model specifically handle the Wyoming surplus and excess water statutes. Diversions under these statutes can sometimes be adequately handled by adjusting the diversion demands in the WIRSOS diversion file or by adding additional water rights with priority dates that force diversions to occur in accordance with the statutes. This must be handled carefully in the StateMod model since the demands and the water right amounts are supplied separately and can be different. Demands in the diversion demand file must be chosen so that surplus water can be diverted when available, but the demand is not overly high when surplus water is not available.

Care should be taken when aggregating smaller diversion rights in order to simplify modeling. Aggregating rights incorrectly can distort water available to both the aggregated rights and other water rights in the system.

Two water rights with the same priority date are administered in StateMod in the order in which they appear in the water right file (*.ddr) which is also in order of the node number (from upstream to downstream). If the rights should be administered in a different order for some reason (i.e., compact considerations), the administration number should be changed to give a higher priority to the right which should receive water first. The order in which the rights are administered can be checked using the water rights list file (*.xwr) created using the report option in StateMod.

F. Operation Right Files

WIRSOS	StateMod
Junior Project Right File (Inp17)	Operation Right File (*.opr)

These two files are not directly comparable because WIRSOS and StateMod use very different input to control special operations not included in standard diversion and reservoir operations. They are discussed together because they both fall in the same general category of special operations.

The WIRSOS junior project right file includes water rights that are junior in priority to their associated reservoir. This category also includes water service contracts from specific reservoirs that may not have a Wyoming water right. Records in the junior project right file are generally duplicates of records in the diversion file (Inp4). The junior project right file is used when there is not enough natural flow in the system to meet the right at its priority date. In this case the right is processed at the reservoir priority date and water is released from the reservoir to make up any shortfall. If the reservoir to which the right is attached is spilling, the junior project right is processed using the record in the diversion file and receives natural flow water under its own priority date. In some cases, as with water service contracts, the record in the junior project right file is not duplicated in the diversion file so that the right must draw all of its demand from the reservoir.

Most other operational type rights that can be handled by WIRSOS are controlled by setting flags or adding data in the diversion file. Among these are senior project rights, which are senior in priority to the reservoir from which they receive water, exchanges of direct flow diversions for reservoir releases, and supplies from multiple reservoirs.

The StateMod operation right file contains flags and data to allow modeling of many different special operations. Operation rights are included for several different types of reservoir releases and exchanges, exchanges of water between different types of rights, and operations to take into account physical peculiarities of a river system. The operation right file also includes special operations to meet requirements of various interstate compacts to which Colorado is a party.

Cautions

WIRSOS cannot handle supplemental supply rights under Wyoming law. These rights allow for diversion from another surface water direct flow source when the supply at the original source is not adequate to meet diversion demands. These rights can be modeled in StateMod, if necessary, by entering the primary right water right at the structure from which it diverts, as usual. The supplemental supply right (with a demand of zero) can then be entered at the structure from which it diverts. A type 11 operation right can then be entered in the operation rights file which delivers water from the supplemental supply diversion to the original right diversion. The amount delivered is limited to the demand at the structure to which the water is delivered. For this reason, if supplemental supply rights are to be modeled, the original water right should be located at a separate structure from any other water rights and the demand at that structure limited to 1 cfs per 70 acres.

StateMod has a problem handling surplus water diversions to rights that also have operation right reservoir supplies. If the demand in the diversion demand file is high enough so that surplus water can be diverted when available, the demand on the reservoir is great enough so that too much water is released from the reservoir. If the demand at the diversion is not set high enough to include surplus water diversions, no surplus water is diverted when available because the demand is met prior to any surplus water diversions. The State of Colorado is developing a new operation right to deal with this problem. The new operation right would allow deliveries from a reservoir to a specific water right and, as a result, the demand for the operation right would not be equivalent to the demand for the entire structure. Until this operation right is available, demands for structures with reservoir supplies should be reduced from the full amount available under surplus and excess water statutes.

StateMod operation rights can use carrier structures. A carrier is a direct conduit (canal or pipeline) that is used to move water from one place to another. The main use of a carrier is to ensure that the flows in the carrier are not included in any available flow calculations – the water is not available for diversion between the source and destination, nor can it be accounted towards meeting instream flow requirements. Care should be taken to use these carrier structures in the appropriate situations.

StateMod operation rights generally have their own priority date or administration number in addition to the priority date of the source and destination of the water. These administration numbers can be used to control how the operation right operates and care should be taken to ensure that their use results in the desired sequence of operations.

G. Return Flow Delay Table Files

WIRSOS	StateMod
Return Flow Delay Table File (Inp7)	Delay Table – Monthly (*.dly)

The WIRSOS return flow delay table contains table ID numbers and then twelve percentage values for each ID number that correspond to months. If the table ID number is less than 50, the twelve delay percentages begin with the current month and end with the eleventh month after the current month. If the delay table number is greater than 50, the twelve percentages in the table begin with January if the model is run on a calendar year and with October if the model is run on a water year.

The StateMod return flow delay table is similar except that the delay pattern always begins with the current month and the number of entries is variable. If the delay table switch in the run control file is greater than one, every record in the delay table file will have the same number of entries as the switch number. If the delay table switch is –1, the number of delay entries can vary in each table and are set by a number following the delay table number. A delay table switch of –1 also indicates that all values are percentages. If the delay table switch is –100, the number of entries in each table is still identified in the table, but the values are decimal values rather than percentages.

H. Reservoir Files

WIRSOS	StateMod
Reservoir Data File (Inp15)	Reservoir Station File (*.res)
Reservoir Rights File (Inp16)	Reservoir Rights File (*.rer)
Reservoir Area-Capacity Curve File (Inp14)	Evaporation File (*.eva)
	Precipitation File (*.pre)
	Reservoir Target Content File (*.tar)
	Historic Reservoir EOM File (*.eom)

The WIRSOS reservoir data file contains the majority of the data required to model a reservoir. Data in this file includes the reservoir name, the station (node) where the reservoir is to be modeled, a reservoir ID number for internal operations, flags indicating whether the reservoir is to be modeled in the current run and whether the reservoir is an off-channel reservoir, the minimum storage volume, the maximum storage volume, the maximum primary outlet capacity, the initial storage volume at the beginning of the modeled period, the net evaporation rate in feet for twelve months beginning in October or January depending on whether the model is run on a water or calendar year, and the total storage volume of all water rights.

Also included in this file are the percentages of storage volume to be released monthly for non-project releases and a target month and volume for power production. Additional data include the percentages of initial storage to be allocated between up to four reservoir rights, the minimum release required from the reservoir, the diversion station if the reservoir is an off-channel reservoir fed by a diversion canal, the diversion efficiency for an off-channel reservoir, the number of return flow stations for an off-channel reservoir along with the amount of return flow at each location and the return flow pattern, and the diversion capacity for the diversion canal.

The WIRSOS reservoir rights file contains information for each reservoir water right. Information includes the reservoir station number, the priority date of the reservoir right, the reservoir right permit number, the reservoir ID number, the storage amount in acre-feet of the right, and a flag indicating whether the right is the most junior right for that particular reservoir.

The WIRSOS area-capacity curve file contains information about the reservoir area-capacity relationship. Curves are fitted to the area-capacity relationships of each reservoir and the coefficients of the mathematical equations that define the curves are given for each reservoir. Up to three different curves can be used to define the area-capacity relationship for each reservoir and five different equations are available to define each curve.

The StateMod reservoir station file contains much of the same data as the WIRSOS reservoir data file. Data in the first record of this file includes the reservoir station ID, the reservoir name, the river node where the reservoir is located, a switch to determine how the reservoir target file is used, and a switch to determine how the one-fill rule is administered. The second record contains the minimum reservoir content in acre-feet, the maximum reservoir content in acre-feet, the maximum reservoir release in cfs, the dead storage in acre-feet, the number of owners, the number of evaporation stations for the reservoir, the number of precipitation stations for the

reservoir, and the number of area-capacity values. The third record is repeated for the number of ownership accounts in the reservoir and includes the owner name, the maximum storage of the owner in acre-feet, the initial storage of the owner in acre-feet, a switch to indicate how evaporation is to be charged to reservoir accounts, and a switch to indicate if the ownership account is tied to a first fill right or a second fill right. The fourth record is repeated for each evaporation station and indicates each station ID and the percentage of that station to use in calculating evaporation for the reservoir. The fifth record is repeated for the number of precipitation stations and includes the same data as the fourth record. The sixth record contains the area-capacity and seepage data for the reservoir and consists of one entry for each point on the area-capacity table. Each entry includes a reservoir content in acre-feet, the associated surface area for that content, and the associated seepage for that content.

The reservoir right file contains the reservoir right ID, the reservoir right name, the reservoir station ID associated with the right, the administration number, the decreed amount in acre-feet, a switch to determine if the right is to be modeled and for what part of the model period the right is to be active. Also, in this file, is the number for the reservoir account that is associated with this right, a switch to indicate whether the right is a standard or out-of-priority right, a switch to indicate whether the right is a first fill or second fill right, and the number of an out-of-priority operational right associated with the out-of-priority reservoir right, if there is one.

The evaporation and precipitation data files contain the evaporation and precipitation data for modeling. Each is in a separate file but the format of the files is the same. The first record in the file indicates the beginning month and year of the data, the ending month and year of the data, the units in which the data is provided, and whether the data is in calendar year, water year, or irrigation year format. The following records contain the year, the evaporation or precipitation station ID and twelve months of data and are repeated for each station and then each station is repeated for every year. Precipitation data is always in inches but the type of evaporation data can be controlled by a switch in the control file.

The reservoir target content file contains minimum and maximum target contents or the forecasted inflow for each reservoir for each month of the simulation. The first record in the file indicates the beginning month and year of the data, the ending month and year of the data, the units in which the data is provided, and whether the data is in calendar year, water year, or irrigation year format. The following record contains the year, the reservoir station ID, and twelve months of minimum target contents for the reservoir. The next record contains the year, the reservoir station ID, and then either the twelve months of maximum target contents or twelve months of forecasted inflow. Forecasted inflows are indicated by entering them as negative numbers. The second and third records are repeated for each reservoir and then for each year of the simulation.

The historic reservoir EOM file contains historic end-of-month contents for each reservoir over the period of record of the model. The first record in the file indicates the beginning month and year of the data, the ending month and year of the data, the units in which the data is provided, and whether the data is in calendar year, water year, or irrigation year format. The following records contain the year, the reservoir station ID, and twelve months of end-of-month storage data and are repeated for each reservoir and then each year of the simulation. This file is only

used in the baseflow module to estimate virgin flows and in the report module to compare actual and modeled end-of-month contents.

Cautions

The reservoir station ID and the reservoir river node in the StateMod files are used interchangeably in most cases. The critical ID is the reservoir river node, however, because it is used to determine reservoir location in the model. The reservoir station ID is more flexible because it is used for reporting only.

The one-fill rule is regulated differently in Colorado than in Wyoming. In Wyoming, the reservoir storage year begins on October 1st with the water year. On October 1st, reservoirs are allowed to begin to store for the following year and the amount that they are allowed to store is the difference between carry-over storage at the end of September 30th and the water right capacity of the reservoir. The Colorado rule is generally the same, however the month in which it takes effect is variable. The reservoir station file contains a switch controlling the month in which the one-fill rule will be administered. The controlling date is the 1st day of the month indicated in the reservoir station file.

The StateMod reservoir input files contain values for the reservoir minimum content and the dead storage (both in the reservoir station file), and the reservoir minimum target (in the reservoir target file). In terms of importance, the reservoir minimum content is the controlling value because water cannot be released below this content, although evaporation can reduce storage below the minimum content. Dead storage is almost always the same as the minimum content. The reservoir minimum target in the reservoir target file is not used in current versions of the model. It was included for future use, but has not yet been incorporated. The maximum reservoir target in the reservoir target file is used in the model and controls storage in order to provide flood control space during the peak runoff months.

Carriage losses to deliveries from a reservoir are not accounted for in the WIRSOS model and are also not currently accounted for in StateMod. The State of Colorado is currently working on a modification to the StateMod model to allow losses to be quantified. In the meantime, the user should be aware that deliveries of reservoir water to downstream users may be overstated.

In WIRSOS, small reservoirs are generally accounted for by including a diversion of the total capacity in the highest runoff month assuming that the amount is 100% consumed with no return flow. Previous StateMod models have typically aggregated small reservoirs and modeled them as one reservoir on each major tributary. Depending on the results desired, either method can be acceptable.

I. Output Files

The output files are so different for the WIRSOS and the StateMod models that it is difficult to easily compare them. Instead, the output files for each model are listed separately below with a general description of each file and the intended use of the file.

1. WIRSOS Model Output Files

a. Initial Runoff File (TAPE8)

The initial runoff file contains an output report entitled "INITIAL RUNOFF IN MONTHLY CFS" which reports the initial river flow in average monthly cfs and the annual total in acre-feet for each accounting station. The stream order number for each accounting station is reported in the column entitled "ORD". An initial runoff report is generated for each year of data included in the runoff file. The name of the run and the year number is printed at the top of every page of output. The initial runoff report is developed directly from the input runoff file before any model operations have taken place and is useful in checking data input from the runoff file.

b. Final River File (TAPE9)

After all water rights have been processed, WIRSOS generates a final river file containing a report entitled "FINAL RIVER SYSTEM STATUS MONTHLY CFS IN RIVER." The format of this output file is identical to the format for the initial runoff output file except for the title. The final river report summarizes the amount of water physically in the river at each station after all diversions and return flows have been made and accounted for. These amounts are reported in average monthly cfs and annual acre-feet at each station. Instream flows, which are streamflows left in the river, are included as part of the final river values and may cause the Final River flows to be greater than the flows available for diversion. The flows in the final river report may be compared to USGS stream gage data provided an accounting station is designated at a USGS stream gage location and can be used to check model calibration.

c. Available River Flow File (Tape10)

In addition to the Final River report, WIRSOS generates an available river flow file containing a report entitled "FINAL RIVER SYSTEM STATUS MONTHLY CFS AVAILABLE IN RIVER." The available flow report summarizes the physical supply of water available for diversion from the river at each station. The amount of water available for diversion during a particular month without harming any other existing rights is determined by finding the minimum available flow at all stations from the location of the potential diversion downstream to the terminus of the model. The format for the available flow output file is the same as for both the initial runoff and final river output files and is reported for each month in average monthly cfs and the total annual amount in acre-feet at each accounting station.

d. Reservoir Report File (TAPE18)

A "RESERVOIR STATUS REPORT" is produced for each reservoir in the model for each year of data processed. This report states maximum and minimum capacities of each reservoir and monthly reservoir activities for each year modeled. The monthly activities accounted for by the program and printed on the report include storage added, downstream flow at the reservoir, power and non-project releases requested and actual releases made, releases for project rights, reservoir evaporation losses, the amount of extreme supply water stored and end-of-month volume in storage. The annual totals are printed in acre-feet at the bottom of each column. The reservoir report file is sorted by reservoir and by year. Data for a single reservoir for any year, group of years, or the entire period of record can be easily extracted for analysis using a text editor.

e. Reservoir Rights Report File (TAPE19)

A "RESERVOIR RIGHTS STATUS REPORT" is produced for each reservoir in the model for each year of data processed. This report states maximum permitted volume of each reservoir right and monthly reservoir right activities for each year modeled. The monthly activities accounted for by the program and printed on the report include water stored by the reservoir right year-to-date, the water controlled by that right, and the factor that limited reservoir storage at the reservoir rights priority date. The factors that can limit reservoir storage are the reservoir one-fill rule, the reservoir right has been satisfied for the year, the year-to-date storage has exceeded the yearly capacity, the remaining reservoir capacity has been filled, the off-channel storage diversion capacity is not large enough to handle the required flow, a senior downstream right was not satisfied, or there is not enough water available to satisfy the right. The reservoir rights report file is sorted by reservoir right and by year. Data for a single reservoir right for any year, group of years, or the entire period of record can be easily extracted for analysis using a text editor.

f. Callout List File (TAPE11)

The water rights requesting diversion or storage amounts and not receiving their full supply (called-out rights) are summarized in the callout list output file. The callout list report summarizes the water right called out, the water right's priority date, the percent called out, the name of the station from which the right diverts, the type of right and the reason the right did not receive its full supply of water. Water rights with diversion or storage demands fully satisfied are not reported on the callout list, with the exception of reservoir project rights which can be reported once or twice depending on the portion of the project right demand met from each source of supply

g. Diversion Callout List File (TAPE12)

In addition to the callout list output file, a diversion callout list is generated by the WIRSOS model. The diversion callout list is a brief summary list of the diversion water right requirements not being fully satisfied and is unformatted. On each line of the list is the month,

permit number, percent called out, and station number of the right which is called out. The unformatted file can be processed using utilities to make it more usable.

h. Instream Flow Use Callout List File (TAPE13)

An instream flow use callout list output file is also generated by the WIRSOS model. The instream flow use callout list is a brief summary list of instream flow uses not being fully satisfied and is also unformatted. The output file is in the same general form as the diversion callout list file and can also be processed using utilities.

i. Reformatted Diversion Callout File (TAPE12A)

The diversion callout list output file (TAPE12) can be reformatted into a more readable and usable format using the WIRSOS reformat option. The reformatted file includes one line of data for each water right that is called out. Each line begins with the permit number of the called out water use followed by 12 values for the percentage called out each month of the year. The last field is the station number of the called out right.

j. Reformatted Instream Flow Callout File (TAPE13A)

The capability to reformat the instream flow use callout list output file (TAPE13) into a more readable form is also present in the WIRSOS model. The reformatted file includes one line of data for each instream flow that is called out. Each line begins with the permit number of the called out water use followed by 12 values for the percentage called out each month of the year. The last field is the station number of the called out right.

k. Reservoir Status List File (TAPE22)

The reservoir status list is a file built by the WIRSOS model which contains the data for the reservoir status report in an unformatted list. WIRSOS reads this file after processing is complete and sorts and reformats it to create the reservoir report. The user is not given the option of naming this file and it is always written to the directory which contains the program executable file used for the model run.

l. Reservoir Rights Status List File (TAPE23)

The reservoir status list is a file built by the WIRSOS model which contains the data for the reservoir rights status report in an unformatted list. WIRSOS reads this file after processing is complete and sorts and reformats it to create the reservoir rights report. The user is not given the option of naming this file and it is always written to the directory which contains the program executable file used for the model run.

m. Debugging File (TAPE6)

The WIRSOS model will create a debugging output file if the user chooses. The debugging file contains messages that are printed whenever the model reads data from the input files and at

major steps of the model operation. It is useful for finding errors in input files because the model operation can be traced to see exactly where an error occurred. The user is not given the option of naming this file and, it is always written to the directory which contains the program executable file used for the model run.

2. StateMod Output Files

StateMod creates several output files in each of the four modules of the model – base flow, simulate, data check, and report. Each output file generated has a name that is the model scenario name plus a three character suffix that identifies the type of output file. Some output files are generated automatically and some are optional and must be requested specifically by either a command line option or through the StateMod GUI.

The amount of data in the output files can be controlled by the output request input file (*.out). The data check module creates an output file (*.xou) that lists each structure in the model system. This file can be renamed as the output request file (*.out) and edited to limit the output to the structures of interest to the modeler.

a. Base Flow Module Output Files

There are four output files from the Base Flow Module; the Base Flow Information File (*.xbi), the Gaged Base Flow Estimate File (*.xbg), the Gaged and Ungaged Base Flow Estimate File (*.xbm), and the Log File (*.log).

i. Base Flow Information File (*.xbi)

The Base Flow Information File (*.xbi) summarizes the data used to develop the base flow estimates at the gaged locations in the basin in a spreadsheet type format so that it can be checked. The Base Flow Information File includes the gaged data at each gaging station and then each of the adjustments used to estimate virgin or base flow at each location. Adjustments include imports, diversions, return flows, alluvial well depletions, changes in upstream storage, and evaporation from upstream reservoirs. The final base flow estimates and the base flow estimates with negative flows set to zero are also included.

ii. Gaged Base Flow Estimate File (*.xbg)

The Gaged Base Flow Estimate File (*.xbg) contains base flow estimates at each gage location in the basin and summarizes the base flow estimates calculated using the information in the Base Flow Information File. If the gaged data is incomplete, the virgin or base flow data in this file is used to develop data relationships by regression or other techniques to fill the data gaps.

iii. Base Flow Estimate for Model Input File (*.xbm)

The Base Flow Estimate for Model Input File (*.xbm) contains the gaged base flow estimates from the Gaged Base Flow Estimate File as well as estimated base flows at all other locations required for model operation. Base flows at ungaged locations are estimated from the gaged base flow data using the distribution data input in the Base Flow File (*.rib). The Base Flow

Estimate for Model Input File is generally used as input for the simulation module of the StateMod model.

iv. Base Flow Log File (*.log)

The Log file (*.log) contains a log of the base flow module operation and is generally used in the case of model problems to find the data causing the problem.

b. Simulate Module Output Files

There are seven standard output files from the Simulate Module; the Diversion Summary File, the Reservoir Summary File, the Well Summary File, the Structure Summary File, the Instream Flow Summary File, the Operations Summary File, and the Log File.

i. Diversion Summary File (*.xdd)

The Diversion Summary File (*.xdd) describes diversion and streamflow data at all river nodes with diversions. The Diversion Summary File (*.xdd) contains a header for each node which describes the structure ID, account and name. In addition, the header includes the water rights data for each water right located at the river node.

Following the header are time series data for that node for each month of the simulation. The time series data are presented as one data line per month and are identified by the structure and river node IDs and then the year and month of simulation. Data on each line includes the demand at the structure and then the amount of demand supplied by each source of water. Following the demand and supply data are the shortage data and then the consumptive use, soil moisture storage, return flow, and loss data at the structure. The next group of data summarizes the inflows and outflows for the station and is followed by the water balance for the station. The final number on each line is the available flow which is defined as the amount of water available at the current node to a potential user that is the most junior in the basin.

The Diversion Summary File repeats the header and then the time series data for each node for which data is requested in the output request file (*.out).

ii. Reservoir Summary File (*.xre)

The Reservoir Summary File (*.xre) describes diversion, release, storage and streamflow data at river nodes that contain a reservoir. A header is printed for each reservoir node that describes the reservoir ID, account, and name and is followed by the water rights data for the reservoir.

Following the header are the time series data for each month of the simulation at the reservoir node. Each line of time series data is identified with the river node ID and the reservoir account followed by the year and month of simulation. For each month, the initial storage at the beginning of the month is shown and then storage gains, releases, and losses are itemized individually. The end of month content is shown followed by the target storage for the month and the remaining amount that can be stored under the one-fill rule. The final group of data on

each line is the river balance which includes the river inflow, the total storage gains and releases, and the river outflow for the current month.

Data for each reservoir is presented first as account zero (0) which summarizes the data for the reservoir as a whole and then the separate accounts in the reservoir are presented individually.

iii. Well Summary File (*.xwe)

The Well Summary File (*.xwe) describes the structure data for every structure that has a well. The header describes the well ID, account, and name followed by the administration number, on/off switch, owner, and decreed amount for each ground water right located at this structure. The time series data for each month of the simulation includes demand and supply (demand, surface supply, ground supply and shortage), use of water (CU, return and loss), and source of water (river, ground water storage and salvage) for the structure. Format of the data is similar to that of the diversion summary file.

iv. Structure Summary File (*.xss)

The Structure Summary File (*.xss) is a standard output file that summarizes additional data created when the variable efficiency option is used. The report has a header for each node that is similar to the other files. The time series portion of the file describes structure water use data related to areas irrigated by sprinklers or wells, demand, surface water, ground water, soil storage, consumptive use, conveyance efficiencies, and return flows.

v. Operation Summary File (*.xop)

The Operation Summary File (*.xop) creates tables showing diversions or releases associated with each operating right for each month of the modeled period.

vi. Instream Reach Summary File (*.xir)

The Instream Reach Summary File (*.xir) creates tables showing total instream flow supply for each node associated with an instream flow reach for each month of the modeled period.

vii. Well Reach Summary File (*.xwe)

The Well Reach Summary File (*.xwe) creates tables showing total well water supply for each node associated with a well structure for each month of the modeled period.

viii. Simulate Module Log File (*.log)

The Simulate Module Log File file (*.log) contains a log of the simulate module operation. The log file is generally used to trace errors in module operation.

c. Report Module Output Files

There are numerous output files available from the Report Module as described below. These output files are created from binary files produced by the model during operation of the simulation module and can be obtained individually by running the report module as the need for additional output data becomes apparent later during data analysis. Each report name is followed by the flag that is added to the command line for the report option in order to produce the report or reports. It is not necessary to know all of the flags in order to obtain the desired reports because the type of report can be entered interactively when the model is run.

i. Basin Water Balance (-xwb)

The Basin Water Balance Report File (*.xwb) contains a description of the total inflows (including return flows), outflows (including consumptive use, soil storage, and losses), and storage changes (including evaporation) for the modeled basin. Totals are provided for each month of the modeled period.

ii. Water Right Report (-xwr)

The Water Right Report File (*.xwr) contains a list of water rights in the basin sorted by priority. Each water right is listed by rank, administration number, type, structure, amount, and name.

iii. Standard Report (-xst)

The Standard Report option (-xst) produces four files; the Demand Summary File (*.xdd), the Reservoir Summary File (*.xre), the Instream Reach Summary File (*.xir), the Well Summary File (*.xwe) and the Operation Right Summary File (*.xop). These are the same files produced by the simulate option.

iv. Node Accounting Report (-xn)

The Node Accounting Report (-xn) produces two files; the Detailed Node Accounting (*.xnm) file and Summary Node Accounting (*.xna) file. Both provide the same results as the standard report but are sorted by the stream order provided in the river network file (*.rin). The detailed node accounting file provides data for every month of the study period while the summary provides an annual average.

v. Diversion Graph Report (-xdg)

The Diversion Graph Report File (*.xdg) contains the same data presented in the diversion and stream gage summary report, but is formatted for easy graphing by a spreadsheet or other plotting package.

vi. Reservoir Graph Report (-xrg)

The Reservoir Graph Report File (*.xrg) contains the same data presented in the reservoir summary report, but is formatted for easy graphing by a spreadsheet or other plotting package.

vii. Well Graph Report (-xwg)

The Well Graph Report File (*.xwg) contains the same data presented in the well summary report, but is formatted for easy graphing by a spreadsheet or other plotting package.

viii. Diversion Comparison Report (-xdc)

The Diversion Comparison Report File (*.xdc) compares the total diversions estimated by the model to the gaged record if available in the historic diversion file (*.ddh).

ix. Reservoir Comparison Report (-xrc)

The Reservoir Comparison Report File (*.xrc) compares the end of month contents estimated by the model to the gaged record if available in the historic end of month content file (*.eom).

x. Well Comparison Report (-xwc)

The Well Comparison Report File (*.xwc) compares the total well pumping estimated by the model to the gaged record if available in the historic well pumping file (*.weh).

xi. Stream Comparison Report (-xsc)

The Stream Comparison Report File (*.xsc) compares the total streamflow estimated by the model to the gaged record if available in the historic streamflow file (*.xsc).

xii. Consumptive Use Water Supply Report (-xcu)

The Consumptive Use Water Supply Report (-xcu) provides four output files; *.xcu, *.xsu, *.xsh and *.xwd designed to interchange with the State of Colorado consumptive use model. The CU summary file (*.xcu) presents the total diversion by each structure in a special format required by the consumptive use model. The supply summary (*.xsu) presents the total supply to each structure. The shortage summary (*.xsh) presents the shortage associated with each structure. The water district summary (*.xwd) presents the total diversion by Colorado water district as determined by combining all structures that have the same first two digits of the water right ID.

xiii. River Data Summary Report (-xrx)

The River Data Summary Report (*.xrx) provides a summary of data by river node. The report is also referred to in the model as the Stream Information File Report. The report summarizes all activities that occur at each river node and also summarizes return flow locations.

xiv. Selected Parameter Report (-xsp)

The Selected Parameter Report (-xsp) provides a printout of a selected parameter (e.g., Total_Diversion) available to the standard diversion (*.xdd), reservoir (*.xre) and well (*.xwe) output files. It reads the Output Request file (*.out) to determine the type of output (e.g., diversion), parameter (e.g., Total_Diversion) and ID to print. It creates two output files with the same data in a different format; the output formatted into a table is named *.xsp while the output formatted into columns is named *.xs2. It is possible to get a list of parameters for each data type (diversion, stream, instream flow, reservoir or well) by entering a dummy variable under parameter type (e.g., x) and reviewing the log file.

xv. Report Log File

The Log File file (*.log) contains a log of the report module operation. The log file is generally used to locate problems encountered during the operation of the module.

d. Data Check Module Output Files

The data check module creates standard output files that can be used to determine if the data files are formatted correctly and that the model is reading them correctly. There are seven (7) standard output files from the Data Check Module.

i. Base Flow File (*.xcb)

The Base Flow File itemizes the input data for streamflows for checking.

ii. Direct Demand File (*.xcd)

The Direct Demand File itemizes the input data for direct flow demands for checking.

iii. Instream Demand File (*.xci)

The Instream Demand File itemizes the input data for instream flow demands for checking.

iv. Well Demand File (*.xcw)

The Well Demand File itemizes the input data for wells for checking.

v. Water Right List File (*.xwr)

The Water Right List File itemizes the water right input data for checking. The water right list file is identical to the water right report created by the report module.

vi. Output Request File (*.xou)

The Output Request File is a list of structures in the modeled river basin. The list can be modified and renamed to use as the input file for data requests by structure (*.out).

vii. Data Check Log File (*.log)

The Log File contains a log of data check module operation which can be used to trace errors in the module output.

V. Conclusions

A. Data Processing

The data processing utilities for StateMod are more than adequate for processing input data and preparing StateMod input files. Although the utilities were developed to interface with State of Colorado databases to develop input data for the model, their data formatting and manipulation capabilities are equivalent to, and in many cases, superior to the Access databases developed for the WIRSOS model. If the StateMod model is chosen for future Wyoming modeling, it may be worthwhile to explore expanding the DMI utilities to use Wyoming databases (e.g., the State Engineer's Office Water Rights Database) to develop Wyoming river basin input files. In the alternative, a Wyoming utility could be developed to do the same types of operations.

B. Modeling

In general, the StateMod model appears to be more than adequate to model Wyoming water rights under Wyoming water law. The model has been under continuous development and revision and the model functionality has evolved beyond that of the WIRSOS model currently used in Wyoming. Since the model was developed specifically for Colorado water rights and Colorado water law, there are some differences that the user should keep in mind when using the model under Wyoming conditions. There are also some sections of the model that were developed to account for the provisions of specific interstate compacts in Colorado and the user should be careful not to incorporate modeling capabilities that are not applicable to Wyoming situations.

C. Output Data Utility

Due to the continuing evolution of the StateMod model, the flexibility of output of model data is superior to that of the WIRSOS model. As a result, the utility of the data to analyze specific situations is also superior to the WIRSOS model. The data processing utilities that are currently available from the CDSS website are adequate for use in most Wyoming data analysis situations and the enhanced utilities that are currently being developed will improve their utility considerably.