RIVERWARE DEMONSTRATION TUTORIAL

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This RiverWare informational tutorial introduces you to the capabilities of RiverWare as an advanced water resource modeling tool and consists of three sections, **Simulation in RiverWare**, **Rulebased Simulation**, and **Multiple Run Management**. These tutorials are independent documents but later topics do build on skills you gain from earlier exercises, so if you have not gone through the earlier topics or have not used RiverWare recently it is recommended that you start with this tutorial on **Simulation in RiverWare**.

Before you start... You must have RiverWare 7.2.1 or later installed on your computer and have a valid license file. For more information about downloading RiverWare, visit RiverWare.org. To acquire a demonstration license, please email Installation Support (installsupport@colorado.edu).

You must have downloaded the files associated with this tutorial and moved them to a reasonable folder like `C:/temp`. The following files are used in this tutorial:

- MuddyBartlettBasin_Start.mdl.gz
- MuddyBartlettBasin_Start_SCT.sct
- MuddyBartlettBasin_Start_monthly_SCT.sct
- MuddyBartlettBasin_Final.mdl.gz (this is the final result of this module)
- UpstreamGage.Inflow

1.   Simulation in RiverWare

This module presents the basics of working within the RiverWare workspace. You will be introduced to:

- Opening a model
- Viewing timestep and controller information
- Navigating throughout the workspace
- Understanding the various types of objects available
- Looking at methods and slots
- Running a model
- Looking at a System Control Table
- Creating a Model Report
- Running a Data Management Interface

1.1   *Investigating a Model*

Opening a Model

To get started let's open a demonstration model in RiverWare:

☞   Double-click the RiverWare icon on the desktop.

☞   Select **File ➥ Open Model...** from the main workspace menu bar or click on the
Open Model File toolbar button.

☞   Open the file `MuddyBartlettBasin_Start.mdl.gz`

*Once the model is loaded, a diagnostic window appears with information regarding the
date and time when the model was last saved, by whom the model was saved, and which
version (release) of RiverWare the model was last saved in. It's fine to close this window.*

Your workspace should now have a model
consisting of two reservoir objects (Muddy
Reservoir and Bartlett Reservoir) along with
various reaches and additional objects.
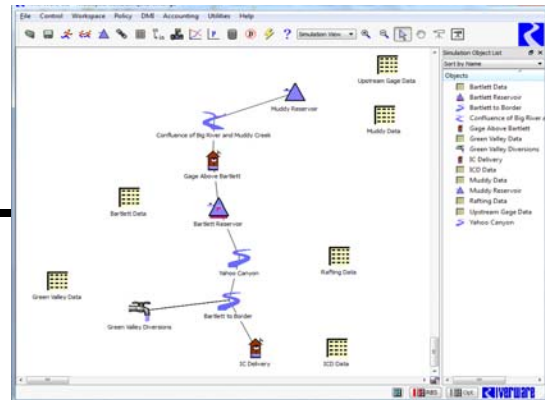
1.2   *Viewing Timestep and Controller Information*

Now that the model is loaded we can investi-
gate how the simulation is set up to run by
taking a look at the **Run Control** dialog. The
Run Control dialog provides the interface for starting a run and for selecting the solution type,
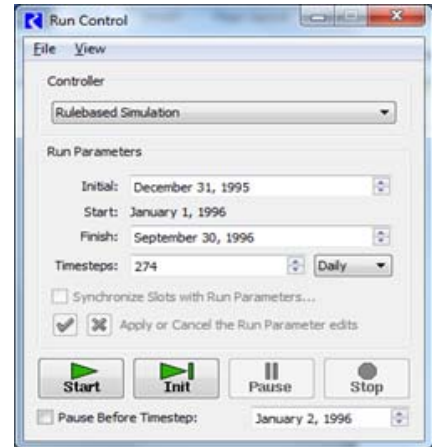timestep, and run times.

☞   From the workspace menu select **Control ➥ Run Control Panel** or click the **Run
Control** toolbar button.

The Run Control window appears.

Notice that this is a **Rulebased Simulation** that is set to run with a daily **Timestep** from January 1, 1996 to September 30, 1996. The purpose of this model is short term planning- it could be used, for instance, to develop an operating plan through the end of the water year.

The available timesteps are 1 hour, 6 hour, 12 hour, Daily, Weekly, Monthly, and Annual; you choose the timestep based on the model's purpose and data available.

The **Start** button executes the run from the initial timestep. The **Init** button executes initialization or the next timestep and can be used to step through the simulation. The simulation may also be paused or stopped once in progress from the **Run Control** dialog.

☞ Experiment with the **Start**, **Init**, and **Continue** buttons to run the model.

You can close the **Run Status** window, **Run Control** dialog, and **Diagnostics Output Window** (if present) by selecting **File ➡ Close Window** or by clicking on the red "**X**" button in the upper right corner of each window.

1.3   Navigating the Model

The workspace is the entire RiverWare window. This section describes some features of the workspace used for navigation. Often models are large and require you to move around them to find the desired objects.
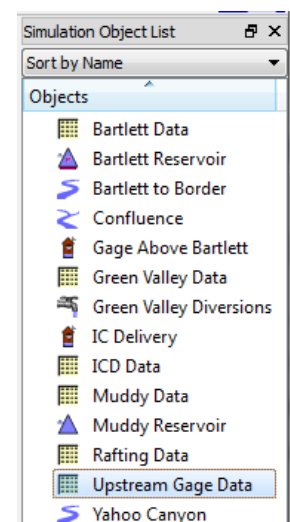
Object List

The **Object List** provides a comprehensive list of objects in the model; click on an object to snap to that location. You can sort the list alphabetically, by object type or position using the **Sort by** menu.

☞ Click on **Upstream Gage Data**.

The canvas adjusts to show the object, which is now highlighted.

Zooming

Zoom to magnify objects or zoom out to examine a model in less detail. Use the zoom buttons on the toolbar or right-click on the workspace and select an option from the **Zoom** menu.

Workspace Cursor Modes: Select / Hand Drag / Locator Mode

The workspace has four cursor modes:

Normal Selection Mode Normal Selection Mode is used for selecting and moving Objects on the workspace. Multiple icons can be selected by dragging a rectangle over the icons or holding down the **Ctrl** key while selecting objects.

Hand Drag Mode Hand Drag Mode (i.e. Pan) allows you to shift to different areas of the workspace canvas within the visible workspace area. Also, use the middle mouse button to pan.

In-View Locator Mode The In-View Locator Mode temporarily re-scales the workspace to show all of the objects within the workspace. Move the rectangle to snap to a new location. This is most useful for very large models.

Locator View Mode The Show Locator Window button displays the entire workspace in a separate Locator View Window. Move the rectangle to change the area displayed.

☞ Take a minute to explore the four workspace navigation methods

Context Menus Right-clicking prompts object or link manipulation menus.

☞ Right-click on a link (indicated by a line between two objects), an object, or the workspace to get a context menus for options such as adding/ deleting links, opening/adding/deleting objects, zooming, etc.

RiverWare also offers context sensitive pop-ups with information about objects and links when you hover above an object or link.

1.4   Objects

The **Objects** on the workspace represent features of your basin. These objects contain the data and the physical process algorithms which drive the simulation. A selection of object types available in RiverWare are described below:

STORAGE RESERVOIR: A reservoir with release and spillways and no hydropower facilities. Storage is a function of Pool Elevation as defined by an Elevation-Volume Table.

LEVEL POWER RESERVOIR: A reservoir with a hydropower plant (Turbine Release) and spillways. Storage is a function of Pool Elevation as defined by an Elevation-Volume Table.

SLOPE POWER RESERVOIR: A reservoir with hydropower facilities and spillways. Storage is a combination of level storage and a wedge storage. Wedge storage is defined by a table which relates headwater elevation and Inflow to a water surface profile.

INLINE POWER: An object used to model power production on a stretch of reach with no storage (run of river power production).

REACH: A river section which routes water using one of many possible routing algorithms. Reaches may lose water to a Diversion and gain water from Return Flow. Reaches can also have side inflows, gains, and/or losses.

PIPELINE: An object that models flow in a pipeline between two objects.

INLINE PUMP: An object used to model a booster pump station. It controls solution direction, calculates added head and calculates the power consumed.

GROUND WATER STORAGE: An underground storage reservoir which receives Inflow from Water User, Return Flow, or Reach seepage and can return water to the system. Can be connected a network of groundwater objects. Solution is head-based and explicit.

WATER USER: An object that diverts water from a Reach or a Reservoir, consumes water, and then returns excess flow to the system.

THERMAL OBJECT: An object which models the economics of the thermal power system and the thermal replacement value of the hydropower.

DATA OBJECT: A container for user-defined data to be imported to and/or exported from RiverWare. Data Objects may also contain expression slots for performing user-defined calculations.

CONTROL POINT: An object used to regulate upstream reservoirs so that channel capacity at the control point is not violated.

☞ Open **Bartlett Reservoir** by double-clicking its object icon on the workspace or by double-clicking on the name in the **Object List**.

1.5 Looking at Slots and Methods

Slots

Slots are the data structures on an object. The slots in the **Open Object** dialog contain all of the numerical data for that object. This includes input and output timeseries data, input tabular data, and input coefficients for various physical process calculations. The list is not static, but can change depending on the selected user Methods.

Different types of slots are used for representing different types of data, but slot variations will not be covered in this introductory document.

The **Slots** tab contains information about each of the object's slots including the slot **Type**, **Name**, **Value** (where applicable), **Units**, and **Status** information.
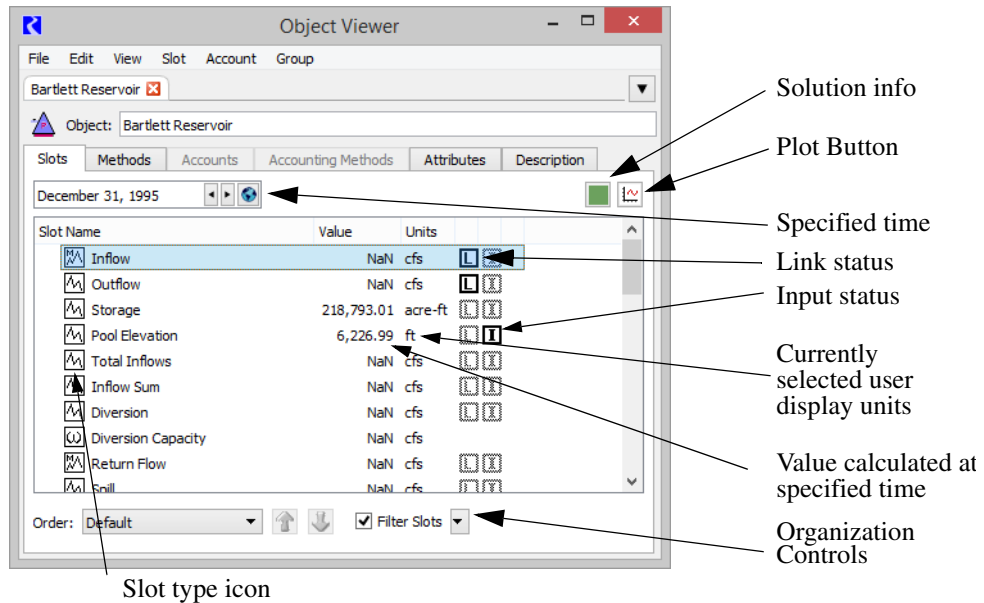

☞ Open the **Inflow** slot by double-clicking on the name and scroll through the inflow entries.

Because you've run the model, the daily inflow data has registered in each row.

All slots have some basic features in common. The main dialog has a menu bar, information about the object, the slot name, and the value from the selected cell. It contains columns and rows of numbers and possibly dates. This is a series slot so it contains a time series of data. Each value represents a value at that particular date.

☞ Plot the Inflow by clicking the **Plot** button 📈.

All series slots have this quick plotting option for visualizing model data.
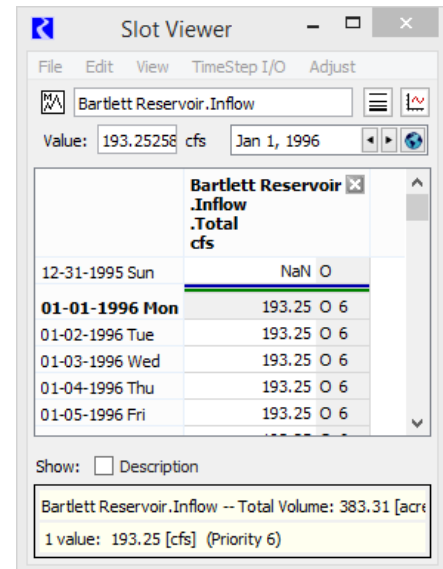
RiverWare provides a robust plotting package that lets you add multiple slots to the plot and show aligned panels with different plots. You can configure line widths, types, colors, etc...

☞ From the main workspace, use the **Utilities ➥ Plot Page Dialog...**

☞ Select the **Bartlett** plot from the list on the right

The following figure shows a sample plot of **Storage**, **Pool Elevation**, and **Outflow** for the Bartlett Reservoir**.** This tutorial does not cover how to create this plot. It simply shows some of the plotting features that are available.

☞ Close the **Bartlett Reservoir.Inflow** slot and the **Bartlett** plot.

Methods

User Methods allow you to customize each object's physical process calculations. User Method categories are defined for calculations such as

- Evaporation,
- Bank storage,
- Power generation,
- Spill,
- Routing,
- Tailwater and
- Canal flow.

Each **Category** contains one or more **Methods.** For example, the Power category contains methods to specify how to compute Power. Some of these are general methods, designed for a variety of users. Others have been developed using custom calculations to meet the needs of particular groups, such as the **LCR Power** which is used on the (lower) Colorado River daily model. Each User Method is described in detail in the *Objects* section of the RiverWare Help.

To switch to the **Methods** view, click on the **Methods** tab, which contains a scrollable list of categories on the left and the corresponding selected method for each category on the right.

☞ Select the **Methods** tab in the Bartlett Open Object dialog.

☞ Browse the available methods for a few categories by highlighting the category and examining the drop down **Selected Method** menu.

☞ Note that the method selected in the **Power** category is the **Plant Power Coefficient** method. Click on the triangle to the left of the category to view the **10** slots associated with the method.

☞ Close the **Bartlett Reservoir Open Object** dialog.

Closing the Object automatically closes the Slots.

Categories

Pull-down Menu
for selecting
Methods

Selected
Methods
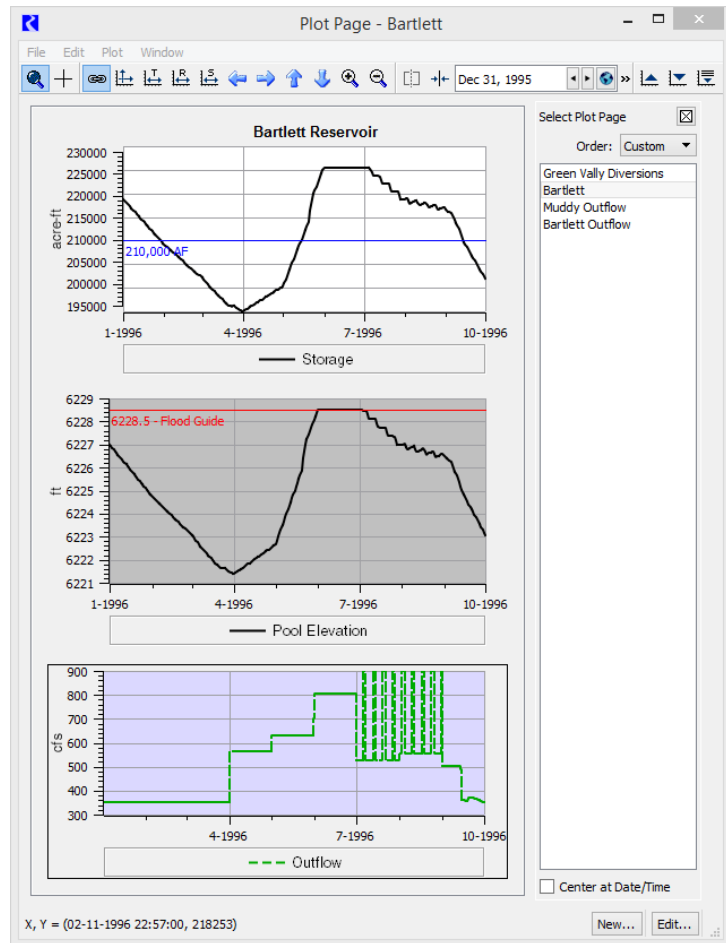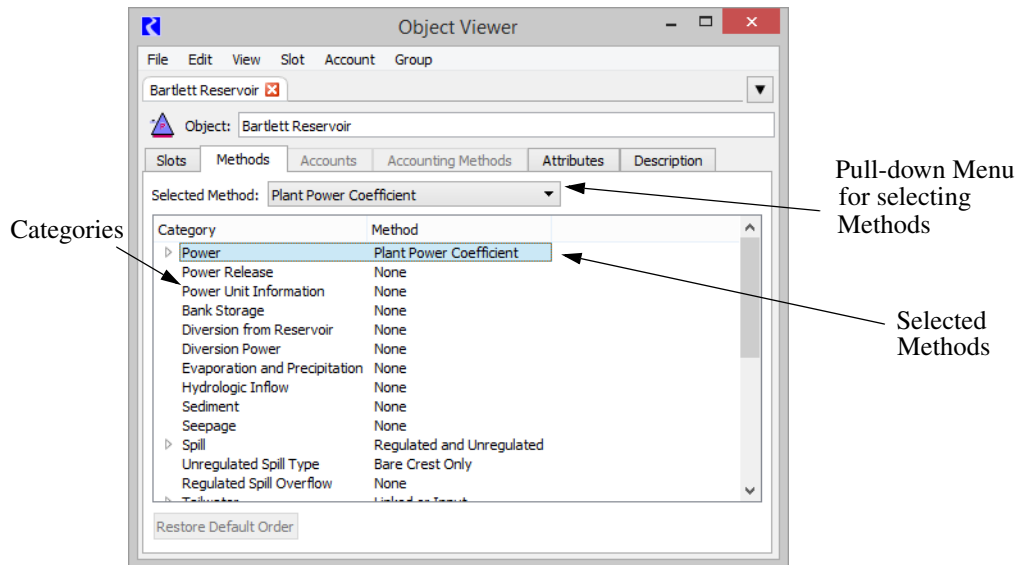
1.6   Using the RiverWare Help

For any modeling tool, it is important to know where to find more information. River-
Ware documentation can be accessed either by clicking **Help ➥ RiverWare
Help...**from the workspace menu bar or by clicking on the Help toolbar button.

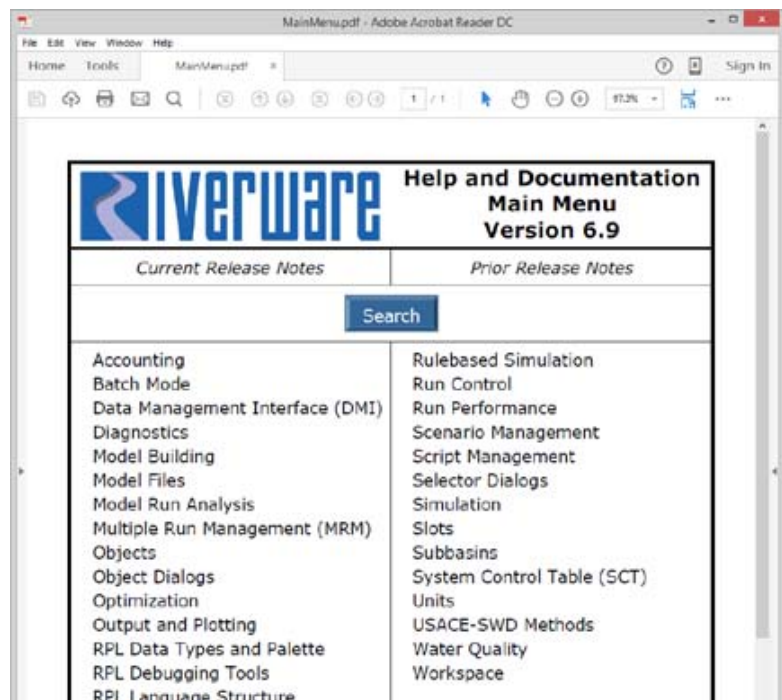☞ Open the RiverWare
Help.

*This brings up the
RiverWare Help Main
Menu.*

Each item in the Main
Menu is a link to a
specific topic in the docu-
mentation.

☞ Click on **Objects**

*You can scroll
through the docu-
ment, which starts
with a table of con-
tents on the topic, or
choose a bookmark
from the left panel.*

☞ Click on **1. Object**

Types.

You jump to a complete list of Objects and a brief description of each type.

☞ Click on the blue LINK to the right of the **Level Power Reservoir** object to go to the object's section.

☞ Scroll through the list of general slots until you reach **16.1 User Methods**.

Here you will find an exhaustive list and description of the Level Power Reservoir's methods, how the methods are implemented, and associated slots.

☞ Find the method being used by the Bartlett Reservoir object: **Plant Power Coefficient** (16.1.1.3).

Just below the name is a paragraph describing how the object's various slots are used to determine the operation of the reservoir.

The process of finding this information is the same for every object type and method. Note that the bookmarks menu on the left side of the document is a good way to navigate quickly.

☞ Click on **Main Menu** in the bookmarks.

The list of main sections reappears.

☞ Close the Help Menu pdf.

1.7 Adding Objects to a Model

This module introduces you to some of the basic steps in building a simple model. Instead of starting from scratch, we will add on to the Muddy-Bartlett Basin model to become familiar with:

- Creating Objects
- Selecting User Methods
- Units in RiverWare
- Configuring slots and entering data

Creating Objects

If continuing from the previous section, continue with your open model.

If starting new,

☞ Start a new RiverWare executable by double clicking on the RiverWare icon on your desktop.

☞ Select **File ➥ Open Model...** from the main workspace menu bar or click on the Open Model File toolbar button.

☞ Open the file: `MuddyBartlettBasin_Start.mdl.gz`

When the model was first created, no side inflows for the confluence were available. Estimated monthly values were used. (You can see this distribution by plotting **Confluence.Inflow1**). Recently, daily streamflows were provided by the local gaging utility. These streamflows have

a one day lag to the confluence. To model this new data and the routing, you should add a stream gage and a reach. Objects are created by dragging them off of a palette. The **Palette** is opened from the main workspace menu or main toolbar.

☞ Click on the **Palette** toolbar icon.

The **Object Palette** contains all the available object types used to represent features of a river basin. It is the source from which objects are created on the workspace. You create objects by dragging the icon off the **Palette** onto the workspace.

☞ Place a **Stream Gage** and a **Reach** on the workspace near the **Confluence** as seen below:
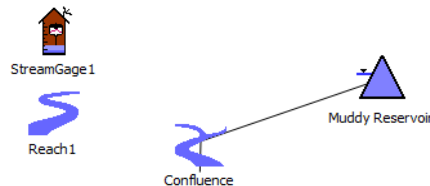
☞ Close the **Palette**.

☞ Open the **Stream Gage** object by double-clicking its icon.

☞ Double-click in the name field and type: Upstream Gage, press Enter, and close the object dialog.

☞ Repeat this step for the Reach and name it Big River Flats.

Selecting User Methods

☞ An object represents a feature in the basin. You, the user, select methods on each object to specify how to model various physical processes. For the Muddy-Bartlett Basin model, the **Big River Flats** reach should be modeled with a 1 day lag time.

☞ Open the **Big River Flats** reach object.

☞ Select the **Methods** tab.

*Notice that the Selected Method for the **Routing** category currently shows **No Routing**, the default until otherwise specified.*

☞ From the **Selected Method** dropdown menu select **Time Lag** routing.

A dialog appears to confirm that you want to create the additional slot associated with the method.

☞ Click OK.

☞ Return to the **Slots** tab.

The new slot, LagTime, has been added.

Units in RiverWare

A **Unit Scheme** describes how RiverWare will display numeric values in terms of four display attributes (collectively called "units"):

- Units
- Scale
- Precision
- Format

You can view and edit the Unit Scheme definitions and easily switch between the Unit Schemes through the **Unit Scheme Manager**.

☞ Open the Unit Scheme Manager by selecting **Units ➥ Unit Scheme Manager...** in the main RiverWare workspace.

The manager appears in a new window with the active scheme shown in pink.

Unit Type Rules

Each unit type listing shows a format example and the chosen units. To change the units for a unit type, highlight the type by clicking on it and changing the settings in the panel to the right. The change will be immediately reflected in the Format Example.

☞ Change the units for Volume to m3 and change the precision to 7.

The units have changed in the Format Example and on slots that have a Volume unit.

☞ Change the units for Volume back to acre-ft with a precision of 2.

Exceptions

Exceptions are used to display specific slots with different units than those defined by the rule. When an object is created, its slots default to the display units set in the rules. An exception can be added in the scheme manager or from within the slot configuration dialog. The unit types that have exceptions are indicated by a small triangle to the left of the name.

☞ Click on the triangle next to **Flow** to see the exceptions.
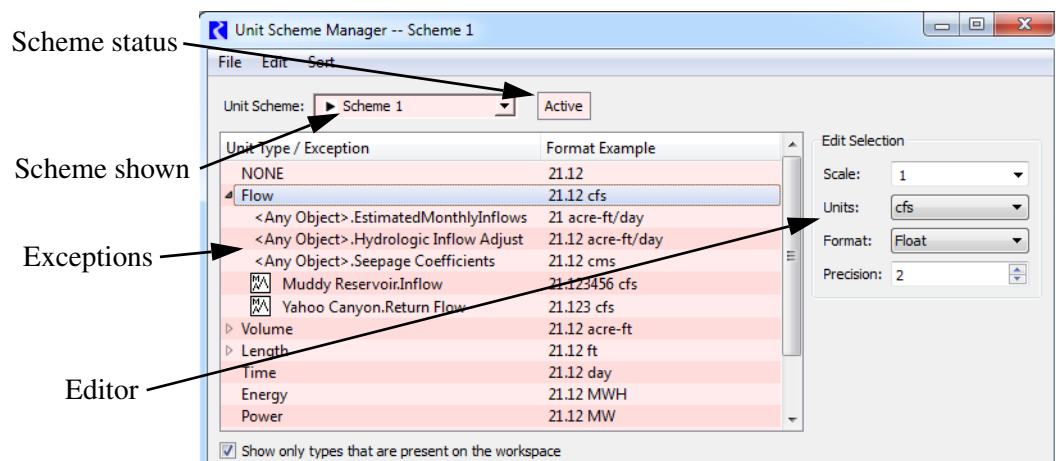
Multiple Schemes
You can have as many Unit Schemes as you need. For example, you may wish to develop a model using cfs, acre-feet, and ft, but you wish to show the model result to international stakeholders who wish to see results in m3/year, 1000 m3, and m.

Internal Units
All RiverWare calculations are performed in internal RiverWare units, generally SI units such as: grams, meters, cms, hours, degrees Celsius, joules, megawatts, etc.

Entering Data

Now let's consider the stream gage object we previously created. We will need to input inflow data. There are many ways to get this data into the slot including: typing, copy/pasting from an external data source such as Excel, and importing a text file.

☞ Open the **Upstream Gage** object.

☞ Open the **Gage Inflow** slot.

Notice that the default units are set to the rule units of cubic feet per second. Our data that we wish to import is in units of acre-ft/day. Let's change the slots units to match the data that we will import
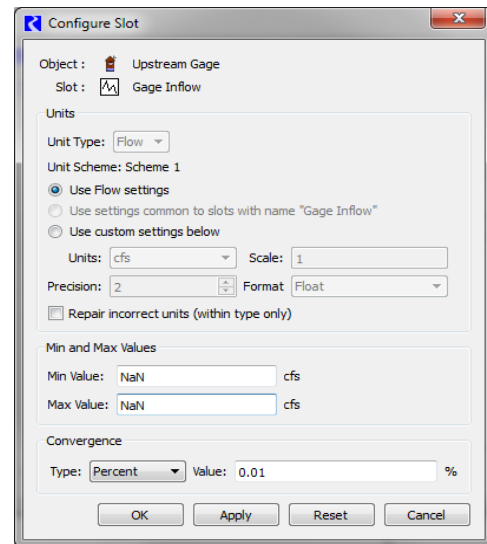
☞ Click on **View ➥ Configure...**

☞ Select **Use custom settings below** and choose **acre-ft/day** from the drop down menu.

☞ Click OK.

Now the user displayed units on our object match the units of the inflow data that we wish to import.

☞ Select **File ➥ Import (Resize)** and from the dialog choose the file:
`UpstreamGage.Inflow`

You have imported data for the series slots. RiverWare marks series slot timesteps with a flag to the right of the value. These flags determine how the simulation will treat the data at each time-step. The most common flags are: O for OUTPUT and I for INPUT. Any user input data is automatically marked with an INPUT flag (I). The values you just imported are considered user input, so they were marked with the I flag. These values are never deleted or overwritten. OUTPUT (O) flagged values were calculated during a previous run or toggled from INPUT status. These values are automatically cleared to NaN at the beginning of a simulation run. This guarantees that no previous solutions remain from one run to the next.

☞ Close the **Gage Inflow** slot.

☞ Open the **Lag Time** slot on **Big River Flats**, click on the cell, type "1" and press Enter.

The reach now has a lag time of 1 day.

☞ Close the **Lag Time** slot and the **Big River Flats** object.

Linking Objects

Let's connect the gage and reach to the rest of the system by linking slots. **Links** connect slots to pass information during a simulation run. They propagate a value from a slot on one object to a slot on a different object.

☞ Select the **Upstream Gage** and **Big River Flats** by holding down Control and clicking on each object in the workspace.

☞ Right click on **Big River Flats** while both objects are selected to prompt a popup menu.

☞ Choose **Smart Linker**.

This utility recommends a set of links between two selected objects based on the type of object, the selected methods, and the relationship between the two objects. The recommended links are not comprehensive, but do cover the most commonly used links in modeling practice.

☞ In the **Smart Linker** dialog, there is a pull down menu that says "Upstream Gage Downstream of Big River Flats". Our gage is upstream of the river, so click the on the pull down menu and choose the reverse orientation.

*The menu should now read "*Upstream Gage Upstream of Big River Flats*".*

☞ Highlight the proposed link and click **Create Selected Links**. Click OK.

On the workspace a black line is drawn between the two objects to indicate the link.
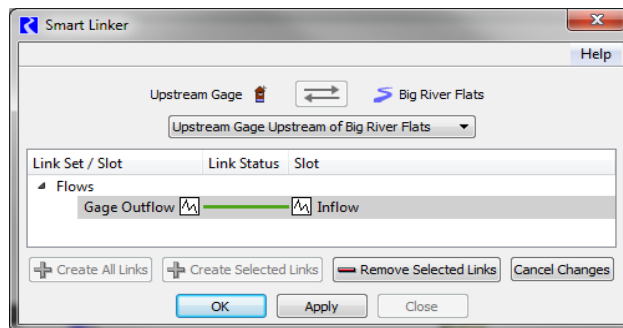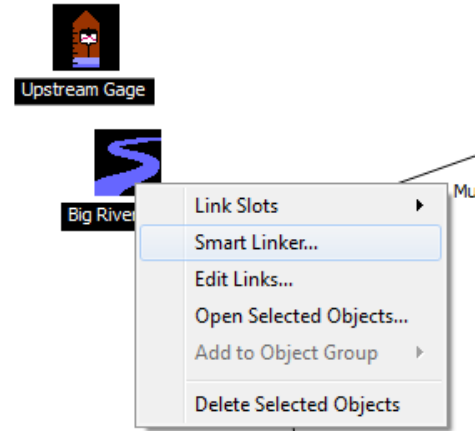
☞ Create another link, this time between **Big River Flats** and **Confluence** by using the same procedure (but do not change the orientation this time- Big River Flats is upstream of the Confluence).

You now have an updated model that uses the input gage flows which are routed through the Big River Flats.

1.8   Running a Model

As we saw in Section 1.2 on page 1-2, The **Run Control** dialog controls the execution of a run, as well as providing the interface for selecting the solution type, timestep, and run times.

☞ Select **Control ➥ Run Control Panel** or by clicking on the Run Control toolbar button.

*The **Run Control** window (which was discussed at the beginning of this tutorial) appears.*

☞ Click on **Start**.

The run finishes.

Close the **Run Status** window and **Run Control** dialog.

How Objects Solve

Reservoir modeling in RiverWare is accomplished using a mass balance approach. The equation for the reservoir mass balance is:

$$Storage_t = Storage_{t-1} + \sum(Inflow \times \Delta t) - \sum(Outflow \times \Delta t) + Gains - Losses$$

The Outflows in the above equation are further expressed as:

$$Outflow = Release + Spill$$

Refinements to the Spill can be made through the Spill Calculation category to specify if the spill is Regulated (controlled) versus Unregulated (uncontrolled). Modifications to the Gains and Losses components may be made through method selections including options to model: Evaporation and Precipitation, Hydrologic Inflows, Bank Storage, Pumped Storage Flow, Seepage, Diversion, Return Flow, and Canal Flow.

Note, The Inflow and Outflow slots contain the average flow during each timestep, while the Storage and Pool Elevation slots contain the values at the end of each timestep. In other words, the flow values are pulse data, while the elevation and storage values are instantaneous data. Values in RiverWare slots are only as precise as the timestep length used to generate them.

Given any two of Inflow, Outflow, or current Storage, the third variable may be solved for when the previous Storage is known. Storage can also be determined from the Pool Elevation. Further, the Release (or Energy) and Spill could be specified (together) to determine Outflow. These solutions are part of the object's **Dispatch Methods**.

Each object in RiverWare has one or more Dispatch Methods. The dispatch methods represent the various combinations of knowns and unknowns which are valid states for solving the object's physical process equations. Each Dispatch Method has a list of Dispatch Conditions, a set of slots with required known values and slots with required unknown values. When the required knowns and unknowns are both satisfied, the Dispatch Method can execute.

Model Run Analysis

The **Model Run Analysis** utility provides diagnostics regarding object dispatching and known values of dispatch slots at every timestep of the simulation.

Two levels of information are provided by the **Model Run Analysis** dialog: at the upper level, the dispatch state of each object for each timestep of the model run is visible in the grid; at a more detailed level, the utility allows you to view the object's dispatch methods and known slot status.

☞ Open the **Model Run Analysis** dialog by selecting **Utilities ➥ Model Run Analysis** or by clicking on the Run Analysis shortcut button on the workspace toolbar.

For a successful run of our simulation, the **Model Run Analysis** dialog will look like this:
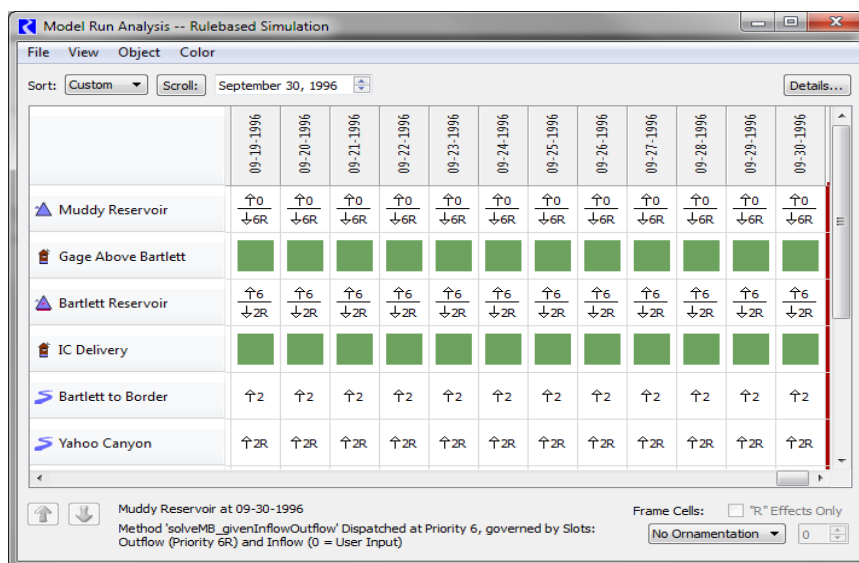
Dispatch State The dialog is a two-dimensional, scrollable matrix with workspace objects on one axis and model run timesteps on the other axis. Each cell in the matrix shows the dispatch state of an object at the indicated timestep. An Object has one of five possible dispatch states:

Object has not dispatched. The known and unknown slots for the timestep did not meet the requirements of any method on the dispatch table for the Object.

Object has fully dispatched with no rule effects. Conditions of a single method on the dispatch table were met; the method dispatched, and the Object solved.

Object has fully dispatched with rule effects. The numbers and arrows indicate the priority (i.e. which rule set a value) of the slots which caused the object to dispatch.

Object has dispatched but not solved. Conditions of a single method on the dispatch table were met; the method dispatched, but the Object did not solve completely. (in yellow)

> Object has no dispatch conditions. The Object has no entries on its dispatch table, the Object has no dispatch conditions (e.g. Gage Object or Thermal Object).

☞ Scroll down the list of object in the run analysis and you will find several things:

- None of the gages have dispatch conditions;
- The Big River Flats object dispatched and solved for all timesteps;
- The reservoirs, diversions, and confluences have number and arrow symbology indicating their solution was driven by rules setting slots.

The model you are working with is set up to operate as a Rulebased Simulation (different than pure Simulation). Future tutorials will address investigating rules.

Dispatch Detail

The **Dispatch Behavior Detail** dialog shows the solution methodology for the selected object and timestep and is accessible from the **Model Run Analysis** dialog.

☞ Double-click on the cell corresponding to **Bartlett Reservoir** on **September 30, 1996** to open the **Dispatch Behavior Detail** dialog.

As you can see, the Bartlett Reservoir solved the mass balance equation (**solveMB**) with two known slots: inflow and outflow (**givenInflowOutflow**). The window lists all the ways this object could have solved if the known values had been different.

☞ Take a moment to scroll through the list of methods.

If we had specified different slots, a different method would have been selected by RiverWare.
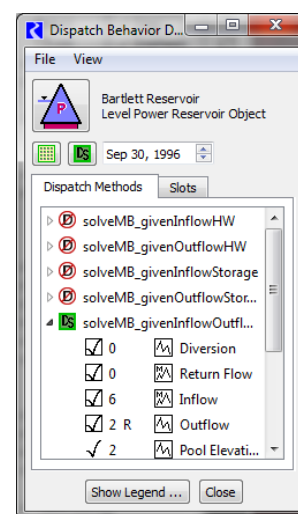
☞ Close the **Dispatch Behavior Detail** dialog and the **Model Run Analysis** dialog.

1.9   Using an SCT

The System Control Table (**SCT**) provides a view of the model with the following features:

- Each SCT can be configured in terms of the slots shown and order.
- There may be more than one SCT open at a time, and each SCT can view the model in different ways.
- The SCT is a spreadsheet view of series data and a list view of other types of slots.
- Slot values can be changed, flags can be set, and plots can be generated directly through the SCT.

Many functions normally associated with running a model have been incorporated into the SCT, enabling it to be a primary interface for interacting with RiverWare under many situations including:

- Models may be opened, run, and saved all from the SCT menus.
- The SCT allows access to Data Management Interfaces (DMIs) to import and export data.

● Optionally show the Diagnostics windows and information for debugging and simulation analysis.

Now let's load an existing SCT, modify it, and use a few of the functions:

☞ Load the SCT by selecting **Utilities ➡ SCT ➡ Open SCT...** or click on the SCT icon. ▦ Choose **MuddyBartlettBasin_Start_SCT**.

The SCT currently has four slots in it:
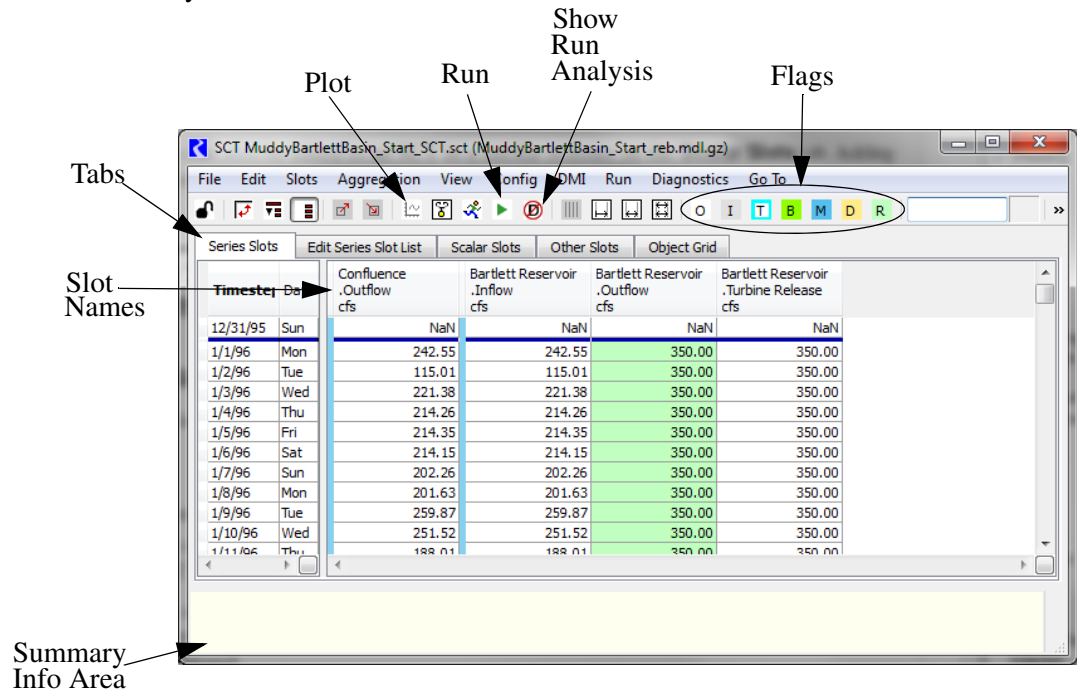
This is a user configured spreadsheet like view of the data. It is currently configure so that each column is slot and each row is a timestep in the run.

Adding Slots

The SCT can be configured to view and edit any of the series slots in the model. You can choose which slots you wish to view and in which order.

☞ If the SCT is locked, click the Lock icon to unlock it.

☞ Click on the **Edit Series Slot List** tab.

This tab provides a list of all series slots. It also provides a convenient place to add, delete, and organize the list of slots. The blue rows represent dividers which are added between objects for viewing and organizational convenience.

☞ Click the **Append ➡ Append Slots...** button.

*The **Slot Selector** dialog appears.*
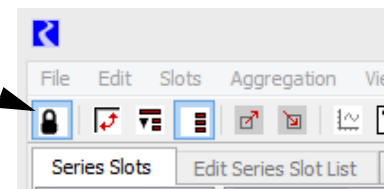
☞ Click the **Divider** button.

This will add a divider between the existing slots and any new slots you add.

The **Slot Selector** dialog box allows you to add multiple slots to the SCT at once. When an object type is selected from the **Object Types** option menu, all objects of that type are listed in the **Object** list. When an object is selected in the **Object** list, all of the slots of the selected object are listed in the **Slot** list. Holding down the Control key and clicking on the desired slots in the **Slot** list allows you to select multiple non-consecutive slots to be added to the SCT.

☞ Select **Reach** from the **Object Types** option menu. Select the **Big River Flats** reach object in the **Objects** list. Finally, select the **Outflow** slot from the **Slots** list.

☞ Click the **Apply** button.

☞ Click the **Divider** button.

This will add a divider between the Reach slot you just added and any new slots.

☞ Select **Reservoir** from the **Object Types** option menu. Select the **Muddy Reservoir** object in the **Objects** list. Finally, hold down the Control key and select the **Outflow** slot and the **Inflow** slot from the **Slots** list.

☞ Click the **OK** button.

*The **Slot Selector** dialog box closes. The new slots appear in the slot list.*

☞ Click **Accept** and resize the window so you can see all of the slots in the SCT.

☞ Save your SCT.
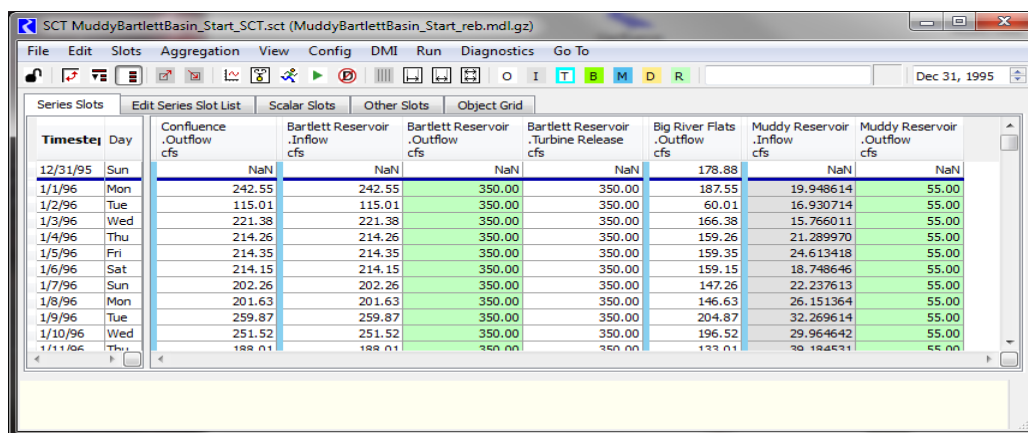
Notice that the **Bartlett Reservoir.Outflow**, the **Muddy Reservoir.Outflow**, and the **Muddy Reservoir.Inflow** slots are different colors; the green represents values that were set by a rule, the gray means the values were user inputs. The white slots are all outputs. These correspond to the flags at the top of the SCT window.

☞ Run the model from the SCT by clicking the Start Run button ▶ .

You see the run progress bar at the bottom of the window and any messages about the run status.

Now, let's plot three slots:

☞ Hold down the Control key and in the SCT select the **Bartlett Reservoir.Inflow**, the **Muddy Reservoir.Inflow**, and the **Muddy Reservoir.Outflow** by clicking on their names in the column headers.

☞ Plot the selected slots by clicking the **Plot** button ⊡ .
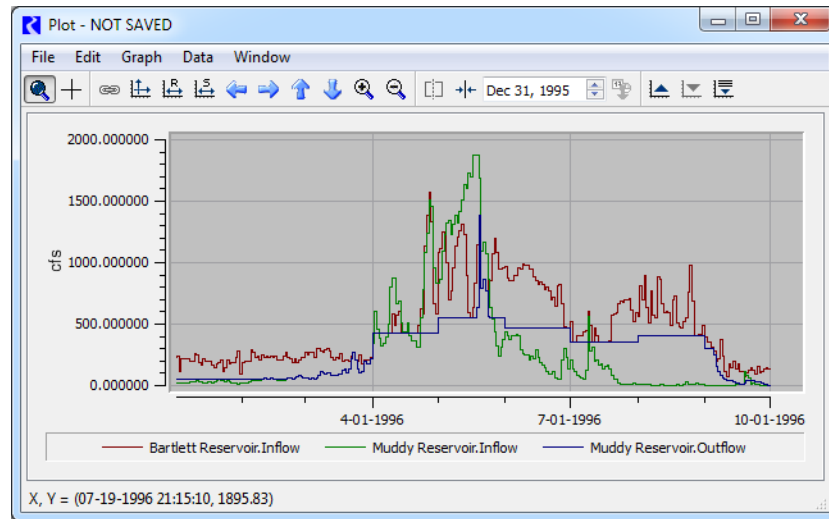
As you can see it is very simple to plot multiple slots for quick visualization of run results.

☞ Close the plot and feel free to experiment with other slot combinations.

Finally, let's open another SCT that shows the data in the model in a different way.

☞ Select **File ➟ Open SCT...** and choose "`MuddyBartlettBasin_Start_monthly_SCT`".

The data that produced this SCT is the same as the data that produced the one you worked with before. Two major adjustments were made:

• The orientation of the rows and columns is switched- now the rows correspond to slots and the columns are dates
• The daily data has been aggregated into monthly values reported at the end of each month using a variety of functions (averaging, summing, and value on the last day of the month).

There are many time scales at which you can summarize data and more functions you can use to report on slots.

☞ Click on the black triangle next to any slot to see the daily data.

☞ When finished investigating all the features of the SCT, close both SCTs.

1.10   Output and Input Options

RiverWare has many ways to import and export data and information about your model. This section will cover two approaches. The first is the Model Report which allows you to create an HTML document describing your model, policy and output data. Then, we describe the Data Management Interface (DMI) which allows you to automatically import or export data from any database. In the example, we will show RiverWare's connection to an Excel workbook.

Model Reports

The Model Report is an output device (within the Output Manager) that generates an HTML file describing the model. The Model Report is flexible with respect to both the contents and appearance of the report, allowing you to configure both the information contained in the report as well as how that information is formatted. Typically, model reports are used to:

- Document the model's table and scalar data, method selection, subbasin configuration etc.
- Document the rules and other policy sets.
- Distribute operating schedules
- Produce water ownership or other accounting reports
- Format other model information that you want to disseminate to stakeholders
- Produce and distribute plots of model results.

☞ Open the **Output Manager** by selecting **Utilities ➥ Output Management...** or by clicking the Output Manager button.

You see the same list of plots that appeared in the plot dialog from section 1.5.

☞ Double click on the **Info Tutorial** Model Report to open the configuration dialog.

Report
Settings

Report
Preview

Report
Layout

Selected
item
settings
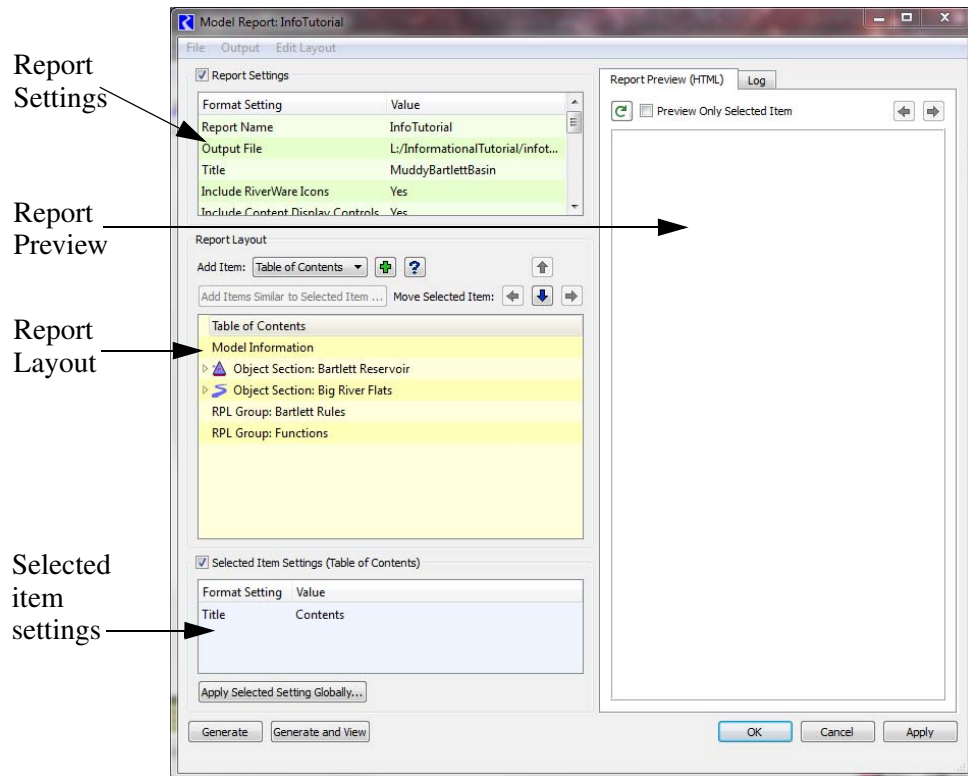
☞ Click on **Object Section: Bartlett Reservoir** in the list of report items and click on the triangle to the left to expend the object section.
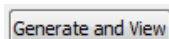
☞ Click on the refresh button on the Preview panel ⟳ .

The entire report appears.

☞ Check the box next to **Preview Only Selected Items.** Then click the refresh button. ⟳

The content changes to several plots and tables, those specified in the list of items in the Bartlett Reservoir Object Section.

☞ At the bottom left of the configuration window, click

[Generate and View] to generate the HTML file (which will be saved to the location specified in the Report Settings) and open the report in your default web browser.

The Table of Contents contains blue links that are shortcuts to the various sections and items contained in the report.

☞ Take a moment to click on the links and explore the report.

DMIs

The RiverWare **DMI**, or Data Management Interface, is a set of tools which allow you to import and export data from a RiverWare model. You can create a connection to any external database. RiverWare has the following types of DMIs:

Firefox

MuddyBartlettBasin   +

file:///L:/InformationalTutorial/infotutorial_modelreport.html

MuddyBartlettBasin

Contents

- 1 🔺 Bartlett Reservoir
- 2 ⤳ Big River Flats
- 3 🅿 Bartlett Rules
  - 3.1 🆁 Bartlett Flood Control
  - 3.2 🆁 IC Delivery
  - 3.3 🆁 Supplement Rafting
  - 3.4 🆁 Supplement Diverters
  - 3.5 🆁 Pass Muddy Outflow for Diverters
- 4 🆄 Functions
  - 4.1 🅵 MaxOut
  - 4.2 🅵 MuddyFloodSeason
  - 4.3 🅵 DiversionShortage
  - 4.4 🅵 ExcessToMax
  - 4.5 🅵 ExcessStorageAsFlow
  - 4.6 🅵 IsRaftingWeekend
  - 4.7 🅵 RaftingShortage
  - 4.8 🅵 BartlettFloodSeason

File Save History

resm1653 06-24-2013 16:21:02 RiverWare 6.3

SimObj Summary

Type	Count
⤳ Confluence	1

- **Control File-Executable**: In the Control File-Executable approach, you develop a **Control File** that specifies the data to move into or out of RiverWare. Also, you develop an external **Executable** which interacts with the control file, RiverWare, and the external database. This approach is the most flexible, but requires you to set up the connection to the database; therefore, it can be more work for the modeler.
- **Database DMI**: The Database DMI supports a direct connection between three databases: the Hydrologic Engineering Center's Data Storage System (**HEC-DSS**), the Hydrologic DataBase (**HDB**), and Microsoft Office **Excel**. In this configuration, all of the slot specification is done within RiverWare using Datasets, Name Maps, and Database DMIs. It is more convenient to setup and maintain, but is limited to the three named databases.

Following are some uses for DMIs. This list is not exhaustive, but will give you an idea of function and flexibility of the utility:

- Importing data to update an operations model with observed or forecasted flows, irrigation demands, energy loads, or other data.
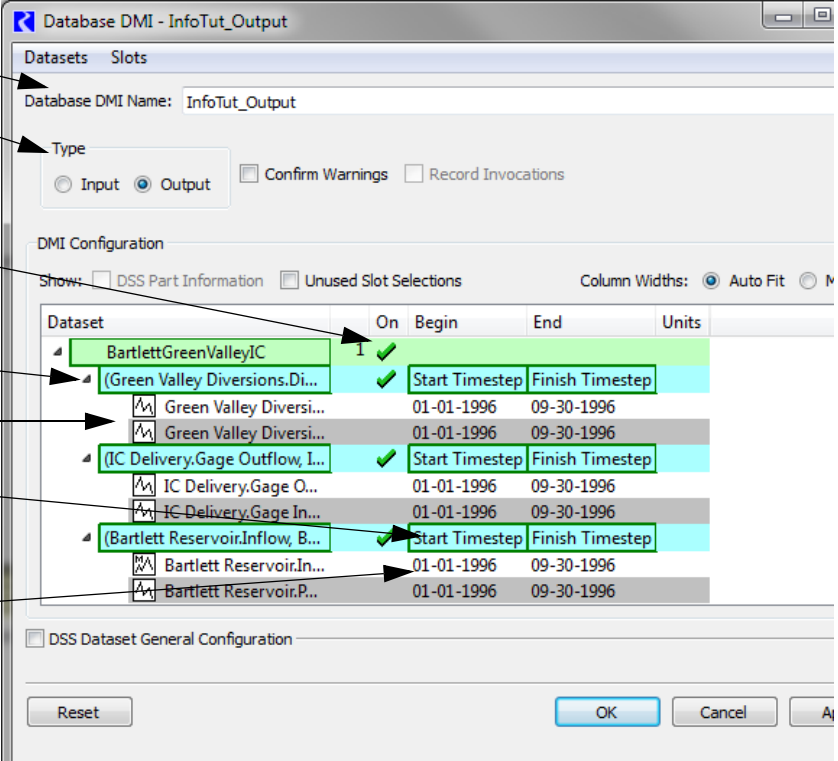
- Importing new hydrologic traces for stochastic climate change analysis as part of a Multiple Run Management.
- Importing new table data as part of a modified reservoir survey
- Exporting flows or reservoir levels that indicate the scheduled releases for some time period.
- Exporting all data from a model for long term official storage of the model run.
- Exporting data that tracks water ownership or use as part of a reporting procedure.

In the following example, we will look at and then run a Database DMI to send (export) some data to an Excel file. Note that you could easily turn the DMI around to become an Input DMI and bring in data from that same Excel file.

Opening a Database DMI

☞ Open the **DMI Manager** by clicking on the icon [icon] at the top of the main workspace or from the **DMI ➡ DMI Manager** menu.

☞ Double click on **InfoTut_Output** to open the pre-built DMI.

To see all the information shown in the above screenshot, click on the triangles next to **BartlettGreenValleyIC** and the resulting blue rows that represent the selection. Below each selection are the slots included in the DMI. You may need to select **Auto Fit** column width to read the full slot names. Notice that above the object and slot listing you see that the specified Type is **Output**.

☞ Double click on **BartlettGreenValleyIC** to examine the settings that govern the Dataset.

The ensuing dialog shows the Dataset name, output file type (Excel), and has options for a name map and units. A **Name Map** allows you to map RiverWare slot names to the names in your database if they are different than the RiverWare slot naming convention.
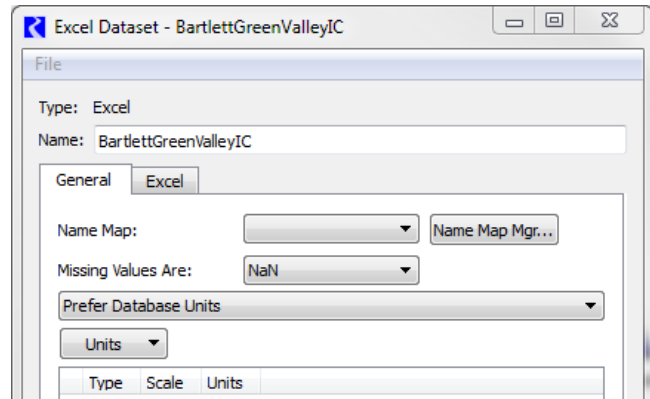
☞ Click on the **Excel** tab.

Here you can specify the location of the Excel file, which will be noted in the **Workbook:** path.

☞ Set the output path and name to something easy for you to find by clicking 📂, entering a path (E.g. `C:\temp\test.xls`) and click **Apply** at the bottom.

This tab also has panels to control mapping and orientation of the data, which is especially useful for Multiple Run Management (**MRM**s).
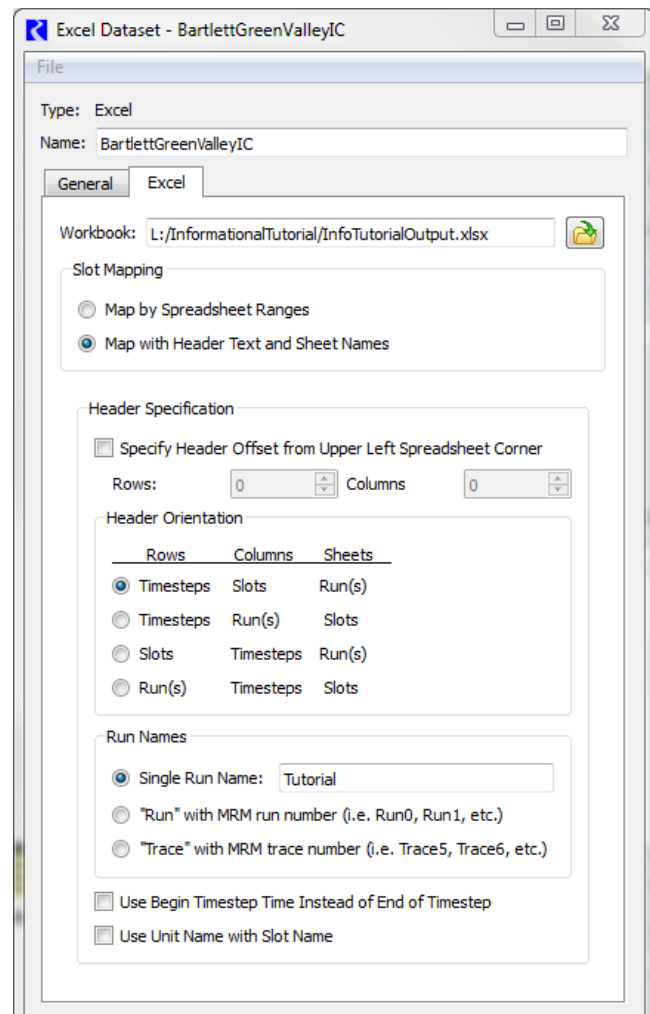
☞ Close the Dataset and DMI windows.

Running a DMI

Now let's generate the Excel file and examine the date:

☞ In the DMI Manager dialog, select the **InfoTut_Output** and click ▶ .

☞ Locate the Excel file you specified and open it.

The output DMI has the chosen slot values for each timestep of the simulation, one column per slot. As you saw in the above screenshot, you could have specified a different orientation for the data. For example, the slots could have been rows and the timesteps could be on the columns.

If you have a lot of data to import for several slots and/or several objects, an easy way to do so is to create and run an output DMI like this to get the correct excel formatting. Then modify the data in the generated Excel file and change the DMI setting to be **Input** on the DMI dialog and re-run. All the data will be imported to RiverWare at once.

As you can see, this is a very simple DMI to show an example of how to write data into or out of the model. The process is similar for more data and for other types of databases.

1.11   *Saving and Exiting RiverWare*

There are three ways to save a model in RiverWare, the default **Save**, **Save As... and Save As Baseline...** The default **Save** command re-saves the current model with the same name and in the same directory as it was last opened or saved. The **Save As...** allows you to save the model to a new file name. The **Save As Baseline...** is used to create an unalterable baseline model for generating alternate simulation scenarios with the **Scenario Manager**.

☞ Select **File ➤ Save As...** from the main workspace menu bar.

   *A **Save Model File** Chooser appears.*

☞ Specify the name of a file and click OK.

   *A **Confirm Save Model As** dialog appears. The ".mdl" is often used to identify a file as a model file. The ".gz" automatically compresses the file to save space.*

☞ Select the **Save Run Results** checkbox.

   Output values will be saved.

☞ Click on the **Save Model** button.

   The model is now saved.

☞ Exit RiverWare by selecting **File ➤ Exit RiverWare** and clicking OK in the confirmation dialog.