Technical Documentation Version 7.3

Slots

Center for Advanced Decision Support for Water and Environmental Systems (CADSWES)

UNIVERSITY OF COLORADO **BOULDER**

Slots
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Slot Dialogs

Slots are variables, or the primary data storage containers on an object. In the **Object Viewer** (or **Open Object)** dialog, the slot list shows all of the data that "resides" on the object. This includes both required input data, calculated output timeseries data, input tabular data, and input coefficients for the various physical process calculations. The list of slots may change depending on the user methods that are selected and/or when custom slots are added. The distinction is:

- **Simulation slots** are a part of the simulation object as either general slots or through a user method. The names of Simulation Slots are pre-determined by the object and cannot be changed. Simulation slots have a white background in the icon. 
- **Custom slots** are created by the user on a simulation or data object. Custom slots have a pale yellow background on the icon. 

1. Slot Dialogs

The data for a particular slot is shown in either the **Slot Viewer** or the **Open Slot** dialog. Both dialogs are introduced in the following section:

1.1 Opening a Slot

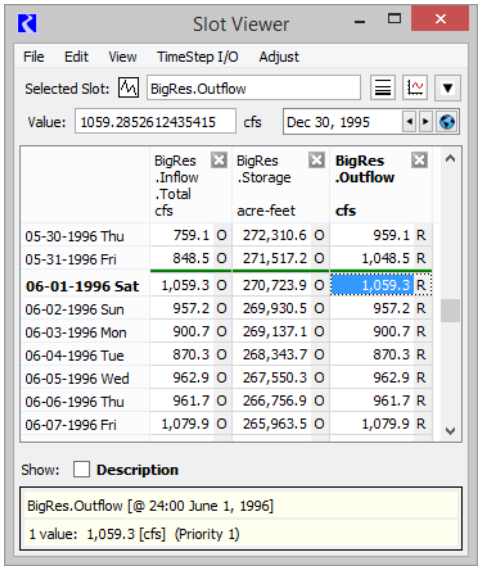
To open a slot:

- in the **Object Viewer (or Open Object)** Slots or Methods tab
  - double-click on the slot's row name
  - right click on a slot's row and use the **Open Slot...** context menu
  - highlight a slot's row and select **Slot ➥ Open Slot** from the command menu bar
  - highlight a slot's row and use the Ctrl-O accelerator
- from the main workspace, use the **Workspace ➥ Slots ➥ Open Slot** menu.

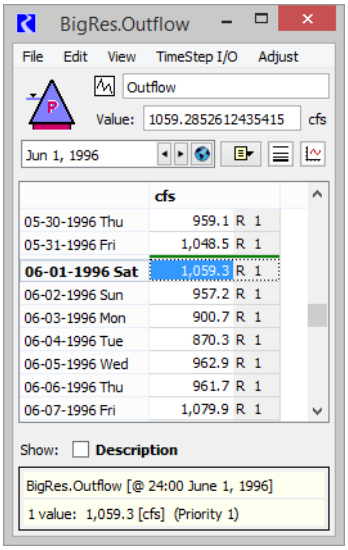
1.2 Sample Slot Dialogs

When you open a slot, the dialog that opens depends on the slot type. Following are some sample slot dialogs:

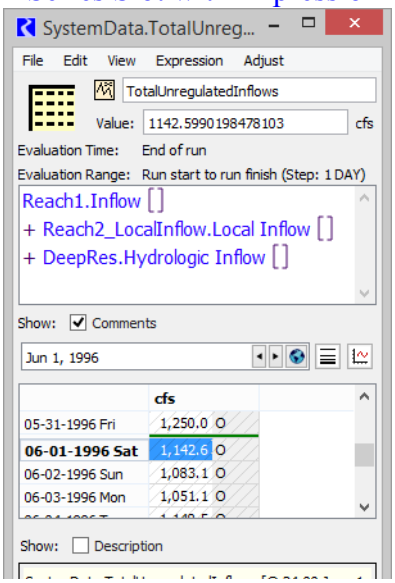
Slot Viewer



Open Slot: Series Slot



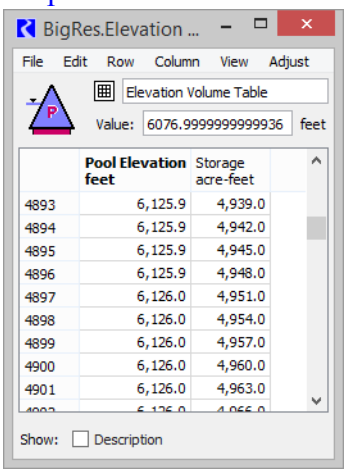
Open Slot:
Series Slot with Expression



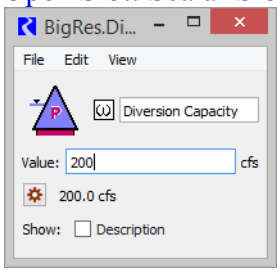
As you can see, the series slot dialogs look similar. Note, that most series slots will open in the Slot Viewer (**HERE (Section 4.1.2)**) to show the data. You can drag the column off the viewer to see the slot.

Below are sample Table, Scalar, and Periodic slots:

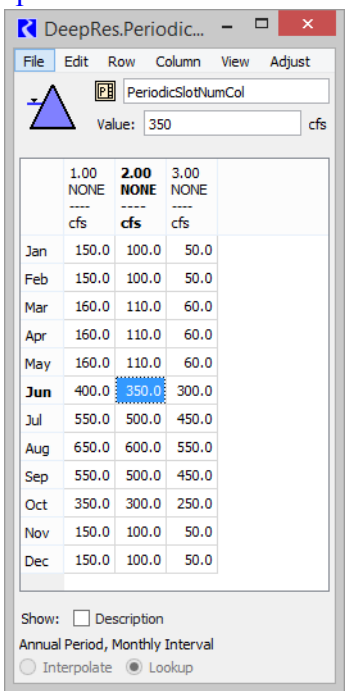
Open Slot: Table Slot



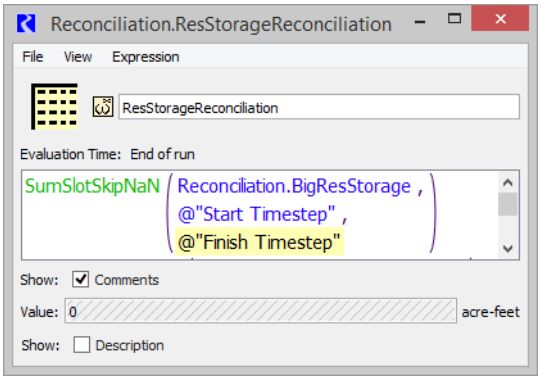
Open Slot: Scalar Slot



Open Slot: Periodic Slot



Open Slot: Scalar Slot with Expression



Again, you can see the similarity in the various slot dialogs. As a result, this document will present general slot functionality and then describe slot specific functionality.

1.3 Closing a Slot

To close an **Open Slot** dialog,

- select **File ➥ Close Window**
- press Control-W when the window is active
- click on the red "X" button in the upper right corner of the dialog
- double click the white icon in the upper left corner of the dialog
- from the main workspace, use the **Workspace ➥ Slots ➥ Close All Slots** menu item to close all Open Slot dialogs.
- from the Slot Viewer, click the x on the slot's column.

2. Slot Dialog Functionality

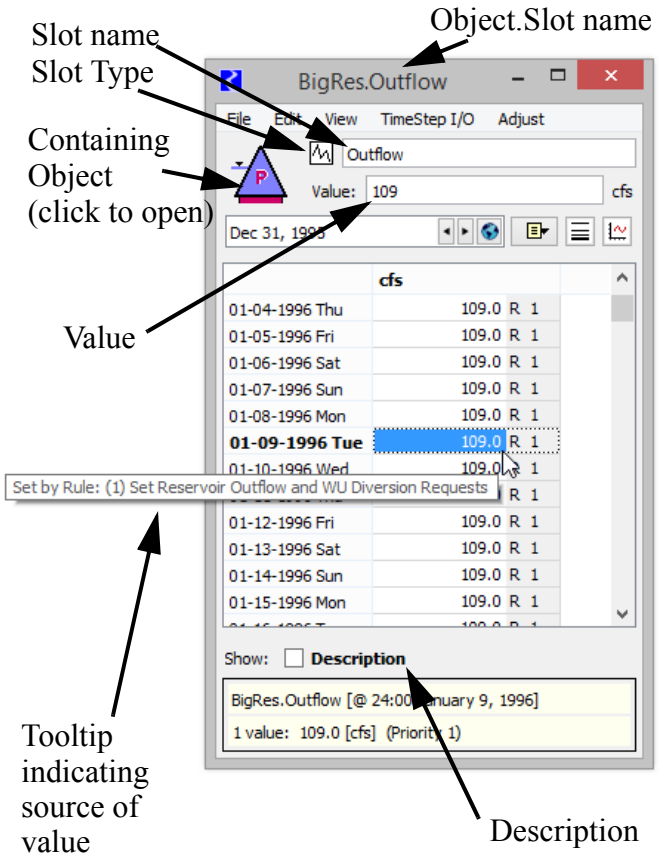
A sample **Open Slot** dialog for a series slot is shown to the right. Although other types of slots have different options, most of the slots have similar menus, look, and feel.

Functionality is essentially the same for either the **Open Slot** or the **Slot Viewer** HERE (Section 4.1.2)

This section first describes the general **Open Slot** layout and menu options. Then each individual type of slot is presented later with further information on type specific configuration options.

The open slot contains the following:

- The title of the Open Slot dialog is the Object.Slot name.
- The slot name is repeated in a text field below the menu bar. On custom slots, you can change the name of the slot by editing this text field.



Note: If you are renaming a custom slot whose old name appears in RPL sets, a dialog asks if you want to search RPL sets for the old name

and optionally replace occurrences with the new name. Answering **yes** will bring up the RPL Search and Replace dialog with the results of a search for the old name in all RPL sets and with the new name filled into the **Replace with** field. You can examine the occurrences and choose to replace some or all of them with the new name.

- The type of slot is displayed by an icon. Click **HERE (Section 4)** for a list of the icons.
- The containing object's icon is shown. Clicking on this icon will open the object.
- The **Value** field shows up to 15 digits of precision of the highlighted cell and the units. The user can type a value directly in here or in the cell.
- Tool tips on the cells indicate the rule or DMI that set or triggered a solution as described **HERE (Toolt-ips)**.
- The **Description** checkbox shows a text description of the slot. Click **HERE (Section 2.2)**.

2.1 Menus

Following is a general description of the menus for the open slot dialog and how it is used. Detailed description of each type of slot is presented **HERE (Section 4)**.

2.1.1 File Menu

The functionality available from the File menu depends on the slot type. In general, this menu is used to:

Import (fixed or resize) and Export (display or model precision): Large sets of data may be imported into, and exported from the Open Slot dialog. Exported data are written to a text file in tab-separated format. Imported data may be tab or space-separated. Exported values are written in the display units and either the precision currently specified in the **Open Slot** dialog (**Display Precision**) or the entire internal precision (**Model Precision**) Likewise, imported data are assumed to be in the same units as the **Open Slot** dialog. The entire precision of an imported value will be preserved, although only the selected display precision is shown. **Import Fixed Size** truncates incoming data if the data file contains more rows than the slot, and leaves existing data if the data file contains fewer rows than the slot. **Import Resize** automatically resizes the slot to match incoming data.

Plot: Open a new plot with the given slot.

Print Expression: On expression slots, print the expression.

SCT: Add the series slot to an existing SCT or create a new SCT with the slot.

Show Workspace: Bring the workspace to the top of the screen.

Close Window: Close the window.

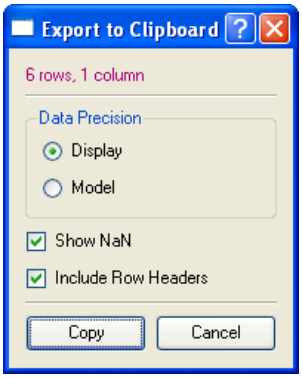
2.1.2 Edit Menu

The Edit menu is available on series, table, periodic and list slots and is used to change the number of rows or columns, and to change values in the slot.

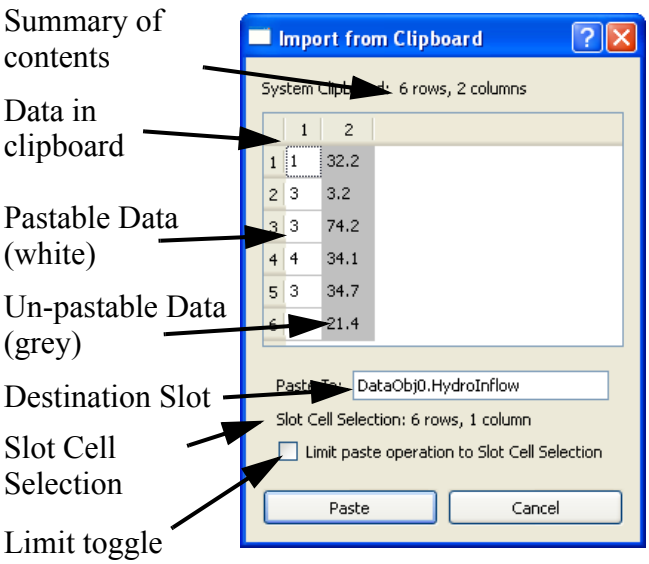
Cut/Copy/Paste: There are options to cut/copy/paste data from the highlighted cells. These use an "internal" clipboard and cannot be copied or pasted from other applications. See the Export Copy and Import Paste options below to use the system clipboard.

Paste as Input: Paste from the internal clipboard and set the Input flag.

Export Copy: The **Export Copy** menu option is used to export the selected data to the operating system's clipboard for use in other applications, like Excel. When the user clicks this option, an **Export to Clipboard** dialog opens as shown to the right. This dialog allows the user to choose the precision, either **Display** or **Model**, whether to **Show NaN** (or copy them as blanks) and whether to **Include the Row Headers**. It also provides information on the number of rows and columns that will be exported. Clicking **Copy** adds the selected data to the operating system's clipboard while **Cancel** stops the operation.

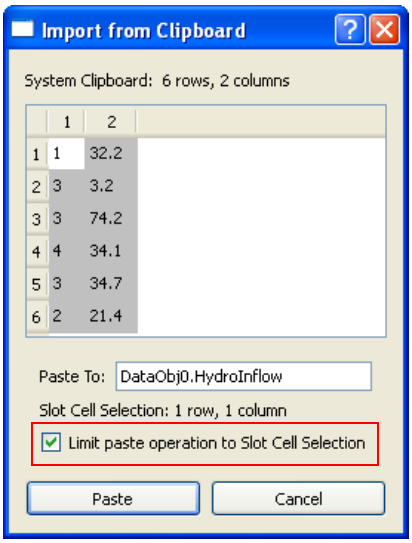


Import Paste: The **Import Paste** menu is used to paste data from the operating system's clipboard into the slot. For example, the user can copy a selection of cells from Excel or a column of data from a text file and **Import Paste** it directly into the slot. After copying the data, the user selects one or more cells of the slot and then selects **Import Paste**. An **Import from Clipboard** dialog similar to the following is shown. This dialog displays the contents of the system clipboard and provides options and information on the paste operation.



The contents of the clipboard will show pastable data (white) and un-pastable data (grey). Data is un-pastable if it does not fit in the content of the cell selection. For example, if the data in the clipboard has multiple columns and the cell is a single series slot, the second column of data is un-pastable as shown in the above screenshot.

Also, the user can choose to **Limit paste operation to Slot Cell Selection** using the check mark toggle. This limits the paste to only affect those cells in the slot that were selected. This selection is shown in the **Slot Cell Selection** line. For example, if only one cell in the slot is selected, but the clipboard contains two rows of data as above, all but the first cell are greyed out. In this example, shown to the right, only the value of 1 will be pasted. If the number of values in the clipboard is larger than slot selection, but the limiting operation is not checked, the paste will import all data and will add the necessary rows to the slot. Note, an import will not add columns to the slot.



Insert/Append/Delete: The Edit menu contains options to Insert, Append, and/or Delete rows or columns from the slot, depending on the type and use of the slot.

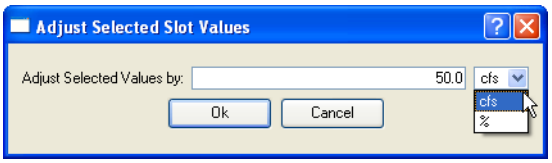
Clear All Outputs: On series slots, this option can be used to clear all the Outputs. Note, all outputs are cleared at the beginning of a run.

Fill Values Below: The Fill Values Below option is used to copy and paste the selected cell to all rows below. This will overwrite any existing data after the confirmation menu is clicked.

Replace NaN's Below: The Replace NaNs Below option is used to replace only NaN with the selected values. Any existing data will not be overwritten.

Interpolate: The Interpolate option is used to interpolate between two known values within a column. It only works on a selection when the first and last value in the selection have values. The option will interpolate between the two values and change all the values to have the Input flag.

Slot Adjust Values: One or more values selected in a slot can be adjusted using the "Adjust Values..." item available from the Edit menu of slot dialogs. When the user selects "Adjust Values..." RiverWare opens a modal Adjust Slot Values dialog which allows the user to provide the amount by which the selected slot values should be adjusted.



Values may be adjusted by a percentage, or if all of the values have the same units, by a fixed increment in user units. After entering the adjustment value the user then applies that value to the selected values by selecting the "Ok" button or cancels the operation by selecting the "Cancel" button.

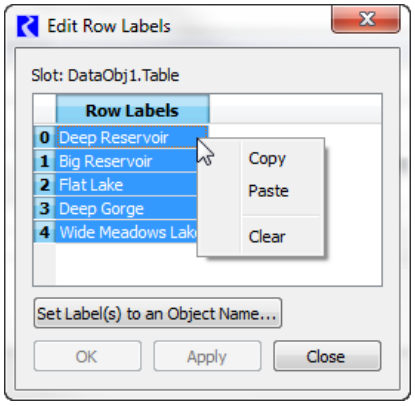
The adjustment is equal to adding a certain amount to the existing value(s) or multiplying by a percentage. The user may specify a positive or negative quantity. Note that the percentage option increases the existing amount by adding a specified percentage of that amount.

For example if the values 10.0 and 100.0 acre-ft/month are selected and the user enters 10 acre-ft/month into the Adjust Slot Values Dialog and selects “Ok”, then the values will be changed to 20.0 and 110.0. If the user enters 10%, the values will be changed to 11.0 and 110.0.

Note that it is easy to select all cells in a column by clicking on the header for that column.

2.1.3 Row Menu

On table and periodic slots, the **Row** menu is used to configure the rows.

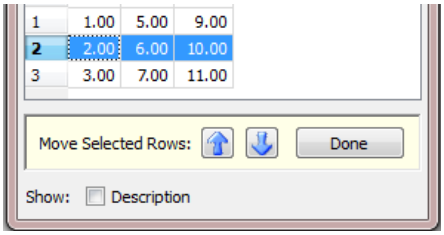


Edit Row Labels: Change the Row Label. All row labels can be configured at once in the dialog. The labels can also be set to object names using the **Set Label(s) to an Object Name** button. Use right click context menus to copy and paste from the system clipboard.

Insert Copied Rows: Insert Copied Rows from the internal clipboard

Insert New Row: Insert a new row after the selected row

Append New Row: Append a new row at the bottom.



Move Rows: The **Move Rows** menu opens a panel at the bottom of the dialog which allows you to move the selected row (or multiple selected rows) up or down. When finished, click the **Done** button. This option is only available on custom table slots.

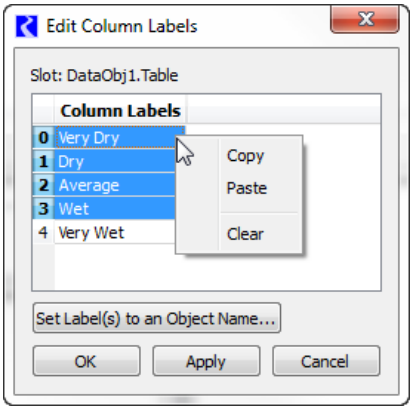
Delete Rows: Delete the selected rows

Delete Rows Below: Delete all rows below the selected row

2.1.4 Column Menu

On some table and periodic slots (such as on custom slots), the user can add or delete columns to the table. The Column menu is used to do this and change column labels.

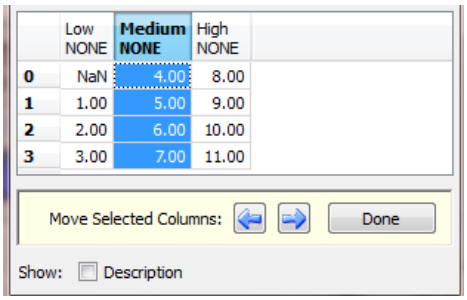
Edit Column Labels: Change the Column Label. All column labels can be configured at once in the dialog. The labels can also be set to object names using the **Set Label(s) to an Object Name** button. Use right click context menus to copy and paste from the system clipboard.



Set Number of Columns: Set the number of columns.

Append Column: Add a column to the end.

Move Column: The **Move Column** menu opens a panel at the bottom of the dialog which allows you to move the selected column (or multiple selected columns) to the right or left. When finished, click the **Done** button. This option is only available on custom table and periodic slots.



Delete Column and Delete Last Column: Delete the selected column or last column, respectively.

Set Dimensions: Set the number of rows and column on the slot

2.1.5 View Menu

2.1.5.1 Slot Configuration Dialog

Following is a description of the general configuration menu. Detailed information is presented **HERE (Section 4)** for each slot type.

The **Configure Slot** dialog is invoked by selecting **View ➥ Configuration** in the Open Slot dialog. Depending on the type of slot opened, the dialog could appear a slightly different. For example, the portion of the dialog showing the **Upper Bounds** and **Lower Bound** is only displayed for Series Slots.

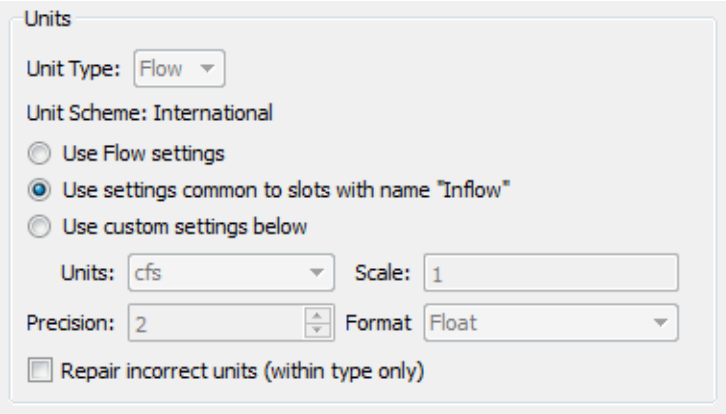
> **Note:** To configure **Bounds** or **Convergence** on multiple slots at one time, use the Configure Existing Slots dialog described **HERE (Section 3)**.

Values are Integers: The **Values are integers** checkbox allows you to specify that values in this slot are in fact integers and should be shown as such. When checked, the precision is set to 0 and cannot be changed. Some slots associated with object's methods have this toggle checked and cannot be changed.

Units: Units (Unit/Scale/Precision/Format) are controlled by the Unit Scheme (described **HERE (Units.pdf, Section 2)**) which presents a comprehensive view of how numeric values are displayed in RiverWare. The units on slots are therefore controlled by the Unit Schemes. But you can configure the

units via exceptions in the Unit Scheme Manager or from the slot itself. This section describes the configuration options on the slot. Exceptions are described **HERE (Units.pdf, Section 2.3.2)**.

The **Configure Slot** dialog lists the unit type and the active scheme. On custom slots, you can change the unit type. On simulation slots, the type is fixed. You can then choose one of the options:

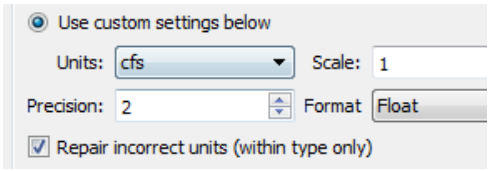


- **Use Flow settings**: use the Unit type rule, i.e. use the generic setting associated with that unit type.
- **Use settings common to slots with the name "Inflow"**: Use a previously configured unit name exception that defines how slots with the same name should be displayed.
- **Use custom settings below**: modify the units for just this slot. When you do this action, you are actually creating a **Slot Exception** for that slot within the currently active Unit Scheme. After making the change in the slot's configuration, you can go to the unit scheme and see that exception.

As you change the selection, the unit settings for that toggle are shown in the Unit/Scale/Precision Format areas.

> Note: **Show Commas in Numbers -** On slots, commas are shown by default as a thousands separator. This is a global setting that is specified from the **Workspace ➥Show Commas in Numbers** menu on the workspace. More information is provided **HERE (Workspace.pdf, Section 5.8)**.

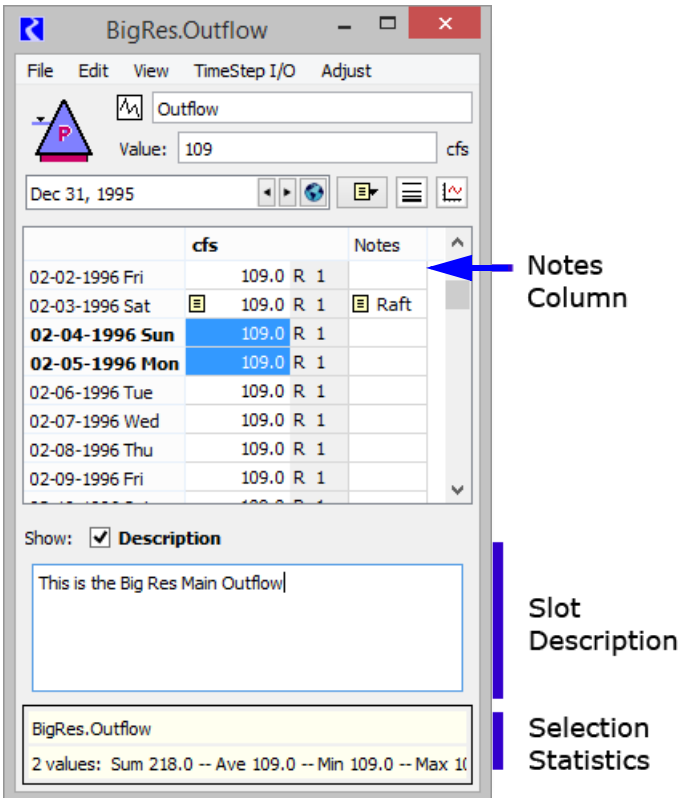
Repairing incorrect Units of Slot Values: Sometimes you enter values into a slot (by typing or importing) but then realize that the slot's display units were not what you expected. For example, you want to enter 100cfs into a slot so you type it in. But, then notice the slot is showing the flows in cms, when you meant to enter them in cfs. So now the slot has a value of 100cms = 3531.5cfs. How do you fix this without re-entering the values?



To change the display units without changing the value displayed, you change the slot's units from the slot using the **View ➥Configure...** menu. Configure that you wish to use custom settings, then change the units. Check the **Repair incorrect units (within type only)** box. When you apply the change and the confirmation dialog, the units will change, but the displayed values will not. This feature can be used to correct data which were accidentally imported or entered with the wrong display units selected. Great care should be exercised when using this feature, so as not to corrupt data.

2.1.5.2 Slot Dialog Display Preferences

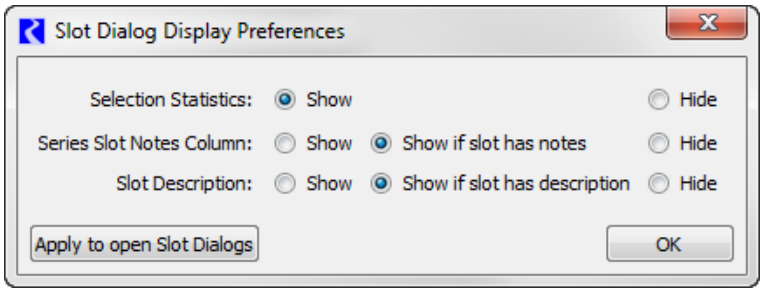
Slot dialogs have setting that allow you to configure which features are visible when the slot is opened. This allows you to specify if you want to see **Selection Statistics**, **Description**, and/or the **Notes** column. This section describes the preferences, saved with the model, which are applied each time a slot dialog is opened. Not that these are strictly preferences, you can still show or hide each feature using the controls or menus.



Accessing the Preferences: The **Slot Dialog Display Preferences** is accessible from two places:

- From the main RiverWare workspace, use the **Workspace ➥ Slots ➥ Slot Dialog Display Preferences** menu.
- From the slot dialog, use the **View ➥ Slot Dialog Display Preferences** menu.

Settings: The preferences dialog consist of the following three items:



- **Selection Statistics**: **Show** or **Hide**. Currently, **Selection Statistics** are supported only on series slots.
- Series Slot **Notes Column**: **Show**, **Hide** or **Show if slot has Notes**.
- **Slot Description**: **Show**, **Hide**, or **Show if slot has description** provided by the user.

As an added feature, the preferences can be immediately applied to all currently open slot dialogs by clicking the **Apply to open Slots Dialog**.

> **Note:** When a series slot opens in the Slot Viewer, the preferences are applied to the first slot. If that slot has a description and the preferences say to "Show if slot has description", the Description panel will be shown. But if the next slot shown doesn't have a description, then the Description panel will remain open.

2.1.5.3 Go To Next NaN

The **View ➥ Go To Next NaN** menu navigates to the next NaN (Not A Number) in the slot. The search always goes first down the column (timesteps), then through the subsequent columns.

An accelerator key combination **Ctrl + Shit + N** also executes the search.

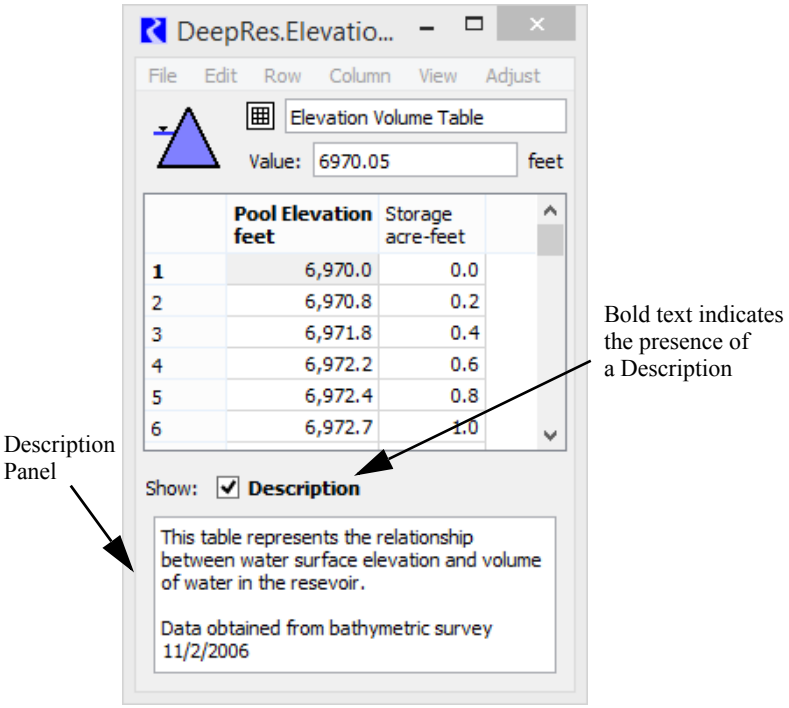
2.1.6 Adjust Menu

The Adjust menu, available on series and table slots, is used to change the display size of the columns in the slot. Users can manually resize columns by dragging the dividers between the column headers. The following five operations are also available in the Adjust menu:

- **Set Column Widths**: set all data columns to the width of the single selected column.
- **Grow Columns to Fit Data**: expand (but don't shrink) the columns to fit the widest numeric value displayed in the corresponding columns.
- **Fit Columns to Data:** resize all of the data columns to fit the widest numeric value displayed in the corresponding columns.
- **Fit Columns to Headers and Data:** resizes all of the data columns to fit the larger of the text in the corresponding column headers or the widest numeric value displayed in the corresponding columns.
- **Fit Columns to Headers:** resizes all of the data columns to fit the text in the corresponding column headers.

2.2 Slot Descriptions

On all slots, you can specify a text description. The description is accessed from the **View ➥ Add (or Show) Description** menu or though the **Description** checkbox. When this option is selected, a panel is added that provides a text box in which you can type the description. For a table slot, the dialog would then look similar to the following screenshot

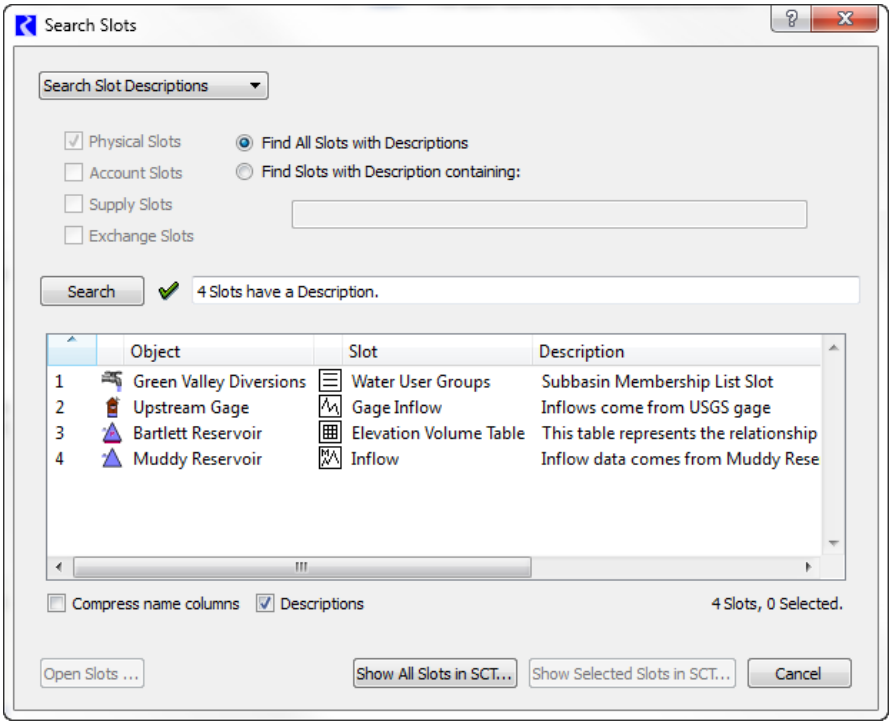


When there is a description, the word **Description** is bold in the dialog. If there is no description, the word Description is slightly gray.

You can also mouse over the word Description to get the first 140 characters of the description as a tool-tip.

Note: You can configure your preferences on whether or not to show Descriptions using **Slot Dialog Display Preferences** described **HERE (Section 2.1.5.2)**.

The **Search Slot Descriptions** utility can be used to find slots that have a description and/or slots that have a specific keyword(s) in their description. It is accessed from the RiverWare Workspace using the: **Workspace ➥ Slots ➥ Find Descriptions...** menu. The dialog shown to the right opens.



In this dialog, you can:

- **Find All Slots with Descriptions** - find any slot that has a description.
- **Find Slots with Descriptions containing** - find slots that have descriptions that contain the specified text. The search is not case sensitive.

You can limit the search to the specified types of slots including physical, account, supply or exchange slots. When any of the search input controls are changed, the Green Check icon turns into a Red “X”, and the search summary description is grayed out. Click the **Search** button to perform a new search.

This dialog has a **Descriptions** checkbox below the slot list. Turning on this checkbox replaces several slot attribute columns with a **Descriptions** column showing up to 150 characters of each Slot's description.

Turning on the **Compress name columns** checkbox replaces the distinct columns for object name, Account name and Slot name with a single “complete” slot name column.

Several context menu (right click) operations are available within the slot list:

- Open Slot -- Show the open slot dialog for the chosen slot item.
- Open Object -- Show the object dialog for the chosen slot item (if applicable).
- Copy Slots -- Put the selected slot items into the slot clipboard, e.g. to paste into an output (manager) device slot list.

Buttons along the bottom of the dialog provide these functions:

- **Open Slots**: Separate open slot dialogs are shown for each of the selected items in the list. If more than four (4) slots are selected, then a query dialog box is shown confirming the operation with a message like this: “Do you want to show 421 Open Slot dialogs?”. Note that all shown open slot dialogs may be hidden with the **Workspace ➥ Slots ➥ Close All Slots**... menu operation.
- **Show All Slots in SCT**: All slots in the list (regardless of item selection) are shown in a new SCT dialog, and the dialog is closed.
- **Show Selected Slots in SCT**: Selected slots in the slot list are shown in a new SCT dialog, and the dialog is closed.
- **Cancel**: The dialog is closed.

The dialog can also be used to find input values on series slots as described **HERE (Section 4.1.7)**.

2.3 Creating and Configuring Slots

Custom slots can be created on any type of object (except snapshot data objects). You can create various types of series, tables, periodic tables, statistical tables, scalar and expression slots. Click **HERE (Section 4)** to view a description of each type of slot. The user is NOT able to create Multi Slots, Table Series Slots or List Slots.

The main menu bar on the **Object Viewer (or Open Object)** dialog has a **Slot** menu (or in the context-sensitive menu activated by right-clicking in the slot list area) which contains commands to:

- **Add Series Slot**
- **Add Series Slot with Expression**
- **Add Integer Indexed Series Slots**
- **Add AggSeries Slot**
- **Add Integer Indexed AggSeries Slot**
- **Add Series Slot with Periodic Input**
- **Add Table Slot**
- **Add Statistical Table Slot**
- **Add Periodic Slot, Text Headers**
- **Add Periodic Slot, Numeric Headers**
- **Add Scalar Slot**
- **Add Scalar Slot with Expression**
- **Add Mass Balance Summary (HERE (Section 4.16.1))**
- **Add Time Aggregation Series Slot**

After the slot is created, the following steps should be taken:

1. Open the newly created slot by double clicking it.
2. Rename the slot by typing directly in the Name field.
3. Use the configure menu option (and the subsequent dialog) to set the unit type, display format, and convergence criteria.

4. On series, consider revising the time series range, if necessary, prior to adding data into the series. On table slots, consider setting the number of rows and columns and changing the row or column labels.

On non-aggregate objects, slots can be organized into user defined groups. More information on this utility is presented **HERE (ObjectDialogs.pdf, Section 2.2.5)**. In addition, slots and groups can be copied and pasted to other objects. This action is described in detail **HERE (ObjectDialogs.pdf, Section 2.2.7)**.

Global Slot Configuration

3. Global Slot Configuration

The **Configure Existing Slots** utility enables you to configure the following parameters on multiple slots at once:

- Convergence
- Unit Type for Custom Slots
- Upper and Lower Bounds on Series Slots
- Upper and Lower Limits for Table Verification

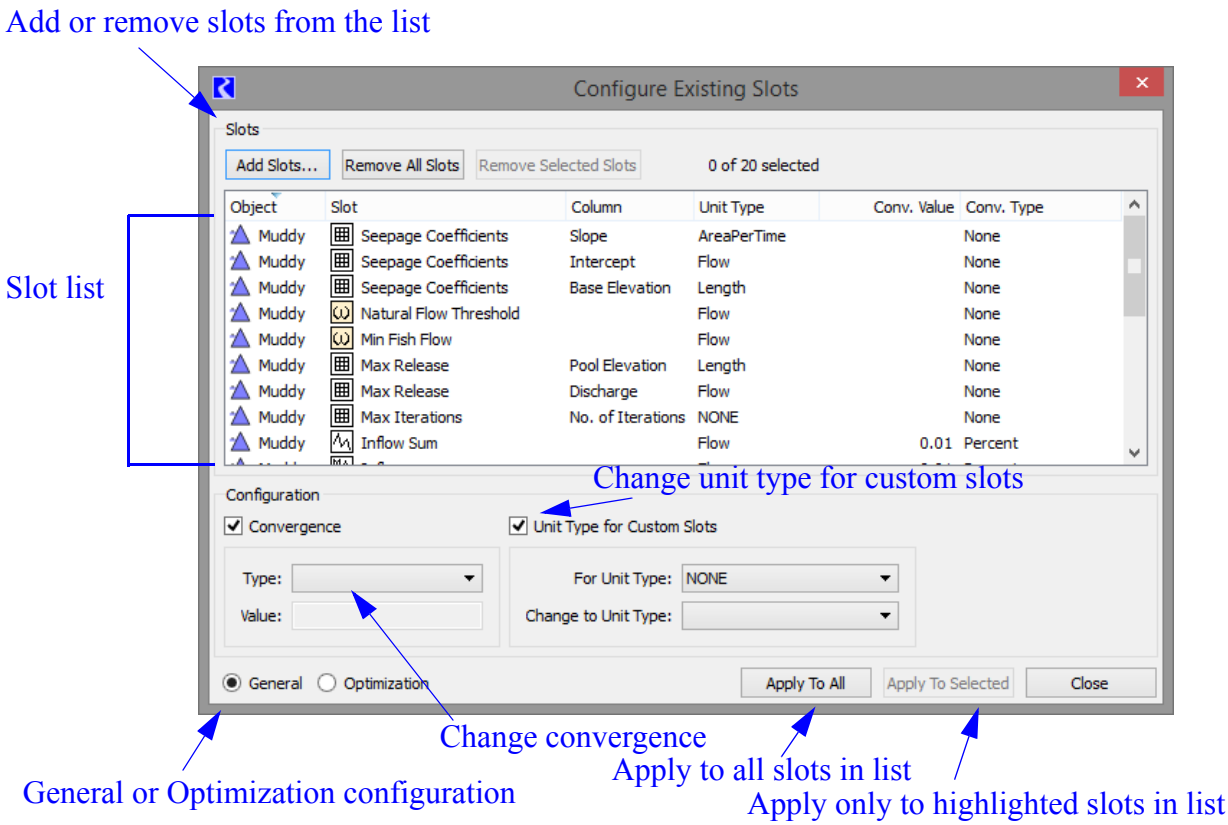
Note: Configuration settings such as **units**, **scale**, **format** and **precision** are set through Unit Schemes as described **HERE (Units.pdf, Section 2)**.

Note: The slots available do not include accounting slots as accounting slots are configured from the Open Account dialog.

To access the **Configure Existing Slots** dialog, click the **Workspace ➥ Slots ➥ Configure Slots** menu item from the main workspace dialog in RiverWare. The dialog is used in the following general sequence:

- Add slots to the list
- Select one or more of the slots from the list
- Select new bounds or convergence. Or, change the unit type custom slots.
- Apply the changes to all or selected slots.

These steps are described in the following sections. Changes are immediate and are reflected in the dialog. Changes only apply to relevant slots, e.g. changes to convergence only apply to slots that have convergence (i.e. Series Slots). Below is a screenshot of the dialog with the main areas noted.



3.1 Selecting Slots

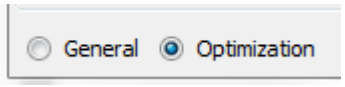
Add the slots you wish to change to the slot list by clicking the **Add Slots** button. This opens RiverWare's slot selector. Click **HERE (Selector.pdf, Section 3)** for more information on using the selector. The selector can be used to add all or a subset of the existing non-accounting slots in the current model.

After making a selection of one or more slots, those slots are added to the list. These slots, or a subset, are the slots you wish to modify. Note that if a slot has multiple columns that can be configured independently, an entry is created in the list for each column. For tables where data in any column must have the same units, only one list item is shown. If some configuration item, like convergence, is not applicable to an item, that column is left blank in the list display.

To remove specific slots from the dialog, first select them. Note that the label above the list view indicates the number of items selected and the total number in the list. Then click the **Remove Selected Slots** button or use the corresponding context menu item available with a right mouse click in the slot list view. All slots can be removed using the **Remove All Slots** button or its corresponding context menu item. Double clicking an item in the slot's list view will bring up the Open Slot dialog for that slot.

3.2 Configuration Options

The configuration depend on whether the General or Optimization radio button is selected. The resulting options are described in the following sections:



3.2.1 General

The configuration panel at the bottom of the dialog has check boxes for two types of configuration items; **Convergence** and **Unit Type for Custom Slots**. By checking or unchecking these, any combination of the configuration options can be used. For example, if only convergence values are to be altered, only use its check box, unit types will not be modified by any applied changes.

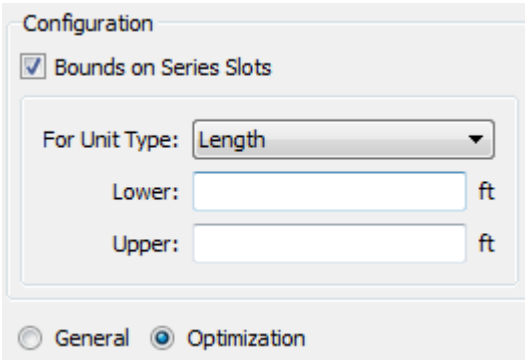
Specifying Convergence: To change convergence, click the **Convergence** check box and enter a **Type** and/or **Value**.

Specifying a new Unit Type for Custom Slots: To change the unit type of a custom slot, click the **Unit Type for Custom Slots** check box and specify the old unit type and the new unit type. These changes only apply to custom slots; you are not allowed to ever change the unit type of a simulation slot. Display units can be set from the slot itself or from the Unit Scheme.

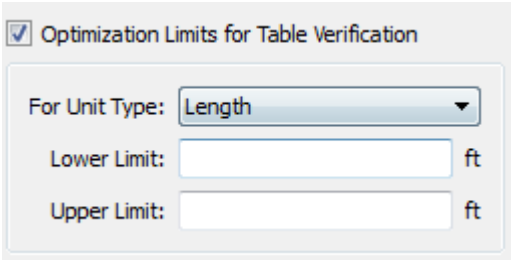
3.2.2 Optimization

When the Optimization radio button is checked, the bottom of the dialog switches to show the Optimization Bounds and Limits regions.

Specifying Bounds on Series Slots: To set the Lower and Upper bounds, check the box, then choose a unit type from the **For Unit Type** pull down menu. Specify a new **Lower** or **Upper Bound**.



Optimization Limits for Data Verification: Configure the Lower and Upper Limits for Table slots that are verified in optimization. To find these slots, use the Supports Opt Limits filter in the Selector, described **HERE (Selector.pdf, Section 3)**.



3.3 Applying the changes

When all desired configuration changes have been made, they can be applied in two ways, **Apply to Selected** or **Apply to All**. To apply changes only to selected items in the slot's list view, click the **Apply To Selected** button at the center bottom of the dialog. Note that the desired items should be selected before entering the configuration information because changing selections clears the configurations. This will change only those slots highlighted in the list view. Configuration changes can be applied to all slots in the slot list, whether selected or not, by clicking the **Apply To All** button at the left bottom of the dialog.

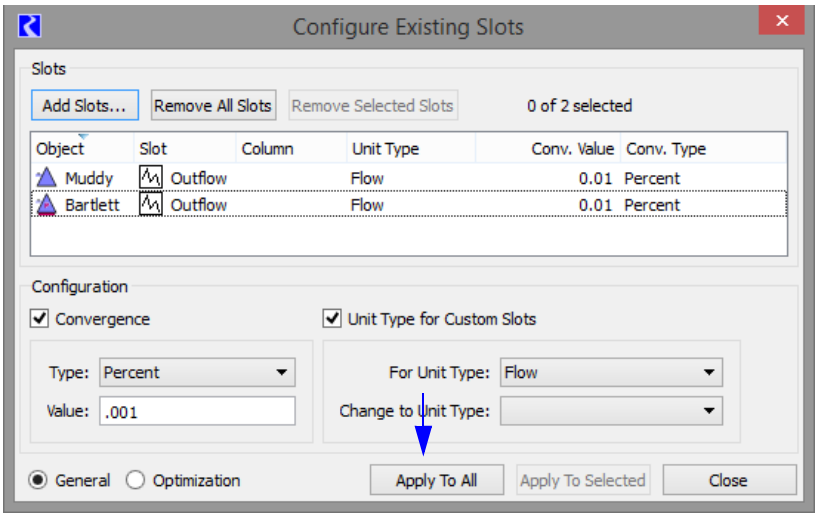
If changes are applied to a slot where they are not applicable, the changes will be ignored for that slot. For example, if convergence is configured to be changed and is applied to a slot that does not have convergence, it will be ignored.

3.4 Use Example

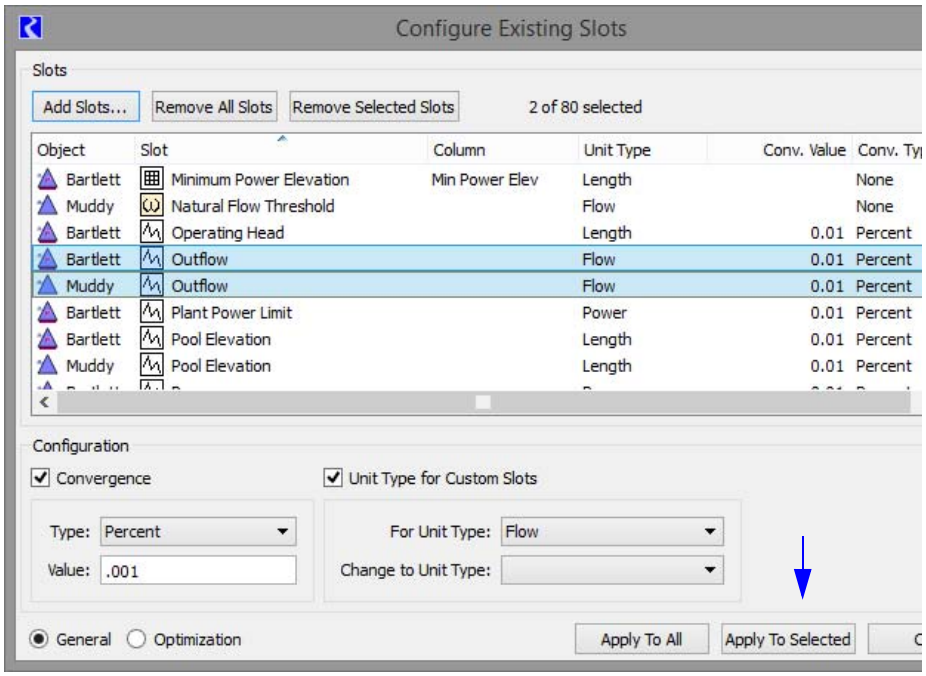
Following is examples of using the **Configure Existing Slots** dialog.

Changing convergence on specific slots: In this example, you decide that for debugging purposes, you need to decrease convergence on all reservoir outflows. There are two approaches with the **Configure Existing Slots** dialog to make these changes:

- Add only the Reservoir Outflow slots to the list using the slot selector. A **Name Filter** can be applied in the selector to filter only the desired slots. In the **Configure Existing Slots** dialog, check the **Convergence** box, select **Percent** for the **Type**, then enter a new value (like 0.001) in the **Value** box. Then click **Apply to All** to commit the changes.



- Add all of the reservoir slots to the list. Highlight only the desired Outflow slots, check the **Convergence** box, select **Percent** for the **Type**, then enter a new value (like 0.001) in the **Value** box. Click **Apply To Selected** button to commit the changes.



Using the selector to choose the appropriate slots is more powerful and more elegant but you don't see the slots' configuration values before you make the selection. Selecting all slots, then choosing the desired slots in the list view allows you to see all of those slots' configuration before you modify them.

Types of Slots

4. Types of Slots

This section presents a brief description of the different types of slots and how they are used for representing different types of data. Click on the link to go to the section that further describes how to view, create, and edit that type of slot.

Name	Icon	Type	Description
Series Slot Go to Section 4.1		Series	A single timeseries of values. These slots may be linked with other Series Slot. Input data in Series Slots controls the simulation solution, and all simulation output data are written to Series Slots. Custom slots can be linked to any linkable slot on the workspace.
Series Slot with Expression Go to Section 4.6		Series	A specialized Series Slot whose value is computed from a user-defined arithmetic expression possibly containing other slot names as variables. They are used to calculate quantities such as “combined Storage of all Reservoirs.”
Integer Indexed Series Slot Go to Section 4.4		Series	A specialized series slot that is indexed by an integer number instead of a date.
Agg Series Slot Go to Section 4.2		Series	A specialized Series Slot that is an aggregation of one or more Series Slots which are independent of one another. They are used to group together similar series of data.
Integer Indexed Agg Series Slot Go to Section 4.4		Series	An agg series slot that is indexed by an integer number instead of a date.
Multi-Slot Go to Section 4.3		Series	A specialized Series Slot aggregating one or more Series Slots. The value in the first Series Slot column is the sum of the values in all of the other Series Slot columns (other slots to which they are linked). New Series Slot columns are automatically added when a link is made to the MultiSlot.
Time Aggregation Series Slots Go to Section 4.7		Series	Time Aggregation Series Slots temporally aggregates any other single series slot. It can be recomputed manually or automatically at the end of a run.

Name	Icon	Type	Description
Series Slot with Periodic Input Go to Section 4.8		Series	A Series Slot with Periodic Input is technically a series slot, but you can optionally input data in the same format as a periodic slot. When entered periodically, the slot automatically fills out the series values.
Text Series Slot Go to Section 4.5		Series	A specialized Series Slot whose values are text strings instead of numerical data. They are used to store annotations or strings.
Table Slot Go to Section 4.9		Table	A two or three-dimensional table of values for representing one or more functional relationships. Each column stores a variable with its own unit type and name. Rows are numbered beginning with 0. Both rows and columns can be referenced by using an index (0, 1, 2 . . . n) or using a label string. For a three-dimensional table lookup to be successful, column 1 must contain blocks of equal values which increase down the table, and column 2 must contain monotonically increasing values within each block of values from column 1. A two-dimensional table only requires monotonically increasing values in its first column. Table functionality includes accessing values beginning with the table indexes and accessing a column index beginning with row index and table value.
Table Series Slot Go to Section 4.10		Table	A specialized table slot whose rows correspond to time values. This slot contains limited timeseries functionality thus making it more efficient, performance wise than Series Slots. It is commonly used for writing and reading large amounts of data. It is primarily used within user methods; you cannot create them as custom slots.
Statistical Table Slot Go to Section 4.11		Table	A specialized table slot allowing the user to specify a statistical function, such as flow duration curve, which is computed at the end of a run using the data in specified model slot(s). This statistical analysis data can then be plotted or exported.

Name	Icon	Type	Description
Periodic Slot Go to Section 4.12		Table	A specialized table slot, the periodic slot is used to hold data that repeats over a specified time period. For example, a set of monthly evaporation coefficients for a reservoir (the same every year), could be held in a periodic slot. The timeseries associated with the data can vary (hourly, daily, monthly, etc.) as well as the period over which the data repeats. The periodic slot can also handle irregular timeseries and can have either text or numeric column headings.
Scalar Slot Go to Section 4.13		Scalar	The scalar slot is used to hold a single piece of numeric data that will not vary with time. The scalar slot is a one-row, one-column table slot.
Scalar Slot with Expression Go to Section 4.14		Scalar	A scalar slot whose value is computed from a user-defined arithmetic expression. The expression can contain values from other slots as variables.
List Slot Go to Section 4.15		List	The list slot is used in certain user methods to specify a list of objects or slots associated with that method. The user cannot add custom List Slots.
Mass Balance Summary Go to Section 4.16		Mass Balance Summary	The mass balance summary slot is a user-defined hierarchy of series slot collections used to check mass balance across many objects.

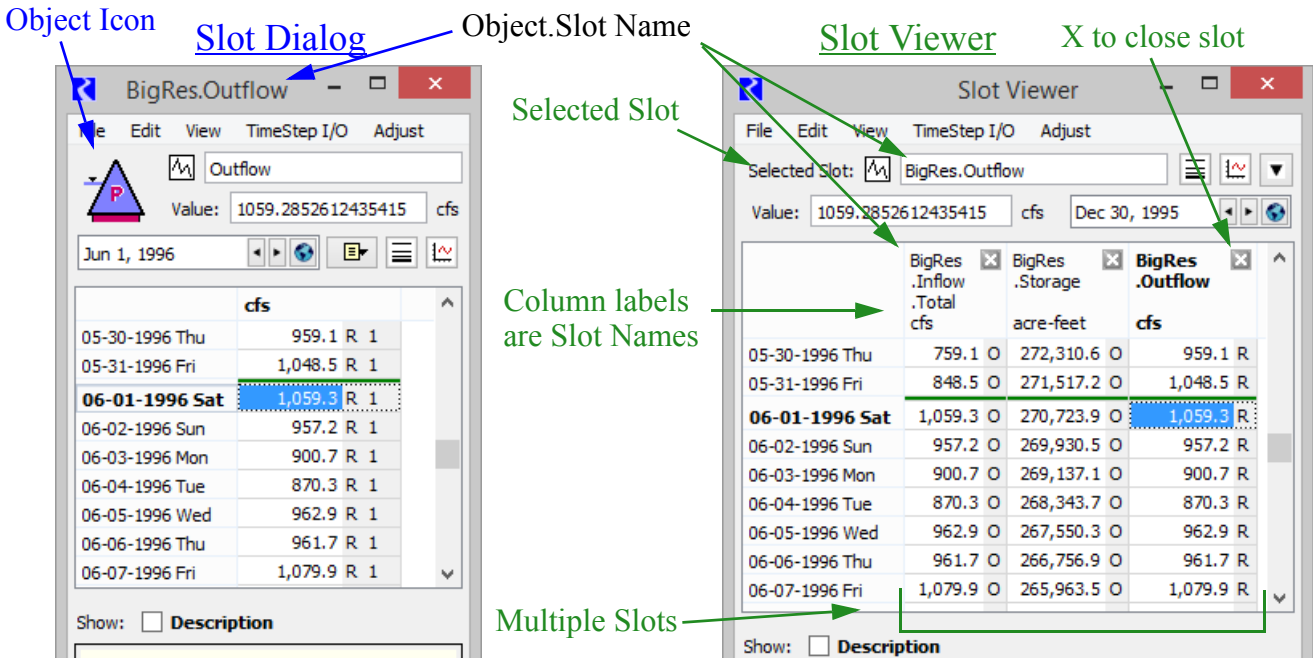
Series Slot

4.1 Series Slot

There are several types of time series slots with various column configurations. Since all of these slot types contain rows which correspond to the series of data, they will be referred to collectively as series slots. Most series slots open automatically in the Slot Viewer. Any slot shown in the viewer can be undocked from the viewer and shown in its own Slot dialog by dragging the column off the viewer.

4.1.1 Slot Dialog Versus Slot Viewer

The following screenshots highlight the difference between the individual Slot dialog and the Slot Viewer.



- **How many of each dialog are there?** There is only one Slot Viewer per model. There can be many Slot dialogs.
- **What types of slots are shown?** There is a Slot dialog for each type of slot. The Slot Viewer only shows series slots that have the same timestep as the Run Control.
- **Which slots will open in the Slot Viewer?** The Slot Viewer only shows series slots that have the same timestep as the Run Control. Standard **Series** slots, **Text Series** slots, **Series Slots with Periodic Input**, and **Multi** slots with a single subslot open automatically in the Slot Viewer. **Multi** slots with two or more subslots and **Expression** slots open in their own Slot dialog but can be docked in the

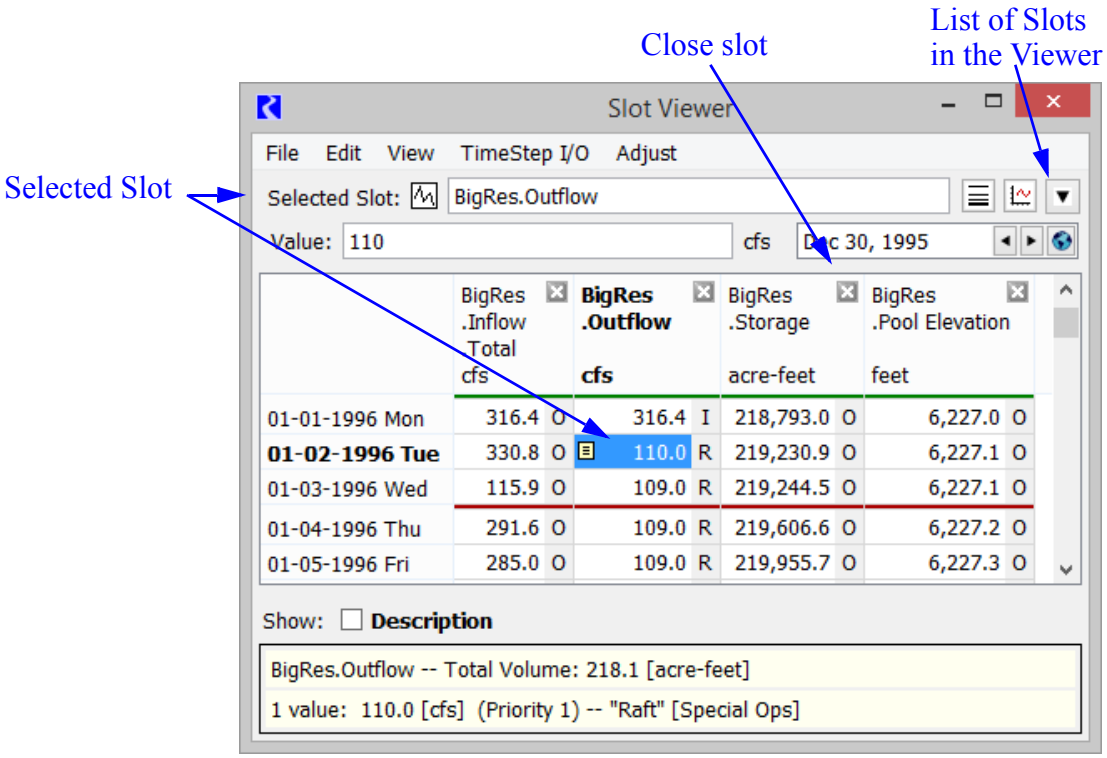
Slot Viewer. **Agg Series** slots with two or more columns, series slots with a timestep different from the Run Control and all other types of slots (**Periodic**, **Table**, **Scalar**) can only be shown in their own Slot dialog.

- **Can the two types of dialogs interact?** From the Slot Viewer, you can drag a slot off of the viewer to become a single Slot dialog. You can then drag the slot icon on the series slot and drop it on the Slot Viewer to re-dock it. This process is described **HERE (Section 4.1.2)**.
- **Where can I find more information?** The Slot dialog is described **HERE (Section 2)**. The Slot Viewer is described in the next section, **HERE (Section 4.1.2)**

4.1.2 Slot Viewer

The Slot Viewer is an ad-hoc tool to view multiple series slots in a single dialog. There is only one Slot Viewer per model. The slots shown and order is not persistent in any way on the viewer. Each time a Series Slot is opened from anywhere in RiverWare, it is added as a column to the Slot Viewer. From the Slot Viewer, any slot can be shown also in the slot's conventional Slot dialog.

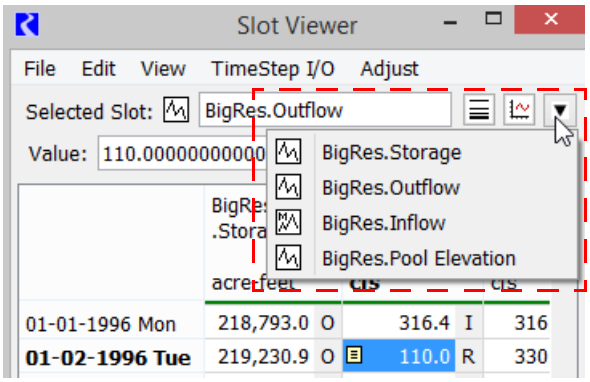
Following is a screenshot of the Slot Viewer showing four slots on BigRes. The Slot Viewer shows different menus based on the selected slot. Highlight cells in a single column (or the entire column) to select a slot. If you highlight cells in multiple columns, the Selected Slot is blank and many of the menu options are disabled.



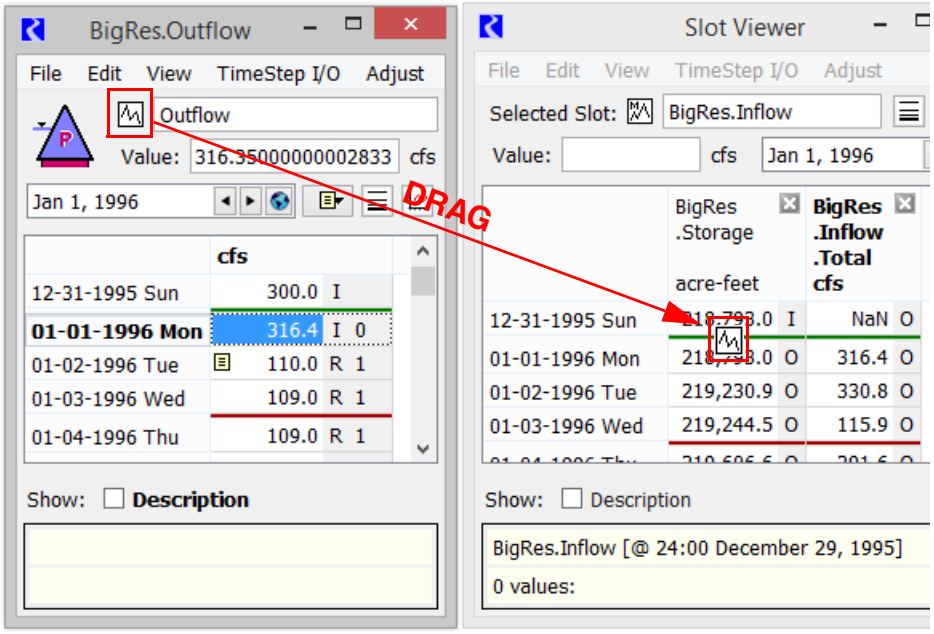
Following are the Slot Viewer specific actions:

- **Rearrange Columns:** Drag a column header to rearrange columns.

- **Undock a single slot**:
  - Drag a column off of the Viewer to show the slot in its own dialog.
  - Right-click the column header and choose **Show In Slot Dialog...**
  - Use the **File ➥ Undock Selected Slot(s)** menu.
- **Undock all Slots:** Use the **File ➥ Undock All Slots** to show all of the slots in their own dialog.
- **Navigate to a slot:** Use the scroll bars to scroll left/right to find the slot or use the down arrow menu (Shown to the right) to list all of the slots in the viewer. Click the desired slot to select and scroll to that slot.
- **Close Slots:**
  - Click on the X at the top right of the slot column.
  - Select one or more slots. Then use the **File ➥ Remove Selected Slot(s)** menu.



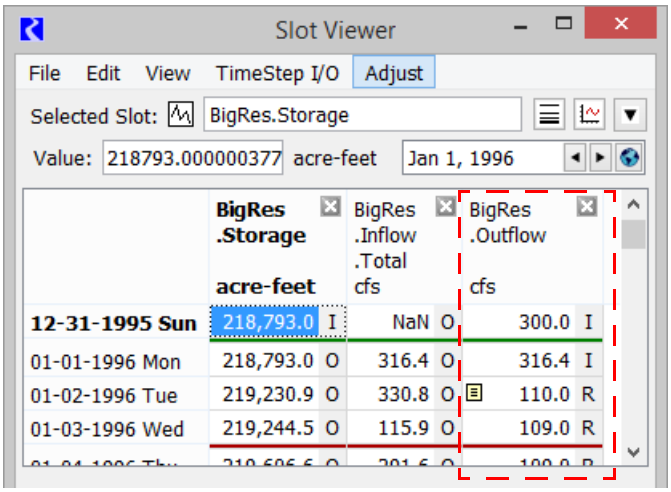
To **dock** a slot onto a Slot Viewer, drag the slot's icon anywhere on the viewer. A screenshot shows the icon that you should drag.



The result is shown:

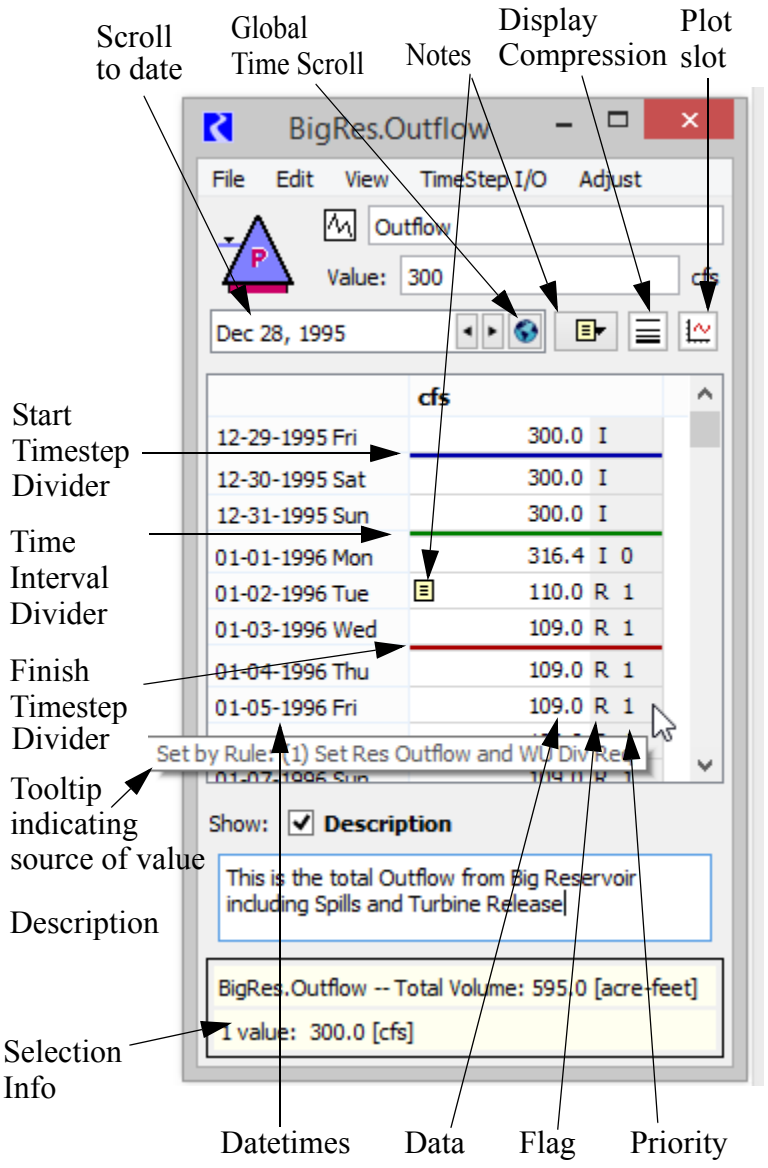
Alternatively, use the **File ➥ Dock in Slot Viewer** menu.

RESULT:



4.1.3 Series Slot Dialog Functionality

Shown is a series slot with the key areas highlighted. There is a datetime spinner and scroll button used to scroll to the given date. Icon/buttons are used to show display compression, show notes, and to Plot the slot. The datetimes are shown as the row headings, the data values are shown in the cells, and each cell's value has a flag. Bold, green separators are automatically created based on the timestep of the slot. For example, in a daily slot, separators are placed between months. In 6-hour slot, days are separated. Also, there is a blue divider between the initial and start timestep. There is a red divider after the finish timestep.



Data: Time series data are displayed with one value per row where each row represents a timestep. A scroll bar along the right side of the field is used to view the entire set of data. Each row contains the full date and time, a status flag, and the slot value at that time. A slot value which shows **NaN** (Not a Number) represents an unsolved variable.

The values which appear in the **Open Slot** dialog use the **Units** for that slot. Units are covered in more detail **HERE (Units.pdf, Section 1)**. Configuring slot units is discussed **HERE (Section 2.1.5)**.

Timesteps: Timesteps are reported chronologically. If the series is an Integer Indexed series, the rows are indexed by an integer number instead of a timestep.

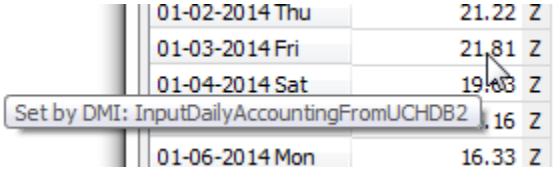
Editing Slot Values: Conventional editing commands are available for all slots. They allow cutting, pasting, filling and clearing of data.

A **Delete** or **Cut** of any timestep except the first shifts data up to replace the lost cell, reassigning values to new timesteps. A **Delete** or **Cut** of the first timestep removes it completely from the series, essentially shifting the start date of the series.

Similarly, **Insert New Cell** or **Insert Copied Cells** when the first timestep is selected adds a new timestep to the beginning of the series. When any other timestep is selected, **Insert New Cell** or **Insert Copied Cells** shifts data down from the added cell, reassigning values to new timesteps.

Priority: In a Rulebased Simulation run, the dialog shows the priority of the slot at the given timestep. This can enable/disabled using the **View ➥ Show Priorities** menu.

Tooltips: Tooltips provide additional information about individual values. In particular, when you hover over a value for which the relevant information is available, one of the following tooltips is displayed:



- **Set by DMI:** Displayed when the value was set by an input DMI that was configured to record invocations. Example: “Set by DMI: Import Lake Levels”. Click **HERE (DMI.pdf, Section 2.4)** for more information on Invocation Records.
- **Set by Initialization Rule:** Displayed when the value was set by an Initialization Rule. Example: “Set by Initialization Rule: (3) Provide Default Hydrology”.
- **Set by Rule:** Displayed when the value was set by a rule. Example: “Set by Rule: (18) Long Lake Fishery Releases”.
- **Rule:** Displayed when the value was solved for as a result of a rule setting a value elsewhere in the system. That is, the value was set during dispatching because a rule set a value somewhere. In this situation, the value has the output flag and the controller's priority which is also the priority of the rule whose execution triggered dispatching. Example: “Rule: (18) Long Lake Fishery Releases”.

For the last three items you can quickly open the rule associated with the value. Right click and choose to **Open Rule N** from the menu.

Additional information may be shown in the tool tips when an optimization run has been made. Examples of the information are “Frozen at Lower Bound”, or “Frozen by (3) Minimum Load 47.6% between limits set by 3.1.1.1 and 2.1.1.1.” or “Frozen by (2) Ending Pool Elevation at a limit set by 2.1.1.1”. More information can be found **HERE (Optimization.pdf, Section 7.2)**.

Selection Info Area: Optionally, the **Selection Info Area** (also called the **Summary Area** or **Selection Statistics**) can be shown using the **View ➥ Show Selection Statistics**. This displays information on the selected cells in the Slot including the name or number of slots and then statistics on the selection. Statistics include Sum, Average, Median, Min, Max, Range, and Difference. All, some or none of these may be shown depending on the number of cells selected and the units of those cells. If a single value is selected and that value was solved for or set as a result of a rule in rulebased simulation, the Priority is also shown. Finally, if the values have units of flow, power, or velocity, the selection area also shows the integrated values over time, thus showing the total volume, energy, or length, respectively. The unit scheme units for that unit type are used.

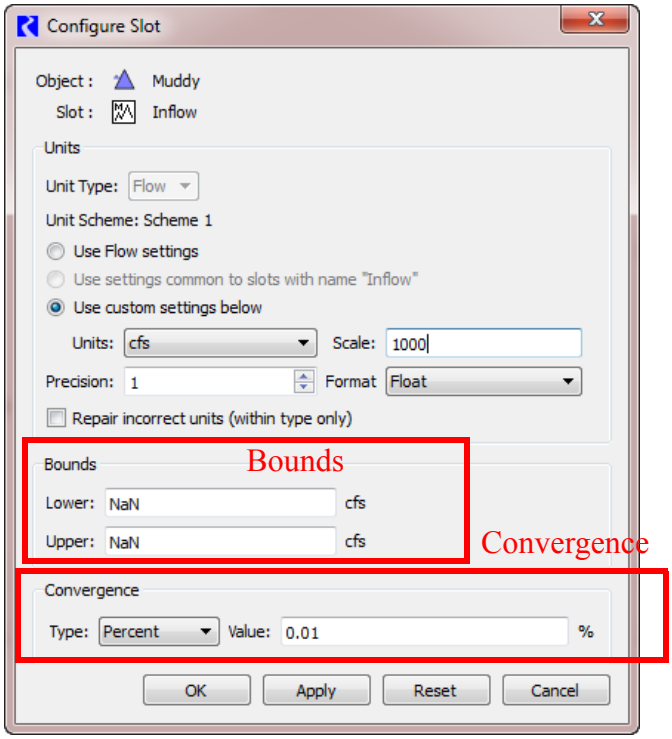
Note: You can configure your preferences on whether or not to show **Selection Statistics** using **Slot Dialog Display Preferences** described HERE (Section 2.1.5.2).

Global Time Scroll: Use the global time scroll button or the right-click context menu to change all date-based dialogs to the selected date. This date is then used for any currently opened dialogs and any that are opened from this point forward.

4.1.4 Configuration

Following are configuration options specific to Series Slots. Further information on general configuration can be found HERE (Section 2.1.5).

Setting Bounds on a Series Slot: series slots have upper and lower bounds which can be entered through the **View ➥ Configure** dialog. In general, these values are not used by the simulation, but are used in optimization. However, there are a few cases where a value can be used by the Object's user methods. For example, the lower bound on Outflow on a Reach object is used to calculate the maximum allowable diversion. If no value is specified, the total Inflow may be diverted.



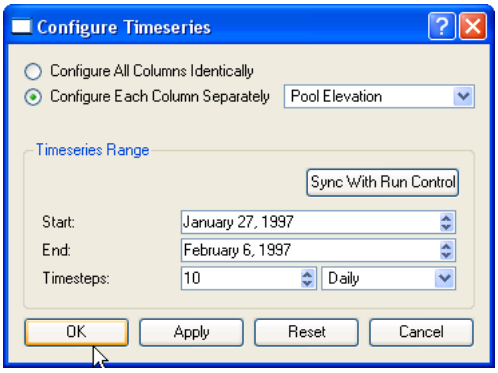
You can optionally show warning messages if values set during Simulation are outside of the bounds. When configured, as described HERE (RunControl.pdf), if the controller sets a value which violates the specified bounds, a warning is issued in the diagnostics window, but the simulation continues.

Setting Convergence: Series slots have Convergence settings which can be edited in the lower portion of the **Configure** dialog. A slot can be reset if the new value is not within convergence of the old value and it has not been set more than the maximum number of times. The Set

Value functionality is described **HERE (Simulation.pdf, Section 4.1)**. The following table describes the available convergence criteria:

Type	Units	Description	Convergence is reached:	Examples:
None	NA	No convergence. Any new value is considered different than the old value.	$Never$	Example of non-convergence: old = 100.0 cms new = 100.001 cms
Absolute	Internal (m, cms, m3, etc)	Absolute difference in internal units. The user enters the value in internal units. If old minus new (in internal units) is less than or equal to the convergence value, it is considered converged.	if $\lvert old - new \rvert \le value$	Example of convergence: old = 100.0 cms new = 100.001 cms value entered = 0.001 cms Example of convergence old = 100.0 cfs new = 100.01 cfs value entered = 0.001 cms why? 100 cfs = 2.83168 cms 100.01 cfs = 2.83197 cms 2.83168 - 2.83197 = -0.00029 0.00029 < 0.001
Percent	NA	Percent difference. The user enters the value as a percentage. If old minus new divided by the old value is less than or equal to the convergence value divided by 100, it is considered converged. If both old and new are zero, it is considered converged if old minus new is less than 1.1E-12	if $\frac{\lvert old - new \rvert}{old} \le \frac{value}{100}$ or If old or new is 0.0, then convergence is reached if $\lvert old - new \rvert \le 1.1X10^{-12}$	Example of convergence: old = 100.0 cms new = 100.001 cms value entered = 0.001 Example of **non**-convergence old = 10.0 cfs new = 10.01 cfs value entered = 0.001 why? $\frac{\lvert 10 - 10.01 \rvert}{10} > \frac{0.001}{100}$
Unit Percent	User Units specified for the slot	Absolute difference in user units. The user enters the value as a percentage in the specified user units, without considering scale. If old minus new (in user units) is less than or equal to the convergence value (in user units) divided by 100, it is considered converged.	if $\lvert old - new \rvert \le \frac{value}{100}$	Example of convergence: old = 100.0 cfs new = 100.001 cfs value entered = 0.1%, cfs Example of **non**-convergence old = 10.0 cfs new = 10.1 cfs value entered = 0.1%, cfs why? $\lvert 10 - 10.1 \rvert > \frac{0.1}{100}$

Time Series Range--Series Slot: The default start times and timestep are inherited from the Run Control settings when the object is instantiated. All series slots are initialized with one timestep to minimize model file size. Other rows are added by the user as needed for input or appended at run time when the slot's output values are calculated. You may change the time series range directly through the Time Series Range Dialog.



On Integer Indexed Series, the user is able to change the number of Values but the start, end, and timestep size configuration areas are disabled.

The time series range and timesteps can also be changed by selecting **Synch With Run Control** in the Time Series Range Dialog. This will update the time series range in the slot to match the time series range set in the **Run Control** dialog. The default start times and timestep are inherited from the Run Control settings when the object is instantiated. All series slots are initialized with one time.

Linked Slots: In the **View** menu, there is a menu to show **Linked Slots**. When selected, this shows all of the slots to which the given slot is linked.

Show Notes Column and Notes Group menu: The Show Notes Column and the Notes Group menu are used to display Notes that are associated with a timestep on a series slot. For more information on Notes on Series Slots, see the documentation **HERE (Section 6)**.

4.1.5 Series Display Compression

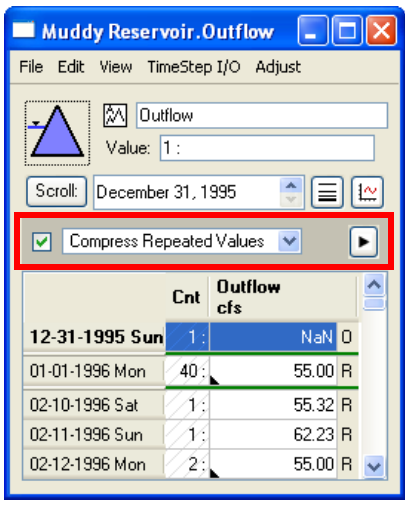
The Series Display Compression utility allows the user to "compress" or hide a particular value, NaNs, both, or any repeated values. This utility is useful for slots that hold data that is often the same value and the user only wishes to see any changes to this standard value. The functionality is available on Series Slots, Agg Series Slots, Multi Slots, and Table Series Slots.

4.1.5.1 Accessing Series Display Compression

Series Display compression can be accessed from

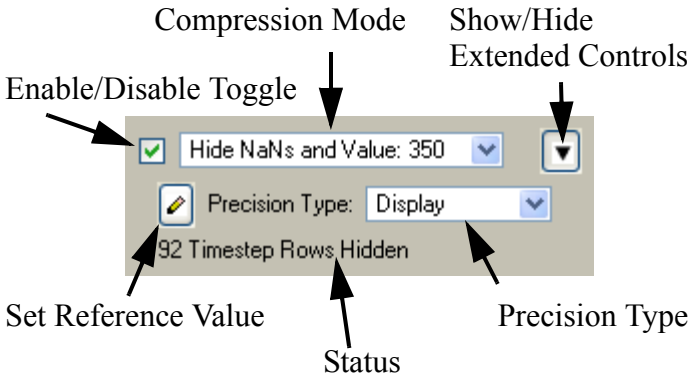
- the Open Slot dialog's **View ➥Series Display Compression** menu
- the Series Display Compression icon on the Open Slot dialog

When either of these options are chosen, the Open Slot dialog adds the display compression area between the scroll area and above the column heading as shown.



4.1.5.2 Configuring Compression

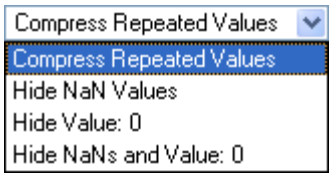
Following is a screenshot showing all of the configuration controls. Each option is then described in detail.

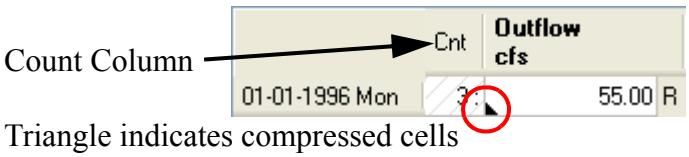


Enable/Disable Toggle: When **Series Display Compression** is first activated, there is a check mark in the toggle indicating that it is active. This toggle is used to toggle the compression on and off. Thus, the user can configure compression, then toggle it off to view or edit all the values, and then toggle it back on to re-enable compression

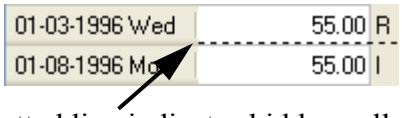
Compression Mode pull-down menu: When first activated, the **Compress Repeated Values** option is selected by default in the pull-down **Compression Mode** menu. The modes listed below are available for display compression:

- **Compress Repeated Values**: Any values that are repeated will be compressed into one row. When this option is selected, the repeated values are all compressed into one cell and a count (**Cnt**) column is added. A small triangle is added to the lower corner of the cell to indicate that the cell represents repeated values. In the screenshot 3 values of 55cfs are repeated on 1/1/1996. These represent 1/1 through 1/3/1996.



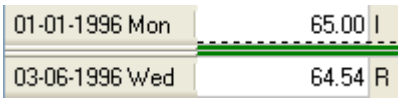


- **Hide NaN Values**: All NaN values will be hidden and a dotted line is shown. For example, NaNs are hidden for 1/4 through 1/7/1996.



- **Hide Value: #**: All values matching the reference value will be hidden and a dotted line is shown. The user can change the value by clicking on the Reference Value icon and entering a new value.
- **Hide NaNs and Value: #**: All NaN values or values matching the reference value will be hidden and a dotted line will be shown. The user can change the reference value by clicking on the Reference Value icon and entering a new value.
- **Show Value: #**: All values that match the reference value are shown. NaNs are hidden. The user can change the reference value by clicking on the Reference Value icon and entering a new value.
- **Show NaNs and Value: #**: All NaNs and values that match the reference value are shown. The user can change the reference value by clicking on the Reference Value icon and entering a new value.
- **Show Values <= #**: All values less than or equal to the reference value are shown. NaNs are hidden. The user can change the reference value by clicking on the Reference Value icon and entering a new value
- **Show Values >= #:**All values greater than or equal to the reference value are shown. NaNs are hidden. The user can change the reference value by clicking on the Reference Value icon and entering a new value

Note: The above text describes the options and how RiverWare represents each option on the screen. In each case, if the compressed/hidden range contains the automatic green datetime interval delineations (e.g. Monthly lines on a daily slot) those green lines will still be shown. In the example to the right, two green lines are shown representing the delineation before Feb. 1 and March 1 in this daily slot.

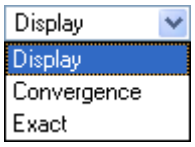


Show/Hide Extended Controls: To the right of the **Compression Mode** pull-down menu, the **Show/Hide Extended Controls** button can be used to further refine how the compression is configured.

When this button is clicked a further set of configuration options is presented and the arrow now points down.

Set Reference Value: When any of the "Hide Value" or "Show Value" compression modes are selected, the Set Reference Value icon become active. Clicking this icon opens a dialog to allow the user to enter a value. Once a new number is entered, the Compression Mode menu options will display that number in the menu. The value does not have a unit associated with it. So if you change the slot's units (via the configuration or through a unit scheme), the reference value will not change.

Precision Type pull-down menu: Each of the above compression modes compares a value in a cell to some other value, either a reference value, NaN or the previous timestep's value. For more flexibility, value comparison can be based on either:



- **Display:** The display precision will be used; this is the default. If two numbers appear the same on the screen, they are considered the same.
- **Convergence:** The slot's convergence value will be used to compare the numbers. A number must be within convergence of the other number to be considered the same.
- **Exact**: The internally stored numbers will be compared.

Status information: The Status information will show the number of rows that are hidden or compressed.

4.1.5.3 Editing Compress/Hidden Values

On the Open Slot dialogs, the user can highlight a number of cells and type a new value that will be entered, as Input, into each selected cells. When **Series Display Compression** is enabled, the editing of values is treated a differently as follows:

Compressed Repeated Values: If the **Compress Repeated Values** is selected, editing of selected cells will edit any compressed cells. For example, if repeated 33 values are repeated and the user selects the repeated value, types in a new number, all 33 values will be set to that new number.

Hidden NaNs or Value: If any of the "Hide" options are selected, editing of selected cells will not affect hidden cells. Hidden values and NaN's will not be overwritten. But, any cells displayed and selected will be affected by the new value. Also, if the entire column is selected, edits will then apply to all values, whether hidden or not.

4.1.5.4 Multi-Column slots

On multi-column slots, (Agg Series, Multi Slots, Table Series Slots, and accounting slots), the Series Display Compression will only compress/hide a row if the compression is valid on all columns of the row. Following is a screenshot where the repeated value compression only applies to a subset of rows:

01-01-1996 Mon	1 :	1.00	I	NaN	O	NaN	O
01-02-1996 Tue	1 :	1.00	I	2.00	I	NaN	O
01-03-1996 Wed	4 :	1.00	I	2.00	I	3.00	I
01-04-1996 Thu	:	1.00	I	2.00	I	3.00	I
01-05-1996 Fri	:	1.00	I	2.00	I	3.00	I
01-06-1996 Sat	:	1.00	I	2.00	I	3.00	I
01-07-1996 Sun	4 :	NaN	O	2.00	I	3.00	I
01-08-1996 Mon	:	NaN	O	2.00	I	3.00	I
01-09-1996 Tue	:	NaN	O	2.00	I	3.00	I
01-10-1996 Wed	:	NaN	O	2.00	I	3.00	I
01-11-1996 Thu	1 :	NaN	O		O	3.00	I

Repeated Value Compression toggled Off

01-01-1996 Mon	1 :	1.00	I	NaN	O	NaN	O
01-02-1996 Tue	1 :	1.00	I	2.00	I	NaN	O
01-03-1996 Wed	4 :	1.00	I	2.00	I	3.00	I
01-07-1996 Sun	4 :	NaN	O	2.00	I	3.00	I
01-11-1996 Thu	1 :	NaN	O		O	3.00	I

Repeated Value Compression toggled On

Notice that only rows 1/3-1/6 and 1/7-1/10 are compressed because the repetition occurs across all columns. Similarly, on multi-column slots, if the user chooses to “Hide NaNs and Value”, it will only hide a row if all three columns have the reference value OR NaN.

4.1.6 Timestep I/O menu - Flags

On Series Slots, the Timestep I/O menu is used to change the status of the cell’s value by changing the flag. Possible flags vary by slot, but may include:

- INPUT (**I**),
- OUTPUT(**O**),
- DMI INPUT (**Z**),
- ITERATIVE MRM (**i**),
- TARGET BEGIN (**TB or tb**),
- TARGET (**T**),
- BEST EFFICIENCY (**B**),
- MAX CAPACITY (**M**),
- DRIFT (**D**),
- SURCHARGE RELEASE (**S**),
- REGULATION DISCHARGE (**G**),
- UNIT VALUES(**U**), and
- RULE (**R**).

User-input data are automatically flagged as INPUT, and may not be overwritten by simulation results. Certain values imported by an input DMI are flagged Z for DMI INPUT and are treated identically to INPUT (I) flags. Initialization Rules can also set values with the Z flag. OUTPUT (**O**) timesteps may contain values 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. Simulation results are written to timesteps flagged as

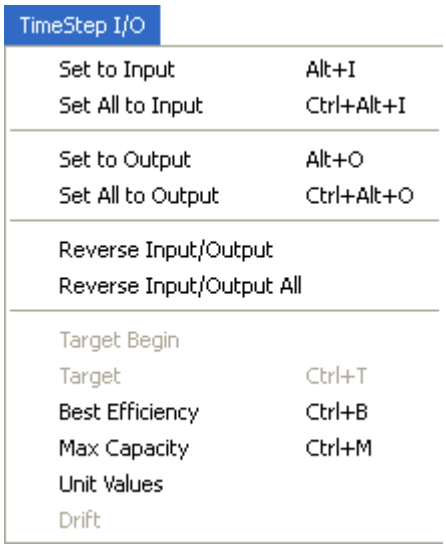
OUTPUT, TARGET BEGIN, BEST EFFICIENCY, MAX CAPACITY, SURCHARGE RELEASE, DRIFT and UNIT VALUES. Flags other than OUTPUT and INPUT are only available for certain series slots.

This section describes the use of special flags which may be set on SeriesSlot timesteps. The flags are typically set by the same mechanisms as INPUT and OUTPUT flags. But, unlike INPUT and OUTPUT flags, each type of special flag is only applicable to one or two slots. All SeriesSlots must have one of the following flags set for every timestep; each flag is indicated by its abbreviation:

- General flags available to all SeriesSlots.
  - **I** for **INPUT**
  - **O** for **OUTPUT**
  - **Z** for **DMI INPUT** - This flag indicates that the value was set by an input DMI or Initialization Rule. Click **HERE (DMI.pdf, Section 2.4)** for more information on DMI Invocations. Click **HERE (RPLUserInterface.pdf, Section 4)** for information on Initialization Rules. In simulation, the Z flag behaves identically to the INPUT (I) flag.
  - **R** for **SET BY RULE -** This flag indicates that the value was set directly by a rule.
  - **i** for **ITERATIVE MRM -** This flag indicates that the value was set during iterative MRM by an MRM rule. Values with the "i" flag can be overwritten as though it is a "O" flag. Values with the "i" flag are cleared at the beginning of a single run and at the start of an MRM run, but are not cleared between each iterative MRM run. They are considered input during an iterative MRM run.
- Power calculation flags available to Energy slots.
  - **B** for **BEST EFFICIENCY**
  - **M** for **MAX CAPACITY**
- Maximum Outflow flag available to Outflow slots
  - **M** for **MAX CAPACITY**
- Target flags available to Storage and Pool Elevation slots.
  - **TB** or **tb** for **TARGET BEGIN**
  - **T** for **TARGET**
- Drift flag available to Regulated Spill and Bypass slots.
  - **D** for **DRIFT**
- Surcharge Release flag available to the Surcharge Release slot
  - **S** for **SURCHARGE RELEASE**
- Regulation Discharge flag available to the Regulation Discharge slot
  - **G** for **REGULATION DISCHARGE**
- Unit Values flag available to Turbine Release and Energy slots on power reservoirs with the Unit Power Table method selected:
  - **U** for **UNIT VALUES**

4.1.6.1 Setting Flags

Flags are set from the Open Slot dialog (or from the SCT). In the Open Slot dialog, a flag is set on the highlighted timestep by selecting the flag from the **Timestep I/O** menu. Flags which are unavailable for that slot will appear grayed-out in the menu.



The **Timestep I/O** menu has options to:

- **Set to Input**: Set selected cells to Input
- **Set All to Input**: Set all cells to Input
- **Set to Output**: Set selected cells to Output
- **Set All to Output**: Set all cells to Output
- **Reverse Input/Output**: Reverse the input and output flags on selected cells
- **Reverse Input/Output All**: Reverse the input and output flags on all the cells
- Set one of the special flags on the selected cells. The following sections describe many of the special flags.

4.1.6.2 Power Calculation Flags on Energy

BEST EFFICIENCY and **MAX CAPACITY** flags may be set on Energy timesteps instead of an **INPUT** Energy request value. These flags are used by the **Plant Power Coefficient Release** User Method to calculate the most efficient or maximum Energy generation possible for the flagged timestep.

The **Plant Power Coefficient Release** method uses tables to relate the current Operating Head to the most efficient Turbine Release or maximum allowable Turbine Release. The **MAX CAPACITY** flag is available for all power method except LCR Power Calc. The **BEST EFFICIENCY** flag is only valid for the following power methods:

- Plant Power Calc
- Plant Efficiency Curve
- Plant Power Equation
- LCR Power Calc
- Unit Power Table

The calculation of the best efficiency Energy generation or max possible Energy generation is an iterative solution. The Outflow required to produce the desired type of Energy affects Tailwater Elevation, which affects Operating Head, which affects the Outflow required to produce the desired Energy. For more information on these methods, click **HERE (Objects.pdf, Section 17.1.2)**.

When an energy value has been calculated using a **MAX CAPACITY** or **BEST EFFICIENCY** flag and it is set as a user input for a subsequent run, a warning may be posted that says “Energy request cannot be met on current iteration.” This is due to the way RiverWare solves. When two reservoirs are modeled in

series, the Tailwater Elevation of the lower reservoir affects the Operating Head of the upper reservoir. The Outflow of the upper reservoir, in turn, affects the Tailwater Elevation of the lower reservoir. This creates an iterative loop between the Outflow from the upper reservoir, the Tailwater Elevation of the lower reservoir, and the Operating Head of the upper reservoir. When an Energy value is set using either a **MAX CAPACITY** or a **BEST EFFICIENCY** flag, the reservoirs iterate over Outflow, Tailwater Elevation, and Operating Head until the values converge. If the Energy value is now set as an input and the model is run again, the Input Energy may not be possible given the Operating Head on the first iteration. If this happens a RiverWare warning is posted but the run does not abort, since the energy value MAY match the Operating Head at a later iteration. The Energy also MAY NOT match the Operating Head at a later iteration. If this occurs, the model will continue running even though the object did not solve. The run will NOT be aborted, but objects may not dispatch because required information was not propagated to them. The user must check the dispatch dialog if they receive the RiverWare warning message given above to make sure the model ran correctly.

4.1.6.3 Maximum Capacity Flag on Outflow

As demonstrated in the simulation exercise, this flag computes the maximum possible Outflow from a Reservoir on a given timestep. Setting the **MAX CAPACITY** flag on a Reservoir Outflow slot forces the Outflow to equal the sum of the maximum (Turbine) Release and the maximum Spill. This flag should be used with great care, as its effects may cause downstream reservoirs to exceed their operating ranges. The use of this flag also depends on having reliable and accurate input tables relating elevation to maximum release and spill.

The **MAX CAPACITY** flag is set by highlighting a simulation timestep on the Outflow slot of a Reservoir and selecting **Timestep I/O ➥ Max Capacity**. RiverWare places an **M** at the selected timestep to indicate that the flag is active. This flag is treated as an INPUT, but does not require a value. If a valid Outflow value is present at the flagged timestep, it is ignored in the simulation; a new Outflow value is calculated and displayed at that timestep. This behavior is similar to the Max Capacity and Best Efficiency flags of the Energy slot and the Drift flags of the Regulated Spill and Bypass slots. A Reservoir which has the Outflow Max Capacity flag set may dispatch under any of the “givenOutflow” dispatch methods:

- solveMB_givenOutflowHW for Level Power, Slope Power, and Storage Reservoirs.
- solveMB_givenOutflowStorage for Level Power, Slope Power, and Storage Reservoirs.
- solveMB_givenInflowOutflow for Level Power, Slope Power, and Storage Reservoirs.
- solveMB_givenOutflowInflow for Pumped Storage Reservoirs.

The Outflow Max Capacity flag may NOT be used on reservoirs when solving for Hydrologic Inflow, or when solving a Target Operation.

The Max Capacity solution is iterative. The exact sequence of calculations in each iterative loop is dependent on the type of Reservoir and the selected Spill Calculation Method. In all cases, the maximum Spill and maximum controlled Release are calculated individually, then summed. If the selected Spill Method includes Regulated Spill, the current or previous Pool Elevation is used to look up the maximum Regulated Spill from the Regulated Spill Table. This value is set in the Regulated

Spill slot, and the selected Spill Calculation Method is called. Any input Bypass and/or required Unregulated Spill are considered within the Spill Method. Next, the maximum release is calculated. If the Reservoir is a Power Reservoir, the selected Tailwater method is executed to determine the Operating Head. This Operating Head or the Pool Elevation (in the case of Storage Reservoirs) is used to look up the maximum release from the Max Turbine Q table, Max Release table, Max Flow Through Turbines table, or Best Generator Flow table. Finally, the maximum release and the calculated Spill are added to determine the total maximum Outflow. This Outflow is used to mass balance the Reservoir. The iteration is repeated until Convergence is met or Max Iterations is exceeded.

4.1.6.4 Target Operation Flags

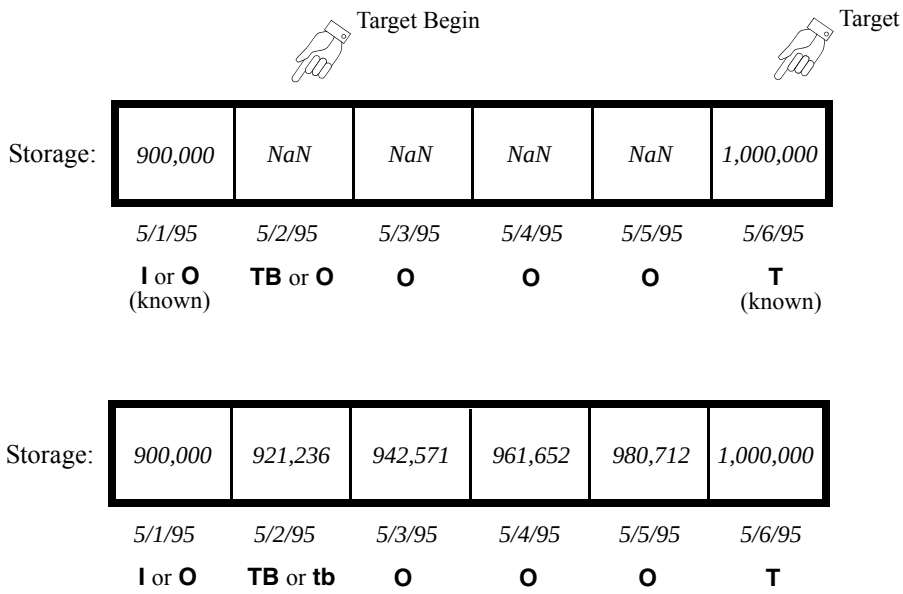
Target Operations are used to calculate a lumped mass balance across several timesteps, in order to exactly meet a user-input **TARGET** Pool Elevation or Storage value. Three conditions are necessary for a Target Operation to execute successfully:

- An initial value must be known at the timestep before the **TARGET BEGIN** timestep. This value may be **INPUT** or a known value at the time the Target Operation solves.
- A target Pool Elevation or Storage value must be specified at the **TARGET** timestep.
- Either Inflow or Outflow must be known for all timesteps in the target range.

Given these conditions, RiverWare calculates the unknown Inflows or Outflows for all of the timesteps within the Target Operation, such that the **TARGET** value is exactly met.

Timestep Range: When solving a target operation, RiverWare searches backwards from the **TARGET** time until it finds a valid **TARGET BEGIN** flag. The Target Operation is solved using the value from the timestep prior to the **TARGET BEGIN** flag as an initial condition. If the timestep prior to the **TARGET BEGIN** does not have a valid Storage or Pool Elevation, or a valid input value exists between the **TARGET BEGIN** and the **TARGET**, the simulation aborts with an error. Likewise, if the **TARGET BEGIN** or **TARGET** timestep already has enough information to dispatch with a different dispatch method, simulation aborts. If no **TARGET BEGIN** flag is specified, RiverWare searches backwards to the first valid value and solves the Target Operation with this initial condition.

When a beginning of target is assumed in this manner, RiverWare marks the timestep where the Target Operation actually begins with a **tb** (lowercase) flag in the Open Slot dialog. This flag is treated as an output, and is automatically cleared at the start of the next run. Setting a Target Operation from an SCT generates both the **TARGET** and **TARGET BEGIN** flags, and clears any previous Target Operations which overlapped with the new range.



Lumped Mass Balance: To calculate the unknown flow values, RiverWare performs a lumped mass balance over the target range. The required change in Storage is found by subtracting the storage just before the **TARGET BEGIN** (converted from Pool Elevation in the case of a Pool Elevation **TARGET**) from the **TARGET** value (also converted from Pool Elevation in the case of a Pool Elevation **TARGET**). All of the known Inflows and/or Outflows are then summed to calculate a side flow gain or loss of Storage over the target range. This volume of side flows is then subtracted from the change in Storage required to meet the **TARGET** value, and the remaining flow volume is distributed equally among the unknown Inflows or Outflows. The following equations represent the calculations discussed above:

$$\text{GainLoss} = \text{Storage(TB-1)} - \text{Storage(T)} + \sum(\text{Inflows} \times \Delta t) - \sum(\text{Outflows} \times \Delta t)$$

$$\text{Constant Inflow or Outflow} = \text{GainLoss} / (\text{Number of Undetermined Timesteps} \times \Delta t)$$

Redispatching: The setting of flow values on intermediate timesteps of the Target Operation forces the object onto the dispatch queue at those times. The timesteps dispatch with enough information to solve completely (Inflow and Outflow are known for all timesteps.) The only timestep which actually re-dispatches is the **TARGET** timestep, since a valid previous Storage value is now known.

4.1.6.5 Spill Drift Flags

Spill **DRIFT** is used to calculate the Regulated or Bypass Spill over a controlled gate as the reservoir Pool Elevation changes over time. The flag is always considered an input on any timestep where it is set but no value is initially set by the user. In this way, it is similar to the Energy **BEST EFFICIENCY** and **MAX CAPACITY** flags. Since **DRIFT** is considered an **INPUT**, it may affect over determination of Spill parameters.

The first timestep prior to initiating drift is used to determine a gate index called the Regulated (or Bypass) Drift Index. This index is interpolated from a 3-dimensional Regulated (or Bypass) Spill Index Table, which relates Pool Elevation to Spill for various gate indices. In all subsequent timesteps where the **DRIFT** flag is set, the same index is used to determine the new Spill. The gate index is maintained throughout the selected time period. At each timestep, the new value of Spill is calculated for the structure based on the current average Pool Elevation.

4.1.6.6 Surcharge Release Flag

The **SURCHARGE RELEASE** flag is used to calculate the surcharge or mandatory release from a reservoir during flood control operations. Surcharge releases are meant to evacuate water from that sits above the top of the flood pool. This flag can only be set on the Surcharge Release slot which is only available when the user has selected a Surcharge Release method. The flag is always considered an input on any timestep where it is set but no value is initially set by the user.

Although the **SURCHARGE RELEASE** flag may be set by selecting **Timestep I/O ➥ Surcharge Release** from the Surcharge Release slot, in practice it should only be set by a rule. When the **SURCHARGE RELEASE** flag is set, and the inflow to the reservoir is known, the reservoir can dispatch with the solveMB_givenInflowSurchargeRelease dispatch method. This dispatch method will calculate the forecasted surcharge releases and will set them on both the Surcharge Release and Outflow slots so that they may propagate downstream. The manner in which the forecasted surcharge releases are calculated depends on the method selected in the Surcharge Release category. If the user is interested in using one of the surcharge release methods, detailed information can be found **HERE (Objects.pdf, Section 24.1.15)** for the Storage Reservoir.

4.1.6.7 Regulation Discharge Flag

The **REGULATION DISCHARGE** flag is used to calculate the regulation discharge at a Control Point. Regulation discharge is used during flood control operations and is defined as the maximum allowable flow in the channel at the control point. This flag should only be set on the Regulation Discharge Calc slot on Control Points. This slot is only available when the user has selected a Flood Control method and a Regulation Discharge method. The flag is always considered an input on any timestep where it is set but no value is initially set by the user. Like the **SURCHARGE RELEASE** flag, the **REGULATION DISCHARGE** flag should only be set by a rule. If the user is interested in using one of the Regulation Discharge methods, detailed information can be found **HERE (Objects.pdf, Section 9.1.9)**.

4.1.6.8 Unit Values Flag

The **UNIT VALUES** (U) flag is used to indicate that the user is going to specify unit level values but would like to use those to drive the solution. The **UNIT VALUES** flag may be set on Energy or Turbine Release on power reservoirs that have the Unit Power Table (**HERE (Objects.pdf, Section 17.1.1.12)**) method selected. If the Unit Power Table method is not selected, an error is issued. This flag is considered a user input but does not require a value (similar to the **MAX CAPACITY** and **BEST EFFICIENCY** flag). At the beginning of the run any numeric values are cleared out. The flag can be set directly on the slot, from the SCT or from a Rule.

U Flag on Energy: Thus, if the U flag is set on Energy, one or more Unit Energy subslots must be specified by user input or a rule. When RiverWare runs, it sees that Energy has this flag which is considered an input. If it has enough other information (like Inflow, Storage, or PE), the reservoir will be able to dispatch one of the following methods:

- solveMB_givenEnergyInflow
- solveMB_givenEnergyStorage
- solveMB_givenEnergyHW

In addition, Energy can be flagged U, if the reservoir dispatches one of the following methods:

- solveMB_givenInflowOutflow
- solveMB_givenOutflowHW
- solveMB_givenOutflowStorage

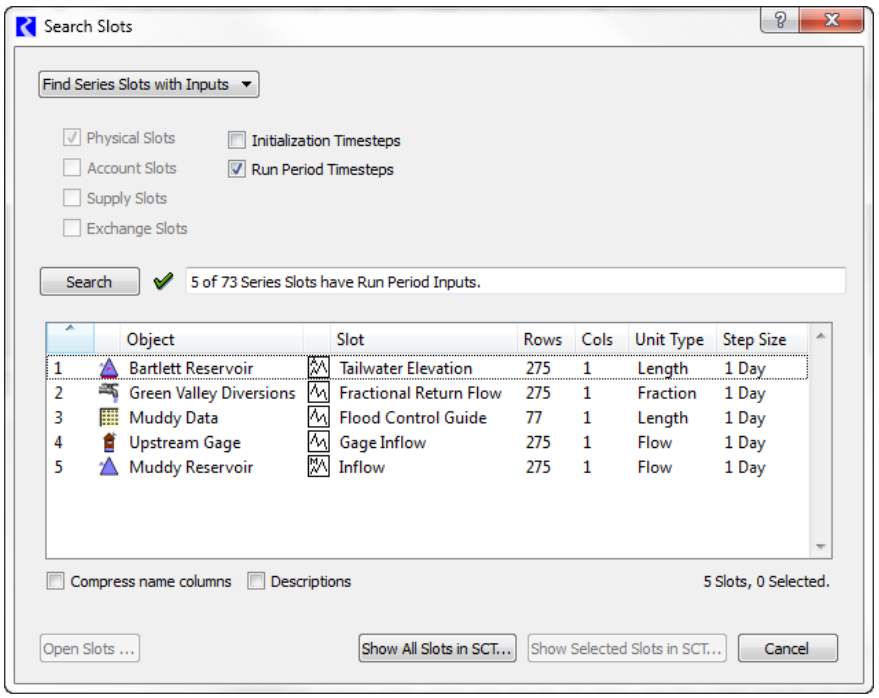
These methods do not require energy to be unknown.

U Flag on Turbine Release: Alternatively, if the U flag is set on Turbine Release, one or more Unit Turbine Release subslots must be specified as user input or by a rule. When RiverWare runs, it sees that Turbine Release has this flag which is considered an input. If it has an Inflow, the reservoir will be able to dispatch the solveMB_givenInflowRelease method.

Because this flag is specific to the Unit Power Table method, the full algorithm is described **HERE (Objects.pdf, Section 17.1.1.12)**.

4.1.7 Finding Inputs

The **Find Series Slots with Inputs** utility can be used to find values that are input in the model. It is accessed from the RiverWare Workspace using the: **Workspace ➥ Slots ➥ Find Inputs... menu.** The dialog shown to the right opens.



The user has options to filter on the types of series slots on which to look for input values. In a pure simulation model, this is only Physical Slots (i.e. Outflow, Inflow, etc.) If Accounting is enabled, the user may choose to search any or all of the following series slot “domains”:

- Physical Slots

- Account Slots
- Supply Slots
- Exchange Slots

The search may be limited to either **Initialization Timesteps** (before the Run Start timestep) or **Run Period Timesteps** (on or after the Run Start timestep). If both are checked, all series slots having any inputs are found, regardless of where (in time) those Input values are within the slots' time series.

The search operation is performed by clicking the **Search** push button. The number of series slots with Input-flagged timesteps, and the total number of series slots matching the checked “domains” are indicated in a status line to the right of the search button. If search criteria is changed (by clicking any of the check boxes at the top of the dialog), a green check icon  is displayed next to the search button indicating that a new search with the new criteria has yet to be performed. The green check icon is hidden upon performing another search.

The user has the option of showing the slots' object name and account name (if applicable) in separate columns. This is controlled by the **Compress columns** check box below the slot list. This is not available if supply slots or exchange slots are shown in the slot list,

Several context menu (right click) operations are available within the slot list:

- Open Slot -- Show the open slot dialog for the picked slot item.
- Open Object -- Show the object dialog for the picked slot item (if applicable).
- Copy Slots -- Put the selected slot items into the slot clipboard, e.g. to paste into an output (manager) device slot list.

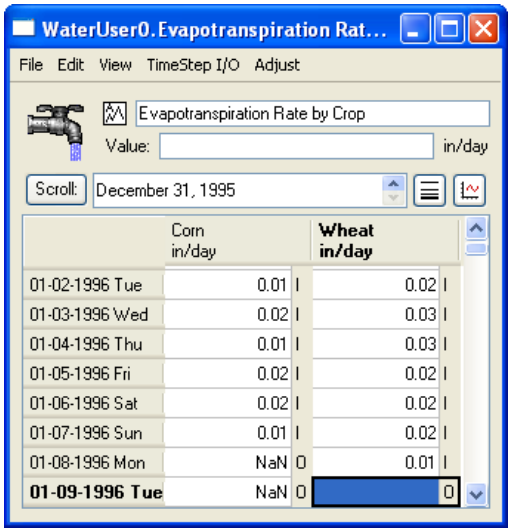
Buttons along the bottom of the dialog provide these functions:

- **Open Slots**: Separate open slot dialogs are shown for each of the selected items in the list. If more than four (4) slots are selected, then a query dialog box is shown confirming the operation with a message like this: “Do you want to show 421 Open Slot dialogs?”. Note that all shown open slot dialogs may be hidden with the **Workspace ➥Slots ➥ Close All Slots**... menu operation.
- **Show All Slots in SCT**: All slots in the list (regardless of item selection) are shown in a new SCT dialog, and the **Find Series Slots with Inputs** dialog is closed.
- **Show Selected Slots in SCT**: Selected slots in the slot list are shown in a new SCT dialog, and the **Find Series Slots with Inputs** dialog is closed.
- **Cancel**: The **Find Series Slots with Inputs** dialog is closed.

The dialog can also be used to find slot descriptions as described **HERE (Section 2.2)**.

4.2 Agg Series Slots

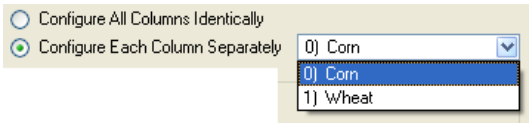
Aggregate Series Slots (Agg Series) are specialized Series Slot that group together one or more Series Slots which are independent of one another. They are used to group together similar series of data. Agg Series slots are essentially multiple individual series of data. The columns of an Agg Series Slot are often referred to as Sub Slots. The screenshot to the right shows the Evapotranspiration Rate by Crop for two different crops, Corn and Wheat.



4.2.1 Configuration

Following are configuration options specific to Agg Series Slots. Further information on general configuration can be found **HERE (Section 2.1.5)** and **HERE (Section 4.1.4)** for Series Slots.

Agg Series slots can be configured such that each column is configured identically or each is configured individually. In the Configuration dialog, there is a toggle to configure the columns identically or separately as shown:



4.2.2 Other Options

Because each column can be configured separately, the time range of each column can be configured to have different start and end dates. The two options allow the columns of the agg series to synch back together:

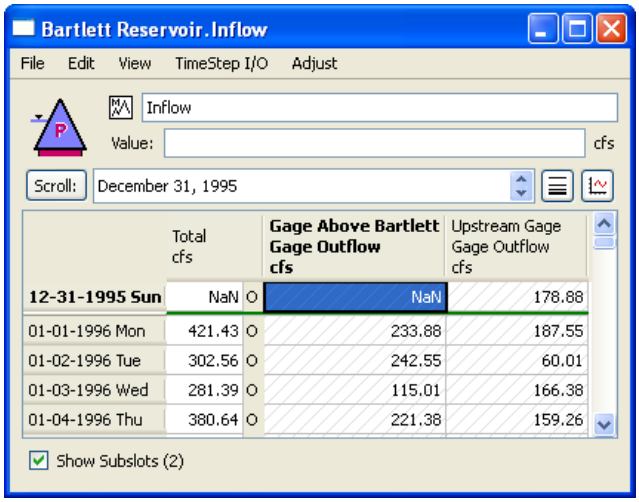
Max Synch: The **Edit ➥Max Synch** option will synchronize each column to fully encompass the earliest and latest date displayed on any column of the slot. For example, if column 1 goes from Jan. 1, 1999 to June 1, 1999 and column 2 goes from Feb. 2, 1999 to July 23, 1999, a **Max Synch** will change the range of both columns to be Jan. 1, 1999 to July 23, 1999.

Synch to Column0: The **Edit ➥Synch to Column0** option will synchronize each to column to match the first column (i.e. column 0). **O**n the previous paragraphs example, a **Synch to Column0** will change the range of all columns to be Jan. 1, 1999 to June 1, 1999.

Note: Many of the general slots in RiverWare, such as Outflow, Storage, and Pool Elevation are Agg Series slots. This is an artifact of how the original optimization system was designed. When enabled, optimization used the second and third columns in the solution. In the current controllers, these columns are never used and can be ignored. In this case, the user can think of a single column Agg Series as a normal Series Slot.

4.3 Multi Slots

Multi Slots are specialized series slots that automatically sum the values of the slots to which they are linked. In the screenshot, two series slots named **Gage Above Bartlett. Gage Outflow** and **Reach2.Outflow** are linked to the **Bartlett.Inflow** slot. Each of the linked slots appears in a column. The cells for these columns are grey hatched indicating that they are not directly editable from this view. The user should edit these values from the other end of the link. The sum of all linked columns is reported in the **Total** column. The columns of a Multi Slot are often referred to as Sub Slots. All of the sub slots must have the same unit type and user unit although the other end of the link can have a different user unit, conversion is automatic.

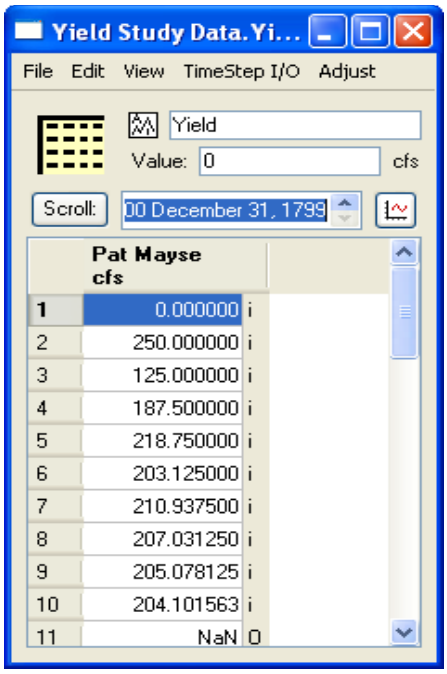


Configuration of Multi Slots is similar to Series Slots **HERE (Section 4.1.4)**. On Multi Slots there is a toggle at the bottom of the dialog that is used to hide or show the subslots. The check box is shown only if the MultiSlot has at least one subslot. It is initialized to OFF if the MultiSlot has exactly one subslot, otherwise, it is initialized to ON. This can be useful for subslots that only have one link, hence it really only represents one series of data.

4.4 Integer Indexed Series Slots and Agg Series

Integer Indexed Series Slots (and Integer Indexed Agg Series Slots) are a specialized type of series slots whose range is not associated with dates, rather just their order in the series. The indices are 1-based, i.e. the first value has index 1.

Configuration of Integer Indexed Series Slots is similar to Series Slots **HERE (Section 4.1.4)** but, because the series is incremented by integer, there are a few differences between this type of slot and a standard series slot. The **View** menu now has a **Series Range** menu instead of the standard **Timeseries Range** menu option. In the **Series Range** menu (the **Configure Series** dialog), the Begin, End, and timestep areas are disabled. The user can change the range only by changing the number of values.



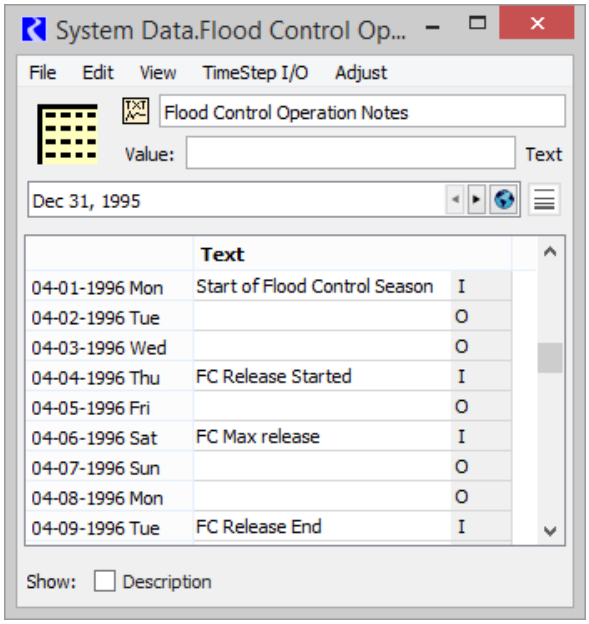
> **Note:** Internally, the slot is actually a standard series slot with a 1 hour timestep starting on 24:00 December 31, 1799. This can be important because this date is shown in the date scroll area.

Integer Indexed Series slots can be used as a part of the following utilities:

- They are plotted with integer values with units of NONE for the x dimension.
- They can be accessed and set from the RiverWare Policy Language. Integer Indexed Slots are particularly useful in Iterative MRM mode as they can be used to store values for a particular run index.
- They can be displayed on a System Control Table (SCT). Note, the SCT can either show standard time series or integer indexed series, but not both.

4.5 Text Series Slots

The Text Series Slot holds a series of user specified text strings. Because it is a series slot, it provides much of the required series slot functionality like display, flags, use in SCTs, and input via DMI. An example Text Series Slot is shown to the right. It has comments about how the system is operated during Flood Season. Following is information on **supported functionality**:



- The Text Series Slots behaves like other slots in terms of showing/hiding/grouping on the open object dialog. They have a description and other normal slot attributes.
- Text values have normal, I, O, and Z flags. A non-specified value is blank, not NaN.
- Convergence, bounds, and changing units on Text Series Slots is not relevant.
- Import/Export through a DMI is supported via Excel Database DMIs **HERE (DMI.pdf, Section 5.3.3)**.
- Text Series Slot values can be displayed and edited in an SCT.

As of version 7.1, the following is **unsupported functionality**:

- Import/Export to a text file is not allowed.
- Text values can NOT be read or set from RPL or Scripts.
- Text Series Slot are not displayable in Model Reports of Tabular Series Slot Reports
- Values in Text Series Slots are not shown in plots or other output devices.
- Text is not exportable to Output Devices that are file based like CSV, RDF, netCDF, Excel.
- Text cannot be copied from Excel and Import Pasted into slots or SCTs. You can copy and paste a single text string, but not a range or text.

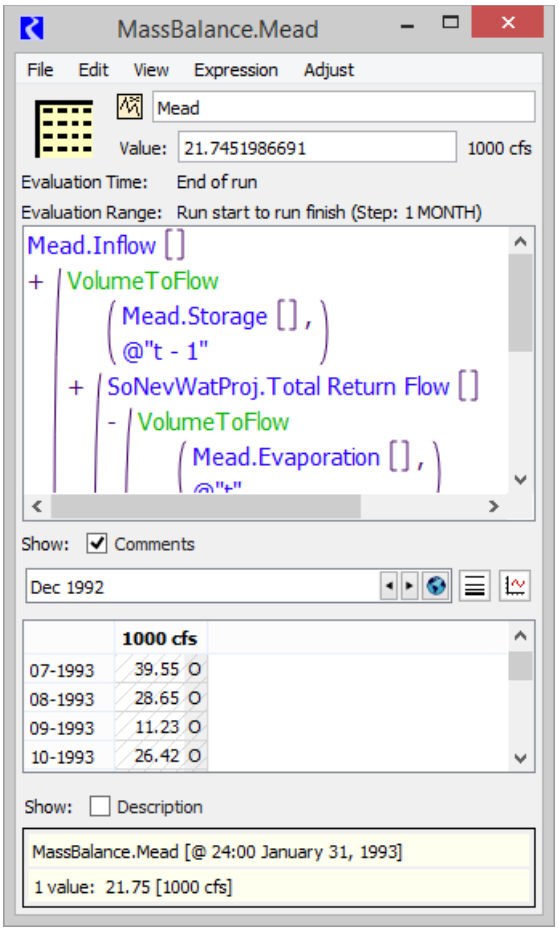
Note: Internally, the Text Series Slots is actually a normal series slot that holds an encoded index which indicates which text string to display. If you try to copy and paste, you will see the encoded number.

4.6 Expression Slots - Series

Expression slots are computational expressions. The user can either create a **Series Slot with Expression** or a **Scalar Slot with Expression**. They are used to calculate quantities such as “combined Storage of all Reservoirs,” “weekly average Outflow of Hoover Dam,” “the ratio of Hydrologic Inflow

to Reach Inflow at selected structures", or any conceivable expression. To add a Series slot with expression select **Slot ➥ Add Series Slot with Expression.**

Expression slots utilize the RiverWare Policy Language (RPL). RPL is computationally expressive language and has an associated structured editor. Because Expression slots utilize RPL (the same language in which RiverWare rules are written) they may contain simple expressions or complex logic and functions. Anything that may be expressed in a rule may also be evaluated in an Expression slot. The use of RPL also provides dimensional analysis to ensure that units are reconciled throughout the expression. It is important to make sure that the unit type of the slot is the same as the units to which the expression evaluate.



4.6.1 Configuration

Following is description of the configuration options available for expression slots.

4.6.1.1 File Menu

On the File menu, the Import options are not available as you cannot import or type data into the slot. The export options are available and can be used to export the calculated data out of the slot. A Print Expression menu option is available to print the expression. This uses the same printing mechanism as other RPL sets, described **HERE (RPLUserInterface.pdf, Section 6.1)**.

4.6.1.2 Edit Menu

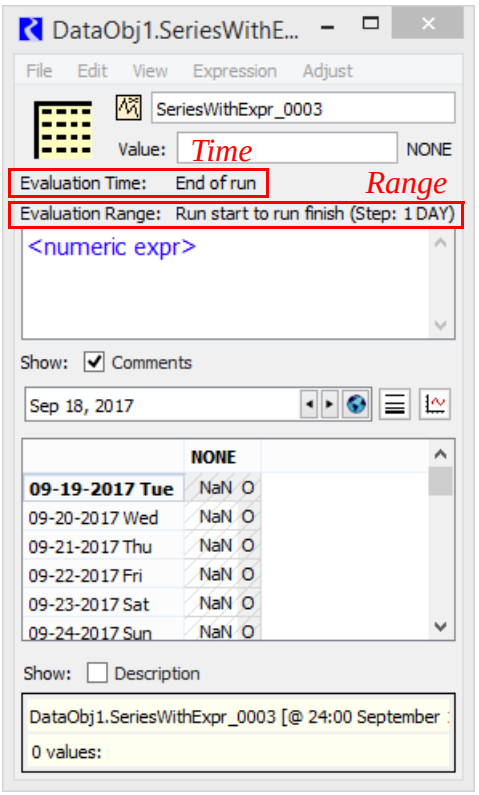
On expression slots, the **Edit** menu has options to **Copy** (to the RiverWare clipboard) and **Export Copy** (to the system clipboard). Importing, pasting, and other data editing features are disabled as the expression slot is "output only".

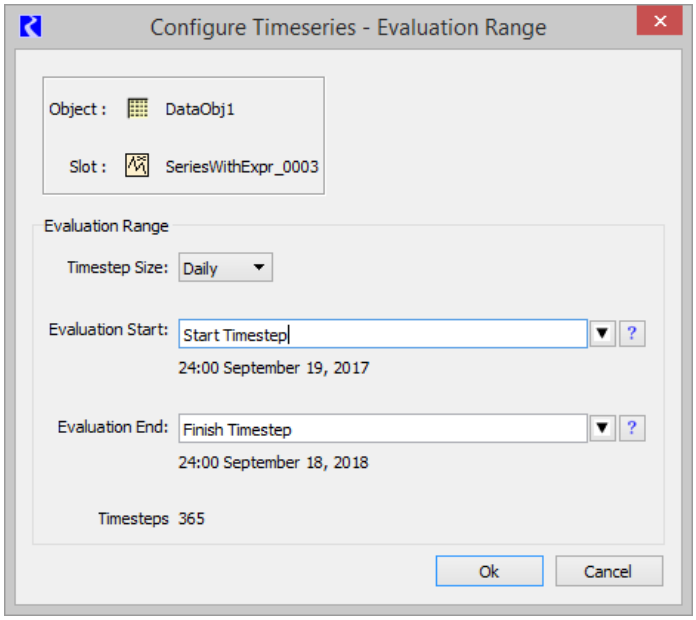
4.6.1.3 View Menu

The View Menu on expression slots show the following menu options:

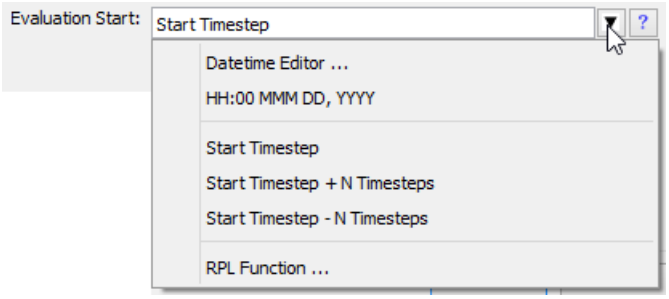
Configure: The configuration uses the standard series slot configuration dialog described **HERE (Section 4.1.4)**. You can change the unit type of the expression slot. It must correspond to the unit type of the RPL expression.

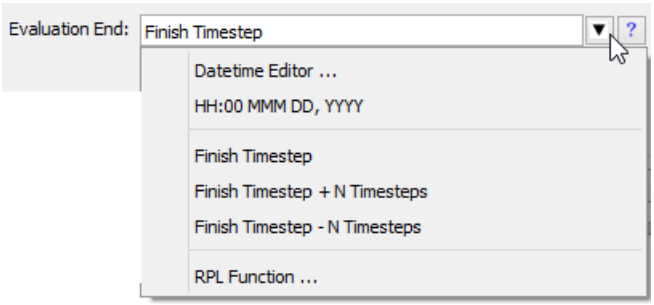
Evaluation Range: By default, Expression slots are evaluated for each timestep in the model run (i.e., the range is synchronized with the run control). If you are only interested in the result of an expression for a reduced range of dates or for a different timestep, you may select **View ➥ Evaluation Range**, to open the **Configure Timeseries - Evaluation Range** dialog and enter the date range in which you are interested.





The Start and End times can be specified explicitly or symbolically as RPL DATETIMES as described **HERE (RPLTypesPalette.pdf, Section 1.3)**. Text below the editor field indicates the actual datetime of the entered symbolic time text (if it is valid), or the status if it is not valid. You can also use the drop-down menu to specify one of the common datetimes. Some of these are expressions which must be edited to become valid, e.g. by replacing "N" with a nonnegative integer and the **HH:00 MMM DD, YYYY** formula, where you substitute the hour, month, day and year.





The **Datetime Editor...** option opens a separate dialog to specify the datetime using a selector configured for the model's timestep size.

The **RPL Function...** opens a Function Selector to select a RPL function in the Expression Slot or Global Function Set. **The selected function must have a return type of DATETIME, and must not have any arguments.**

Click the Help Button (question mark icon button) on the right side of the symbolic datetime editor to show a description of symbolic datetime representations.

Note: An expression slot does not need to have the same timestep as the run control. For slots with a different timestep than the run, the slot will evaluate for only those timesteps that fall within the run dates. When entering a symbolic date such as "Start Timestep - N Timesteps", the slot's timestep will be used in the subtraction.

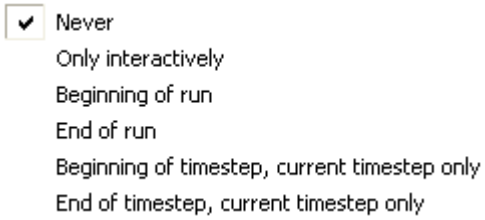
4.6.1.4 Expression Menu

Show Expression: This toggle is used to show or hide the expression. By default, the expression is shown.

Evaluate: The user can manually evaluate the expression from the **Expression ➥ Evaluate** menu.

Validate: The user can manually verify the expressions validity using the **Expression ➥ Validate** menu.

Evaluation Time: Expression slots can be evaluated at the beginning or end of each simulation run, at the beginning or end of each timestep, never, or interactively on demand. These options are particularly useful for performance when running large models and when evaluating a large number of expression slots. To select when an Expression slot is evaluated select **Expression ➥ Evaluation Time** from the Expression slot menu, and choose from the options shown to the right. A check mark will be shown next to the selected option.



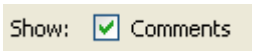
Note: Unlike rules, expression slots do not **re-evaluate** if dependent slots change. But, if the expression slot returns a NaN, the expression slot is put on a list of slots to be re-evaluated during that same evaluation time. The NaN might come from an expression slot that hasn't been

evaluated yet, so it should evaluate later, once that expression has had a chance to evaluate. The palette operations IsNaN and NanToZero return a valid value, so do not cause re-evaluation of the expression slot.

Editing Menu items: The Expression menu is used to build expressions. There are options to **Cut**, **Copy**, **Paste, Delete**, and **Enable** and expression. **Undo** and **Redo** are available to go back or go forward when editing expressions. These are only available when a relevant expression is selected. Finally, there is a menu option to bring up the **Palette** open the **RPL Debugger** and open the **RPL set**.

Open RPL Set: The RPL set containing functions used by any expression slot can be opened by **View ➥ Open RPL Set.** All of the functionality associated with a RPL set can be utilized from this RPL set editor such as importing/exporting, analysis, search and replace, and creating utility groups of functions. Note, that only functions will be shown in the RPL set editor, the expressions on the slots themselves are the equivalent to the rules in a ruleset. Click **HERE (RPLUserInterface.pdf, Section 1)** for more information on RPL sets. From the RPL set, the user can control the layout using the **Set p Layout...** menu. Click **HERE (RPLUserInterface.pdf, Section 6.2)** for more information on layouts.

Show Comments: The **Show Comments** menu allows you to hide or show inline RPL comments (added from the palette). There is also a toggle on the slot dialog below the RPL expression that hides/shows the comments (shown to the right). Comments are shown by default. If there are any comments defined, a box is shown around the toggle.



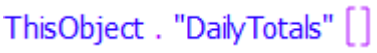
4.6.2 Building Expressions

Expression slots utilize the RPL palette to build expressions. The RPL palette provides a syntax-guided editor designed to assist in the construction of complex syntactically correct expressions within the RiverWare Policy Language environment. The editor works by maintaining a partially constructed expression and allowing the user to manipulate unfinished portions using the palette. Initially, the buttons in the palette are grayed out. When building an expression, the **palette** enables any buttons that could possibly go in a highlighted portion of the expression.

See the documentation **HERE (RPLUserInterface.pdf, Section 1)** on RPL and the palette for further information on any of the RPL topics described.

Note: For Expression Series Slots, the symbolic datetime specifications @"Start Timestep" and @"Finish Timestep" refer to the expression slot's evaluation range, not the controller's start or end dates. The predefined functions, RunStartDate() and RunEndDate(), **HERE (RPLPredefinedFunctions.pdf, Section 161)**, provide a reference to the controller's start and end dates, respectively.

Note: For Expression Slots, you can use the keyword ThisObject to access the containing object. For example, to get the slot named DailyTotals from this object, you could create the expression shown in the image.



4.6.3 Diagnostics for Expression Slots

Diagnostics for expression slot evaluation can be configured in the **Diagnostics Manager** HERE (Diagnostics.pdf, Section 1.2).

If expression slots are evaluated outside of a run, using the **Expression ➥ Evaluate** menu on the slot or the **Control ➥Evaluate Expression Slots** menu from the workspace, then diagnostics must be set up using the Workspace diagnostics HERE (Diagnostics.pdf, Section 5.1).

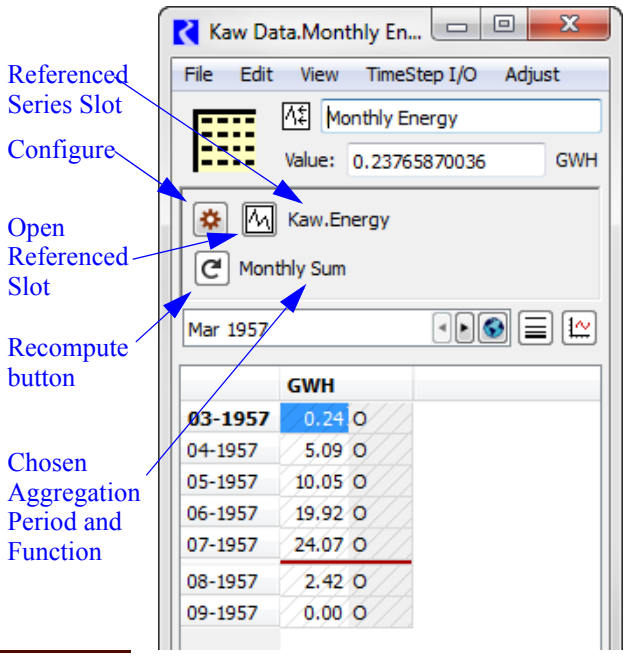
If expression slots are evaluate during a run, either beginning or end of timestep or beginning or end of run, then diagnostics must be set up using Simulation diagnostics HERE (Diagnostic.pdf, Section 2.1) or Rulebased Simulation diagnostics HERE (Diagnostics.pdf, Section 3.1), depending on the selected controller. Within each of those diagnostics configurations, the **Expr. Slot Execution** and **Expr. Slot Function Execution** categories deal with expression slots.

4.7 Time Aggregation Series Slots

Time Aggregation Series Slots temporally aggregate another series slot. For example, you might aggregate a daily flow to an annual average. They can be recomputed manually or automatically at the end of a run. The configuration of a Time Aggregation Series Slot includes the following properties:

- The series slot to be aggregated, chosen using the slot selector.
- The aggregation function, one of:
  - **Sum**: Add the values during the aggregation period.

$$\text{Sum} = \sum_{i=\text{first timestep}}^{i=\text{last timestep}} \text{Value}_i$$



Note: For slots with a rate unit type (flow or velocity), a true sum does not make sense and is therefore not an option in the menu. Instead, use the average which represents a time weighted average. Change the display units as needed to see the values desired.

- **Average**: Report the mean during the aggregation period.

$$Average = \frac{\sum_{i = \text{first timestep}}^{i = \text{last timestep}} Value_i \times \Delta t_i}{\sum_{i = \text{first timestep}}^{i = \text{last timestep}} \Delta t_i}$$

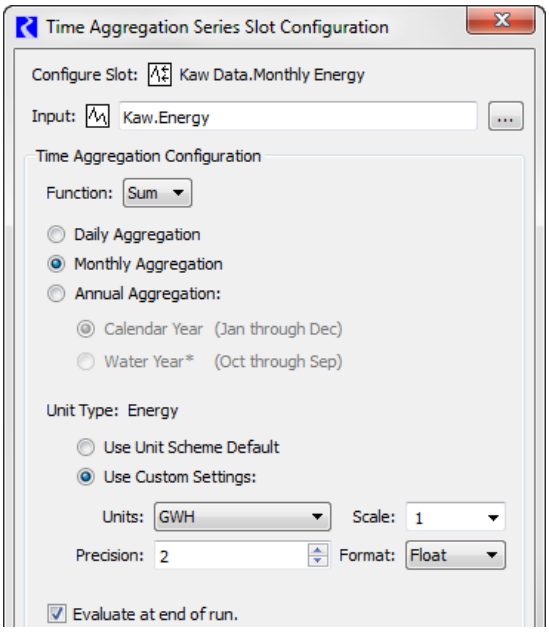
- **Minimum**: The smallest value (in units displayed) in the aggregation period is reported.
- **Maximum:** The largest value (in units displayed) in the aggregation period is reported.
- **First value**: The first value in the aggregation period is reported.
- **Last value**: The last value in the aggregation period is reported.

- Choice of aggregation period, one of:
  - Daily
  - Monthly
  - Annual -- Calendar Year
  - Annual -- Water Year*
- The **Units** you wish to show, including display unit, scale, precision, and format.
- If you wish to evaluate them at end of run
- What to do when encountering NaN:

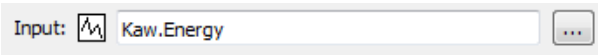
Functionality is provided to duplicate a Time Aggregation Series Slot for the same named slot on multiple other "similar" objects.

4.7.1 Configuration settings

Once created (from the Object's **Slot ➥Add Time Aggregation Series Slot** menu), open the slot dialog to configure the slot. Configuration controls are available in a separate dialog which is shown by clicking on the "configure" icon  .



First, select the slot to aggregate using the Input field



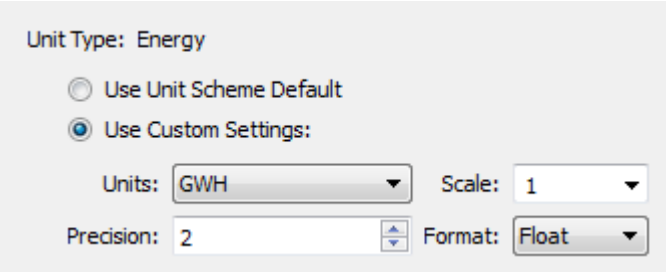
Then choose the aggregation function; use the **Function** pull-down menu to select the aggregation function to be used. The functions are described above.

Then choose the aggregation period:

- **Daily Aggregation**
- **Monthly Aggregation**
- **Annual Aggregation / Calendar Year**
- **Annual Aggregation / Water Year***

Hover over the Water Year text to get a tool tip. The "Water Year" is described **HERE (Section 4.7.1.1)**.

Then choose the **Units** to show for the aggregated data. The Unit Type is fixed to the Unit Type of the referenced series slot. But you can specify any display units to use. For example, you can show daily flows in cfs averaged as monthly values, displayed in acre-feet/month. The options are:



- **Use Unit Scheme Default**: When this is selected, the unit scheme specification, including any slot name exceptions will be used. Unit Schemes are described **HERE (Units.pdf, Section 1)**.
- **Use Custom Settings:** When selected, specify the units directly in this dialog. Note, this will actually make a Slot Exception in the Unit Scheme with the specified units.

The **Evaluate at end of run** checkbox controls whether this slot is automatically evaluated (recalculated) at the end of the run. The "end of run" evaluations are performed after all "end of run" RPL Expression Slot evaluations. (So, it would be reasonable for a Time Series Aggregation Slot to aggregate an "end of run" RPL Expression Series Slot).

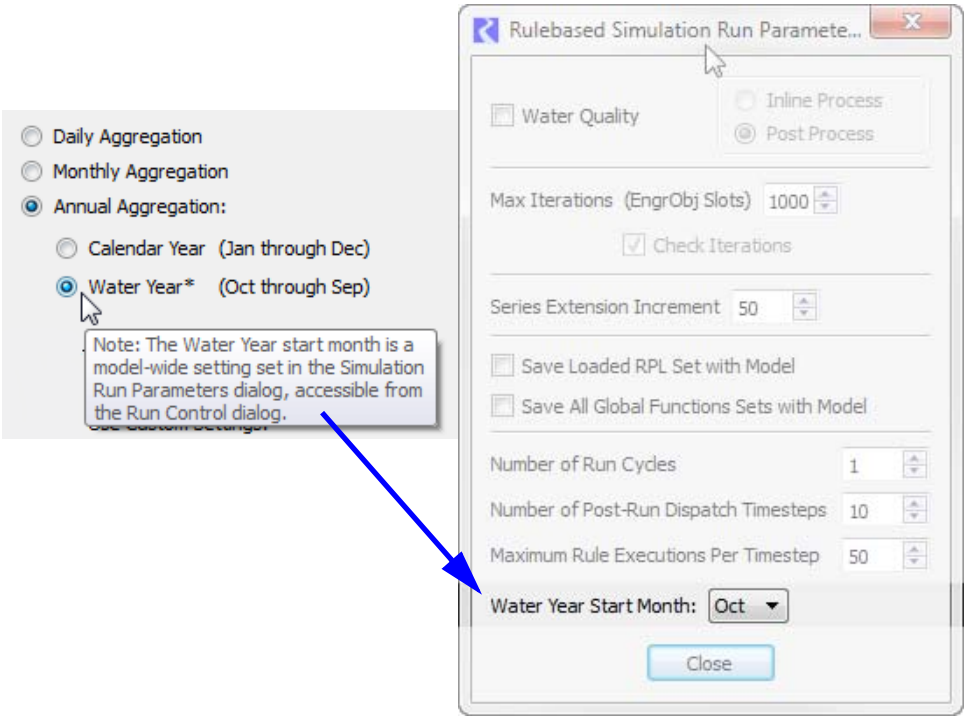
The following options are available to deal with NaN values:

- **Ignore NaNs:** NaNs do not contribute to the aggregated values. Intervals with some values and some NaNs will become values at the larger timestep.
- **Do not aggregate intervals having NaNs:** Any interval with NaNs are not aggregated. Intervals with some values and some NaNs will be NaN at the larger timestep. Note, for the **First** and **Last** aggregation function, only the **First** and **Last** timestep is considered. Other timesteps do not matter in their NaN status.
- **Error on NaN (excluding pre-simulation timesteps):** An error is issued to diagnostics.

4.7.1.1 Annual Aggregation support for Non-Calendar Water Years

One of the supported aggregation modes is aggregation to "Water Years" starting in a user-specified month.

The **Water Year Start Month** is a model-wide setting, configured in the **Simulation Run Parameters** dialog, accessible from the **Run Control Dialog** HERE (RunControl.pdf, Section 2.1).



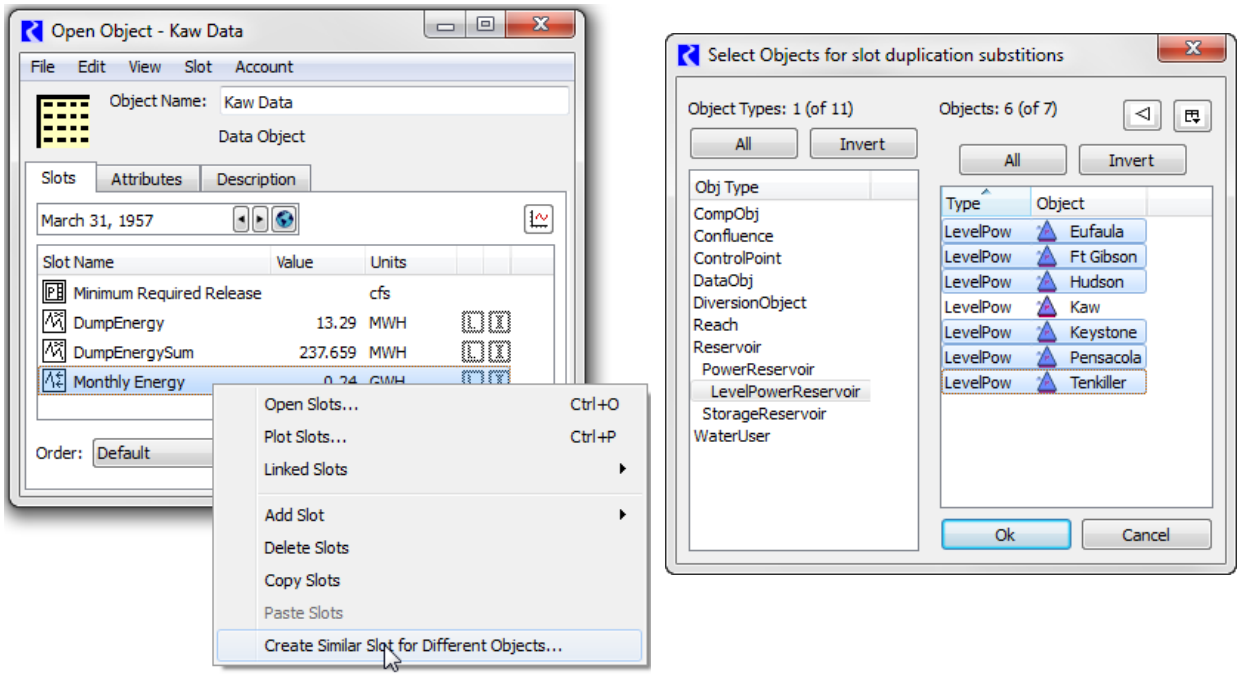
Note: The resulting annual series is still nominally identified as a calendar year (ending on December 31). Water years are named by the year in which the water year ends, i.e. a water year from October 2000 through September 2001 is the "2001" water year.

4.7.2 Creating Similar Time Aggregation Series Slots for Different Objects

In a single operation, you can create a Time Aggregation Series Slot for the aggregation of the same series slot on multiple other selected simulation objects. For example, if a given time aggregation slot is annually summing the Energy slot on a power reservoir, similar aggregation slots can be created for all other power reservoirs, in a single operation.

When a properly configured Time Aggregation Series Slot item is selected within an Object's slot list, the **Create Similar Slot for Different Objects...** operation under the **Slot** menu is enabled. Activating that menu item brings up the simulation object selector dialog where multiple objects can be selected. The selector is initialized to show objects of the same type as the object containing the reference slot (e.g. in this example, Power Reservoirs). Ultimately though, you can select a broader range of simulation objects.

The names of the new slots are devised as follows: If the originally selected time aggregation slot's name contains the name of the referenced slot's containing object, then the new names are that name, with the original containing object name replaced by the new selected objects. In the example, the original time aggregation slot named "Monthly Energy" is aggregating the "Kaw.Energy" slot. However, the originally selected time aggregation slot's name does not contain the name of the

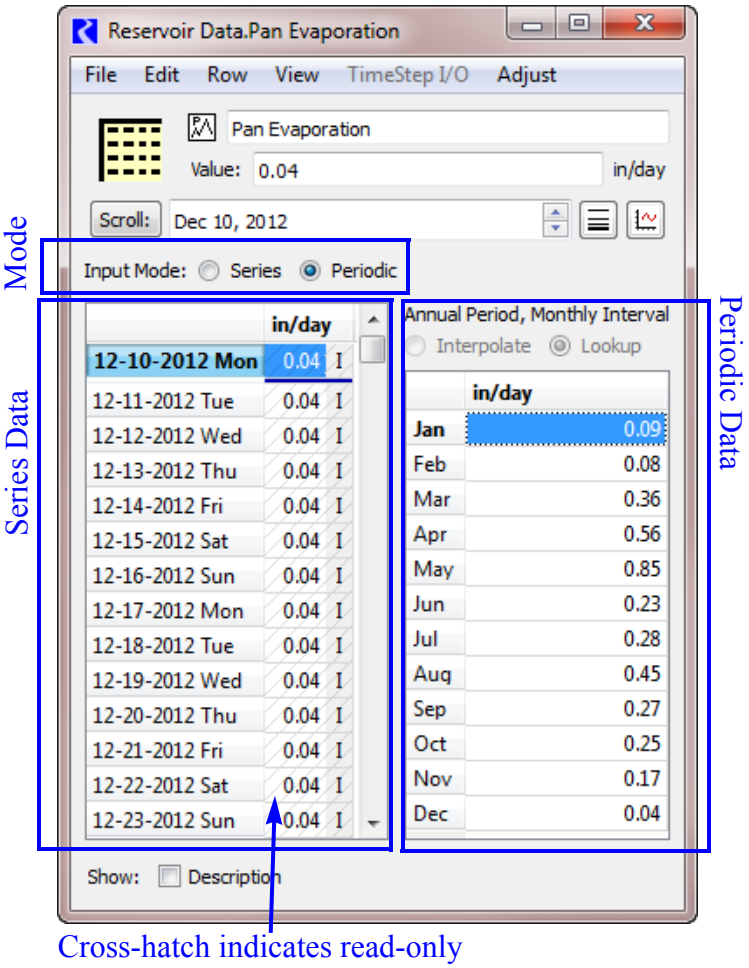


referenced slot's containing object, no direct name substitution is possible. Instead, the names of the new selected objects are appended to the slot name for the new slots: Monthly Energy_Eufaula, Monthly Energy_Hudson,...

4.8 Series Slots with Periodic Input

Series Slots with Periodic Input allow you to specify either a series of values or a periodic relationship. You can specify data in either of the two **Input Modes**:

- **Series**: The individual time-series values are directly editable in the slot dialog and in an SCT. In this mode, these slots are functionally equivalent to ordinary series slots.
- **Periodic**: The periodic values are editable and shown in a separate panel. As periodic values are entered, the series values are filled in. As with other periodic slots, you have the choice of several standard periods (e.g. annual, monthly, daily), either "irregular" or "regular" intervals within the period, and interpolation or lookup.



Series Slots with Periodic Input behave as ordinary series slots in virtually all ways, including RPL access, plotting, outputs, etc. A minor exception to this is that DMI import operation to these slots is blocked when they are in Periodic input mode.

In general, when switching a Series Slot with Periodic Input from Series to Periodic input mode, the existing series values are lost; they are overwritten with values computed from the periodic input definition. When switching from Periodic to Series input mode, the periodic input values are hidden and become inactive.

The remainder of this section describes creation and editing of these types of slots.

4.8.1 Slot Creation

Series Slots with Periodic Input exist on some engineering objects (particularly the reservoirs) and can be created by the user. From the Object dialog, choose the **Slot ➥Add Series Slot with Periodic Input** menu item.

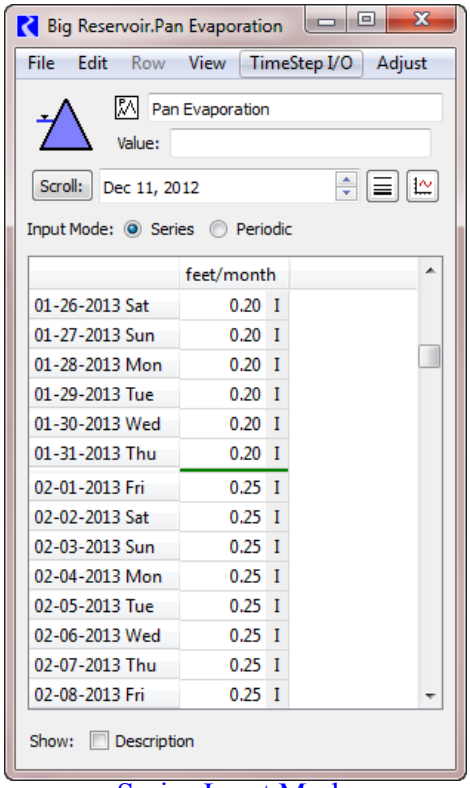
4.8.2 Slot Configuration

Following are configuration options for this type of slot.

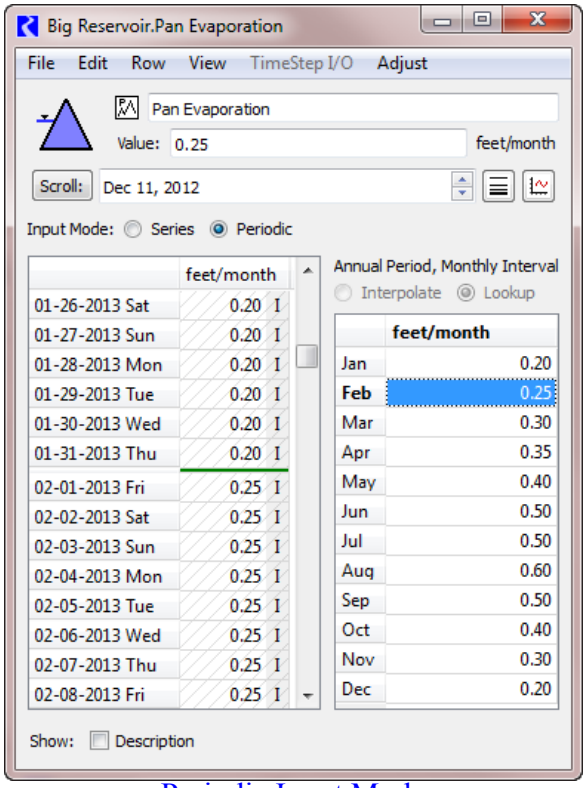
4.8.2.1 Series Input Mode

Series Slots with Periodic Input start in **Series** input mode where they appear and behave as ordinary series slots. The image below, left shows Series input mode.

The slots are accessed from RPL using standard series syntax, i.e. by datetime: Slot[ ] or Slot [E].



Series Input Mode



Periodic Input Mode

4.8.2.2 Periodic Input Mode

In **Periodic** input mode, the series data is shown as "read-only" (non-editable) but an editable periodic data panel is shown to the right (*see the right-side image, above*). Edits and operations on the periodic values immediately cause a recomputation of the series values -- assigned as *Inputs* except where periodic values are undefined, in which case NaNs (flagged as *Outputs*) are shown. Series values are computed for the series slot's currently configured time range.

The periodic configuration is accessible from the **View ➥Configure Period** menu. Refer to Periodic Slot configuration **HERE (Section 4.12)** for an explanation of the available period, interval, and data interpolation settings. Use the options in the **Row** menu to modify the rows of the periodic table.

Although they have periodic data, the slots are accessed from RPL using standard series syntax, i.e. by datetime: Slot[ ] or Slot [E].

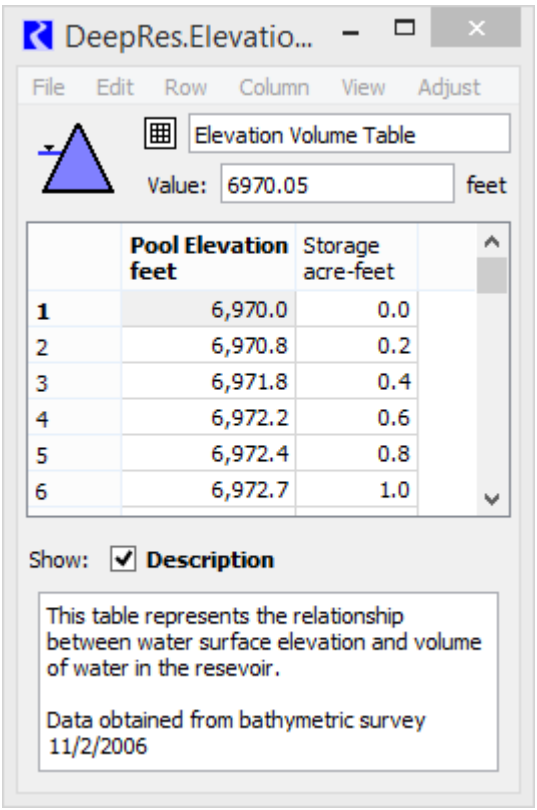
4.8.2.3 Switching between Series and Periodic Mode

In general, when switching from **Series** input mode to **Periodic** input mode, the series values are overwritten by values computed from the periodic values. When series values are overwritten by periodic data, the you must confirm the warning dialog. No confirmation dialog is shown when switching from Periodic input mode to Series input mode, as there is no loss of data in that change.

Table Slots

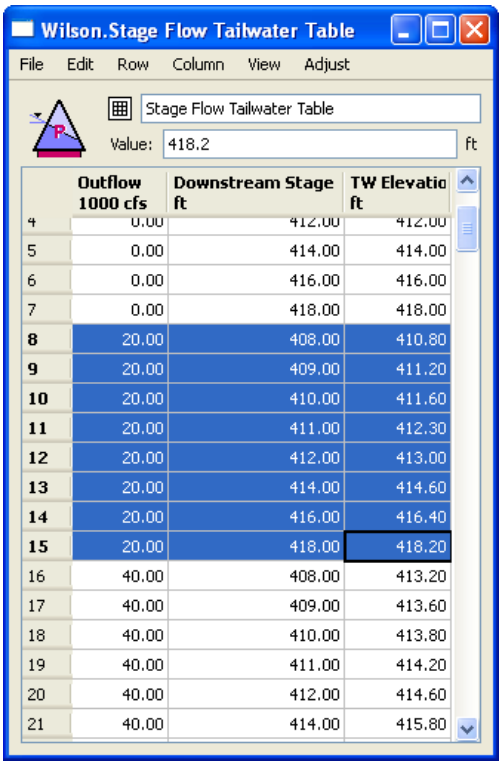
4.9 Table Slots

Table Slots are used to store any table of data. They can define a curve (2-Dimensional), a surface (3-Dimensional), or several unrelated sets. A 2-Dimensional table may require monotonically increasing values in its first column as shown in the Elevation Volume table.



4.9.1 Configuration

The configuration of Table Slots is described in the general slot configuration section **HERE (Section 2.1.5)**. Each column of the table has both a Label and a Unit (user units are configurable). On simulation slots, the Rows are labeled by number unless defined otherwise. Both columns and rows are zero based, i.e. the first column is column 0. On custom slots the user is able to change both the Units, Display Format, Column Labels, and Row Labels. Table Slots can be configured such that each column is configured identically or each is configured individually. In the View menu, there is a menu to Configure Columns Identically or separately using the Configure Column menu on the selected column.



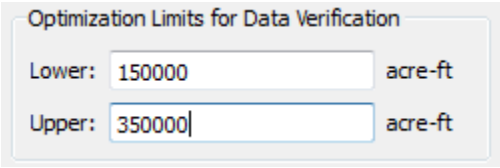
A 3-Dimensional table requires that column 1 contain sets of equal values which increase down the table, and column 2 must contain monotonically increasing values within each set of values from column 1. Column 3 then contains the values to look up for columns 1 and 2. For example, the **Stage Flow Tailwater Table** is a 3-Dimensional table relating **TW Elevation** to the independent variables of reservoir **Outflow** and **Downstream Stage**. A set where Outflow is equal to 20,000 cfs is highlighted.

Edit Row Configuration: The user is able to change the number of rows in most tables. This is done through the Row menu using the **Insert**/**Append**/**Delete** rows options. Move rows up or down using the **Row ➥ Move Rows** menu (Custom Slots only).

Editing Column Configuration: Some Table Slots allow columns to be appended and deleted. This is done to store a variable number of data sets within a single slot. A "block" is defined as the number of columns which must be appended or deleted together. In the case of the Elevation Volume Table, the block size is 2, one column for Pool Elevation and one for Storage (although the user can't add blocks to this table). When appending or deleting columns from a Table Slot and its dependents, reconfiguring must be done in blocks. The minimum table size is 1 block. The user can change the number of columns using the **Set Number of Columns**, **Append Column**, **Delete Column**, **Delete Last Column**, and **Set Dimensions** menu options from the Column menu. Move columns to the right or left using the **Column ➥ Move Columns** menu (custom slots only). The **Column ➥ Set Dimensions** can also be used to change the number of rows and columns at the same time.

Show Column Sum Row: The user is able to show the sum of the column rows using the **View ➥ Show Column Sum** Row menu item. This option adds a special read-only SUM row to the bottom of the column that sums all of the values above (NaNs are assumed to be zero). This feature is especially useful when setting up routing coefficients or factors where the sum of the column must equal 1.0.

Optimization Limits for Data Verification: The Table Slot single-column configuration dialog presents an **Optimization Limits for Data Verification** panel if the column is configured to support optimization checking limits. Click **HERE (Optimization.pdf, Section 6.7)** for more information.

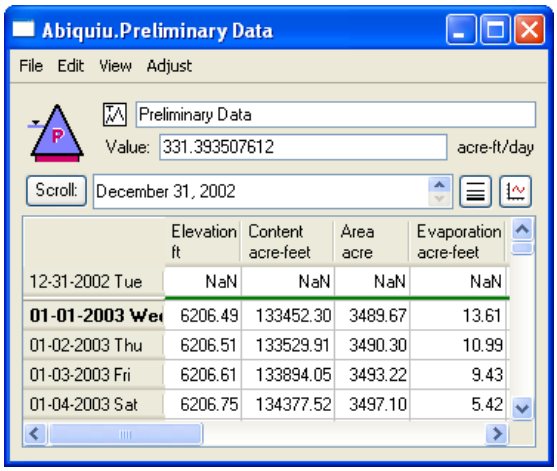


4.9.2 Source Slots

Some specific scalars and tables have a “Source” slot. When a slot has a source slot, the values are computed from the source slot’s values. Thus, the destination slot becomes read-only and displays a cross hatch over the data. The slot also provides a note indicating the source slot used to compute the data. The source slot is typically set/un-set at beginning of run, so you must initialize the run to see the read-only status.

4.10 Table Series Slot

Table Series Slots are a specialized table slot whose rows correspond to time values. This slot contains limited timeseries functionality thus making it more efficient than Series Slots. It was created as a way to efficiently write and/or read large amounts of data. Table Series Slots are primarily used within object user methods such as the Muskingum Cunge hydraulic routing methods. These types of slots cannot be created as custom slots.



4.11 Statistical Table Slots

Statistical table slots allow the user to specify a statistical function, such as a flow duration curve, which is computed at the end of a run using the data in specified model slot(s). This statistical analysis data can then be plotting or exported to another application.

This statistical analysis could be computed using Riverware’s existing export or output manager functionality coupled with a third-party analysis application such as Excel. Statistical table slots provides this functionality inside Riverware to allow quick analysis at the end of a run without leaving the Riverware environment.

4.11.1 Creating a Statistical Table Slot

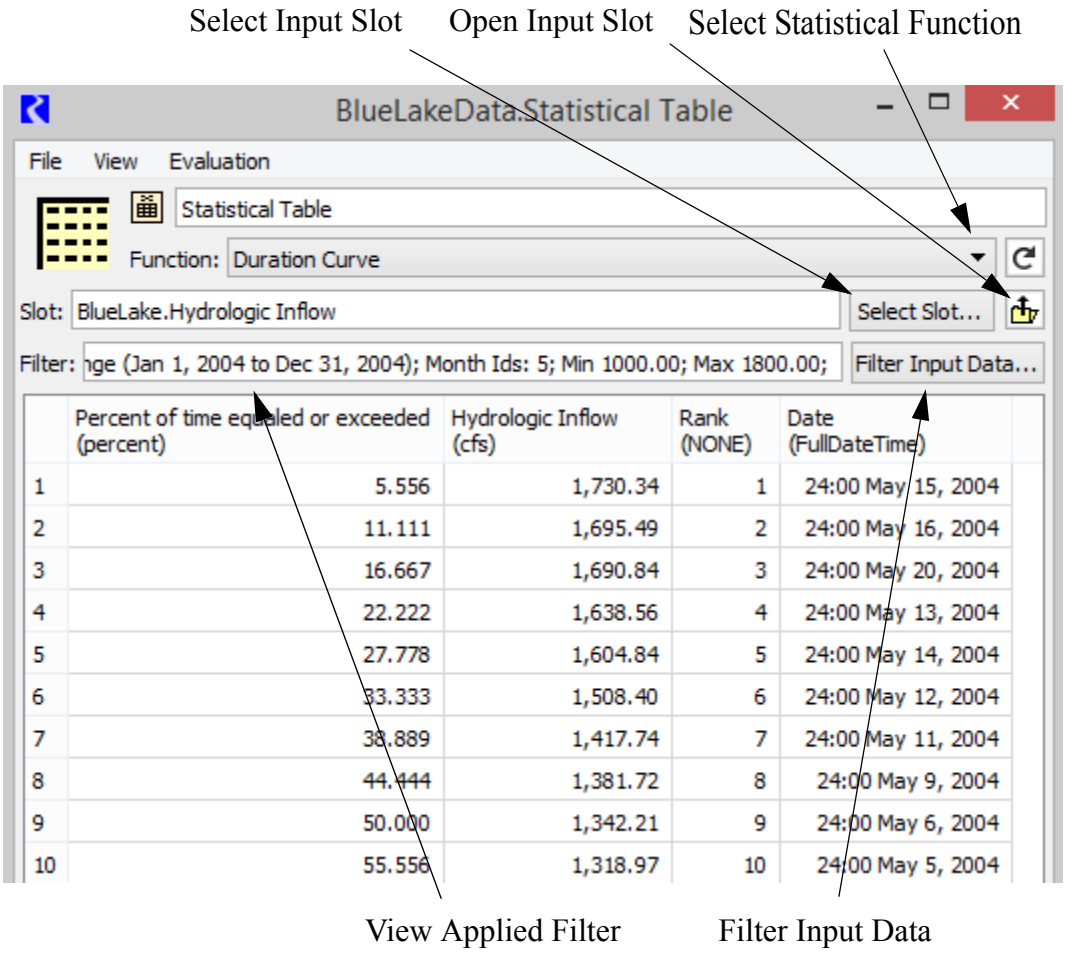
To create a statistical table slot, open the object dialog for a object. From this dialog:

- Select **Slot ➥ Add Statistical Table Slot** from the object’s main menu bar.
- Right-click over the slots list and select **Add Slot ➥ Statistical Table Slot** from the context menu.

A statistical table slot will be displayed in the slot list with the slot icon:

4.11.2 Configuring a Statistical Table Slot.

A statistical table slot is configured and viewed using the Statistical Table Slot Dialog. Open this dialog by double-clicking on the statistical table slot in the object dialog.



The basic steps in configuring a statistical table slot are:

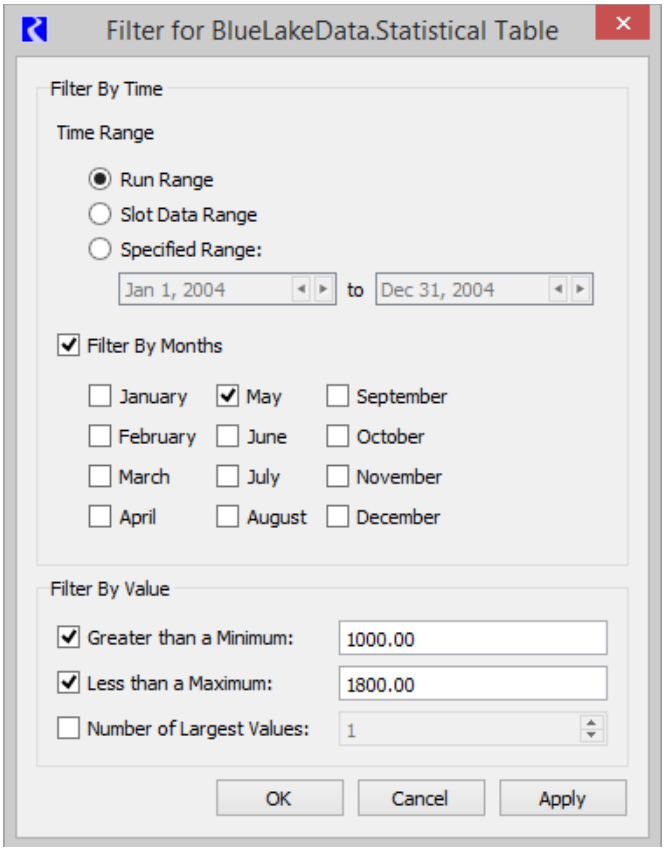
1. Select the desired statistical function from the **Function** pull-down list. The functions are described **HERE (Section 4.11.6)**.

2. Select the input slot for the statistical function by pressing the **Select Slot...** button. A selected input slot can then be opened by pressing the icon next to the **Select Slot...** button.

3. Select any desired filtering of the input data by pressing the **Filter Input Data...** button. Data can be filtered by:

- Time Range, select the **Run Range** (default), full **Slot Data Range**, or a **Specified Range**
- Months, choose the desired months
- Values **Greater than a Minimum**
- Values **Less than a Maximum**
- A specified **Number of Largest Values**

Multiple filters can be applied concurrently. A summary of any applied filtering can be viewed on the Statistical Table Slot Dialog in the Filter text window.



4. Specify the display units, scale, and precision for each column in the table by selecting **View ➥ Configure...** from the dialog's menu bar.

4.11.3 Evaluating a Statistical Table Slot

By default, all statistical table slots will be cleared at the beginning of the run and evaluated at the end of the run.

- To prevent a statistical table slot from being evaluated at the end of the run select **Evaluation ➥ Disabled** on the dialog's menu bar.

The contents of a statistical table slot can also be cleared and evaluated manually.

- To manually evaluate a statistical table slot select **Evaluation ➥ Evaluate (Alt+E)** from the slot dialog's menu bar.
- To manually clear the contents of a statistical table slot select **Evaluation ➥ Clear** from the slot dialog's menu bar.

4.11.4 Analyzing a Statistical Table Slot.

Snapshots can be made of statistical slots to easily preserve and compare their values from different runs.

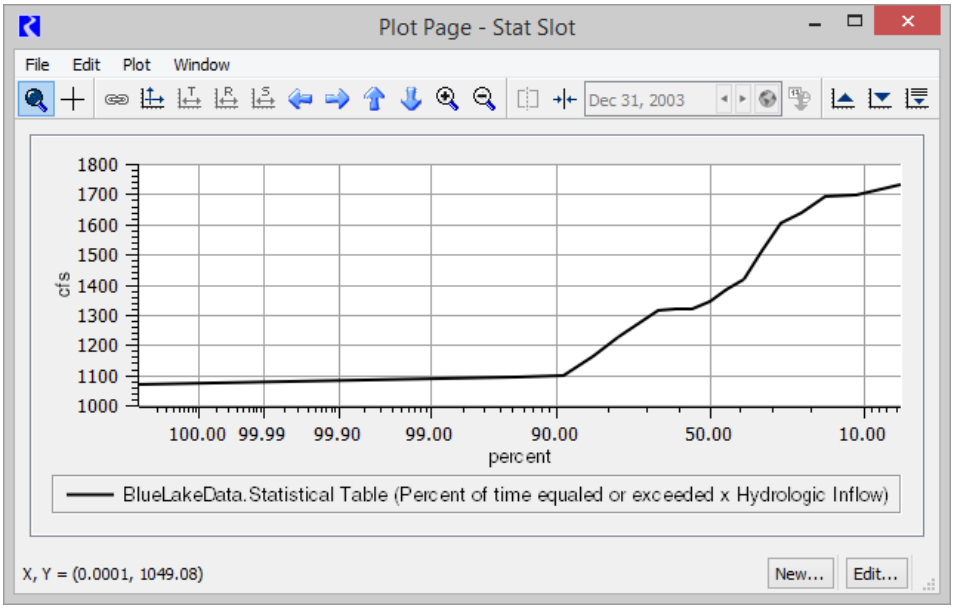
- To create a snapshot of the statistical slot select **View ➥ Snapshot Mgr (Alt+S)** from the slot dialog's menu bar.
- The snapshot manager dialog will be opened and the statistical slot and its input slot will be added to the manager's slot list if not already present.
- Taking a snapshot creates a data object with copies of all slots that are in the manager's list.

- To preserve the data, the snapshots of statistical slots have all functionality disabled that could change the values of the data in the slot.

4.11.5 Plotting a Statistical Table Slot

The contents of a statistical table slot can be plotted.

- To plot the contents of the statistical table slot select **File ➥ Plot (Ctrl+P)** from the slot dialog's menu bar.
- If the statistical slot has more than 2 columns, a dialog appears to allow specification of which columns to plot (some functions may present a check box option for plotting all the result data columns, for example to plot all duration columns from a value duration function). A typical choice would be percent exceedence probabilities versus values. In this case, the percent exceedences will, by default, be plotted on a probability scale as you would see on normal probability paper. On such a scale, normally distributed values will plot as a straight line.



- If desired, the probability axis can be changed to a linear scale by selecting **Edit ➥ Axis Configuration** from the plot dialog's menu bar, then choosing the X-Axis and changing the toggle.
- The axes of the generated plot can also be configured to be logarithmic by selecting **Edit ➥ Axis Configuration** from the plot dialog's menu bar. This can be used, for example, to plot a log-normal representation of the data.
- The configuration of the plot can be saved for quick access by using either the output manager or the **File ➥ Save As...** option on the plot dialog.

A statistical slot can be plotted with all of its snapshots.

- To plot the contents of the statistical table slot along with all of its snapshots, select **File ➥ Plot with Snapshots (Alt+P)** from the slot dialog's menu bar.
- If the statistical slot has more than 2 columns, a dialog appears to allow specification of which columns to plot (some functions may provide a check box option to plot all the result data columns). The selections are used for the slot as well as for all the snapshots.

- The slot's data and the data in all of its snapshots are plotted on the same graph to allow for an easy visual comparison.
- The axes of the generated plot can be configured to logarithmic scale by selecting **Edit ➥ Axis Configuration** from the plot dialog's menu bar.
- The configuration of this plot can be saved for quick access by using either the output manager or the **File ➥ Save As...** option on the plot dialog.

User data input to a table slot can be plotted with a statistical slot.

- Add a table slot by selecting **Slot ➥ Add Table Slot** menu.
- A dialog will appear asking for the number of rows and columns you want in your table slot. You will probably want at least two columns to plot the slot.
- The new table slot with a default name will appear in the slot list. Double click on the new table slot in this list to bring up the table slot's dialog.
- Select **View ➥ Column Labels** from the table slot's dialog. Give the columns heading names in the new dialog that comes up and click OK.
- Now select **View ➥ Configure** from the table slot's dialog. Assign Unit Type and User Units to your columns by using the Configure Each Column Separately option.
- Enter the desired data into the cells of the table slot's dialog.
- From a plot of your statistical slot, select **Data ➥ Add Table Curve** from the plot's menu bar.
- From the resulting Curve Configuration dialog, click the **Select Table Slot** button and select the table slot you created above.
- The Curve Configuration dialog will allow you to select what columns you wish to plot on the x and y axes of the plot along with line styles and formats.
- Clicking OK on the Curve Configuration dialog will then add your user input data from the table slot onto the plot with the statistical slot.

The contents of the statistical table slot can also be exported to a text file for analysis using an external tool.

- To export the contents of the table slot select **File ➥ Export (Display Precision)** or **File ➥ Export (Model Precision)** from the slot dialog's menu bar.

4.11.6 Statistical Functions

The following statistical functions are provided on Riverware's statistical table slots.

4.11.6.1 Duration Curve

Name	Duration Curve
Input Slot(s)	1 series slot
Column 0	*Label:* Percent of time equaled or exceeded *Unit Type:* Fraction
Column 1	*Label*: [Name of input slot] *Unit Type:* [Unit type of input slot]
Column 2	*Label:* Rank *Unit Type:* None
Column 3	*Label:* Date *Unit Type:* DateTime
Algorithm	1. Filter the input data from the input slot per the user's specifications. 2. Sort all n resulting values in decreasing order. 3. Assign a rank to each sorted item from 1 to n. The rank of the item is m. For the largest slot value, m=1. For the smallest slot value, m = n. 4. Compute the statistical exceedence percentage value (P) for each item using the formula: P = m / n. 5. The final output is the list of: P, the slot values in sorted descending order, rank, and date of the values.

4.11.6.2 Annual Max Frequency Curve

	Annual Max Frequency Curve
Input Slot(s)	1 series slot
Column 0	*Label:* Max exceedence frequency in percent of years *Unit Type:* Fraction
Column 1	*Label*: [Name of input slot] *Unit Type:* [Unit Type of input slot]
Column 2	*Label:* Rank *Unit Type:* None

	Annual Max Frequency Curve
Column 3	*Label:* Date *Unit Type:* DateTime
Algorithm	1. Filter the input data from the input slot per the user's specifications. 2. Create a list of the maximum annual values for each year within the resulting data. 3. Sort all n annual values in decreasing order. 4. Assign a rank to each sorted item from 1 to n. The rank of the item is m. For the largest slot value, m=1. For the smallest slot value, m=n. 5. Compute the statistical exceedence percentage value (P) for each item using the formula: $P_1 = 1 - 0.5^{1/n}$; $P_n = 1 - P_1$; P for all others interpolated between these two based on rank. 6. The final output is the list of: P, the max annual values in sorted descending order, rank, and date of the value.

4.11.6.3 Annual Min Frequency Curve

	Annual Min Frequency Curve
Input Slot(s)	1 series slot
Column 0	*Label:* Min exceedence frequency in percent of years *Unit Type:* Fraction
Column 1	*Label*: [Name of input slot] *Unit Type:* [Unit Type of input slot]
Column 2	*Label:* Rank *Unit Type:* None
Column 3	*Label:* Date *Unit Type:* DateTime
Algorithm	1. Filter the input data from the input slot per the user's specifications. 2. Create a list of the minimum annual values for each year within the resulting data. 3. Sort all n annual values in increasing order. 4. Assign a rank to each sorted item from 1 to n. The rank of the item is m. For the largest slot value, m=1. For the smallest slot value, m=n. 5. Compute the statistical exceedence percentage value (P) for each item using the formula: $P_1 = 1 - 0.5^{1/n}$; $P_n = 1 - P_1$; P for all others interpolated between these two based on rank. 6.The final output is the list of: P, the min annual values in sorted ascending order, rank, and date of the value.

4.11.6.4 Annual Avg Frequency Curve

	Annual Avg Frequency Curve
Input Slot(s)	1 series slot
Column 0	*Label:* Avg exceedence frequency in percent of years *Unit Type:* Fraction
Column 1	*Label*: [Name of input slot] *Unit Type:* [Unit Type of input slot]
Column 2	*Label:* Rank *Unit Type:* None

	Annual Avg Frequency Curve
Column 3	*Label:* Date *Unit Type:* DateTime
Algorithm	1. Filter the input data from the input slot per the user's specifications. 2. Create a list of the average annual values for each year within the resulting data. 3. Sort all n annual values in decreasing order. 4. Assign a rank to each sorted item from 1 to n. The rank of the item is m. For the largest slot value, m=1. For the smallest slot value, m=n. 5. Compute the statistical exceedence percentage value (P) for each item using the formula: $P_1 = 1 - 0.5^{1/n}$; $P_n = 1 - P_1$; P for all others interpolated between these two based on rank. 6. The final output is the list of: P, the avg annual values in sorted descending order, rank, and date of the value.

4.11.6.5 Monthly Maximums By Year

	Monthly Maximums By Year
Input Slot(s)	1 series slot
Column 0	*Label:* Year *Unit Type:* DateTime
Columns 1 - 12	*Label*: [Month} Max *Unit Type:* [Unit Type of input slot]
Column 13	*Label*: Annual Max *Unit Type:* [Unit Type of input slot]
Final Rows	*Labels*: Maximum, Minimum, Average (of the columns) *Unit Type:* [Unit Type of input slot]
Algorithm	1. Filter the input data from the input slot per the user's specifications. 2. Iterate the data and track and save the maximum value for each month and for each year. 3. Generate average maximum values for each month across all years and for the annual maximum across all years. 4. The final output is a row for each year and final rows for maximums, minimums, and averages across all the years. Columns are the date for the year, a column for each month's maximum, and an annual maximum column.

4.11.6.6 Monthly Minimums By Year

	Monthly Minimums By Year
Input Slot(s)	1 series slot
Column 0	*Label:* Year *Unit Type:* DateTime
Columns 1 - 12	*Label*: [Month} Min *Unit Type:* [Unit Type of input slot]
Column 13	*Label*: Annual Min *Unit Type:* [Unit Type of input slot]
Final Rows	*Labels*: Maximum, Minimum, Average (of the columns) *Unit Type:* [Unit Type of input slot]
Algorithm	1. Filter the input data from the input slot per the user's specifications. 2. Iterate the data and track and save the minimum value for each month and for each year. 3. Generate average minimum values for each month across all years and for the annual minimum across all years. 4. The final output is a row for each year and final rows for maximums, minimums, and averages across all the years. Columns are the date for the year, a column for each month's minimum, and an annual minimum column.

4.11.6.7 Monthly Averages By Year

	Monthly Averages By Year
Input Slot(s)	1 series slot
Column 0	*Label:* Year *Unit Type:* DateTime
Columns 1 - 12	*Label*: [Month} Avg *Unit Type:* [Unit Type of input slot]
Column 13	*Label*: Annual Avg *Unit Type:* [Unit Type of input slot]

	Monthly Averages By Year
Final Rows	*Labels*: Maximum, Minimum, Average (of the columns) *Unit Type:* [Unit Type of input slot]
Algorithm	1. Filter the input data from the input slot per the user's specifications. 2. Iterate the data and calculate and save the average value for each month and for each year. 3. Generate averages from the average values for each month across all years and for the annual average value across all years. 4. The final output is a row for each year and final rows for maximums, minimums, and averages across all the years. Columns are the date for the year, a column for each month's average, and an annual average column.

4.11.6.8 Monthly Totals By Year

Note that totals generated by this function may not make sense for some slots (i.e, flow or storage).

	Monthly Totals By Year
Input Slot(s)	1 series slot
Column 0	*Label:* Year *Unit Type:* DateTime
Columns 1 - 12	*Label*: [Month} Tot *Unit Type:* [Unit Type of input slot]
Column 13	*Label*: Annual Tot *Unit Type:* [Unit Type of input slot]
Final Rows	*Labels*: Maximum, Minimum, Average (of the columns) *Unit Type:* [Unit Type of input slot]
Algorithm	1. Filter the input data from the input slot per the user's specifications. 2. Iterate the data and track and save the total value for each month and for each year. 3. Generate average total values for each month across all years and for the annual total across all years. 4. The final output is a row for each year and final rows for maximums, minimums, and averages across all the years. Columns are the date for the year, a column for each month's total, and an annual total column.

4.11.6.9 Partial Duration Max Frequency Curve

	Partial Duration Max Frequency Curve
Input Slot(s)	1 series slot
Column 0	*Label:* Max exceedence frequency in percent *Unit Type:* Fraction
Column 1	*Label*: [Name of input slot] *Unit Type:* [Unit Type of input slot]
Column 2	*Label:* Rank *Unit Type:* None
Column 3	*Label:* Date *Unit Type:* DateTime
Algorithm	1. Filter the input data from the input slot per the user's specifications. 2. If user has specified a base value, use it in the call to the partial duration calculation and present all the results generated. 3. If not a user-supplied base value, sort the input values in decreasing order and assume a base equal to the value at position (number of years of input data plus one). Make successive calls to the partial duration calculation with decreasing base values until the number of results equals or exceeds the number of years of data in the input slot. 4. The partial duration calculation tabulates the largest values that are greater than the base value, which are separated by events less than the base value. 5. Sort all n result values in decreasing order. 6. Assign a rank to each sorted item from 1 to n. The rank of the item is m. For the largest slot value, m=1. For the smallest slot value, m=n. 7. Compute the statistical exceedence percentage value (P) for each item. For the top half of items, use the formula: $P_1 = 1 - 0.5^{1/n}$; $P_n = 1 - P_1$; P for all others in the top half are interpolated between these two based on rank. For the bottom half of items, use the formula: $\frac{2m-1}{2n}$ 8. The final output is the list of: P, the max partial duration values in sorted descending order, rank, and date of the value.

4.11.6.10 Partial Duration Min Frequency Curve

	Partial Duration Min Frequency Curve
Input Slot(s)	1 series slot
Column 0	*Label:* Min exceedence frequency in percent *Unit Type:* Fraction

	Partial Duration Min Frequency Curve
Column 1	*Label*: [Name of input slot] *Unit Type:* [Unit Type of input slot]
Column 2	*Label:* Rank *Unit Type:* None
Column 3	*Label:* Date *Unit Type:* DateTime
Algorithm	1. Filter the input data from the input slot per the user's specifications. 2. If user has specified a base value, use it in the call to the partial duration calculation and present all the results generated. 3. If not a user-supplied base value, sort the input values in increasing order and assume a base equal to the value at position (number of years of input data plus one). Make successive calls to the partial duration calculation with increasing base values until the number of results equals or exceeds the number of years of data in the input slot. 4. The partial duration calculation tabulates the smallest values that are less than the base value, which are separated by events greater than the base value. 5. Sort all n result values in increasing order. 6. Assign a rank to each sorted item from 1 to n. The rank of the item is m. For the largest slot value, m=1. For the smallest slot value, m=n. 7. Compute the statistical exceedence percentage value (P) for each item. For the top half of items, use the formula: $P_1 = 1 - 0.5^{1/n}$; $P_n = 1 - P_1$; P for all others in the top half are interpolated between these two based on rank. For the bottom half of items, use the formula: $\frac{2m-1}{2n}$ 8. The final output is the list of: P, the min partial duration values in sorted ascending order, rank, and date of the value.

4.11.6.11 Value Duration Max Frequency Curve

	Value Duration Max Frequency Curve
Input Slot(s)	1 series slot
Column 0	*Label:* Max exceedence frequency in percent of years *Unit Type:* Fraction
Columns 1 - N	*Label*: [Duration represented by column] *Unit Type:* [Unit Type of input slot]
Algorithm	1. Filter the input data from the input slot per the user's specifications. 2. Determine the durations to use in calculation based on timestep of input slot. Currently only implemented for day (1, 2, 3, 5, 7, 19, 15, 60, 90 and 365 day) and month (1, 2, 3, 4, 6 and 12 month) 3. Loop for each duration. 4. For each year, average the slot values over the duration starting with timestep 1, then starting with timestep 2, etc. to generate a set of values over this duration for the year. Take the maximum of this set of values and record this as the single result for the year. 6. Sort all the result values (one for each year) in decreasing order and present as a column of results for this duration. 7. Move on to the next duration. 4. Assign a rank to each row of results from 1 to n. 5. Compute the statistical exceedence percentage value (P) for each row using the formula: $P_1 = 1 - 0.5^{1/n}$; $P_n = 1 - P_1$; P for all others interpolated between these two based on row rank. 6. The final output is the list of: P and a column of results for each duration used.

4.11.6.12 Value Duration Min Frequency Curve

	Value Duration Min Frequency Curve
Input Slot(s)	1 series slot
Column 0	*Label:* Min exceedence frequency in percent of years *Unit Type:* Fraction

	Value Duration Min Frequency Curve
Columns 1 - N	*Label*: [Duration represented by column] *Unit Type:* [Unit Type of input slot]
Algorithm	1. Filter the input data from the input slot per the user's specifications. 2. Determine the durations to use in calculation based on timestep of input slot. Currently only implemented for day (1, 2, 3, 5, 7, 19, 15, 60, 90 and 365 day) and month (1, 2, 3, 4, 6 and 12 month) 3. Loop for each duration. 4. For each year, average the slot values over the duration starting with timestep 1, then starting with timestep 2, etc. to generate a set of values over this duration for the year. Take the minimum of this set of values and record this as the single result for the year. 6. Sort all the result values (one for each year) in increasing order and present as a column of results for this duration. 7. Move on to the next duration. 4. Assign a rank to each row of results from 1 to n. 5. Compute the statistical exceedence percentage value (P) for each row using the formula: $P_1 = 1 - 0.5^{1/n}$; $P_n = 1 - P_1$; P for all others interpolated between these two based on row rank. 6. The final output is the list of: P and a column of results for each duration used.

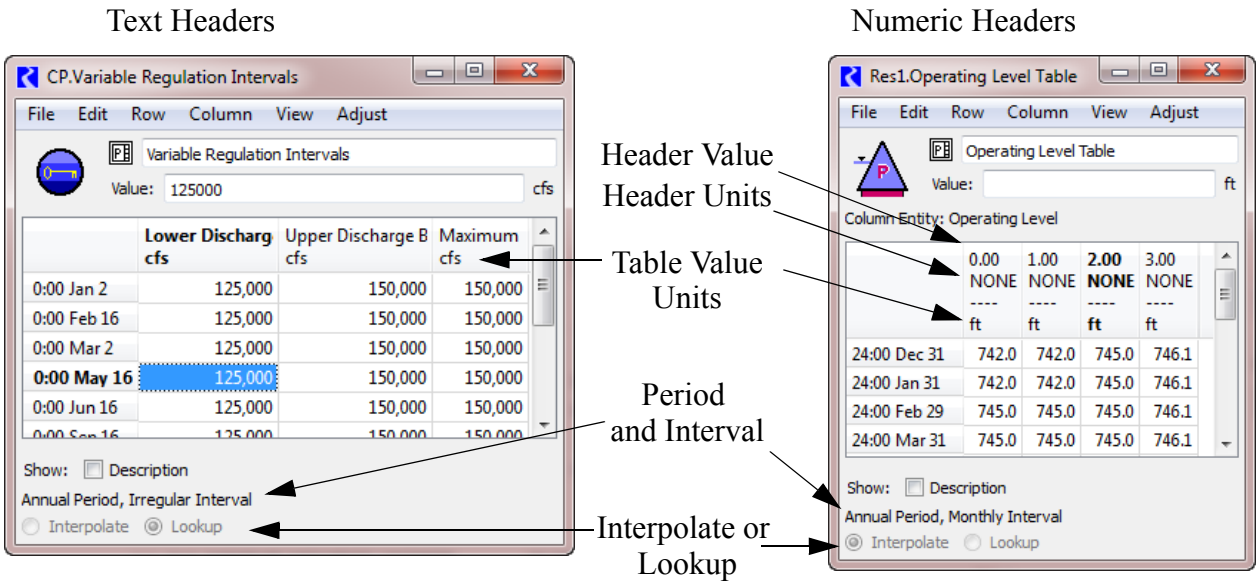
4.11.6.13 Value Duration Avg Frequency Curve

	Value Duration Avg Frequency Curve
Input Slot(s)	1 series slot
Column 0	*Label:* Avg exceedence frequency in percent of years *Unit Type:* Fraction
Columns 1 - N	*Label*: [Duration represented by column] *Unit Type:* [Unit Type of input slot]
Algorithm	1. Filter the input data from the input slot per the user's specifications. 2. Determine the durations to use in calculation based on timestep of input slot. Currently only implemented for day (1, 2, 3, 5, 7, 19, 15, 60, 90 and 365 day) and month (1, 2, 3, 4, 6 and 12 month) 3. Loop for each duration. 4. For each year, average the slot values over the duration starting with timestep 1, then starting with timestep 2, etc. to generate a set of values over this duration for the year. Take the average of this set of values and record this as the single result for the year. 6. Sort all the result values (one for each year) in decreasing order and present as a column of results for this duration. 7. Move on to the next duration. 4. Assign a rank to each row of results from 1 to n. 5. Compute the statistical exceedence percentage value (P) for each row using the formula: $P_1 = 1 - 0.5^{1/n}$; $P_n = 1 - P_1$; P for all others interpolated between these two based on row rank. 6. The final output is the list of: P and a column of results for each duration used.

4.12 Periodic Slots

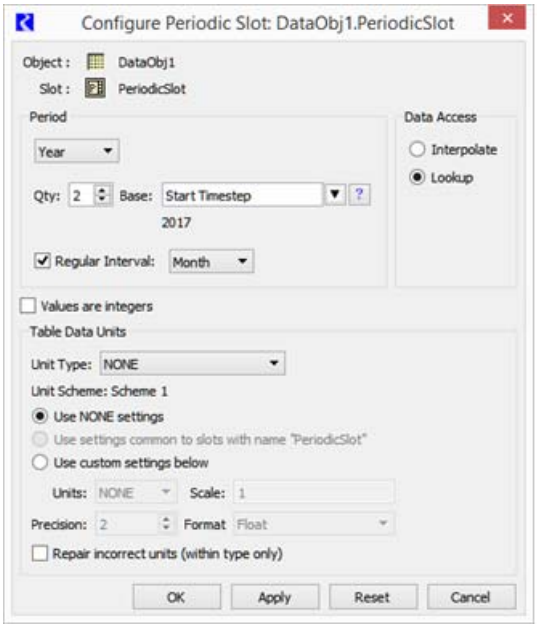
Periodic slots are tables used to represent periodic data which repeats at regular time interval. An example might be a set of evaporation coefficients for a reservoir. The rate of evaporation varies with such factors as temperature and wind speed, factors which vary seasonally. It is natural to assume that this variation is the same for each year. If this sort of data were entered into a series slot, then the same data would need to be repeated every year. This would be impractical and inconvenient for the user. On the other hand, if this data were entered in to a table slot, then the data would lose the time element

associated with each value. This would make it difficult to look up or interpolate values with respect to time. The periodic slot solves both of these problems.



4.12.1 Configuration Options

Periodic slots are configured like other slots using the **View ➥ Configure** menu.



The upper left portion of the **Configure Slot** dialog, under the **Period** section, is used to set the period and interval of the periodic slot. The period can range from 6-hours to several years while the interval depends on the period selected. If the period required is more than 1 year, the **Qty** value should be modified from 1 to the number of years and the **Base** year--the first year in the period--should be defined. Base year can be specified explicitly or symbolically using the drop down menu. If not specified explicitly, they must be edited to become valid, e.g. by replacing the "N" with a nonnegative integer or "YYYY" with a year. Text below the editor field indicates the actual year or indicates the entry is invalid. The "?" button provides more information on legal datetimes.

Also notice the checkbox next to **Regular Interval**. If the data interval is not a consistent length of time, the user can de-select this option and the periodic slot would then have an irregular interval. The user is then free to configure the rows/timesteps in any fashion. Click **HERE (Section 4.12.1.1)** for more information.

The **Data Access** section located in the upper right portion of the **Configure Slot** dialog is used to specify whether or not data should be interpolated or looked up directly when accessing the table at a

time that is not specifically listed as a row label. For example, the monthly data is shown for the beginning of each month. If we're in the middle of the month, should we use that same piece of data, or should we interpolate between the two months? This is a question that would need to be answered on a per model basis, however, the default behavior is a direct lookup.

> **Note:** Slots configured to **Lookup** use the value in the row that has a datetime less than or equal to the desired datetime and the datetime in the next row is greater than the desired datetime. Slots configured to **Interpolate**, perform a linear interpolation using values whose rows' datetimes bound the desired datetime.

Columns can be added/deleted by selecting a column and using the **Column** menu.

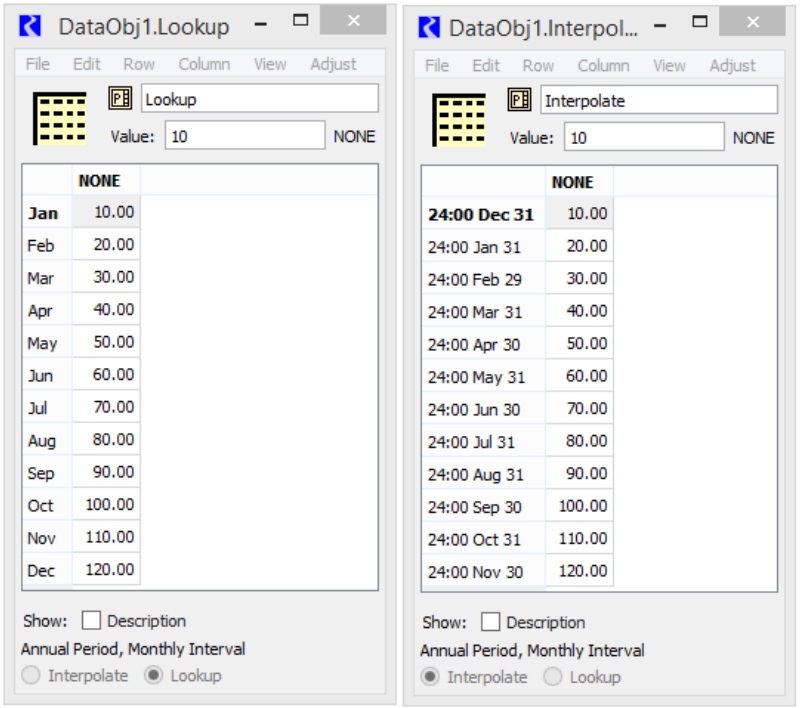
4.12.1.1 Display of Dates

The rows of a periodic slot represent dates and are displayed differently if the interval is Regular or Irregular. This distinction in dates is described below.

Regular Intervals: Regular Interval periodic slots only show enough information to identify the date. The display is different if the slot is configured to Lookup or Interpolate. When the slot is configured to **Lookup**, the rows only show the part of the date the changes from one row to the next. Thus, if it is a monthly interval, only the month is shown not the hour or day. If it is a daily interval with an annual period, only the day number is shown.

For periodic slots that are configured to **Interpolate**, the date represents an instant in time that corresponds to the end of a timestep. Thus, for a monthly interval, the dates are 24:00 Dec 31, 24:00 Jan1, etc... Note, Feb 29th is shown in this case but actually behaves as though it is 0:00 March 1.

The following figure shows screenshots of a periodic slot that has a Regular Interval and Monthly Interval. When a new periodic slot (Text Headers) is added, this is how it appears. The following table shows some sample results for the slots shown using the specified datetime.



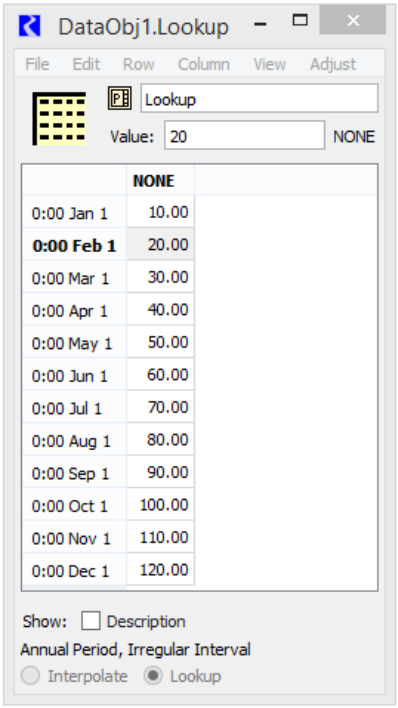
A. Regular Interval - Lookup B. Regular Interval - Interpolate

Datetime	A.Regular Interval - Lookup	B. Regular Interval - Interpolate
24:00 January 13, 2001	10	14.2
24:00 February 23, 2003	20	28.2
24:00 October 21, 2009	100	106.8

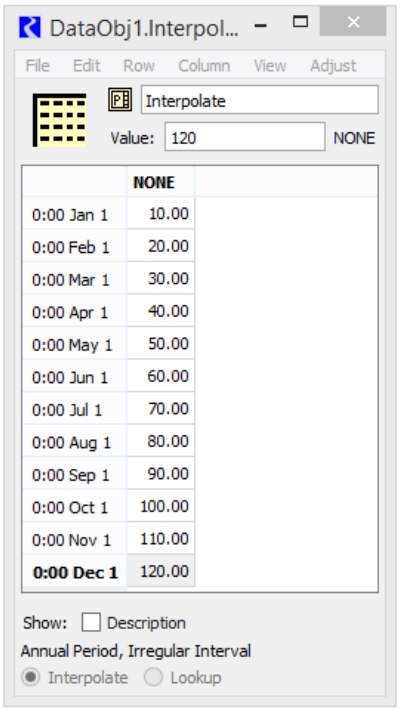
For Regular Intervals, the user cannot add or delete rows. The slot must be converted to an Irregular Interval first.

Irregular Intervals: For Irregular Intervals, the timestep displayed is an instant in time. The screenshot shows the same slots above converted to an Irregular Interval. Because they have the same rows (displayed differently), the A slots would behave the same and the B slots would behave the same.

The user can add or delete rows from periodic slots with an Irregular Interval using the **Row** menu.



A. Irregular Interval - Lookup



B. Irregular Interval - Interpolate

4.12.2 Headers

The user can create two different types of periodic slots: with text headers for the columns or with numeric headers for the columns.

4.12.2.1 Text headers

In this mode, the periodic slot simply contains columns of data that may or may not be related. There can be no interpolation across columns.To add a periodic slot with Text Headers:

1. Append a periodic slot by selecting **Slots ➥ Add Periodic Slot, Text Headers**
2. If the columns are to be accessed using text, select **Column ➥ Set Column Label** to add a text header to each of the columns.

Columns of Periodic Slots with Text Headers can be re-arranged using the **Column ➥ Move Columns** menu (custom slots only).

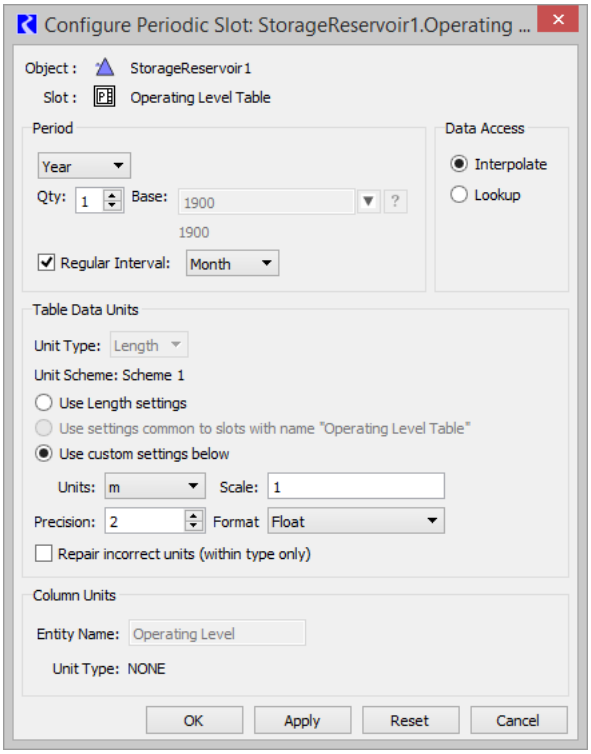
4.12.2.2 Numeric headers

Consider a periodic slot containing loss coefficients. The periodic slot may contain loss coefficients that vary not only with time, but also with flow rate in a reach. RiverWare could identify which coefficient to use by indexing the table row using the current time step and the table columns using a flow rate. The user could specify as many columns as necessary to sufficiently describe the variation of loss coefficients as a function of flow rate. The periodic slot's **Column Units** would be configured to be flow, perhaps with units of 1000 cfs.

To add a periodic slot with Numeric Headers:

1. Append a periodic slot by selecting **Slots ➥ Add Periodic Slot, Numeric Headers.**

2. Select **View ➥ Configure** to configure the periodic slot

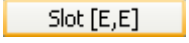


The dialog now has a **Column Units** section. This may be useful if the columns are indexed using numeric header values and the values have some physical (not simply descriptive) significance. The unit specification uses the unit type settings for the active Unit Scheme as described **HERE (Units.pdf, Section 2.3.1)**

The periodic slot can be used backwards to work from the table values and date outward to define a value associated with the column(s). For example, suppose the periodic slot defines the various pools or phases in a reservoir. The conservation pool may be defined as phase 1 with the first column containing pool elevations defining the conservation pool throughout the year. This first column would have a header of 1.0, meaning phase 1. The flood pool may be phase 2.0 with a second column using 2.0 as its header. The surcharge pool may be phase 3.0, etc. Knowing the pool elevation at a given time, the periodic slot can be used to determine the current phase. Interpolating across columns, this outward lookup may determine that the current phase is 2.5 for a given pool elevation and date, meaning pool is halfway from the bottom of flood pool to the bottom of the surcharge pool.

4.12.3 Referencing Periodic Slots in RPL

In RPL, periodic slots are referenced using the Slot[E, E] syntax. Like other tables, this is a row by column reference. But, because it is a periodic slot, the row is a datetime: Slot[<Datetime>, E]. When referenced in RPL, the configuration of the slot



will be used when accessing dates that are “between rows”. That is, it will either interpolate or look up depending on the slot’s configuration.

For periodic slots with **text headers**, the column specification is a text string matching a column or the zero-based column index. For periodic slots with **numeric headers**, the column specification is a numeric value with units. You can specify any number that falls within the min and max column values. That is, you don’t have to specify an exact column’s value, but can use numeric values that are “between columns” and it will linearly interpolate for you. For example, the following slot represents low flows that are based on reservoir levels. It is configured to lookup:

	5000 ft	5010 ft
Jan. 1	10 cfs	20 cfs
Feb 1	40 cfs	60 cfs
March 1	60 cfs	80 cfs

In RPL, to reference this slot on January 15th for reservoir elevation 5002ft, the following would be used:

```
Slot[@"January 15,2011", 5002 ft]
```

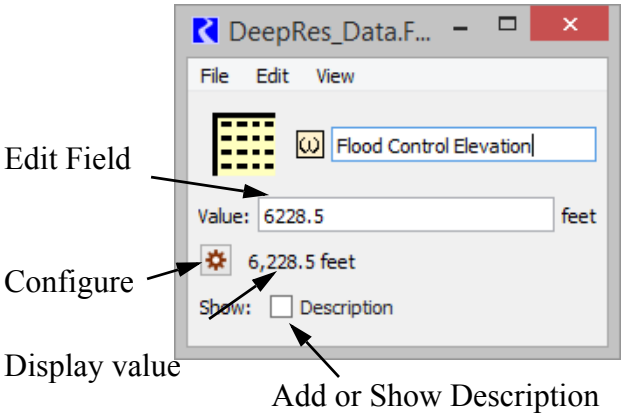
It would return:

```
12 cfs
```

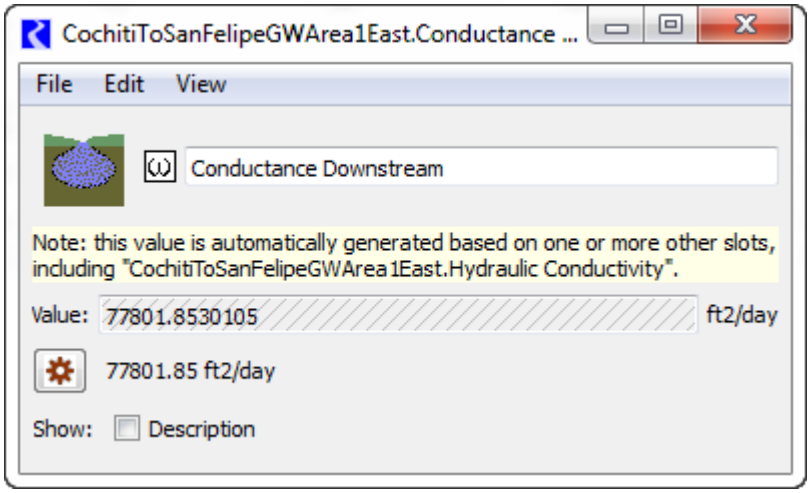
Scalar and List Slots

4.13 Scalar Slots

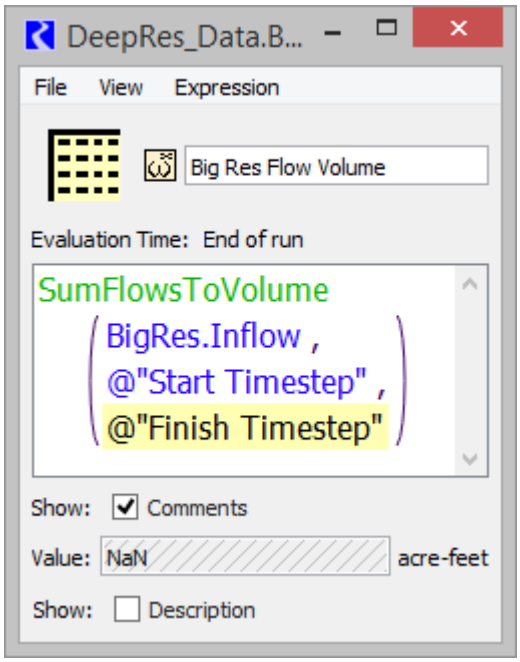
Scalar slots represent a single value. Configuration options include units and display format. Scalar slots are used only for input data parameters. The configuration of Scalar Slots is the same as the general slot configuration section **HERE (Section 2.1.5)**.



Some specific scalars and tables have a "Source" slot. When a slot has a source slot, the values are computed from other slot values. Thus, it becomes read-only and displays a cross hatch over the data. See screenshot. It also provides a note indicating the source slot used to compute the data. The source slot is typically set/un-set at beginning of run, so the user must initialize the run to see the read-only status.

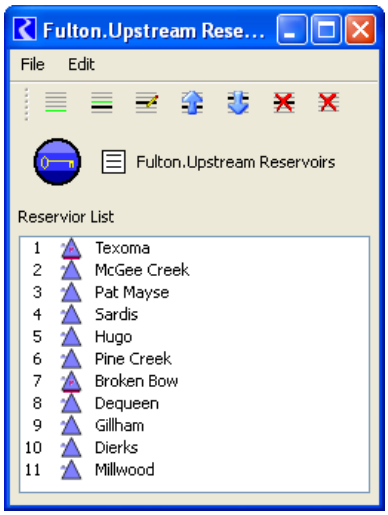


4.14 Expression Slots - Scalar

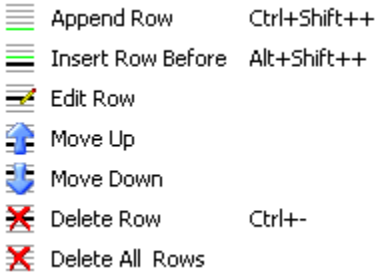


To add a Scalar slot with expression select **Slot ➥ Add Scalar Slot with Expression.** This slot, similar to the Series Slot with Expression, is used to evaluate an expression that evaluates to only one value, i.e. timestep independent. Click **HERE (Section 4.6)** for more information on **Series Slots with Expression** as that information is valid here too. The difference is that the scalar expression slot does not have an **Evaluation Range**, it will evaluate for the single value only. Like the series expression slot, the user can configure when it evaluates. Use the **Expression ➥ Evaluation Time** menu to choose.

4.15 List Slots



A List Slot is used to store a collection of non-numeric data, typically a group of objects. Shown to the right is a sample **Upstream Reservoirs** List Slot. This slot contains the Reservoirs that are upstream of the given control point. It is used in the Regulation Discharge and Flood Control algorithm to specify the reservoir which contribute to the flow at this control point. The following options are available from the **Edit** menu, from the toolbar icons, and from the right click context menu:



On a List Slot that contains either Objects, Slots, Accounts, or Supplies, when the user clicks on either the Append Row, Insert Row Before, or Edit Row, a selector will open allowing the user to choose the appropriate items.

Mass Balance Summary

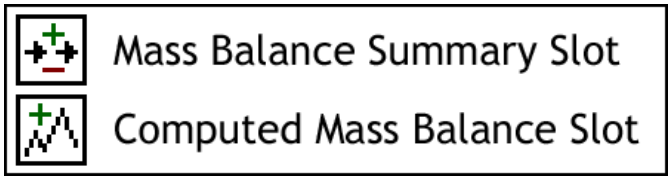
4.16 Mass Balance Summary

The Mass Balance Summary slot is a user-defined hierarchy of series slot collections used to check (i.e. sum) mass balance across many objects. The collections are themselves series slots representing the sum of the contained slots. These slots can be used within RPL expressions and any other place where series slots are used.

There are two levels of within a Mass Balance Summary slot:

- **Water Balance** -- the sum of one or more **Slot Sums**. For example, a water balance might represent all water flowing in/out of the main channel or all flows in the groundwater.
- **Slot Sum** -- the sum of one or more series slots. Slot sums are useful to summarize or classify different slots. For example, a **Slot Sum** might represent all the seepage, evaporation, diversions or return flow slots. The sum is represented as either the positive or negative sense. **Negative** Slot Sums are subtracted from their containing Water Balance. **Positive** Slot Sums are added in the containing Water Balance. Only flow/volume or mass (unit type) series slots having the model run timestep size can be used. References to RPL expression slots are supported for entities not represented by simulation slots.

The screenshot shows the icons for: (1) the Mass Balance Summary Slot, and (2) The Computed Mass Balance Slots (i.e. Water Balances and Slot Sums).

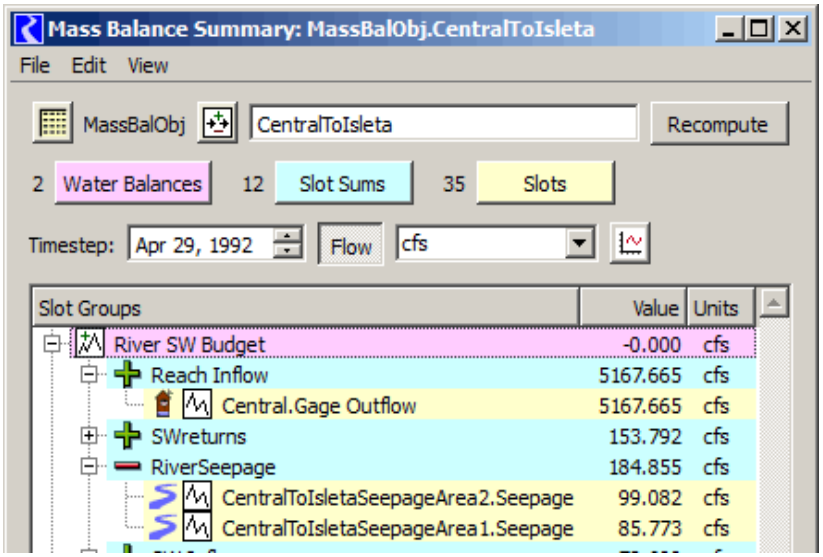


The Computed Mass Balance Slots are computed:

- On demand (by you) and/or
- At the end of a run, immediately after the evaluation of post-run RPL expression slots.

Also, a list of RPL expression slots to be evaluated after a Mass Balance Summary slot computation can be specified within the summary definition -- this can be used, for example, for annualization of mass balance summary results.

The screenshot shows the dialog for a **Mass Balance Summary Slot**. Colors are associated with the three collection levels:



Collection Level		Backgrond Color
1	Water Balance	Pink
2	Slot Sum	Cyan
3	Slot Reference	Yellow

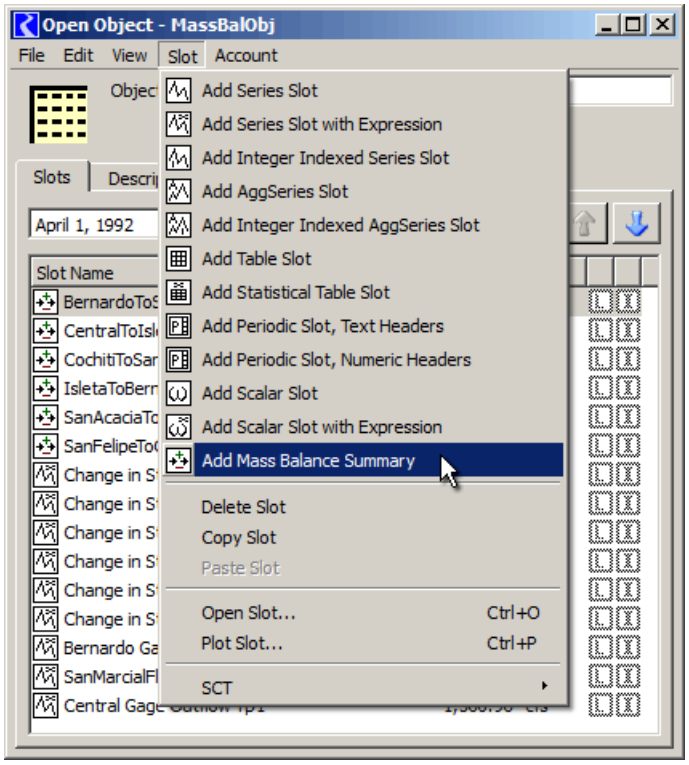
The three color buttons at the top of this dialog function as a “legend” for the three levels. Also, clicking on those buttons open the tree items in the list to the corresponding level. Also individual collection items can be opened and closed in the usual way -- by clicking on the tree controls.

Finally, the slots can be shown in any user units and plotted as needed.

4.16.1 Slot Construction

Creating a Mass Balance Summary Slot: A **Mass Balance Summary Slot** can be created by selecting the **Add Mass Balance Summary** operation.

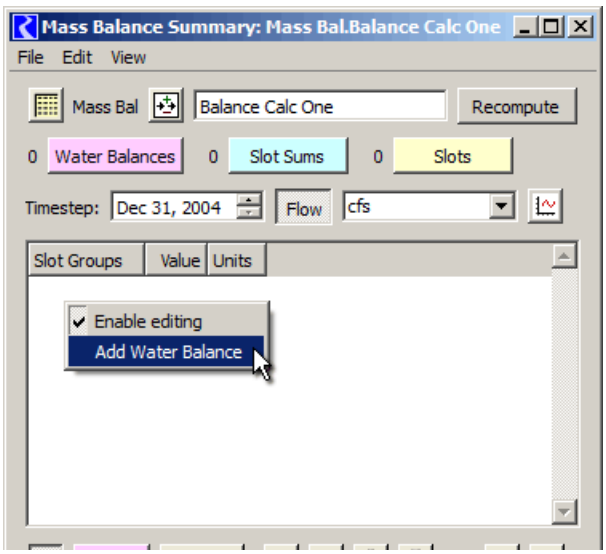
The name of the new Mass Balance Slot can be edited in it’s dialog. When the typed name is not valid, the text in the name entry field is shown in red.



Configuring a Mass Balance Summary Slot:

Editing the configuration of a **Mass Balance Summary Slot** can be enabled or disabled. It is initially enabled on a newly created slot. Editing can be enabled or disabled with the following controls:

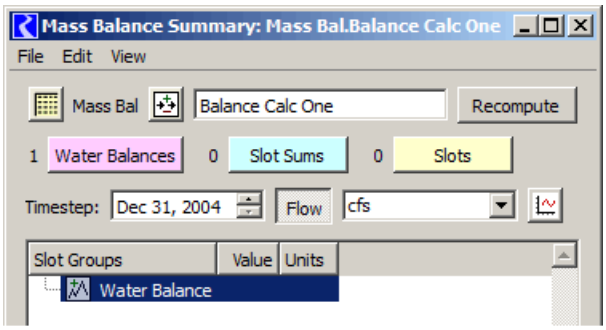
- The lock icon toggle button in the bottom left of the dialog. 
- The **Enable editing** item in the right-click context menu.
- The **Enable editing** item in the Edit menu.

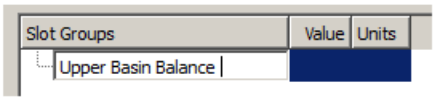


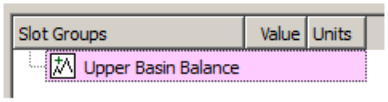
Right-clicking in the list outside of any defined items (e.g. when the list is empty) shows a simple context menu including the **Add Water Balance** operation.

The buttons along the bottom of the dialog are also context sensitive -- their operation and enabledness depends on the selection within the slot list. When no items are selected, the **New** button also adds a water balance to the list.

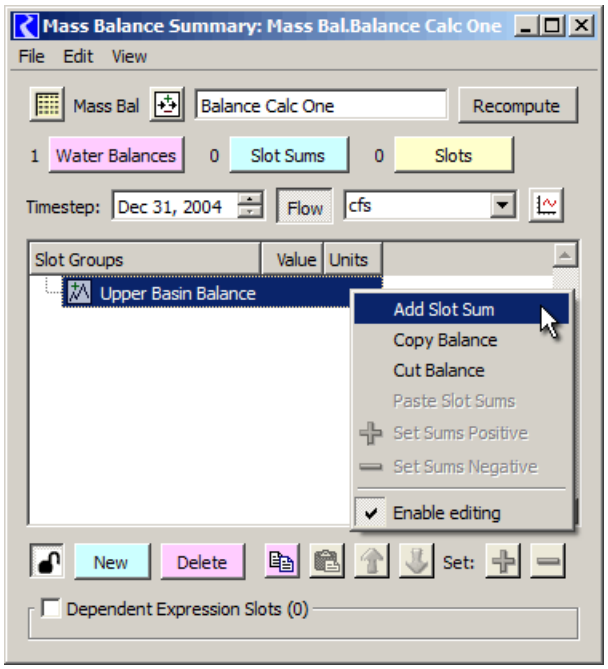
When new **Water Balances** or **Slot Sums** are created, they are given a unique default name. The name can be edited "inline" by double-clicking on the name.

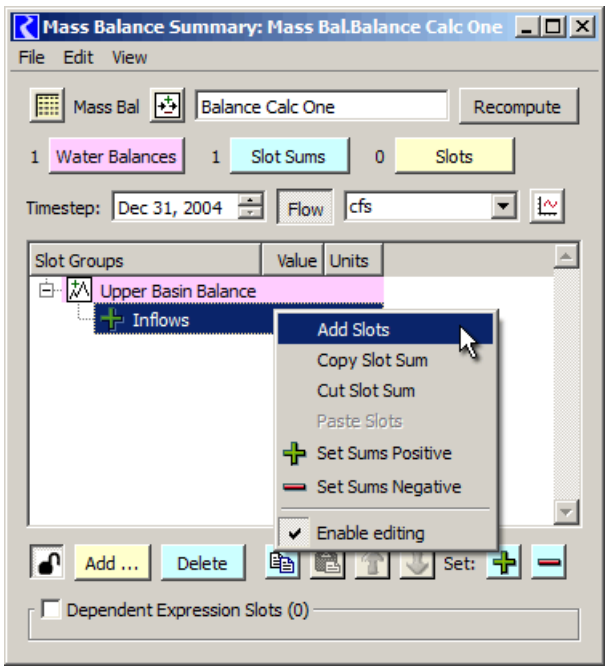






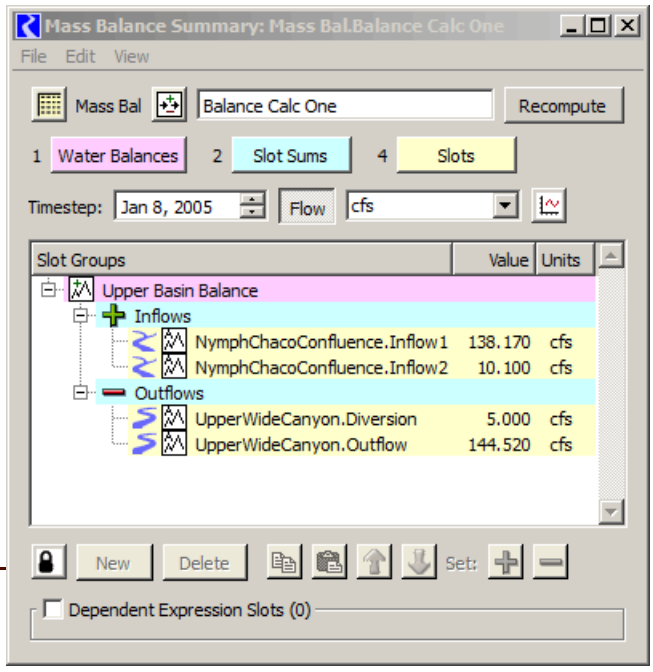
Slot Sums can be added to **Water Balances**, and **Slot References** can be added to **Slot Sums** using the **Add** context menu operation or the bottom context buttons.





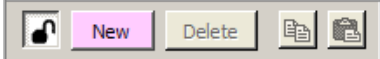
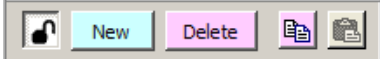
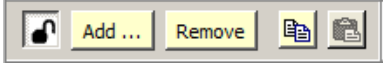
When adding Slots, the slot selector dialog is shown. This will allow the selection of only series slots. The slot selector's unit type filter will be shown, initialized to "Flow". It is also valid to select "Volume" slots which represent a non-static volume entity -- i.e. those which can be converted to "Flow" by dividing its value by the timestep interval (i.e. volume per time). (The computed results will be strange if a static volume slot, such as Reservoir Storage, is selected).

Alternatively, slots representing mass units (g, kg, tons, etc) can be chosen. This is particularly useful when looking at the salinity mass balance across many objects.

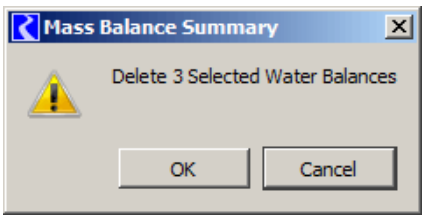


Note: A Mass Balance Summary can either show Flow/Volume units or Mass units, but not both. If both types of slots are shown (or slots with any other unit type), an error will be issued when the mass balance is computed.

The following table illustrates the operations provided by the first several buttons, as a function of the selected item or items. Tooltips on these buttons provide additional information.

	Selected Item	Operations
	None	Create new Water Balance
	Water Balance	Create New Slot Sum; Delete / Copy Water Balance
	Slot Sum	Add Slot Reference; Delete / Copy Slot Sum
	Slot Reference	Add Slot Reference; Remove / Copy Slot Reference

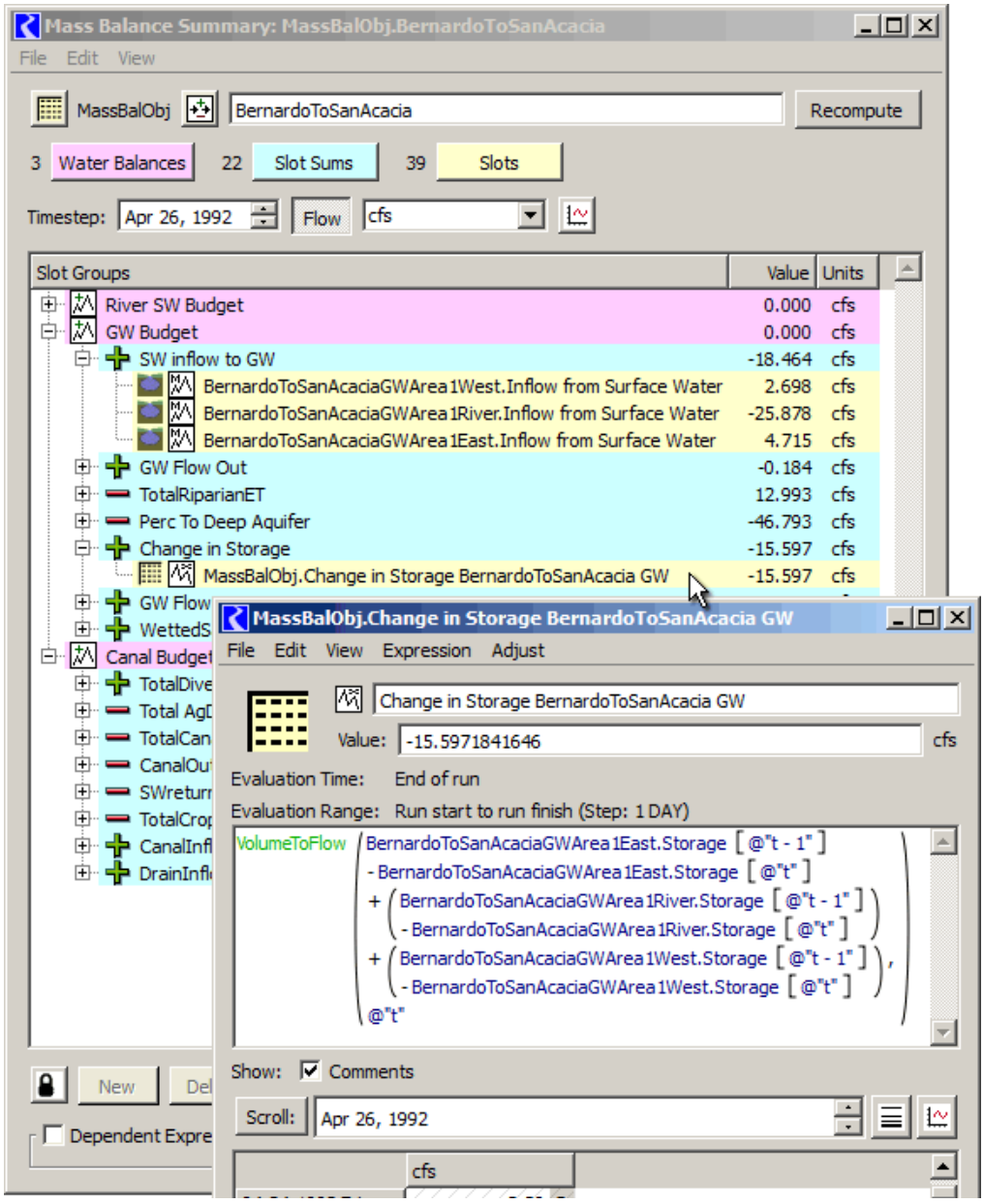
The **New** / **Add** and **Paste** operations are enabled only for single-item selections. The **Delete** / **Remove** and **Copy** operations are enabled on single or multiple selections when all selected items are at the same level. The enabledness of the **Paste** operation depends also on the type of items (Water Balances, Slot Sums, or Slot References) in the clipboard. You must confirm **Delete** / **Remove** operations.



The up and down arrows move the selected items up or down within the set of "sibling" items. They are enabled only when the selected items are all at the same level.

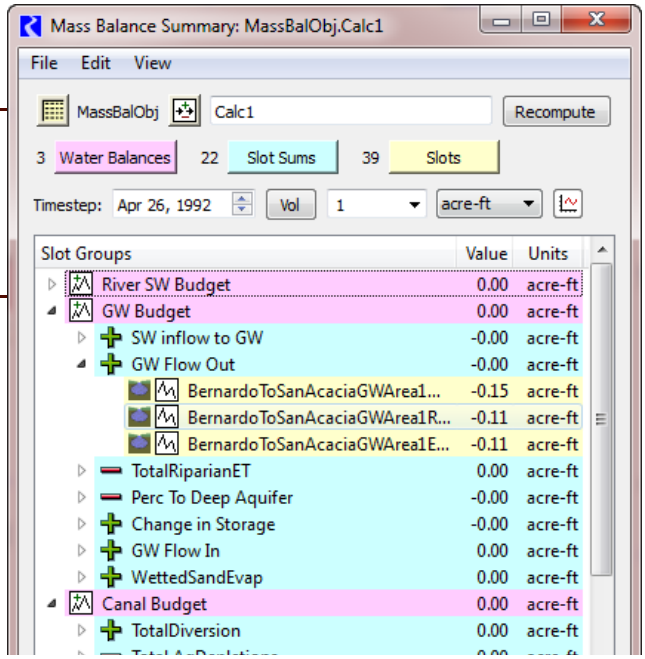
The  and  buttons affect the Slot Sums within the set of selected items. **When the mass balance summary is computed, the values of "positive" Slot Sums are added to the containing Water Balance; the values of "negative" Slot Sums are subtracted.**

RPL Expressions for Other Slots: For any value not provided as a RiverWare slot, you will need to define and refer to a RPL expression slot. Here is an example of the inclusion of a "change in storage" expression slot from the previous to the current timestep.



4.16.2 Display Operations

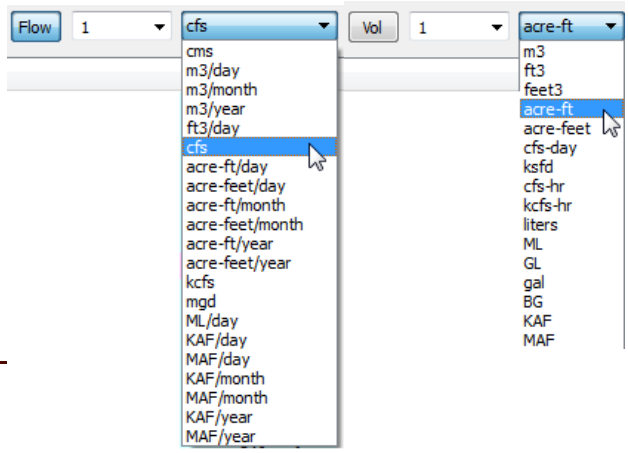
The **Mass Balance Summary Slot** dialog shows a single timestep value of all contained series slots.



> **Note:** All Water Balances, Slot Sums and series slot references must have the same timestep size as the model run. Water Balances and Slot Sums are computed for the model run interval (start to finish timesteps).

Units: In this dialog, series values can have either:

- Flow or Volume units. Volume values are converted to flows by dividing by the timestep interval. The individual settings for Flow and for Volume units are separately retained. That is, clicking the Flow and Volume toggle button switches between the last selected unit for those two unit types.
- Mass units. This is typically used for salinity.



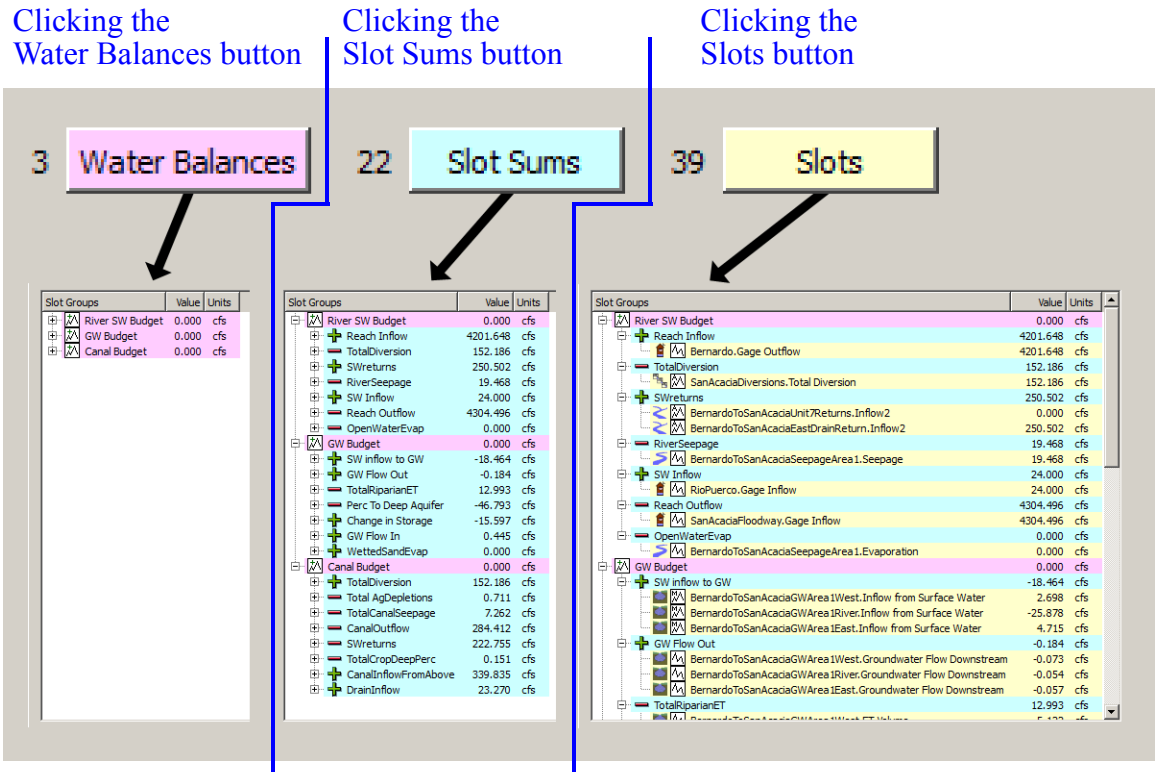
> **Note:** A Mass Balance Summary can either show Flow/Volume units or Mass units, but not both. If both types of slots are shown (or slots with any other unit type), an error will be issued when the mass balance is computed.

The selected unit type, scale and unit is both a display setting and a configuration setting; when the mass balance summary is computed, the computed slots are shown with these units. Precision can be set from the **View ➥ Set Precision** menu.

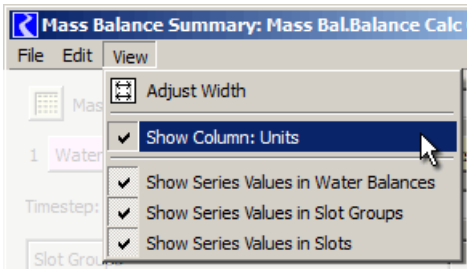
In fact, changing the unit, scale, or precision from this dialog actually changes the active Unit Scheme (by adding exceptions). You can also change the settings from the Unit Scheme Manager by changing attributes or activating a different scheme. Click **HERE (Units.pdf, Section 2)** for more information on Unit Schemes.

Note: When the computed results (Water Balances and Slot Sums) are referred to by RPL expressions, the units must work correctly or an error will be issued. Unit type incompatibilities will be reported by the RPL expression evaluation mechanism in the usual way.

Tree Display: As previously mentioned, the level "legend" buttons function to open the entire tree to the indicated level. Of course, individual tree items can be opened or closed by clicking on the standard tree controls.

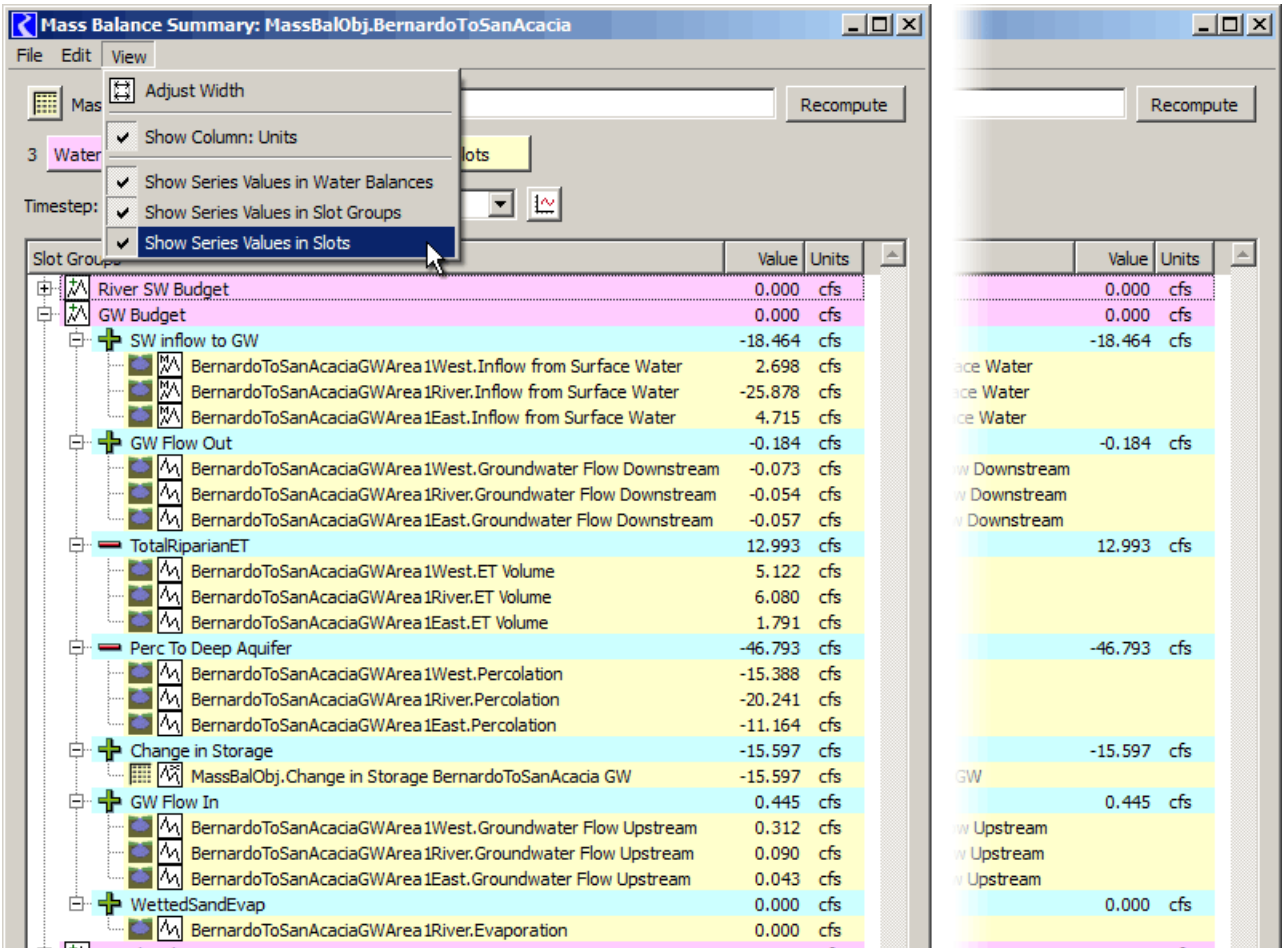


The **View** menu provides operations which effect data display within this dialog.



Show Column: Units: The units column in the slot list can be hidden. But, if slots having different unit types (other than flow/volume or mass) are added to the list, units are unconditionally shown and the option to hide the units column is disabled.

Show Values: You may want to hide values at any of the levels, so that only comparable values (at the same level) are displayed. The three **Show Series Values** toggles in the **View** menus are used to show/hide the numeric values as illustrated on the following screenshot.



4.16.3 Other Display Operations

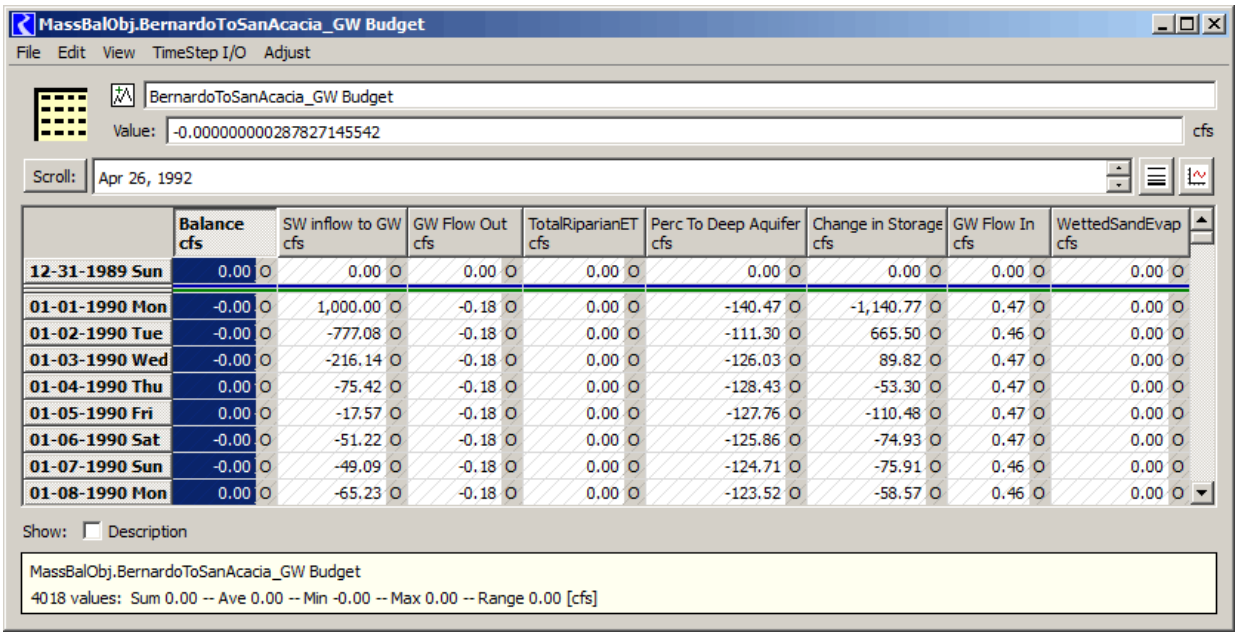
From the **Open Mass Balance Summary Slot** dialog, you can:

- Show selected slots in an open slot dialog.
- Show slots in a new SCT or in the single open SCT. You can show either the visible (in the tree), or only the selected slots.
- Plot the selected slots.
- Copy selected slots, e.g. to an Output Device or to the Snapshot Manager.

These options are described in the following sections:

Show Computed Slots in an Open Slot Dialog: As currently implemented, **Water Balances** are generated as aggregate series slots and each of the **Water Balance**'s **Slot Sums** are generated as series

slot columns on that aggregate. Use the **Open Slots... c**ontext menu to show the slot dialog for the selected component (editing disabled).



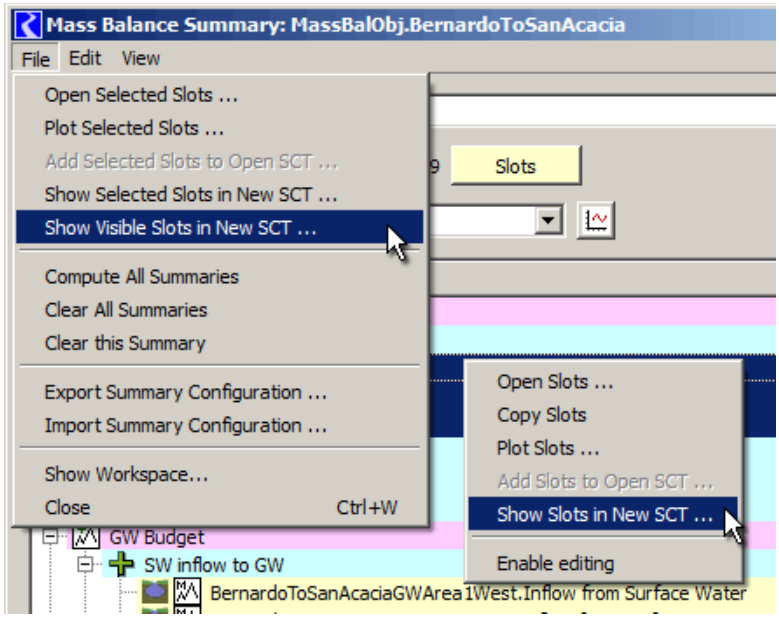
	Balance cfs	SW inflow to GW cfs	GW Flow Out cfs	TotalRiparianET cfs	Perc To Deep Aquifer cfs	Change in Storage cfs	GW Flow In cfs	WettedSandEvap cfs
12-31-1989 Sun	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
01-01-1990 Mon	-0.00	1,000.00	-0.18	0.00	-140.47	-1,140.77	0.47	0.00
01-02-1990 Tue	-0.00	-777.08	-0.18	0.00	-111.30	665.50	0.46	0.00
01-03-1990 Wed	-0.00	-216.14	-0.18	0.00	-126.03	89.82	0.47	0.00
01-04-1990 Thu	0.00	-75.42	-0.18	0.00	-128.43	-53.30	0.47	0.00
01-05-1990 Fri	0.00	-17.57	-0.18	0.00	-127.76	-110.48	0.47	0.00
01-06-1990 Sat	-0.00	-51.22	-0.18	0.00	-125.86	-74.93	0.47	0.00
01-07-1990 Sun	-0.00	-49.09	-0.18	0.00	-124.71	-75.91	0.46	0.00
01-08-1990 Mon	0.00	-65.23	-0.18	0.00	-123.52	-58.57	0.46	0.00

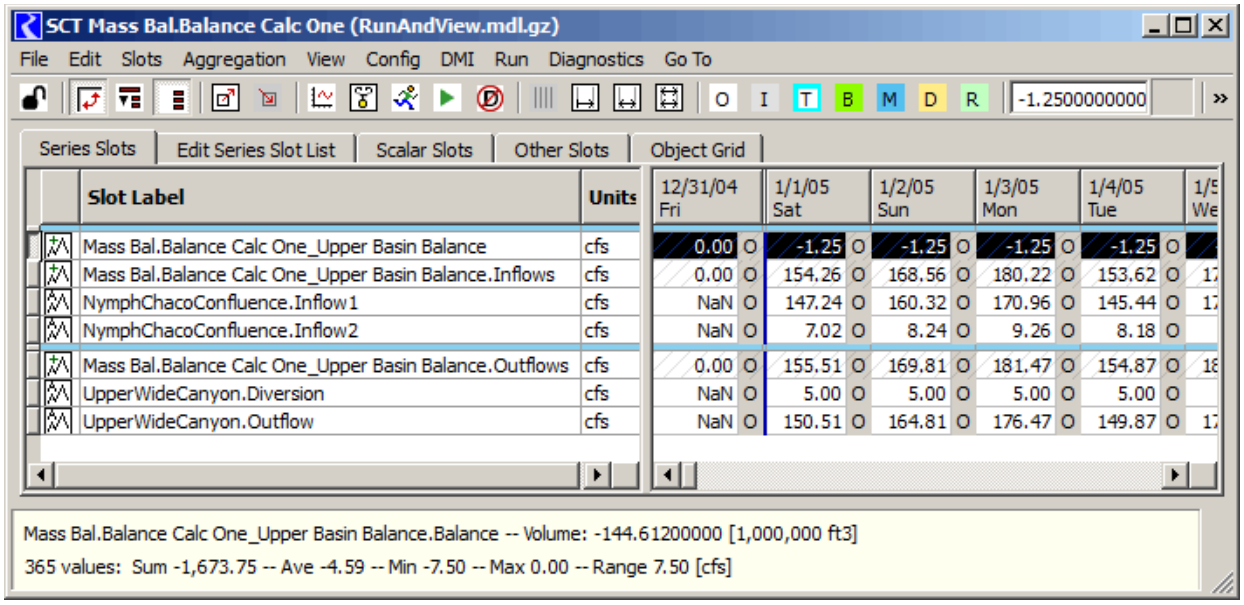
Note: There is currently no indication of the Slot Sums' "sense" being positive or negative.

Values are displayed with a crosshatch indicating that they are "read-only" (non-editable). Notice, in the image above, the not-quite-zero value in the "Value" line edit field from the single selected cell (upper left cell) -- this sort of value will be typical of actual computed Water Balance values (due to convergence). Enabling the display of the selection statistics (from the View menu) and selecting the first column provides a convenient way to determine whether or not the whole Water Balance series is zero.

Show Slots in an SCT: Computed summary and referenced slots can be shown in an SCT. If a single SCT is open, slots from the Mass Balance Summary dialog can be *added to* that SCT (the SCT must have the same timestep size as the model run).

The **File** menu's **Show Visible Slots in New SCT** shows all slot items current visible in the slot list (i.e. excluding those hidden under a closed tree branch).

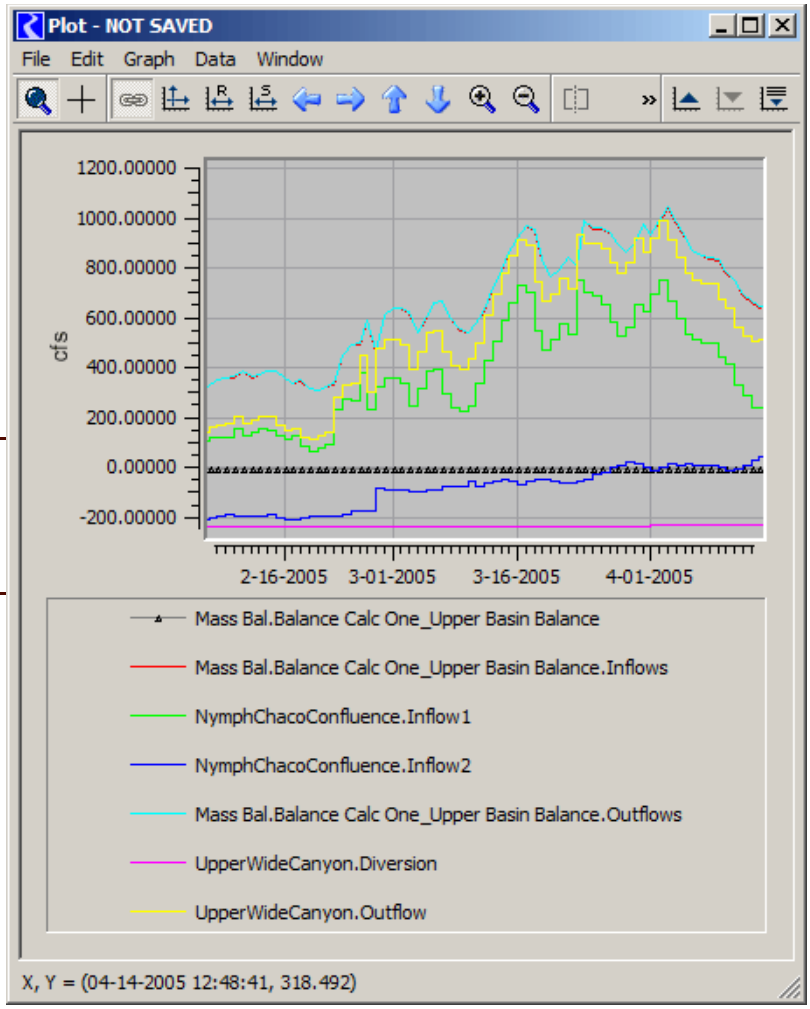




Note: Water Balance and Slot Sum slots are shown with the values and units set at the time of the most recent mass balance computation -- i.e. not necessarily the current unit setting in the Open Mass Balance Summary Slot dialog. If referenced slots are including in the "show in SCT" operation, they will be shown with their currently configured (or "active") units. And if they are editable slots, they will be editable in the SCT. (Notice the rows in the image above which are not cross-hatched -- those values are directly editable).

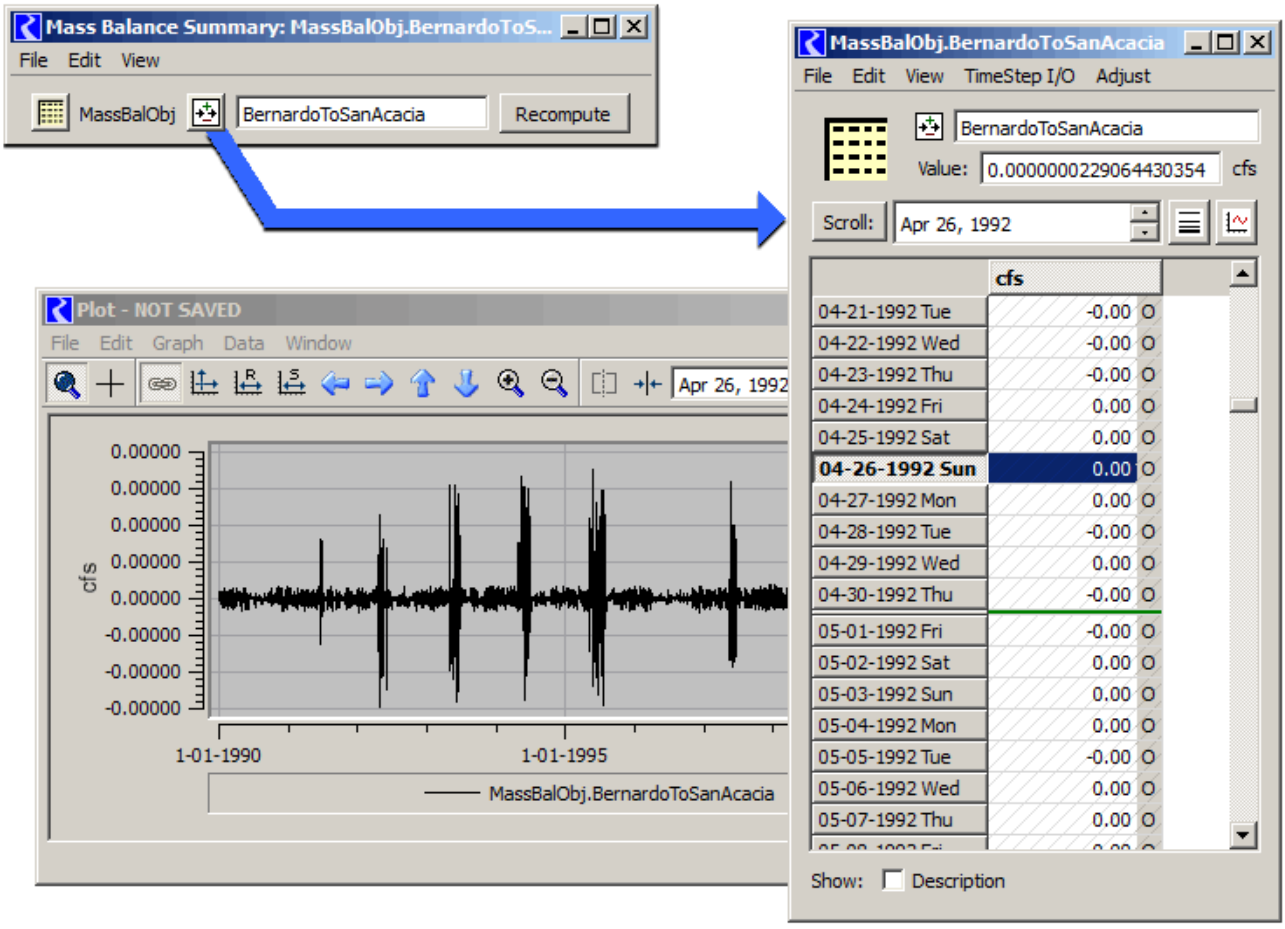
Plot Slots: Computed summary and referenced slots can be plotted in a single plot. Those operations are visible in the menus shown in the prior section. The note above regarding the active units of computed and referenced slots applies also to Plots -- i.e. the units used will not necessarily be those of the current settings in the Open Mass Balance Summary slot dialog.

> **Note:** All values are plotted in their positive (actual) sense -- values in negated Slot Sums are not shown as negated values.



Copy Slots: Computed summary and referenced slots can be copied to the RiverWare Slot Clipboard. From there, they can be pasted into various slot lists in RiverWare, including the general **Output Device** slot list and the **Snapshot Manager** slot list.

Examining the Mass Balance Summary Slot's Series: The Mass Balance Summary Slot is itself a series slot and can be examined by clicking on the Mass Balance Summary Slot icon button at the top of the dialog. (In a sense, a Mass Balance Summary Slot has two different "open slot" dialogs).



In the plot above, notice how all of the values represented on the vertical axis are zero (to a precision of five fractional decimal digits), in this example.

4.16.4 Dependent RPL Expression Slot Support

Mass Balance Summaries are designed in such a way that intermediate and final sum results (Slot Sums and Water Balances) are usable for custom user calculations implemented in RPL Expression Slots, such as annualization of values. In a run, the mass balance summary is computed after RPL Expression slots. To allow RPL expression slots to reference mass balance summary data, the **Dependent Expression Slot List** in a Mass Balance Summary is evaluated, in order, once, after each **Mass Balance Summary** is computed.

Dependent Expression Slot results will generally be incomplete when computing a Mass Balance Summary if the RPL Expression Slots in the list depends on sums from *multiple* mass balance summaries. The following provisions address this problem:

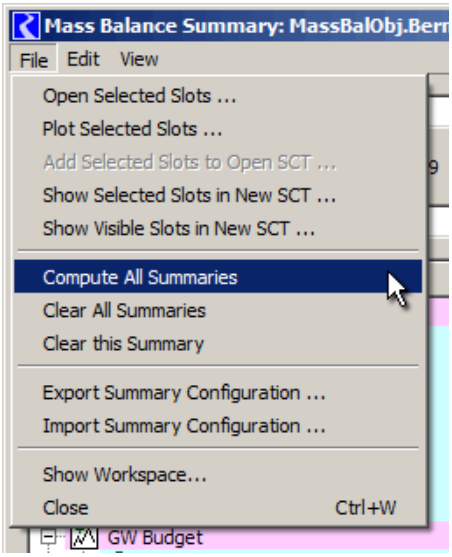
- The automatic "end-of-run" mass balance computations are performed in this order:

  1. The RPL Expression slots in the Dependent Expression Slot Lists in ALL Mass Balance Summaries are cleared.

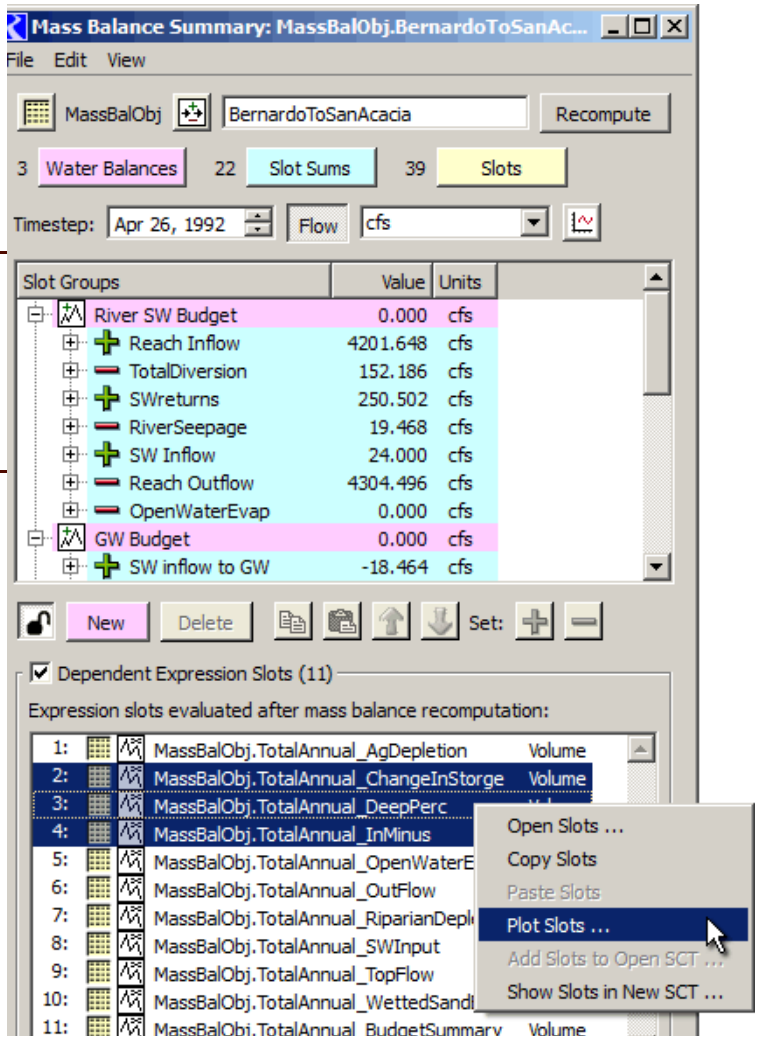
  2. All Mass Balance Summaries are computed.

  3. The RPL Expression slots in the Dependent Expression Slot Lists in ALL Mass Balance Summaries are evaluated.

- In addition, in the **File** menu, there is a **Compute All Summaries** option that perform this model-wide computation (the three steps in the prior item)



The Dependent Expression Slot panel at the bottom of the Open Mass Balance Summary Slot dialog implements editing and display operations similar to those of the main slot list.



> **Note:** If the dependent Expression Slots use a different from the model's run timestep, they can't be displayed in the same SCT as the computed summary slots and slot references.

Clicking the **Add** button opens the slot selector, initialized with **Has RPL Expression** and **Unit Type** ("Flow") filters on by default.

4.16.5 Computation

When computed, the timestep size and timestep range of each of the Mass Balance Summary and Slot Sums are set to the step size and range of the run controller. The unit type and configured display units are set to those specified. For each

timestep in the run time range, any of the contained slots having a valid value at that timestep contributes that value to the Slot Sum or Water Balance's value at that timestep. NaNs are ignored (effectively zero). The computed slots are set to be "read-only".

Limitations of the current Mass Balance Summary Computation:

- No "routed terms". A timestep offset cannot be applied to any slot reference within a Slot Sum, or to any Slot Sum within a Water Balance.
- No knowledge of "static volumes". The mechanism unconditionally converts all volumes to flows by dividing the volume by the timestep size (for each timestep). A RPL implementation of the "change in storage" calculation can be seen **HERE (RPL Expressions for Other Slots:)**.

Mass Balance Summary Computations are performed in these ways:

- By clicking the "Recompute" button in the Open Mass Balance Summary Slot dialog.
- By selecting the "Compute All Summaries" operation in the "File" menu of that dialog.
- Automatically, at the end of a run, immediately after the "end-of-run" RPL Expression Slots evaluation. This is performed unconditionally.

As a tool for debugging and testing Mass Balance Summary implementations (including user definitions), operations to **clear** an individual Mass Balance Summary, and all Mass Balance Summaries (including Dependent Expression Slots) is provided in the **File** menu.

4.16.6 Persistence

All Mass Balance Summary configuration information is stored on the Mass Balance Summary Slot. This is applied both in the RiverWare model file and in Export files.

A Mass Balance Summary Slot's computed slots are created as (effectively) invisible slots on the same object. They do show up in the slot selector!

A Mass Balance Summary Slot's configuration can also be saved to, and read from a file using Export and Import operations in **File** menu.

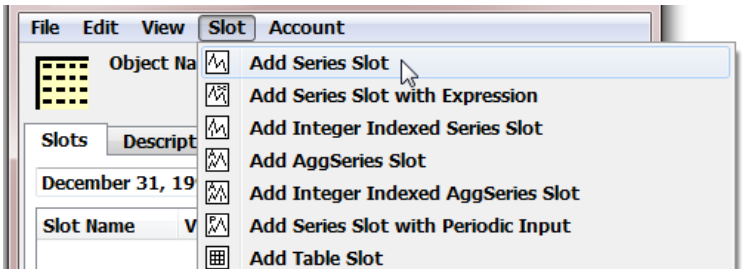
DateTime Values in Slots

5. DateTime Values in Slots

In addition to the standard unit types (Flow, Length, Volume, etc...) that can be configured on custom slots. It is possible to add slots that have values in the slot that represents a DateTime. This is possible by configuring the slot to have a DateTime unit type. Following is a walk through describing how to add a slot with a DateTime value. Following that is a description of each of the date times and a description of how to use the values in RPL.

5.1 Walk-through: Adding a Slot with DateTime Values

To introduce how DateTime Values exist on RiverWare Slots, this section walks the user through the process of creating a Series Slot with DateTime value on a Data Object.

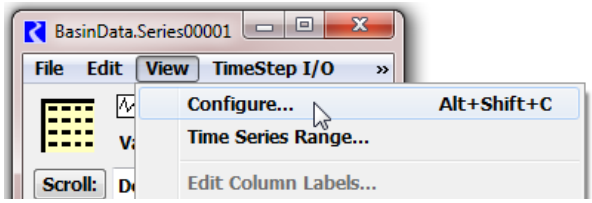


STEP 1: Create a Data Object and **Add a Series Slot,** or any of the following types of Slots. All of the following support DateTime values:

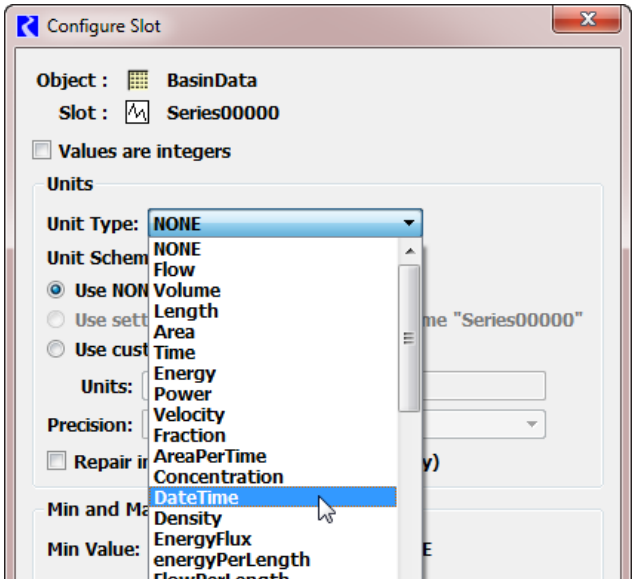
- Series Slot
- AggSeries Slot
- Table Slot
- Scalar Slot

STEP 2: From the object dialog, double click on your new Series Slot to show the Open Series Slot dialog.

STEP 3: From the Open Series Slot's **View** menu**,** select **Configure** to open the Series Slot Configuration dialog box...

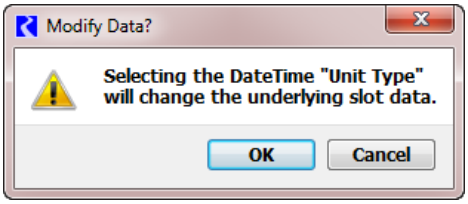


STEP 4: From the Series Slot Configuration dialog box, select the last item from the Unit Type option menu: **DateTime**.



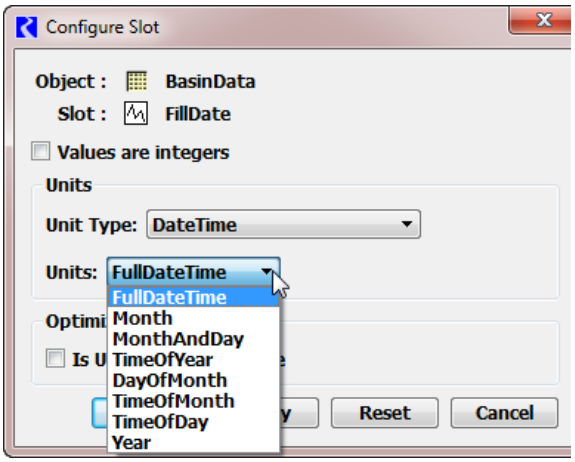
The "DateTime" Unit Type, and the eight supported DateTime User Units are special in RiverWare. These selections cause the Slot's values to be displayed and edited as DateTimes rather than as numeric values.

Unlike switching between ordinary Unit Types, switching to the "Date Time" Unit Type, and between the various DateTime "User Units" causes a change in the underlying Slot values. The user must confirm these changes with this popup dialog.



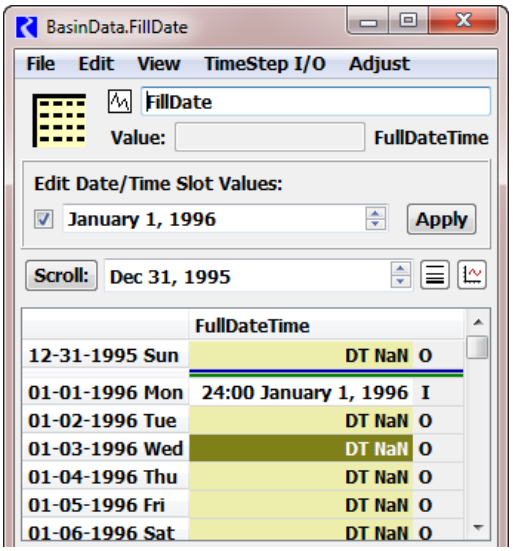
STEP 5: As a result of switching to the "DateTime" Unit Type and clicking apply, configuration properties associated with only numeric values are hidden (e.g. Min/Max values, Display Format, Convergence).

Notice the eight different "User Units" associated with the DateTime Unit Type. You can keep the default selection, "FullDateTime"... **Click OK.**



Note: AggSeries Slots and Table Slots support independent Numeric / DateTime configuration on each column.

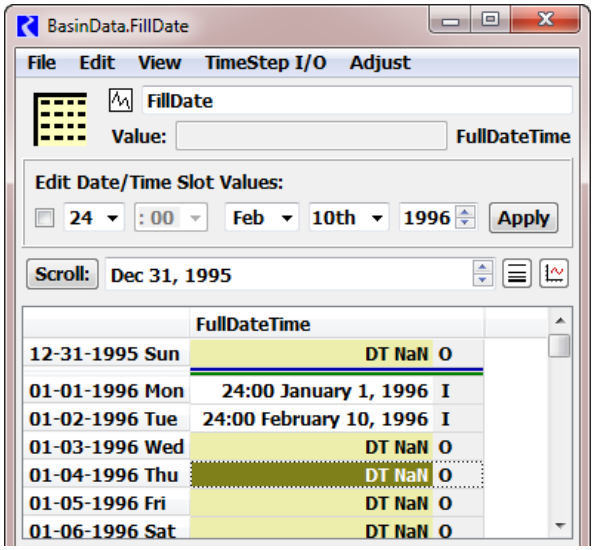
STEP 6: As a result of selecting a "DateTime" unit, the **Edit Date/Time Slot Values:** area is added to the Open Slot dialog.



The entry and selection fields shown within the **Edit Date/Time Slot Values:** area depend on which DateTime "User Unit" selection was made. For the **FullDateTime** selection, two alternative entry modes are available, selectable with the checkbox on the left.

- **Timestep Spinner** -- for DateTimes on Timestep Boundaries. (first image).
- **Unconstrained Date/Times** -- for selection of any DateTime within the supported RiverWare date range. (second image)....

Try making different cell selections, hitting the **Apply** button and repeating these steps with different DateTime entry values.



Notice that the **Value** field at the top of the Open Slot dialog is disabled (not editable, and shown with a gray background). This field shows the actual internal numeric value associated with the selected cell's DateTime value.

Double-clicking on a cell assigns the cell's value to the **Edit Date/Time Slot Values:** area.

When a range of cells is selected with the first and last cell having valid values, interpolated DateTimes can be assigned to the intervening cells. Try: **Edit ➥ Interpolate** (not illustrated here).

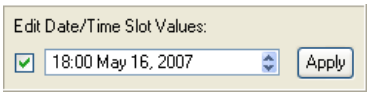
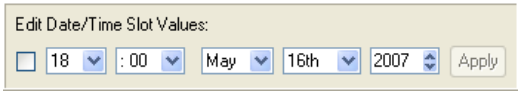
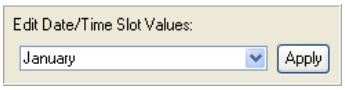
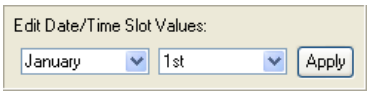
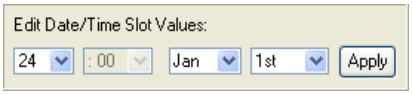
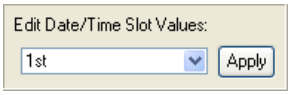
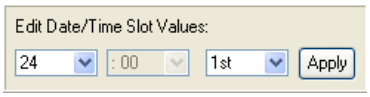
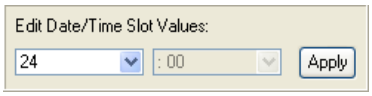
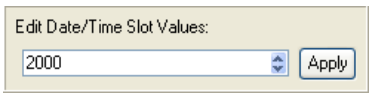
Plotting of DateTime value series is also supported. (Hit the Plot icon button on the right side of the dialog). DateTime coordinates are not shown on the axes, but relative DateTime "magnitudes" can be discerned.

DateTime values which don't conform to the Slot's (or Slot column's) configured DateTime "units" (Partial DateTime configuration) are shown with a yellow cell background. In addition, a value that is Not a Number (NaN) is shown with the syntax **DT NaN**.

5.2 Partial DateTime Editor

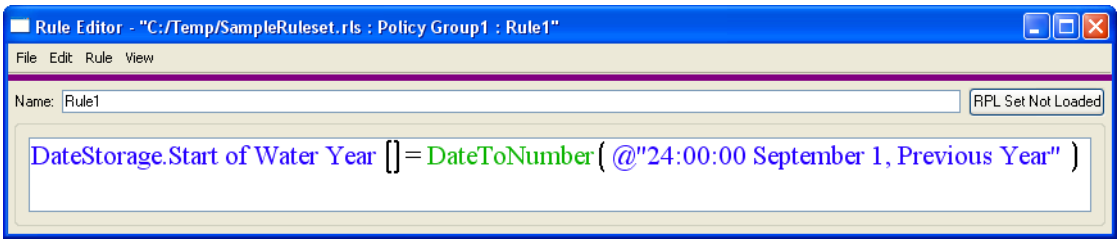
The Partial DateTime Editor in the Open Slot dialog also shows the applied DateTime. This page shows this dialog in standard numeric configuration and in the various Full and Partial DateTime

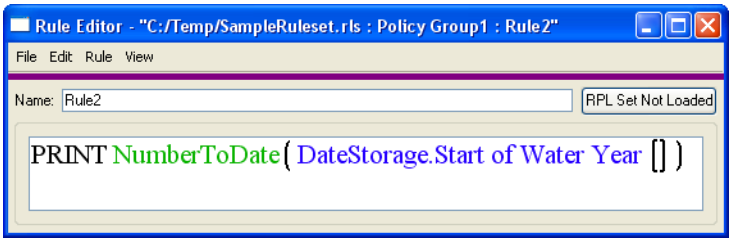
configurations. The screenshots shown are for a Scalar slot but they are applicable to the other supported slots as well

DateTime User Unit	Example	Selection Mechanism
Full DateTime	18:00 May 16, 2007	 Timestep Spinner or  Unconstrained Date/Times
Month	January	 Month pulldown menu
Month and Day	January 1st	 Month and Day pulldown menu
Time of Year	24:00 Jan. 1	 Hour, Month, Day pulldown menu
Day of Month	1st	 Day of Month pulldown menu
Time of Month	24:00 1st	 Hour and Day of Month pulldown menu
Time of Day	24:00	 Hour pulldown menu
Year	2000	 Year Spinner

5.3 Access to DateTime values via RPL

RPL doesn't directly support DateTime Slot values as DATETIMES. All Slot values are handled as numeric values. Two Predefined RPL Functions are used to convert the Slot DateTime values to and from RPL DATETIME values. The following illustration demonstrates the use of the **DateToNumber** and **NumberToDate** Predefined functions. The following two sections provide more information about these predefined functions.





The following links will take you to the appropriate documentation

- DateToNumber - This function converts a DATETIME to the corresponding number. Click **HERE (RPLPredefinedFunctions.pdf, Section 24)** for more information.
- NumberToDate - This function converts a number to a corresponding DateTime. Click **HERE (RPLPredefinedFunctions.pdf, Section 132)** for more information

5.4 Conversion of DateTimes to Numeric Values

Although rare, you may need to see the value that is stored on the slot. Use the **Unit Converter** and the DateTime unit type for this purpose. This is described in detail **HERE (Units.pdf, Section 3.2)**.

Notes on Series Slots

6. Notes on Series Slots

6.1 Introduction

Annotation of series slots using “Notes” allows you to comment on data in a RiverWare model. For example, you may:

- Document certain characteristics of input data such as filled values, storm events, etc.
- Provide meta-data on the source of the input data.
- Call attention to specific operations, decisions, or outcomes for a model run.

Notes are for documentation purposes; they do not affect the solution and they cannot be accessed (read or assigned) via rules or other RPL sets. In general, notes are available for all types of series (Series, Multi, Agg, Series with Expression) and can be edited via the Open Slot dialogs, the SCT, and the Edit Account dialogs.

So what are Notes? Notes are short text strings that are associated with one or more timesteps. Each note belongs to a “Note Group”. Each Note Group contains a list of associated slots and the timestep(s) to which they apply. The “Note Group Manager” utility dialog facilitates creation and management of Note Groups. The display icon for each group can be assigned a color.

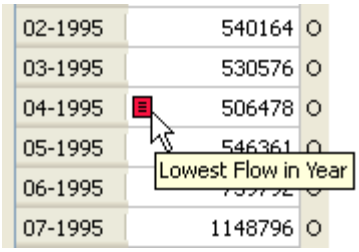
Notes can be imported and exported:

- From/to text files using the Control File-Executable (non-direct-to-database) DMI functionality as described **HERE (Section 6.9)**
- From/to an external xml file using the Note Group Manager as described **HERE (Section 6.8)**

Note: Support for text Notes on series slot timesteps (“Annotations” or just “Notes”) was redesigned in RiverWare 5.2. Notes are still organized within Note Groups, but notes are now directly applied to individual series slot timesteps rather than by associating their containing Note Groups with whole series slots. Additionally, multiple notes can be associated with a timestep on an individual series slot.

6.1.1 Notes

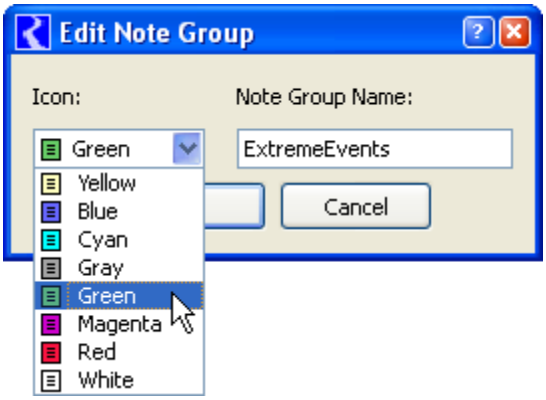
A Note is a text string that is associated with a series slot at a timestep and each note belongs to a **Note Group**. A Note has the following properties:



1. Note text: The text string that makes up the Note.
2. Note group membership: A note belongs to exactly one Note Group.
3. Slots and timesteps: A note is applied to one or more series slots at specified timesteps

6.1.2 Note Groups

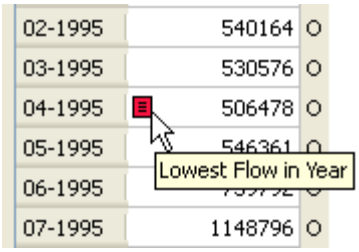
A **Note Group** is composed of three properties:



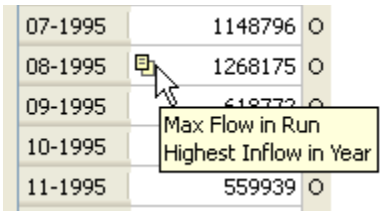
1. Name: a name is generally provided by the user.
2. Icon Color: A note group has one of eight basic colors.
3. Set of Notes: A Note Group has a set of one or more text **Notes**.

6.2 Display and Editing of Notes

Note text can be seen and reviewed in the series slot dialogs. In the series slot dialogs (for Series Slots, Agg Series Slots, Multi Slots, Table Series Slots and Edit Account dialogs), the presence of a note is shown by a small icon to the left of the value. The color of the icon is defined for the Note Group. Mousing over the icon displays a tool tip with the Note's text.



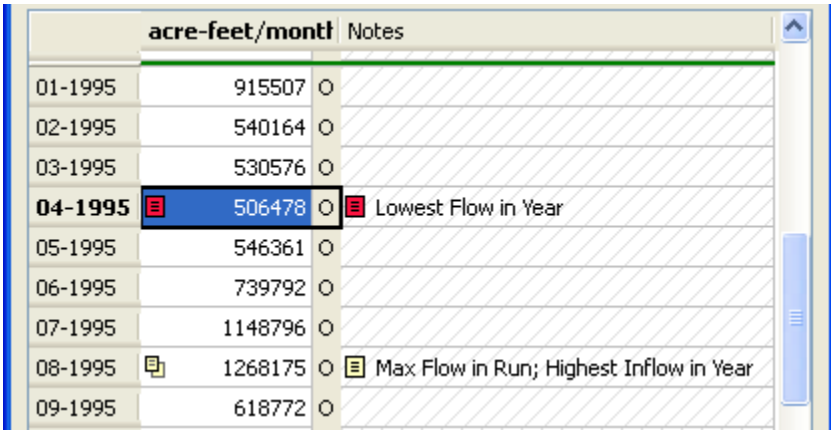
Cells having more than one note have a special icon suggesting one note stacked on the other. The tool tip lists each note, one per line. See image to the right.That icon is always yellow and does not reflect the color of any of the corresponding Note Groups.



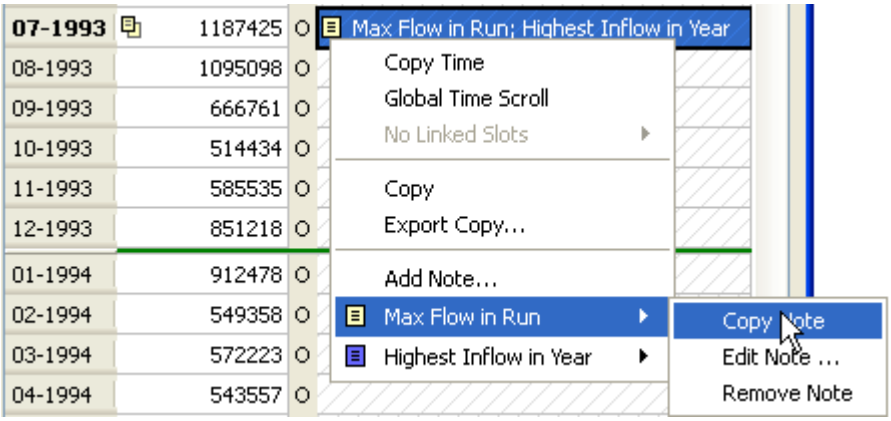
The note text can be shown in a separate column using the **View ➥ Show Notes Column** toggle menu item.

> **Note:** You can configure your preferences on whether or not to show the Notes column using **Slot Dialog Display Preferences** described HERE (Section 2.1.5.2).

If the Notes Column is visible and the open slot belongs to one and only one Note Group, a new note can be created by simply typing in the Notes Column. The Note will be created as a member of the slot's Note Group.

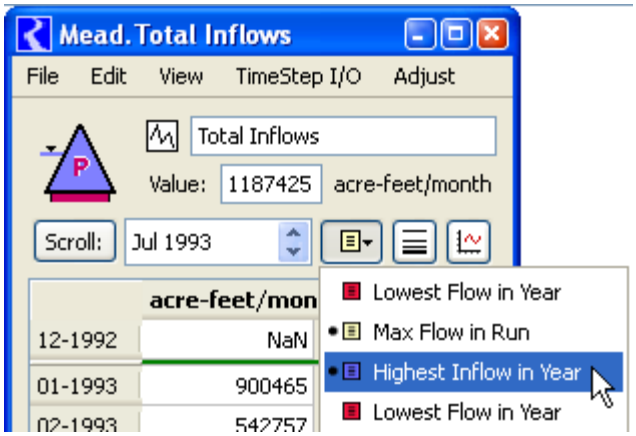


When one or more notes exist on a particular Slot/Timestep, the context menu (right-click) on the cell includes a submenu for each note. See the image below. The title of the submenu shows the Note Group icon and the Note Text. The submenu contains three operations:



- **Copy Note:** The **Copy Note** menu item copies a Note reference to the **Note Copy Buffer.** In the example shown to the right, the "Max Flow in Run" note would be copied to the buffer. The note can then be pasted in one or more cells using the **Paste Note** operations.
- **Edit Note:** The **Edit Note...** menu item shows the Note Group Manager Dialog, with the indicated Note pre-selected. You may change the note text, or move the note to a different Note Group (potentially having a different Note Group icon).
- **Remove Note:** The **Remove Note** menu item removes the indicated note from the selected Slot/Timestep (only). This does not effect the appearance of the same note at other timesteps on the same Slot, or on any other Slot.

The dialog can be scrolled to the timestep of a note on the Slot via the **Note Navigation** menu button**.** See the screenshot to the right. Items in the **Note Navigation** menu having a bullet indicate that the timestep of the note matches that of the timestep spinner.



Holding down the Shift Key while selecting an item causes a Global Time Scroll (scrolling all open series-related dialogs to the corresponding timestep).

6.3 Creation of Notes

Following are three ways to create a note:

1. In an open series slot dialog, edit account dialog or SCT

- Right-click in a cell
- Select **Add Note...** from the context-sensitive pop-up menu. This will open the **Note Group Manager** which is described in detail **HERE (Section 6.4).**
- Choose or create a **Note Group**
- Choose or create the **Note** text.
- Choose the slots and timesteps to which the note should apply by clicking on the **Add Entry Using Context** button. This opens the **Apply Notes to Slots** dialog which is described **HERE (Section 6.5)**. The slot and timestep from which this right-click operation began are selected.
- Change/add slots or timesteps (if necessary) and click **Ok** to associate the Note with the slot/timestep.

2. From the main workspace:

- Choose the **Utilities ➥ Note Group Management...** menu. This opens the **Note Group Manager** dialog as described **HERE (Section 6.4)**
- Choose or create a **Note Group**.
- Choose or create the **Note** text.
- Click the **Add Slot Entries...** button to open the **Apply Notes to Slots** dialog which is described **HERE (Section 6.5)**.
- Click the **Add Slots...** button and choose the slots to which the note applies.
- Specify the timestep or range of timesteps to which the note applies.

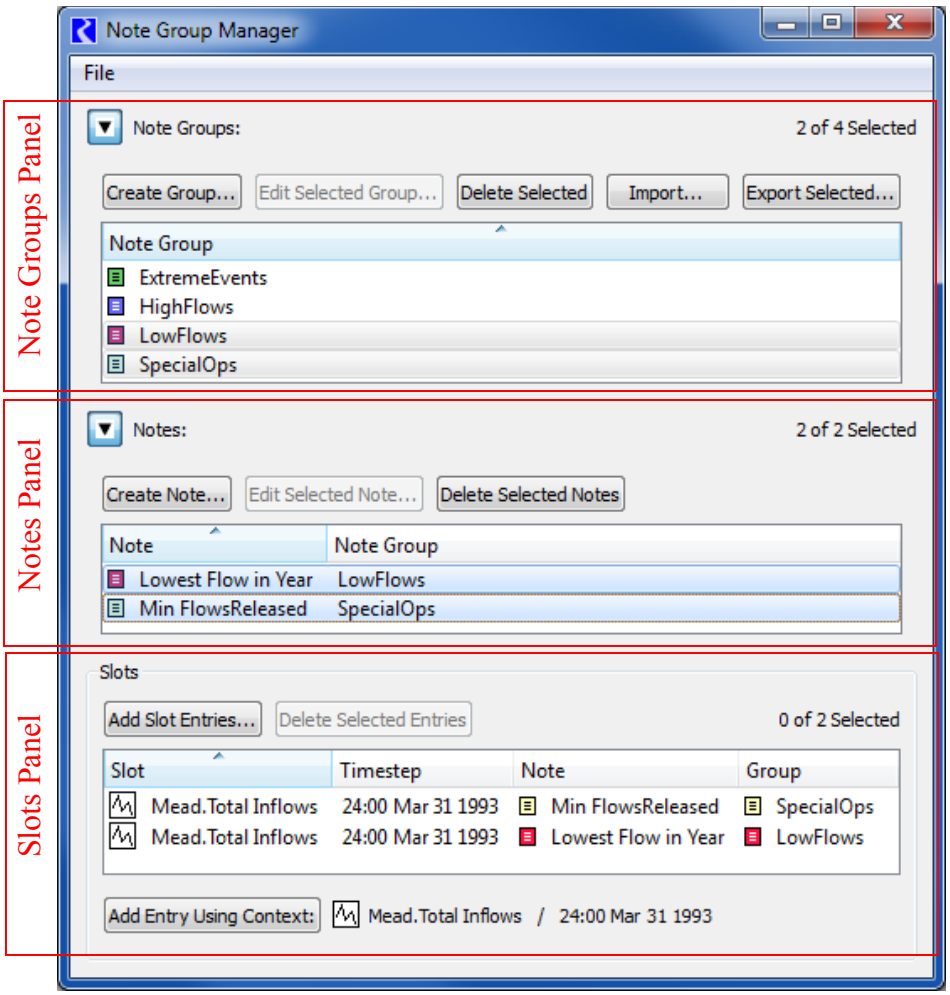
3. To create a note based upon an existing note (copy/paste of note). In an open series slot dialog, edit account dialog or SCT

- Right-click in a cell that has the desired noted.
- Select the note from the context-sensitive menu and choose **Copy Note.**

- Go to the destination slot and timestep and right-click in the cell.
- Choose **Paste Note: Name**.

6.4 Note Group Manager Dialog

The **Note Group Manager** and supporting sub-dialogs are used to maintain the set of notes on series slots.



This dialog is arranged vertically in three hierarchically defined panels as shown in the following figure: **Note Groups**, **Notes**, and **Slots**. The first two panels can show either a list or a pulldown menu, controlled by the triangle arrow button in each panel. The combo boxes allow for the selection of a single item (Note Group or Note), or "All" items.

The panels are used in a top to bottom order. First you select (highlight) one or more **Note Groups**. Then the member **Notes** are displayed in the **Notes** panel. Then you select one or more **Notes** in the **Notes** panel and the member slots and timesteps are displayed in the **Slots** panel.

Following is a description of these three panels.

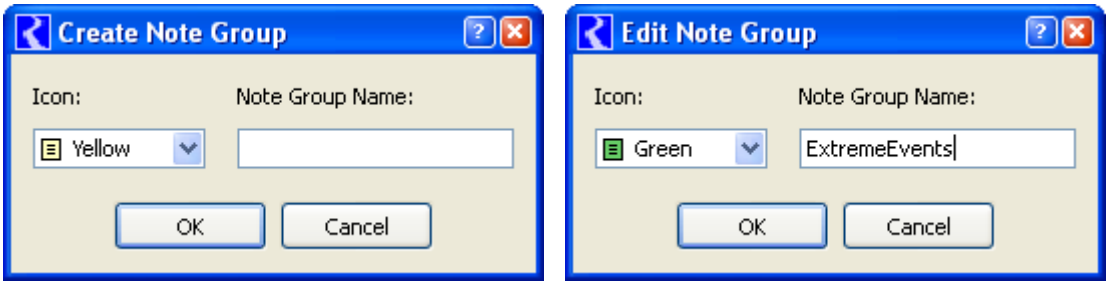
6.4.1 Note Groups panel:

The **Note Groups** panel shows all the defined Note Groups and supports five operations (buttons):

- **Create Group...**
- **Edit Selected Group...**
- **Delete Selected**

- **Import...** (Described **HERE (Section 6.8)**)
- **Export Selected...**(Described **HERE (Section 6.8)**)

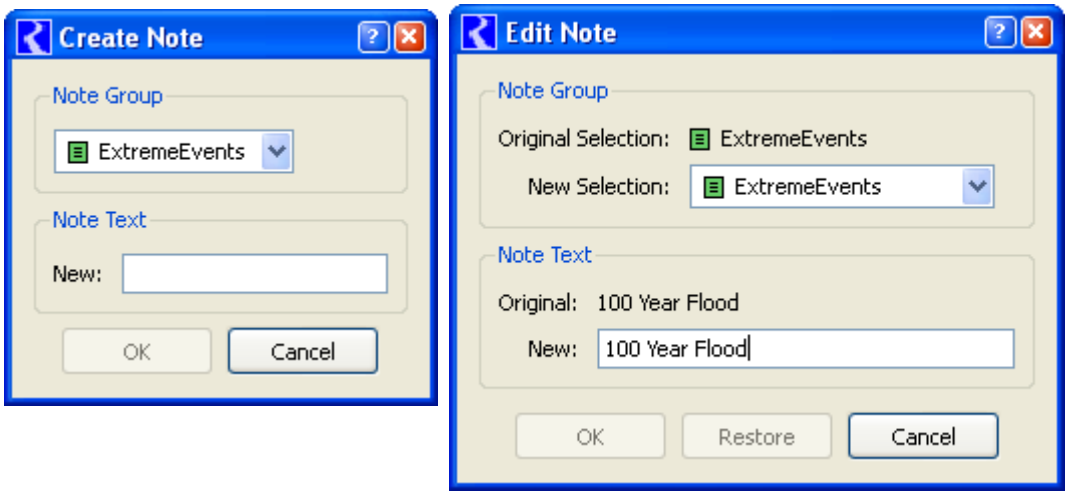
The first three buttons bring up dialogs for creating (define the name and icon color) or editing (changing the name and icon color), or confirming deletion of Note Groups as shown below:



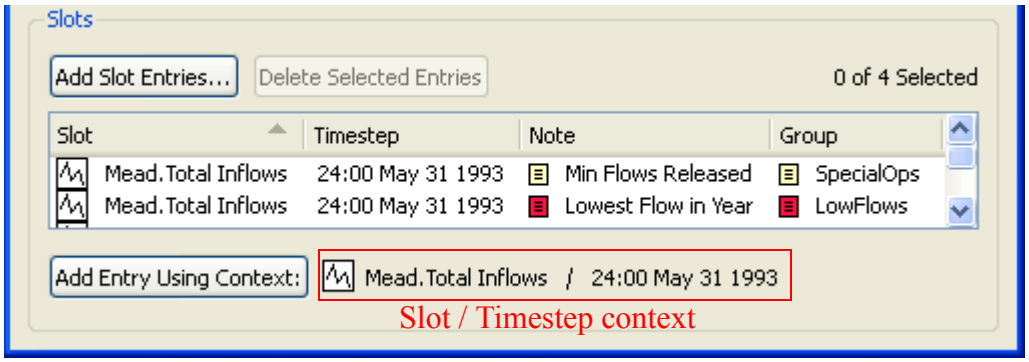
6.4.2 Notes panel:

For the selected **Note Group** in the above panel, the **Notes** panel shows the notes that are a member of that group. It supports three operations (buttons):

- **Create Note...**: Enter a new **Note** text and choose the **Note Group** to which it belongs.
- **Edit Selected Note...**: Edit existing **Note** text or change the **Note Group** to which it belongs.
- **Delete Selected Notes...**: Delete the selected **Note** after confirmation.



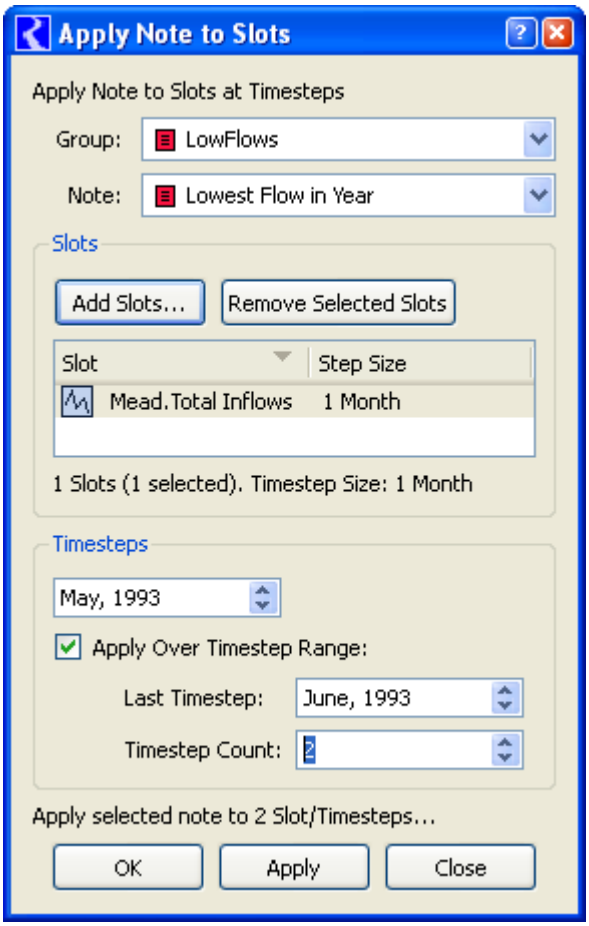
6.4.3 Slots:



For the selected **Note**(s) in the middle panel, the **Slots** panel shows the slots and timesteps to which the note has been applied:

Both the **Add Slot Entries...** and **Add Entry Using Context:** buttons bring up the **Apply Notes to Slots** dialog described in the next section. These differ only in the initial selections used in that dialog. The **Add Entry Using Context** button is available when the manager dialog is shown from the context of a particular slot and timestep, i.e. right clicking on a cell in a slot or SCT then choosing **Add** (or **Edit**) Note. The current context (Object.Slot and Timestep) is listed on the same line as the button.

6.5 Apply Note to Slots dialog



The **Apply Note to Slots** dialog allows the user to associate a particular note with one or more Slots at one or more contiguous timesteps.

The list of slots and the timestep selections are sometimes pre-selected, depending on how the **Apply Note to Slots** dialog is shown. These selections can be modified before creating the new Note/Slot/Timestep associations.

The Group and Note combo boxes can be modified to select a different note. Only one note can be selected at any one time.

Additional Slots can be added to the Slot List by clicking the **"Add Slots..."** button. This brings up the RiverWare Slot Selector.

Slots can be removed from the Slot List by selecting items in the list and clicking the **"Remove Selected Slots"** button. Doing so has no effect on any existing Note/Slot/Timestep associations.

In the **Timesteps** section, the user can choose one timestep or range of timesteps (continuous only) to which the note will apply.

The **OK** or **Apply** buttons are enabled only if the inputs specify a valid state representing Note/Slot/Timestep associations that are not yet existing. For one thing, all of the Slots in the Slot list must have the same timestep size. If enabled, the **OK** and **Apply** buttons create a Note/Slot/Timestep association for all of the Slots in the list (i.e. not just the selected Slot items).

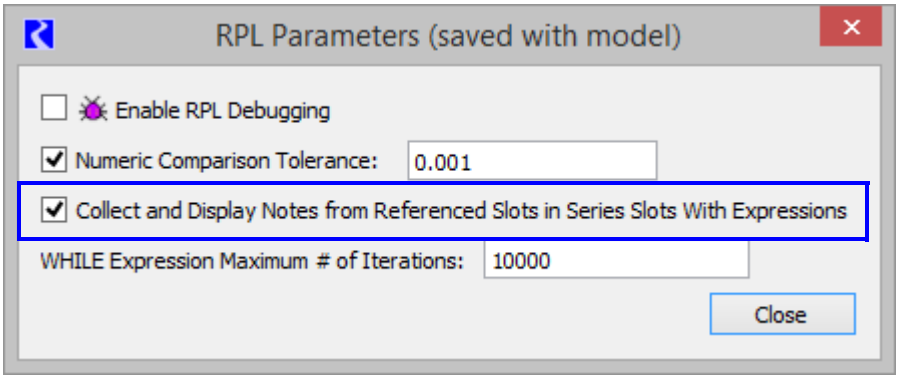
Status lines under the Slot List and above the bottom buttons indicate the state of the inputs. Examples of the various messages shown in the bottom status line are as follows. (The OK and Apply buttons are enabled only in the 4th example):

- No defined Note is selected.
- The Slot list is empty.
- The Slot list includes Slots having different timestep sizes.
- Apply selected note to 6 Slot/Timesteps... [enabled state]
- The selected note has been applied to 6 Slot/Timesteps.

6.6 Collected Notes on Expression Slots

Collected notes are a special type of note associated with series expression slots (i.e. **Series Slot with Expression)**. When the expression slot is evaluated, notes from the series slots referenced in its expression ("source" slots) are copied to corresponding timesteps in the expression slot. The source slots for providing notes are an accumulated list of the source slots referenced across the expression slot's evaluations at all timesteps. The notes from the source slots are collected and copied once at the end of the expression slot's evaluation. The collected notes are removed and re-collected each time the expression slot evaluates. In the context of a run, they are removed at the beginning of the run and collected at the end of the run, so if the run is paused or aborts in the middle, the collected notes will be absent.

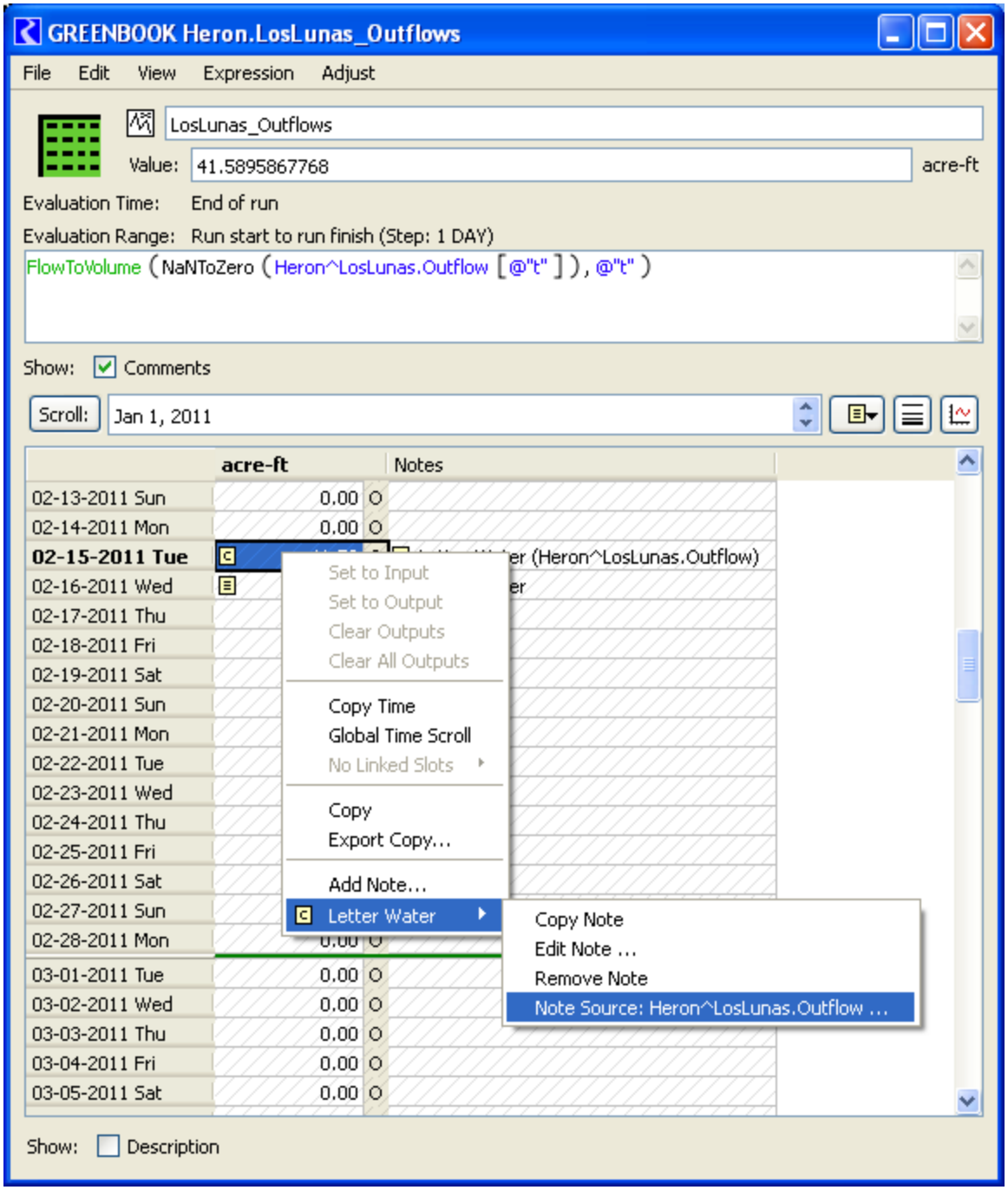
The collection of notes for series with expressions is optional and is controlled on a model-wide basis by a parameter selection in the **RPL Parameters** dialog. This dialog is available from the RiverWare workspace under the **Policy** menu.



In the places where notes for series can be displayed (Series Slot, SCT and Notes Group Manager dialogs), collected notes are differentiated by having a C in their icon. See the image below. The text of a collected note, where displayed in the notes column or in a tool tip when mousing over a note icon, will show the text of the note followed by the source slot name in parentheses.

Note: Note that if a note is propagated up through a number of expression slots, the slot where the note originated is maintained as the source slot for the note even though one expression slot may be picking it up from another expression slot that referred to the source slot.

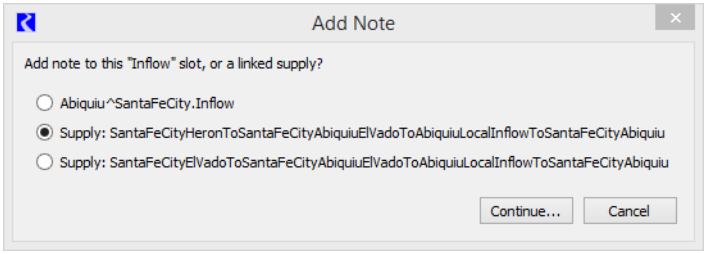
The context menu (right-click) on a cell for a collected note in the series slot and SCT dialogs will have an additional menu entry showing the source slot of the collected note. Click the item to open the source slot's dialog. If a source slot is deleted from the model, the collected notes that refer to that source slot will also be deleted.


GREENBOOK Heron.LosLunas_Outflows
File Edit View Expression Adjust
LosLunas_Outflows
Value: 41.5895867768
acre-ft
Evaluation Time: End of run
Evaluation Range: Run start to run finish (Step: 1 DAY)
FlowToVolume (NaNToZero (Heron^LosLunas.Outflow [@"t"]), @"t")
Show: Comments
Scroll: Jan 1, 2011
acre-ft
Notes
02-13-2011 Sun 0.00 O
02-14-2011 Mon 0.00 O
02-15-2011 Tue
02-16-2011 Wed
02-17-2011 Thu
02-18-2011 Fri
02-19-2011 Sat
02-20-2011 Sun
02-21-2011 Mon
02-22-2011 Tue
02-23-2011 Wed
02-24-2011 Thu
02-25-2011 Fri
02-26-2011 Sat
02-27-2011 Sun
02-28-2011 Mon
03-01-2011 Tue 0.00 O
03-02-2011 Wed 0.00 O
03-03-2011 Thu 0.00 O
03-04-2011 Fri 0.00 O
03-05-2011 Sat 0.00 O
er (Heron^LosLunas.Outflow)
Set to Input
Set to Output
Clear Outputs
Clear All Outputs
Copy Time
Global Time Scroll
No Linked Slots
Copy
Export Copy...
Add Note...
Letter Water
Copy Note
Edit Note ...
Remove Note
Note Source: Heron^LosLunas.Outflow ...
Show: Description

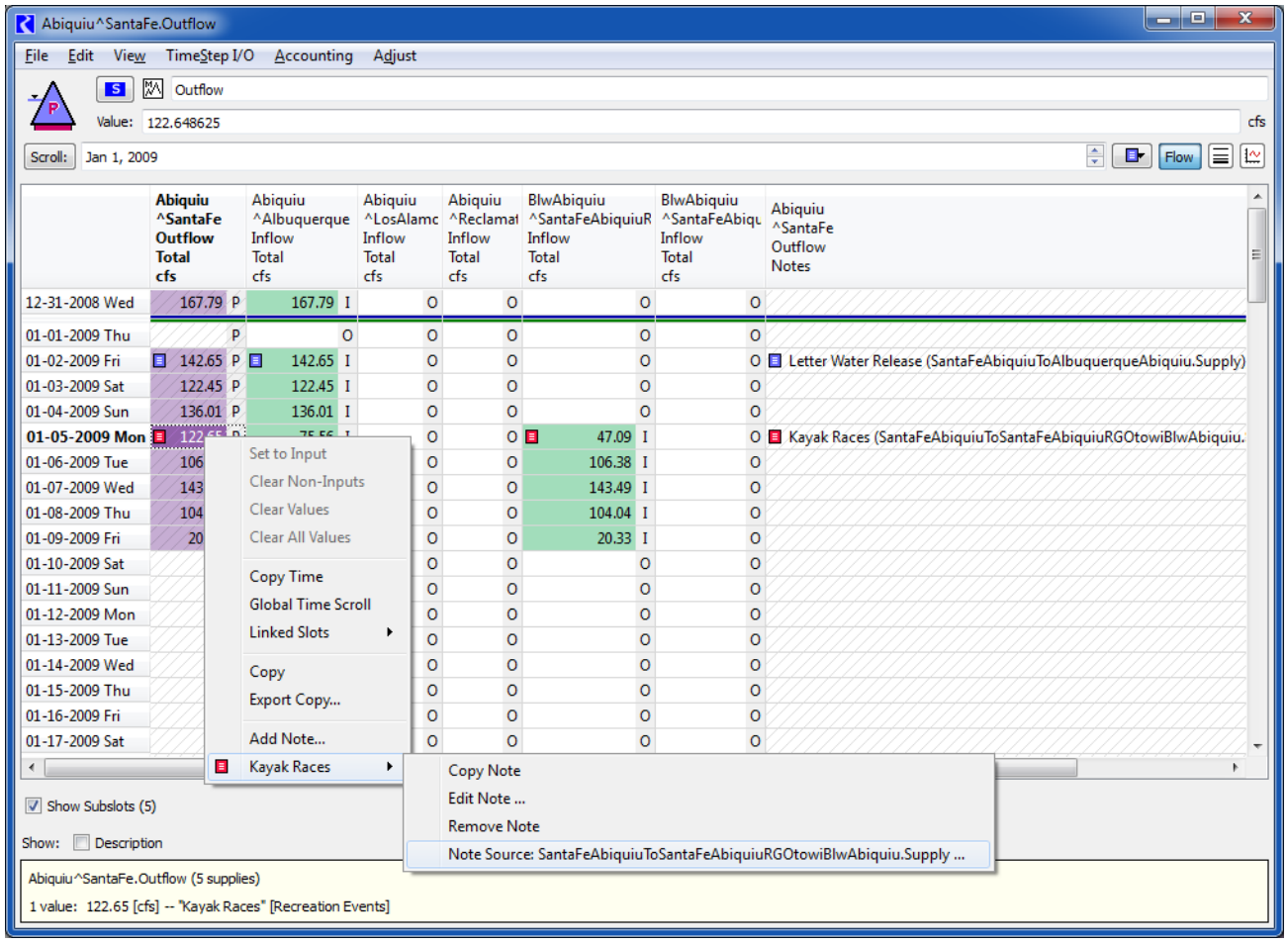
6.7 Accounting Multi Slot Notes

Accounting multislots, such as storage account inflow or outflow, have a subslot for each supply linked to the multislot. You can add a note to the multi slot or the supply/subslot.

When you add a note to a multi slot that has one or more subslots/supplies, a confirmation asks you which you would like to use. Typically, it is better practice to add the note to one of the linked supplies, as shown.



When a note is added to a linked supply, the note is automatically propagated to the multislots on either end of the supply. Notes propagated in this way are assigned a source slot corresponding to the supply. The display of the propagated note is similar to collected notes **HERE (Section 6.6)**, where the source slot name is displayed in parentheses after the note text in the notes column, and the right-click context menu contains an item for the source slot that, when clicked, will open the source supply's slot dialog. When a note on the supply is deleted, or the supply itself is deleted, propagated notes will be removed from the corresponding accounting multi slots.



6.8 Import / Export of Notes

Notes can be imported or exported to a text (xml) file. The export/import functionality allows notes made in a copy of a model to be transferred back into the original.

Clicking the **Import...** or **Export Selected...** buttons brings up a file selector to specify an import or export file for Note Groups. These operation are also available from menu items in the **File** menu at the top of the dialog. Exporting one or more selected **Note Groups** will write information to the file for the group, its notes, and the slot associations for those notes. On import from a file, a Note Group is created if it does not already exist, notes in the group are created if they do not already exist, and slot associations for the notes are created if they do not already exist. A feedback dialog will indicate if note associations with slots cannot be made (i.e. if the slot is not in the new model).

6.9 DMI I/O

Notes can be output from RiverWare slots to data files using control file-executable DMI's. The control file keyword used to specify notes is as follows:

```
slot_anno = true
```

The default value for slot_anno (i.e. slot annotations) is false, meaning no Notes will be written.

A line in RiverWare time series format (for DMI import or from DMI export) containing a note will be formatted as:

```
<value> anno {Storm Events} {4.3 Inches}
```

where <value> will be a numeric value, "anno" is a keyword, Storm Events defines the Note Group to which the note belongs and 4.3 Inches is the note itself. The "<"a ">" will not exist in actual output. The "{" and "}" do exist, delimiting the Note Group name from the note text itself.

Note: In the external RiverWare time series format, only one Note will be supported at one given timestep on any one SeriesSlot. That is, if a given SeriesSlot is a member of more than one (say, two) Note Groups, and if both of those Note Groups have a Note at the same timestep (say, 2-13-2007), then only ONE of those Notes will be preserved in the DMI operation.

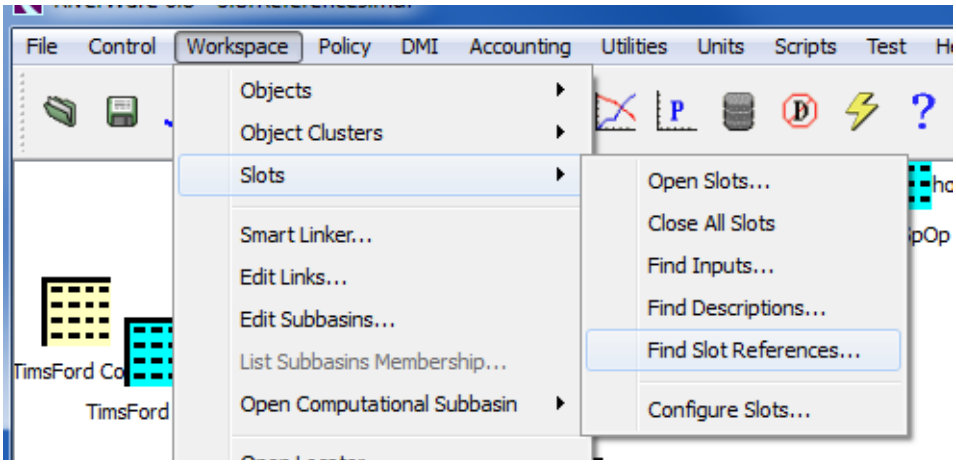
Find Slot References

7. Find Slot References

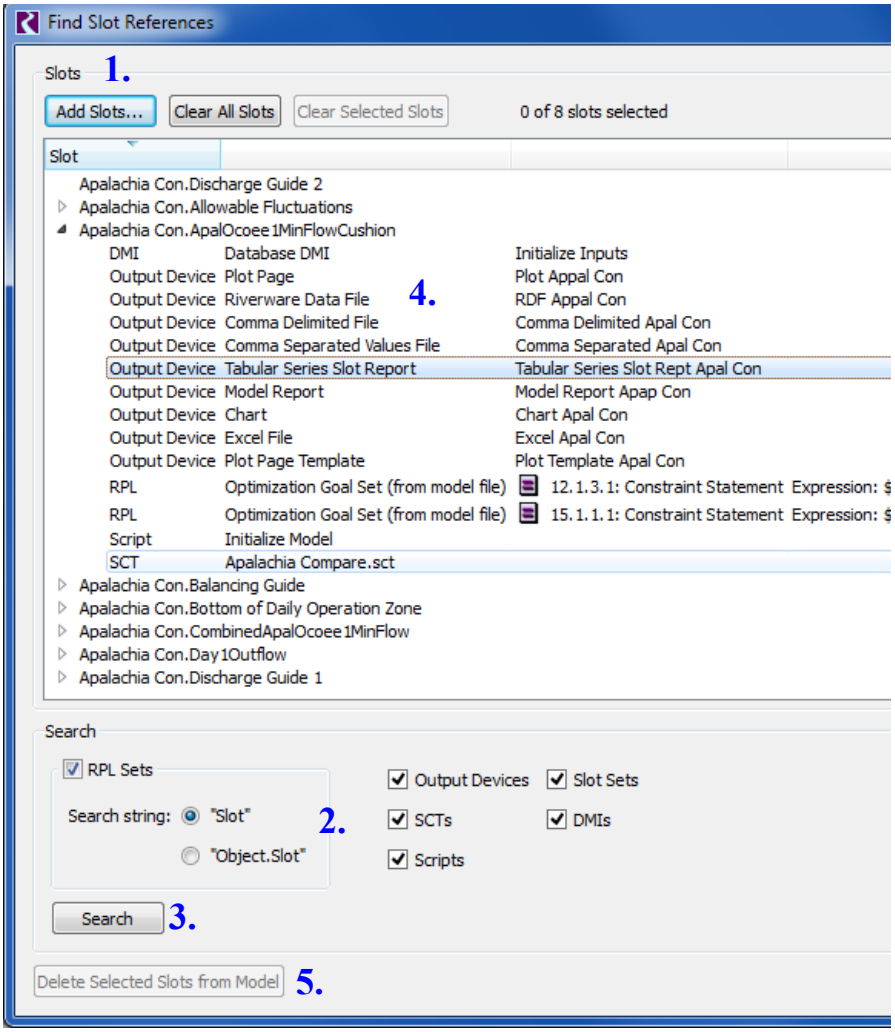
RiverWare models are often built by multiple modelers over many years. Sometimes, slots are created for a particular task. When the task is over, the slot is set aside and may never be used again, but no-one wants to delete the slot for fear that it is accessed somewhere else. In addition, you may want to know where a slot on a simulation object is used. Are there any plots or output devices for Reservoir.Outflow? Is it imported or exported by any DMIs? There are many places in RiverWare where a slot can be referenced. Finding these references for a particular slot would be a very tedious and time consuming task. For this reason, a utility was created to centralize and streamline this search process. This section describes this utility which searches through a model to find references to specified slots.

The utility then lists where the slot is referenced and you can investigate the matches. If you determine that the slots are obsolete or no longer necessary, you can delete the slots (custom slots) directly from this utility.

The **Find Slot References** dialog is available from the **Workspace ➥ Slots** menu.



The general work flow of the dialog is to add slots to the list (1), select the areas to search (2), and initiate the search for references to the chosen slots (3). Found references are listed as sub-items under the slot (4). Double click an item to open that reference. Slots no longer needed can be selected and deleted from the model using the **Delete Selected Slots from Model** button (5).



The following sections describe these steps and configuration options in more detail:

7.1 Slots

The **Slots** frame is where you select the slots for which to look for references.

- The **Add Slots** button opens the slot selector to choose slots to add to the list.
- The **Clear All Slots button** removes all slots from the slot list.
- The **Clear Selected Slots** button removes only the selected slots from the list.

7.2 Search

Check the areas where you would like to search for references to your slots and click the **Search** button to initiate the search. Search results are listed as sub-items under each slot. Sorting the search results by clicking on the row header will group together slots with results versus slots without results. Following is a description of the areas to search:

- **RPL Sets -** Search through the following RPL expressions/sets open in the RiverWare session:
  - Expression Slots (i.e. the RPL expressions shown on the open slot dialog)
  - Expression Slot Functions Set
  - Global Functions Sets

- Initialization Rules Set
- Iterative MRM Rules Set
- Object Level Accounting Method Set
- Optimization Goal Sets
- Rulebased Simulation Rulesets

The two radio buttons allow for the search string to be the "Slot" name or the complete "Object.Slot" name. Any occurrences of the specified string in RPL will be located, so may identify places that are not actually references to the slot. For example, if you have BigRes.Inflow in the slot list, the following will occur:

- "Slot": Any occurrence of the string "Inflow" will be found including references to the Inflow on each reservoir, reach, control point, etc in the model. But, this setting is useful to search RPL logic where the slot names are created during RPL evaluation. For example a FOR loop that is looping over reservoirs and creating the slot using the expression: Res."Inflow".
- "Object.Slot": Only occurrences of the slot/string "BigRes.Inflow" will be found. The search is a basic text search, so the utility will find references to BigRes.Inflow and BigRes.Inflow Sum.

Double-clicking a RPL result item will open the associated RPL set dialog so you can examine the reference.

- **Output Devices** - Search through output devices to see if the specified slots are referenced in the configuration of the device. An output device result line gives the type of the device and the device's name. Double-clicking the line will open the configuration dialog for the device.
- **SCTs** - Search open SCTs to find specified slots in the configuration of the SCT. An SCT result line gives the name of the SCT and double-clicking the line brings up the associated SCT dialog. Note that a slot may be used in the configuration of a custom summary row for the SCT that might not be visible under the current SCT view orientation.
- **Scripts** - Search scripts in the model to find references to the specified slots in script actions. A script result line gives the name of the script and double-clicking the line opens the script editor dialog.
- **Slot Sets** - Search for references to the specified slots in Slot Sets. A result line gives the name of the Slot Set. Double-click the line to open the Slot Set Manager.
- **DMIs** - Search DMIs in the model to find if the specified slots are imported or exported with the DMI. A DMI result line gives the type of the DMI and its name. Searching control file-executable and trace directory type DMIs requires parsing the associated control file. If there is a problem during this DMI validation, error messages will be posted in the diagnostic window. Double-clicking a DMI result line will open the DMI's edit dialog.

7.3 Deleting Slots

If you search for references to one or more slots and find that they are no longer needed, you can use the **Delete Selected Slots From Model** button at the bottom of the dialog to permanently delete them from

the model. This is only allowed for custom slots. If the slot is a simulation slot, these are not deleted; a warning message is issued indicating the number of slots not deleted.

Slot Sets

8. Slot Sets

Many utilities in RiverWare require you to specify a set of slots, e.g., as part of the configuration of DSS datasets, scripts, and output devices. You can either specify the slots in the configuration of each utility or you can create and name a collection of slots in the Slot Set Manager and refer to that set in one or more utilities.

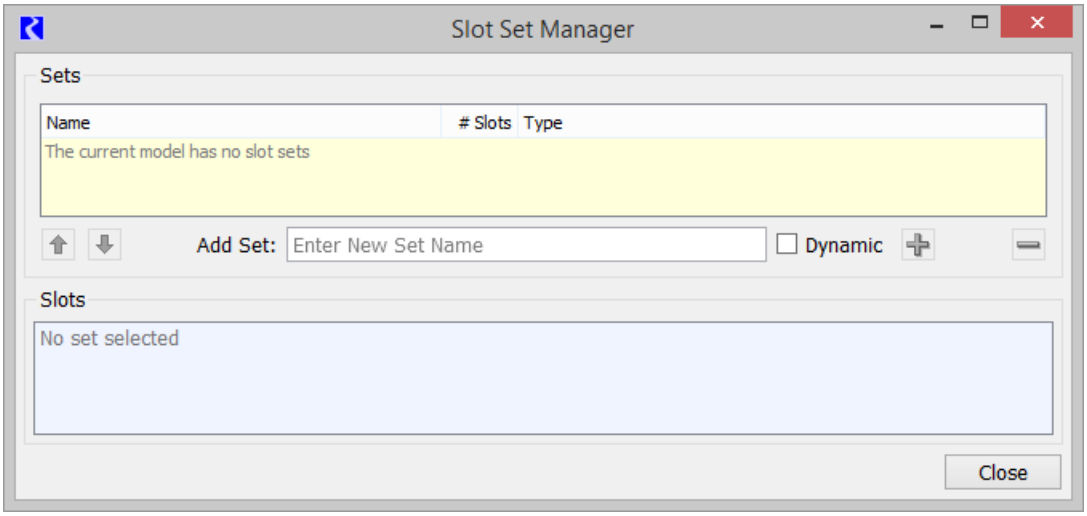
A Slot Set is a named collection of slots. Slot sets support wildcarding and can be referenced in contexts that require a user-specified set of slots, such as Script actions, DMI datasets, and Output Devices. Where the same set of slots is used in multiple contexts within the same model, the use of named slot sets eliminate duplication of input effort and ensures consistency across the multiple uses. Within RPL, Slot Sets provide a re-usable collection of slots that can be referenced by a RPL predefined function.

8.1 Managing Slot Sets

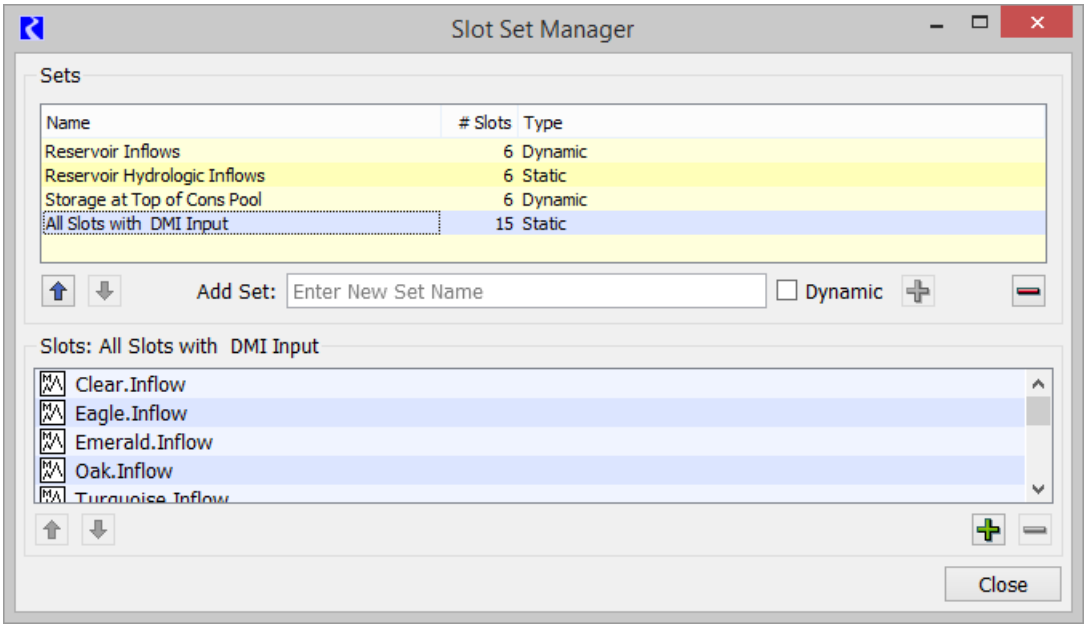
Slot sets are created, deleted and organized in the Slot Set Manager.

8.1.1 Accessing the Slot Set Manager

To open the Slot Set Manager, use the **Workspace ➥ Slots ➥ Slot Set Management...** menu. The following dialog opens:



The upper portion (the Sets panel) shows the sets defined in the model; if one of these slots is selected, the lower portion (the Slots panel) lists the slots in the selected set. A screenshot of the manager dialog for a model with multiple sets is shown below:



The selected set in the Sets panel is highlighted in blue, and its slots are shown in the Slots panel. In addition to the slot set name, the Sets panel shows the number of slots in each set and whether the set is Dynamic or Static.

To re-arrange the order of the sets, use the arrow buttons to move the selected row up or down. To create a new Set, enter a name in the Add Set field, choose whether it is Dynamic (or conversely Static) and then click the green plus button. A slot selector will open allowing you to define the slots in the set.

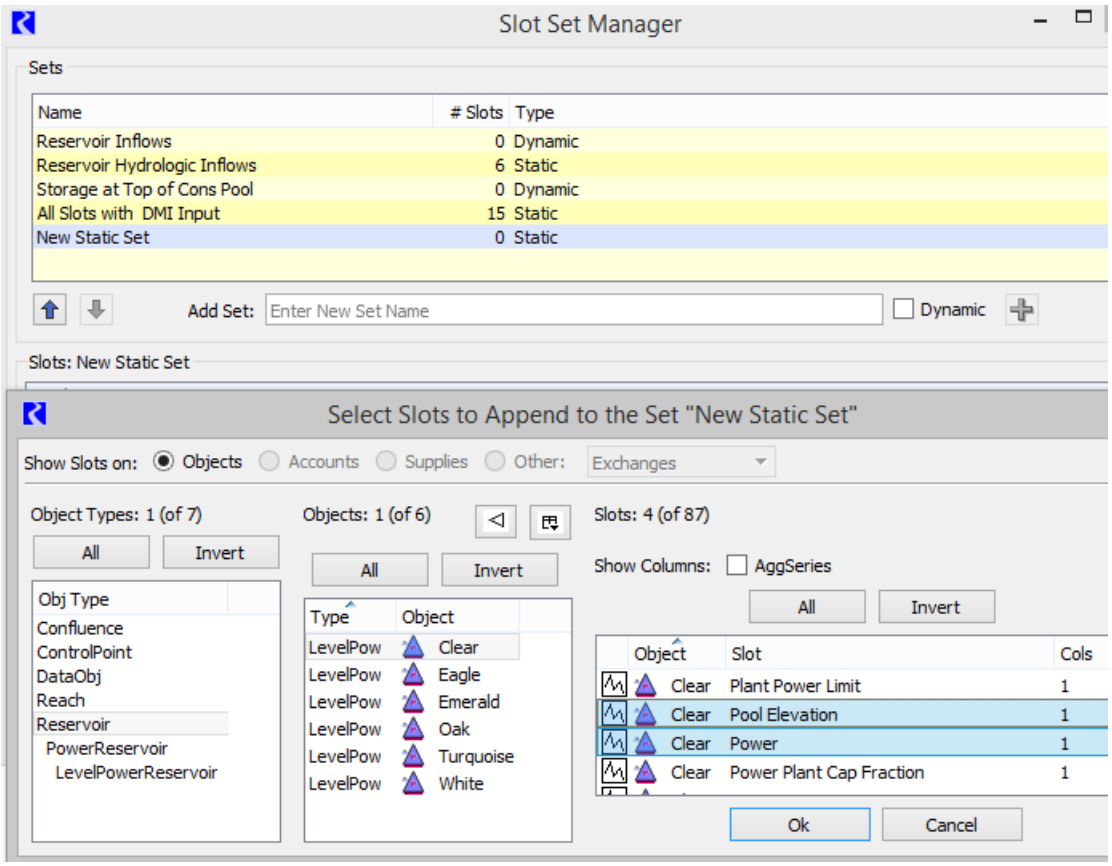
Note: Choosing whether a set is dynamic or static must be done at the time the set is created. It influences how the slot selection is made. The type of set cannot be changed later; although you can delete and re-create it.

The two types of sets are:

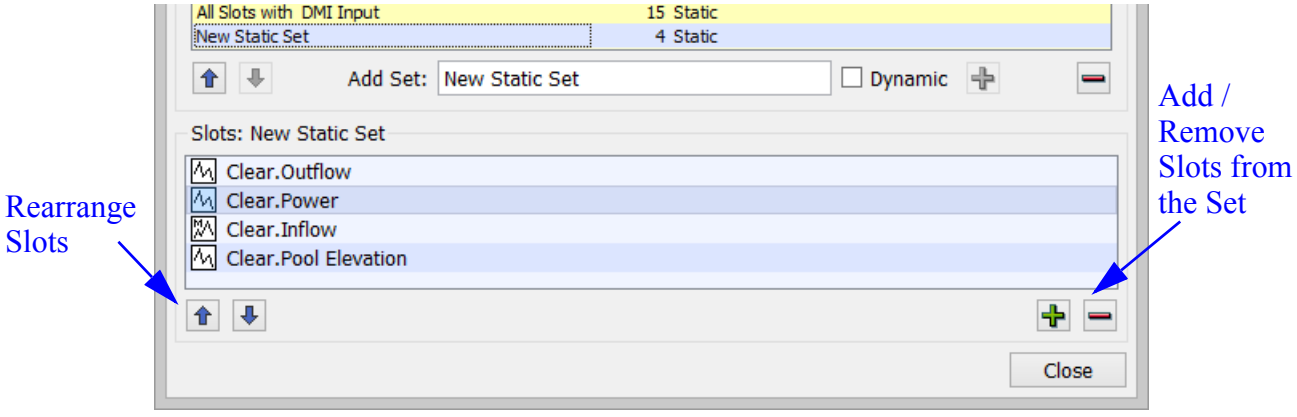
- **Static** Slot Sets contain an ordered list of slots that will not change automatically. You can add and remove slots from the set manually, as well as rearrange their order, but the set will not be updated if slots are added to the model. These are described **HERE (Section 8.1.2)**
- **Dynamic** Slot Sets contain a symbolically specified slot selection. With this type of set, if you add an object/slot to the model that meets the set definition, it will automatically be added to the set. These are described **HERE (Section 8.1.3)**.

8.1.2 Static Sets

Static Slot Sets contain a list of slots that will not change automatically. The contents and order of slots in a static set are specified when the set is created and only change when the slot set is edited.



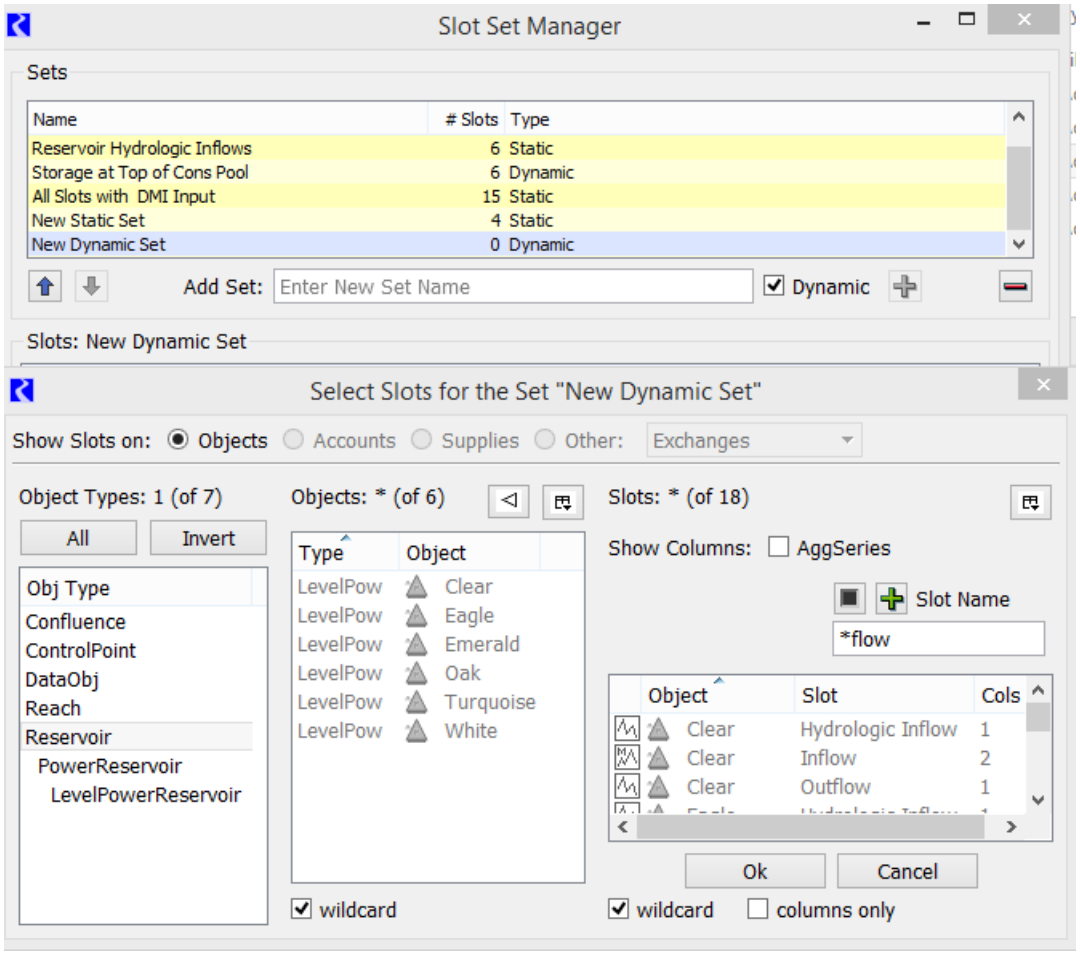
The resulting Static set looks like:



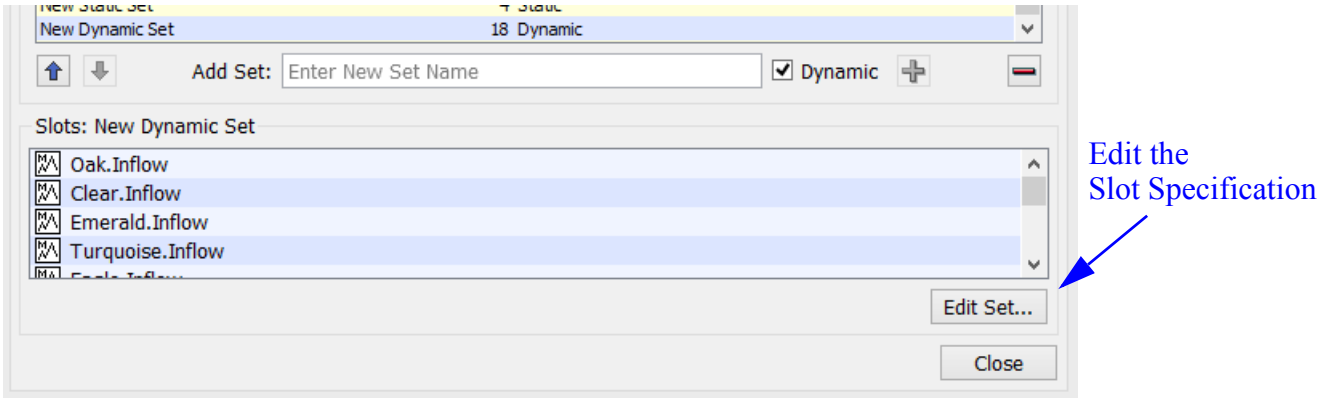
Notice the buttons to rearrange the slots and add or remove slots from the set.

8.1.3 Dynamic Sets

Dynamic Slot Sets contain a symbolically specified slot selection. The contents and order of the slots in a dynamic slot set are determined when the set is used, by evaluating the set specification. The set specification may include wildcards and filters, which could lead to different results for different evaluations.



The resulting set looks like the following:



Notice that there are no buttons to re-arrange the slots as the order in a dynamic set is indeterminate. Also notice that you cannot add or remove slots, but instead you can **Edit Set...** to modify the selection.

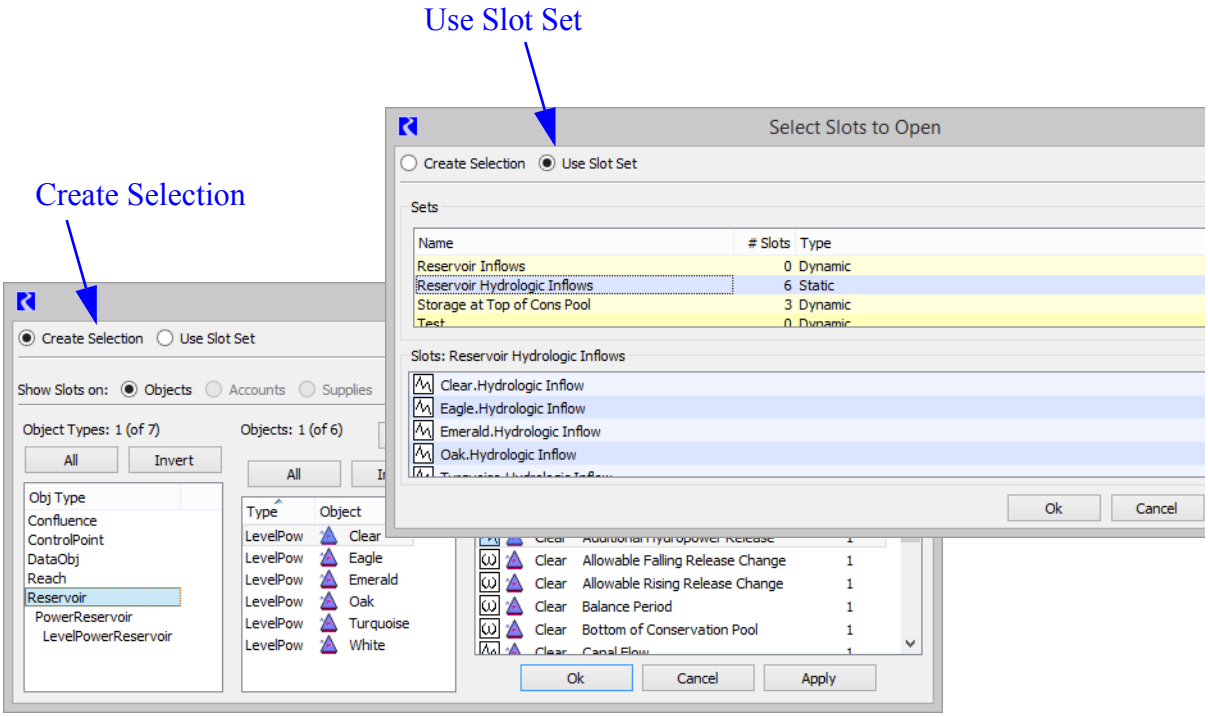
8.2 Referencing Slot Sets

The power of Slot Sets is realized when you refer to a Slot Set from various applications. Examples include Scripts setting one or more slots, DMI slot selections, and RPL accessing lists.

This section describes how to reference sets in the Selector and from RPL and DMIs.

8.2.1 Using Slot Sets when Selecting Slots

Slot sets can be referenced in most places that a Slot Selection is made. To refer to a Slot Set, in the Selector, choose **Use Slot Set** instead of **Create Selection**. Both views are shown below:



Within the **Use Slot Set** view, select the desired Slot Set. The slots in that set are shown in the lower, non-editable panel. Click **Ok** to confirm.

More information on using Slot Sets can be found **HERE (Selector.pdf, Section 3.2)**.

> **Note:** When the application only needs one slot (like adding a curve to a plot), the first slot in the Slot Set is used.

8.2.2 Using Slot Sets in RPL and DMIs

Slot Sets can be referenced from RPL logic using the `ListSlotSet` predefined function described **HERE (RPLPredefinedFunctions.pdf, Section 110)**. This function returns a list where each item is a slot in the set.

Within Database DMIs, Slot Sets can be referenced within the Slot Selection as described above. Within Control-File Executable and Trace Directory DMIs, Slot sets can be referenced using the key word SlotSet and the set name. Thus, the slot specification of a control file entry is:

```
SlotSet.<slot set name>
```

For example, `SlotSet.Reservoir Hydrologic Inflow: file=~/%o.%s` would expand to all of the slots in the Reservoir Hydrologic Inflow set.

For more information, click **HERE (DMI.pdf, Section 3.2.1)**.