Mass Balance Summary Slots in RiverWare 6.2 Version 1

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This document describes a new capability in RiverWare to support checking mass balance across many objects.

0.1 Document Status

02-10-2012: Initial Writing. 02-13-2012: Minor Edits.

0.2 Related Documents

Mass Balance Summary Tool David Neumann, Edie Zagona / 2 pages, 11-14-2011 R:\doc\MassBalanceTool\MassBalanceTool_Rqmts.2011.11.14.fm

Mass Balance Summaries in RiverWare 6.2 -- Initial Design Phil Weinstein, David Neumann, Edie Zagona / 18 pages, 12-30-2011 R:\doc\MassBalanceTool\MassBalSumDesign.fm

0.3 Contents

1.0	Overview
2.0 2.1 2.2	Mass Balance Summary Slot Construction3Creating a Mass Balance Summary Slot3Configuring a Mass Balance Summary Slot4
3.0	Mass Balance Summary Internal Display Operations
4.0 4.1 4.2 4.3 4.4 4.5	Mass Balance Summary External Display Operations11Show Computed Slots in an Open Slot Dialog11Show Slots in an SCT12Plot Slots13Copy Slots13Examining the Mass Balance Summary Slot's Series14
5.0	Dependent RPL Expression Slot Support 15
6.0	Mass Balance Summary Computation
7.0	Persistence

1.0 Overview

The Mass Balance Summary slot is a new type of slot which can be created by the user on a RiverWare data object. It consists of a user-defined hierarchy of series slot collections used to check mass balance across many objects in a RiverWare model. The series slot collections are themselves series slots representing the sum of the contained slots, and can be used within RPL expressions, and pretty much any other place where series slots are used.

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

- Water Balance -- the sum of one or more "Slot Sums".
- Slot Sum -- the sum of one or more references to series slots in the RiverWare model -- applied in either the positive or negative sense. "Negative" Slot Sums are subtracted from -- rather than added to -- their containing Water Balance. Only flow or volume (unit type) series slots having the model run timestep size can be included in a Slot Sum. References to RPL expression slots are supported for entities not represented by existing RiverWare slots.

New slot type icons represent: (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 the user) and 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. These "dependent expression slots" can be used, for example, for annualization of mass balance summary results.

In the Open Slot Dialog for Mass Balance Summary Slots, colors are associated with the three levels of slot collections and references.

Collection Level		Backgrond Color	
1 Water Balance		ce 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. 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.

Computed and referenced slots can be shown in any flow or volume units.

Mass Balance Summary: MassBalObj.CentralToIslet	а		
File Edit View			
MassBalObj 🛃 CentralToIsleta	Re	ecomput	te
2 Water Balances 12 Slot Sums 35 Slots			
Timestep: Apr 29, 1992 🔹 Flow Cfs	• 🗠		
Slot Groups	Value	Units	
□ A River SW Budget	-0.000	cfs	
🛱 🕂 Reach Inflow	5167.665	cfs	
🔄 📫 🧌 Central.Gage Outflow	5167.665	cfs	
🕀 🕂 SWreturns	153.792	cfs	
🛱 📥 RiverSeepage	184.855	cfs	
CentralToIsletaSeepageArea2.Seepage	99.082	cfs	
CentralToIsletaSeepageArea1.Seepage	85.773	cfs	
🕀 🕂 SW Inflow	78.600	cfs	
🕀 📥 Reach Outflow	5215.203	cfs	
🕀 🚍 OpenWaterEvap	0.000	cfs	
🗈 🕅 GW Budget	0.000	cfs	-
New Delete Expression Slots (11)			

2.0 Mass Balance Summary Slot Construction

2.1 Creating a Mass Balance Summary Slot

A Mass Balance Summary Slot can be created on any Data Object. This is done in the Open Object Dialog's Slot menu by selecting the "Add Mass Balance Summary" operation. This creates a new default-named Mass Balance Summary slot.

Double clicking on a Mass Balance Summary Slot item in the slot list shows the Open Slot dialog for that slot.

The name of a Mass Balance Slot can be edited in it's Open Slot dialog; *see below*. The name of the slot must be unique among all slots on the containing data object. When the typed name is not valid, the text in the name entry field is shown in red.

【 Open Object ·	- MassBalObj	_ 🗆 🗵
File Edit View	Slot Account	
Object	Add Series Slot	
	Add Series Slot with Expression	
• •	Add Integer Indexed Series Slot	
Slots Descrip	Add AggSeries Slot	
April 1, 1992	Add Integer Indexed AggSeries Slot	1 🕹
Slot Name	Add Table Slot	
++ BernardoToS	Add Statistical Table Slot	
+ CentralToIs	Add Periodic Slot, Text Headers	
CochitiToSar	Add Periodic Slot, Numeric Headers	
IsletaToBern	😡 Add Scalar Slot	
+ SanAcaciaTo	Add Scalar Slot with Expression	
High SanFelipelo	🛃 Add Mass Balance Summary	
M Change in S	Delete Slot	
M Change in S	Copy Slot	
- Change in S	Paste Slot	
Change in St	Open Slat Ctrl I O	<u>m</u>
M Change in S	Plot Slot Ctrl+D	
M Bernardo Ga Ma SanMarcialEl		
Central Gage	SCT	
		00 0.000

2.2 Configuring a Mass Balance Summary Slot

Editing the configuration of a Mass Balance Summary Slot can be enabled (editable) or disabled (locked). It is initially enabled on a newly created slot. Editing is 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 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 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 of one of these items can be edited "inline" by doubleclicking on the name.

Mass Balance Summary: Mass Bal.Balance Calc One _ [] X File Edit View
Mass Bal 🛃 Balance Calc One Recompute
0 Water Balances 0 Slot Sums 0 Slots
Timestep: Dec 31, 2004 📰 Flow cfs 💽 🔛
Slot Groups Value Units
✓ Enable editing
Add Water Balance
New Delete Delete Set: Set:
Dependent expression slots (U)

🔀 Mass Balance Summary: Mass Bal.Balance Calc One 📃 🔲 🗙
File Edit View
Mass Bal 🛃 Balance Calc One Recompute
1 Water Balances 0 Slot Sums 0 Slots
Timestep: Dec 31, 2004 👘 Flow Cfs 💌 🚉
Slot Groups Value Units
🛄 🕅 Water Balance
Slot Groups Value Units
Upper Basin Balance
-
Slot Groups Value Units
Upper Basin Balance

🔀 Mass Balance Summary: Mass Bal.Balance Calc One 💶 🗵
File Edit View
Mass Bal 🛃 Balance Calc One Recompute
1 Water Balances 0 Slot Sums 0 Slots
Timestep: Dec 31, 2004 👘 Flow cfs 💌 🔛
Slot Groups Value Units
Upper Basin Balance
Copy Balance
Cut Balance
Paste Slot Sums
🕂 Set Sums Positive
👄 Set Sums Negative
Enable editing
💽 New Delete 🗈 🛍 😭 送 Set: 🕂 🗕
Dependent Expression Slots (0)

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 "New" context button (below the slot list).

When adding slot references to a Slot Sum, the slot selector dialog is shown. This supports selection of only series slots, including aggregate series slot columns. The slot selector's unit type filter will be shown and initialized to "Flow".

It is also valid to change the filter to "Volume" to select slots which represent a non-static volume entity -- i.e. volume slots which can be converted to "Flow" by dividing the volume timestep 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).

Including a particular series slot within a Slot Sum multiple times is allowed -- this will result in the values of that slots being added to the Slot Sum's values multiple times.

Mass Balance Summary: File Edit View	Mass Bal.Balance Calc One 💶 🗙
Mass Bal 🛃 Balance	Calc One Recompute
1 Water Balances 1 S	lot Sums 0 Slots
Timestep: Dec 31, 2004	Flow cfs
Slot Groups	Value Units
Upper Basin Balance	
	Add Slots
	Copy Slot Sum
	Cut Slot Sum
	Paste Slots
	🕂 Set Sums Positive
	🛥 Set Sums Negative
	✓ Enable editing
Add Delete	🗎 🛅 🕔 Set: 🕂 💻
Dependent Expression Slo	ots (0)

Mass Balance Summary: Mass Bal.Balance Calc One
Image: Control of the second seco
Slot Groups Value Units Image: Construct of the state
New Delete Delete Set: Dependent Expression Slots (0)

Mass Balance Summary Slots and Computed Mass Balance Slots (Water Balances and Slot Sums) cannot be included in a Slot Sum.

The user will need to define and refer to a RPL expression slot for any flow entity not provided as a RiverWare slot. Here is an example of the inclusion of a "change in storage" entity of a set of static storage values.

Mass Balance Summa File Edit View	ry: MassBalObj.I	3ernardoToSanAcacia			_	
MassBalObj 🛃 Be	ernardoToSanAcaci	a		R	ecompu	te
3 Water Balances 22 Timestep: Apr 26, 1992	Slot Sums	39 Slots ⊥				
Slot Groups				Value	Units	
River SW Budget				0.000	cfs	
🕞 🥂 GW Budget	GW			-18 464	cfs	
- 🔛 🎊 Berna	rdoToSanAcaciaGV	/Area1West.Inflow from S	Surface Water	2.698	cfs	
- 🔤 🏧 Berna	rdoToSanAcaciaGV	/Area1River.Inflow from S	urface Water	-25.878	cfs	
Berna	rdoToSanAcaciaGV	/Area1East.Inflow from So	urface Water	4.715	cfs	
GW Flow Out	-T			-0.184	cfs	
🕀 📟 Perc To Deep	Aquifer			-46.793	cfs	
🖻 🕂 Change in Sto	orage			-15.597	cfs	
🔚 🦾 🛄 MassE	BalObj.Change in S	torage BernardoToSanAca	cia GW	-15.597	cfs	
E WettedS	MassBalObj.Cha	nge in Storage Bernar	doToSanAca	cia GW		<u>- 🗆 ×</u>
Canal Budget	e Edit View Ex	pression Adjust				
🕀 🕂 TotalDive	Mi Ch	ange in Storage Bernardo	ToSanAcacia G	N		
Total AgL	Value	-15 5071841646				
🕀 💳 CanalOut	unition Times	-15.55710-10-10				cia
E SWreturr	aluation Panger	un start to run finish (Ste	n: 1 DAY)			
	lumeToFlow / Bern	ardoToSanAcaciaGWArea	1East.Storage	[@"t - 1"]	1	
	- Bei	nardoToSanAcaciaGWAre	a 1East.Storage	[@"t"]		
	+ (BernardoToSanAcaciaGWA	Area 1River. Stor	age [@"t	- 1"])	
		- BernardoToSanAcaciaGW	/Area1River.Sto	orage [@"	ť]/	
	+(BernardoToSanAcaciaGWA	Area 1West.Stor	rage [@"t araaa [@"	-1"J)	1
	(@"t'	·	Area Iwest.St	orage [@	(])	
	10.1					· 🔻
A New Del Sh	iow: 🔽 Comment	ts				
	Scroll: Apr 26, 19	992			-	≣ 1⊻
Dependent Expre						
		cts				
	4-24-1992 Fri	-3,30 0				
		Y/////////////////////////////////////				_
Sł	now: 🗌 Descripti	on				

As mentioned above, the buttons along the bottom of the Open Mass Balance Summary Slot dialog are context sensitive -- their operation and enabledness depend on the selection within the slot list. 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
New Delete	None	Create new Water Balance
New Delete 🗈 🛍 Water Balance		Create New Slot Sum; Delete / Copy Water Balance
Add Delete 🗈 🛍	Slot Sum	Add Slot Reference; Delete / Copy Slot Sum
Add Remove	Slot Reference	Add Slot Reference; Remove / Copy Slot Reference

The "New / Add" and "Paste" operations are enabled only for singleitem 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. The user 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 "Set" (Plus) and (Minus) 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.

The only context button which is enabled when editing is disabled (locked) is the "copy" button.



Different context menus are displayed within the slot list, depending on whether editing is enabled or disabled.

The configuration of dependent RPL Expression slots is described in a subsequent section.



3.0 Mass Balance Summary Internal Display Operations

Similar to the Open Object dialog box, the Open Mass Balance Summary Slot dialog shows a single series value -- at one timestep -- of all contained series slots. The timestep date/time is set by the Date/Time spinner.

> Note: All Water Balances, Slot Sums and Series Slot references have the same timestep size -- that of the model run. Water Balances and Slot Sums are computed for the model run interval.

As currently implemented, a global time scroll cannot be initiated from this dialog, but a global time scroll performed elsewhere will set the date/time of this dialog.

The Open Mass Balance Summary Slot dialog does not support editing of any series values. Of course, all computed sum values are "read only".

Series values can be displayed in any Flow or Volume units in this dialog. (Volume values are converted to flows by dividing by the timestep interval, which can be specific to the particular timestep date/time in the case of monthly and annual series). The available Flow and Volume units are determined by the external RiverWare "units" file.

The individual settings for Flow and for Volume units are separately retained. That is, clicking the Flow and Volume toggle button switches between the most recently selected unit for of those two unit types.

The selected unit type and unit is both a display setting and a configuration setting: when the mass balance summary is computed, the computed slots are reconfigured with these units. This works except when the computed results (Water Balances and Slot Sums) are referred to from RPL expressions which require these





slots to have one particular unit type. This is an issue for any such RPL expressions -- including, but not limited to those in the Dependent Expression Slot list associated with a mass balance summary. Unit type incompatibilities will be reported by the RPL expression evaluation mechanism in the usual way.

As previously mentioned, the colored level 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.

The "Adjust Width" operation fits the slot list's column widths and the overall dialog width. This adjustment is automatic for certain dialog operations, but not all (e.g. not when opening and closing individual tree items).

In general, the units column in the slot list can be hidden. But, in the usual circumstance that slots having different unit types (other than flow and volume)

【 Mass I	Balance Summary: Mass Bal.Balance Calc
File Edit	View
III Ma	Adjust Width
1 Wate	Show Column: Units
	Show Series Values in Water Balances
Timestep	Show Series Values in Slot Groups
Slot Gro	Show Series Values in Slots

somehow show up in the list, units are unconditionally shown and the option to hide the units column is disabled.

Use of the three "Show Series Values" toggles is illustrated on the following page.

Especially when items from all three levels are displayed, the user may want to hide values at any of those levels, so that only comparable values (at the same level) are displayed:

Mass Balance Summary: MassBalObj.BernardoToSanAcacia		
File Edit View		
Mas Adjust Width	Recompute	Recompute
3 Water Show Column: Units		
Show Series Values in Water Balances		
Timestep: Values in Slot Groups		
Slot Group	Value Units 🔶	Value Units
E A River SW Budget	0.000 cfs	0.000 cfs
白 协 GW Budget	0.000 cfs	0.000 cfs
🗇 🕂 SW inflow to GW	-18.464 cfs	-18.464 cfs
BernardoToSanAcaciaGWArea 1West. Inflow from Surface Water	2.698 cfs	ace Water
BernardoToSanAcaciaGWArea 1River.Inflow from Surface Water	-25.878 cfs	ace Water
BernardoToSanAcaciaGWArea 1East.Inflow from Surface Water	4.715 cfs	ice Water
🗇 🕂 GW Flow Out	-0.184 cfs	-0.184 cfs
🔤 🕅 BernardoToSanAcaciaGWArea 1West. Groundwater Flow Downstream	-0.073 cfs	w Downstream
🔤 🚧 BernardoToSanAcaciaGWArea 1River. Groundwater Flow Downstream	-0.054 cfs	w Downstream
🔤 🚧 BernardoToSanAcaciaGWArea 1East. Groundwater Flow Downstream	-0.057 cfs	v Downstream
🗇 🚍 TotalRiparianET	12.993 cfs	12.993 cfs
Marca Carla C	5.122 cfs	
🔤 📶 BernardoToSanAcaciaGWArea 1River.ET Volume	6.080 cfs	
🔤 📉 🔤 🕅 BernardoToSanAcaciaGWArea 1East.ET Volume	1.791 cfs	
🕀 🛥 Perc To Deep Aquifer	-46.793 cfs	-46.793 cfs
🔤 📶 BernardoToSanAcaciaGWArea 1West.Percolation	-15.388 cfs	
🔤 📶 BernardoToSanAcaciaGWArea 1River.Percolation	-20.241 cfs	
🔤 📶 BernardoToSanAcaciaGWArea 1East.Percolation	-11.164 cfs	
🖨 🕂 Change in Storage	-15.597 cfs	-15.597 cfs
🔚 🔚 🕅 MassBalObj. Change in Storage BernardoToSanAcacia GW	-15.597 cfs	GW
🖨 🕂 🕂 GW_Flow In	0.445 cfs	0.445 cfs
🔤 🧑 BernardoToSanAcaciaGWArea 1West.Groundwater Flow Upstream	0.312 cfs	w Upstream
🔤 📶 BernardoToSanAcaciaGWArea 1River. Groundwater Flow Upstream	0.090 cfs	w Upstream
🛄 📶 BernardoToSanAcaciaGWArea 1East.Groundwater Flow Upstream	0.043 cfs	v Upstream
🖻 🕂 WettedSandEvap	0.000 cfs	0.000 cfs
🔄 🔄 🔄 🕅 BernardoToSanAcaciaGWArea 1River.Evaporation	0.000 cfs	
由 🖄 Canal Budget	0.000 cfs	0.000 cfs
	V	v
🔒 New Delete 🖹 😭 🕼 Set: 🕂 🗕		
Dependent Expression Slots (11)		

4.0 Mass Balance Summary External Display Operations

From the Open Mass Balance Summary Slot dialog, the user can:

- Show selected slots in their Open Slot Dialogs
- Show slots -- either "visible" (in the tree), or "selected" -- in a new SCT or in the single open SCT.
- Plot the selected slots.
- Copy selected slots, e.g. to an Output Device or to the Snapshot Manager.

4.1 Show Computed Slots in an Open Slot Dialog

As currently implemented, Water Balances are generated as Agg-SeriesSlots with the Water Balance's Slot Sums generated as series slot *columns* on that AggSeriesSlot. In the "editing-disabled" version of the context menu, the "Open Slots …" item shows the Open Agg-SeriesSlot Dialog for the selected computed items -- and the appropriate Open Slot dialog for any of the selected referenced series slots. When operating "Open Slots …" on a selected Slot Sum, the Open Slot



dialog for the containing Water Balance (AggSeriesSlot) is shown, and the column corresponding to the selected Slot Sum is selected. Before opening more than five (5) Open Slot dialogs, the operation is confirmed with the user.

🔾 MassBalObj.Ber	nardoToSan/	Acacia_GW Budg	et						<u>」></u>
File Edit View Tin	neStep I/O A	djust							
Value:	nardoToSanAc	acia_GW Budget 287827145542							cfs
Scroll: Apr 26, 19	992								₩
	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	0,00 0	0.00 0	0.00 0	0,00 0	0.00 0	0.00 0	0.00 0	
01-01-1990 Mon	-0.00 0	1,000.00 O	-0.18 O	0.00 0	-140.47 0	-1,140.77 0	0.47 0	0.00 0	
01-02-1990 Tue	-0.00 0	-777.08 0	-0,18 0	0.00 0	-111.30 O	665.50 O	0.46 0	0.00 0	
01-03-1990 Wed	-0.00 0	-216,14 0	-0.18 0	0.00 0	-126.03 O	89.82 O	0.47 0	0.00 0	(
01-04-1990 Thu	0.00 0	-75.42 0	-0.18 0	0.00 0	-128.43 O	-53.30 O	0.47 0	0.00 0	r,
01-05-1990 Fri	0.00 0	-17.57 0	-0.18 0	0.00 0	-127.76 0	-110,48 0	0,47 0	0.00 0	2
01-06-1990 Sat	-0.00 0	-51.22 0	-0.18 0	0.00 0	-125.86 O	-74.93 0	0.47 0	0.00 0	0
01-07-1990 Sun	-0.00 0	-49.09 O	-0,18 0	0.00 0	-124.71 0	-75.91 0	0.46 0	0.00 0	
01-08-1990 Mon	0.00 0	-65.23 0	-0.18 0	0.00 0	-123.52 O	-58.57 0	0.46 O	0.00 0	
Show: Descripti MassBalObj.Bernard 4018 values: Sum 0	on loToSanAcacia <u>.</u>).00 Ave 0.0	_GW Budget 0 Min -0.00 M	ax 0.00 Range	e 0.00 [cfs]					

Note that 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. 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 approximately zero.

4.2 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. In the latter case, this will work as desired only if that single open SCT has the same timestep size as the model run.

The operations to show slots in an SCT are available in the dialog's "File" menu and in the non-editable (locked) context menu.

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



C S	T Mass Bal.Balance Calc One (RunAndView.mdl.gz)							L
File	Edit Slots Aggregation View Config DMI Run D	agnostics	Go To					
₽	🔽 🎫 🔳 🖉 🖌 🔛 🖉 💷	$\square \square$	🛱 o 1	I T B	M D F	-1.2500	000000	>>
Se	ries Slots Edit Series Slot List Scalar Slots Other	Slots	Object Grid					
	Slot Label	Units	12/31/04 Fri	1/1/05 Sat	1/2/05 Sun	1/3/05 Mon	1/4/05 Tue	1/5 We
Γ <i>þ</i>	Mass Bal.Balance Calc One_Upper Basin Balance	cfs	0.00 0	-1,25 0	-1,25 0	-1,25 0	-1,25 0	
	Mass Bal.Balance Calc One_Upper Basin Balance.Inflows	cfs	0.00 0	154,26 O	168,56 O	180,22 O	153,62 0	<u>_1</u>
	NymphChacoConfluence.Inflow1	cfs	NaN O	147.24 O	160.32 O	170.96 O	145.44 0	17
Цβ	NymphChacoConfluence.Inflow2	cfs	NaN O	7.02 O	8.24 O	9.26 O	8.18 O	
1	Mass Bal.Balance Calc One_Upper Basin Balance.Outflows	cfs	0.00 0	155.51 O	169.81 O	181.47 O	154.87 0	18
	UpperWideCanyon.Diversion	cfs	NaN O	5.00 O	5.00 O	5.00 O	5.00 O	
	UpperWideCanyon.Outflow	cfs	NaN O	150.51 O	164.81 O	176.47 O	149.87 O	17
			•				Þ	
Mass 365	Bal.Balance Calc One_Upper Basin Balance.Balance Volur values: Sum -1,673.75 Ave -4.59 Min -7.50 Max 0.0(ne: -144.() Range	51200000 [1,0 2 7.50 [cfs]	00,000 ft3]				
1								- //_

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 series values are directly editable).

4.3 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 that the current RiverWare plot device isn't particularly smart in dealing with units. Only slots having two of the unit types *and units* represented in the set of slots being plotted actually show up. Those two units are assigned to the left and right axis, but no attempt is made to line up the vertical values of those axis even if they are of the same unit type! (And certainly no attempt is made in the Plot device to align flow values with volume values).

The accompanying image does not demonstrate the limitations and problems described above.



Note also that all values are plotted

in their positive (actual) sense -- values in negated Slot Sums are not shown as negated values. (Actually, this is currently true of all Slot Sum value displays -- even in the Open Mass Balance Summary Slot dialog).

4.4 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.

4.5 Examining the Mass Balance Summary Slot's Series

The Mass Balance Summary Slot is itself a series slot (contained on a data object). In general, each of the Mass Balance Summary Slot's top level items -- Water Balances -- are expected to "zero." So should their sum; the Mass Balance Summary Slot's series is that sum. This may not be fundamental to any given application of the mass balance summary capability, but it is available.

The Mass Balance Summary Slot's series 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.

In both of the "open slot" dialogs illustrated above, the data object icon is a button which shows the Open Object dialog for the containing data object.

5.0 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 within custom user calculations implemented in RPL Expression Slots. The initial application of Mass Balance Summaries implements annualization of summation series with this capability.

In fact, a mass balance calculation involving 560 physical slots implemented by the URGWOM team using only RPL served as a prototype for this built-in Riverware capability. This included an additional dozen RPL Expression slots to annualize the computed daily timestep sums. Given the iterative re-evaluation mechanism within RPL, the RPL implementation was able to guarantee that the dependent annualization RPL Expression slots were recomputed when any RPL Expression slots on which they depended were recomputed.

Re-implementing the basic mass balance computations in C++ effectively breaks this guaranteed correct reevaluation of dependent RPL Expression Slots. To address the loss of this behavior, special support for a "Dependent Expression Slot List" was added to Mass Balance Summaries.

The "Dependent Expression Slot List" in a Mass Balance Summary is evaluated, in order, once through, each time a 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 depend on sums from *multiple* (distinct) mass balance summaries. (This is true of the URGWOM annualization computations). The following provisions were introduced to 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 in the model are cleared. (This is done to insure deterministic results in case any of these slots are mistakenly included IN a mass balance summary Slot Sum).
 - 2.All Mass Balance Summaries are computed.
 - **3.**The RPL Expression slots in the Dependent Expression Slot Lists in ALL Mass Balance Summaries in the model are evaluated.
- A "Compute All Summaries" menu operation which performs this model-wide computation (the three steps outlined above) is provided in the "File" menu of the Open Mass Balance Summary Slot dialog. *See image to the right*.



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

Note that if the Dependent Expression Slots are used for annualization computations -with an annual timestep being 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 in the Dependent Expressoin Slots panel brings up the Slot Selector, initialized with "Has RPL Expression" and "Unit Type" ("Flow") filters turned on. Any one RPL Expression slot can appear in the dependent expression slot list only once.

The order of slots in this list is significant -- it is the evaluation order. The selected slot items can be moved up or down in the list with the up and down arrow buttons.

The selected dependent slot items can be removed from the list by clicking the "Remove" button.



6.0 Mass Balance Summary Computation

Mass Balance Summary Computations are performed in these ways:

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

Note: We decided to not provide a conditional configuration setting for this, as the computation runs very quickly -- e.g. about half a second for a 4000-timestep version of the URGWOM calibration model, summing about 560 physical slots in a debug build in Visual Studio. [64-bit Intel Core i7-2600 CPU @ 3.4 GHz; 16 GB; Windows 7; DELL OptiPlex 990].

The latter two methods compute all mass balance summaries within the model, with processing of Dependent Expression Slots both before and after (clearing and re-evaluationg) the mass balance summary computation. (See the prior section).

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) are provided in the "File" menu of the Open Mass Balance Summary Slot dialog.

6.0.1 Computation Detail

AggSeriesSlots are dynamically maintained for each Water Balance, with AggSeriesSlot columns (series slots) created for each Slot Sum within the Water Balance. As an initial step in the Mass Balance Summary computation, the instantiation of these slots is assured, and their timestep size and timestep range is set to the step size and time range of the run controller. Also, the unit type and configured display units are set to those last applied by the user in the Open Mass Balance Summary Slot dialog (by clicking "Recompute"). 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 "readonly" -- not editable by the user.

6.0.2 Limitations of the current Mass Balance Summary Computation:

- 1. No "routed terms". A timestep offset cannot be applied to any slot reference within a Slot Sum, nor to any Slot Sum within a Water Balance.
- 2. No knowledge of "static volumes". The mechanism unconditionally converts all volumes to flows by dividing the volume by the timestep size (at each timestep, to yield a volume-per-time value). For *static* volumes, it would generally be reasonable to instead subtract the value at the prior timestep from that of the current timestep to compute a "change in storage" entity. However, it doesn't seem that that computation could unconditionally be applied in the "volume" domain (though sometimes that would be correct). A RPL implementation of the "change in storage" calculation can be seen in this document, in section 2.2 (though, apparently negated from the natural representation of that entity).

Currently, to accommodate either of these sorts of computations, the user can define a RPL Expression slot for use as a term in a Slot Sum.

7.0 Persistence

All Mass Balance Summary configuration information is stored on the Mass Balance Summary Slot -- in an instance of the Sim/MassBalSumConfig C++ class; this instance is maintained within the Slot class (not SeriesS-lot). The Tcl-based Slot serialization incorporates an XML-based MassBalSumConfig instance, when one exists on the Slot. This is applied both in the RiverWare model file and in Export SimObj (data object) files.

A Mass Balance Summary Slot's computed Water Balance AggSeriesSlots (along with the contained Slot Sum SeriesSlots) are created as (effectively) invisible slots on the same data object as the generating Mass Balance Summary Slot. (These aren't "invisible" in the ordinary sense -- they do show up in the RiverWare "GUS" Slot Selector, e.g. for use in RPL Expression slots). The computed AggSeriesSlots DO persist in the RiverWare model file -- but not in Export SimObj (data object) files.

As needed for support for the GUI implementation of the Mass Balance Summary tree view, both item selection and tree open/closed states ARE part of the MassBalSumConfig serialization. An unimportant implication is that, after saving and reloading a model with Mass Balance Summary Slots, when re-opening one of these slots, the prior tree open/close states AND the item selection are restored!

A Mass Balance Summary Slot's configuration (MassBalSumConfig) can also be saved to, and read from an XML file using the Export and Import operations in the Open Mass Balance Summary Dialog's "File" menu. Below is an example of one of these XML files:

1	< RiverWare Mass Balance Summary Config file created: 22:36 Feb 9 2012>
	Generated from RiverWare 6.2 Development [Feb 9 2012 16:36:05]
	CADSWES, University of Colorado, http://cadswes.colorado.edu/
	<massbalsum name="Balance Calc One"></massbalsum>
	<compvalues valid="1"></compvalues>
	<showvals balgrps="0" bals="1" slotgrps="1" slots="1"></showvals>
	<refdatetime>01-09-2005 00:00</refdatetime>
	<unitsel flowunit="cfs" isflow="1" volunit="acre-ft"></unitsel>
	<slotprefix activebal="" activebalgrp=""></slotprefix>
10	<waterbalgrp lev="1" name="Water Balance Group" open="1"></waterbalgrp>
11	<sumslot name="Mass Bal.Balance Calc One"></sumslot>
12	<waterbal lev="2" name="Upper Basin Balance" open="1"></waterbal>
13	<sumslot name="Mass Bal.Balance Calc One_Upper Basin Balance"></sumslot>
14	<slotgrp lev="3" name="Inflows" open="1" sense="1"></slotgrp>
15	<sumslot name="Mass Bal.Balance Calc One_Upper Basin Balance.Inflows"></sumslot>
16	<slot name="NymphChacoConfluence.Inflow1" objtyp="Confluence" slottyp="aggSerSlot"></slot>
17	<slot name="NymphChacoConfluence.Inflow2" objtyp="Confluence" slottyp="aggSerSlot"></slot>
18	
19	<slotgrp lev="3" name="Outflows" open="1" sense="0"></slotgrp>
20	<sumslot name="Mass Bal.Balance Calc One_Upper Basin Balance.Outflows"></sumslot>
21	<slot name="UpperWideCanyon.Diversion" objtyp="Reach" slottyp="aggSerSlot"></slot>
22	<slot name="UpperWideCanyon.Outflow" objtyp="Reach" slottyp="aggSerSlot"></slot>
23	
24	
25	
26	<depslot name="Mass Bal.Full Annual Balance" objtyp="DataObj" slottyp="serRplExp"></depslot>
27	<depslot name="Mass Bal.Upper Basin Annual Balance" objtyp="DataObj" slottyp="serRplExp"></depslot>
28	

--- (end) ---