



**CADSWES**

University of Colorado

Center for Advanced Decision Support for Water and Environmental Systems

# Water Accounting Modeling

## Overview, Training, and Enhancements

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RiverWare User Group Meeting  
August 13-14, 2008

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# Presentation Outline

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## ➤ Water Accounting Overview

- Water Accounting Motivation
- Accounts
- Supplies
- Solution Algorithm
- User Defined Accounting Methods
- Exchanges

## ➤ Accounting Class Outline

## ➤ Recent and Upcoming Enhancements

# Motivation

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- In many basins, it is necessary to track not only volume of water but the **ownership** and **type**
- Operating decisions are dependent on a user's available water, legal restrictions, physical constraints, exchange mechanism, and priority water rights allocation

**Solution:**  
**Water Accounting**

# How is water accounting modeled in RiverWare?

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- Physical and Paper water are modeled separately;
  - Network of accounts on the simulation objects
  - Accounts are linked indicating the possible transfers
- Legal Accounts – Storage, Diversion, Instream Flow
- Non Legal - Passthrough accounts track transfer of water between legal accounts
- Accounts are labeled by ownership and type and can be given a priority date
- Rules can access accounting information and also set account transfers
- Can simulate water accounting components like accrual, exchanges, carryover, allocation, etc.

# Types of Accounts

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## ➤ Legal Accounts:

- **Storage Account** - on Reservoirs:

Storage, gain/loss, accrual, carry-over, inflow and outflow, transfers

- **Diversion Account** - on Water Users, Aggregate Diversions:  
diversion, consumption, and return flow

- **Instream Flow** – on Control Points: Track total flow into all accounts

## ➤ Non-Legal Accounts

- **Passthrough Accounts** - Reaches, Confluences, Gages, Reservoirs:

keep track of water moving between legal accounts

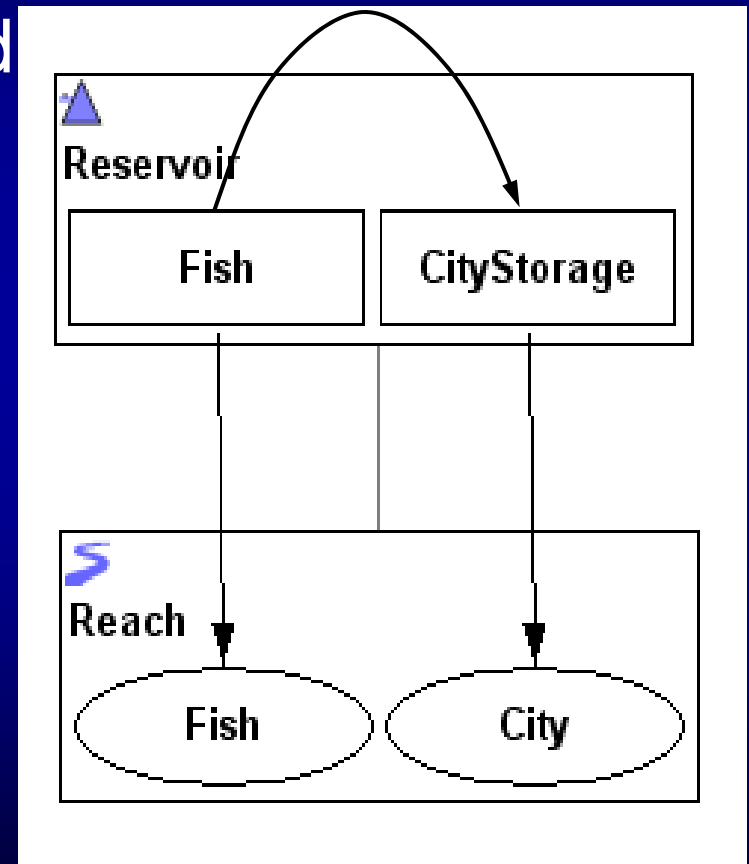
## ➤ Properties of Accounts

- **Water Type** – E.g., trans-basin or local water

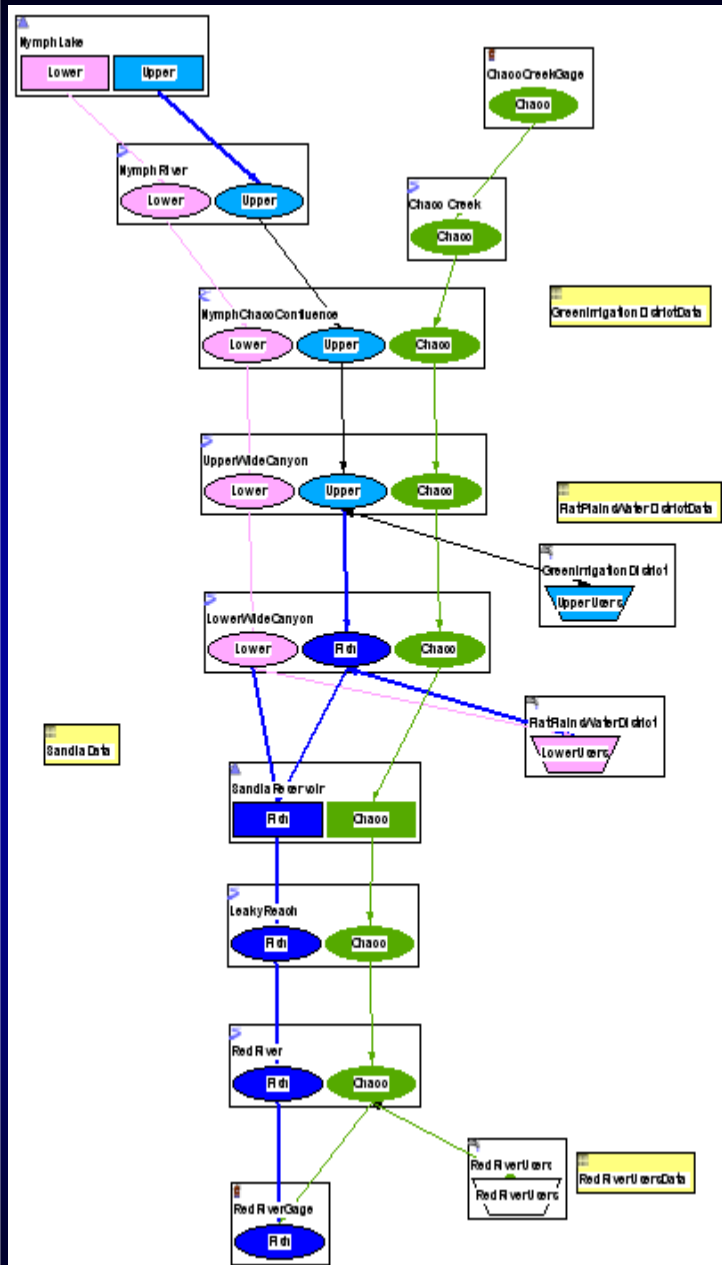
- **Water Owner** – E.g., Contractor A, Contractor B, and City

# Linking Accounts - Supplies

- Accounting network is formed by links between accounts called “supplies”: represent movement of paper water
- Supply Properties:
  - **Type** – Inflow/Outflow, Diversion/Return Flow, Transfer
  - **Destination** – E.g., Diversion A, Red Reach
  - **Release Type** – E.g., Diversion, Fish



# Accounting View



- Display the system to stakeholders and water managers
- Allows for color coding, formatting, and aggregation of accounts and supplies
- Useful to:
  - Create
  - Reorganize
  - Link

# Accounting Solution

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## ➤ “Spreadsheet” type solution

- Account solves when it has the required knowns
- Account solves whenever it gets a new value (not controlled by dispatcher during a run)
- Account slots and supplies are set by user input, methods, or rules

## ➤ Mass balance solutions:

- Storage accounts solve for Storage and Accrual
- Diversion accounts solve for Depletion and/or Return flow
- Instream Flow accounts solve for Flow and Outflow
- Passthrough accounts solve only downstream for outflow



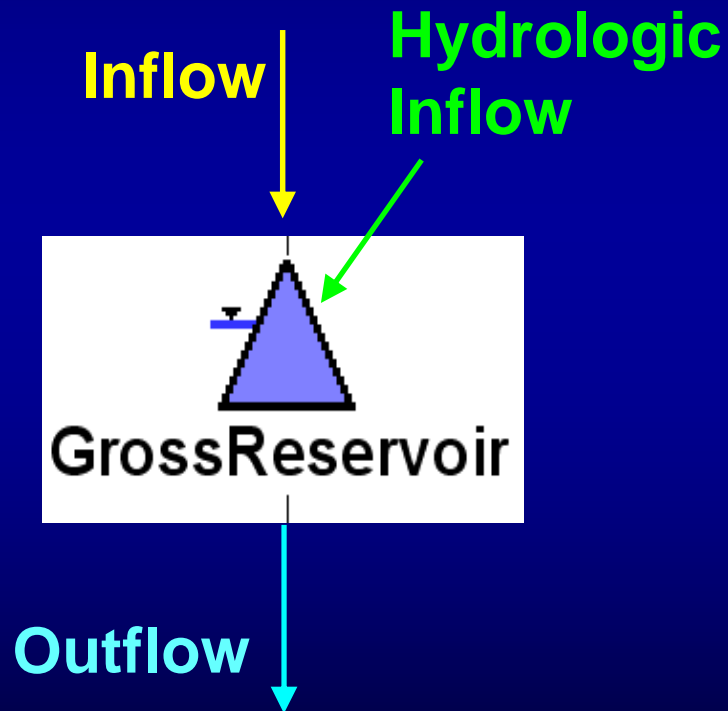
# Object Level Accounting Methods

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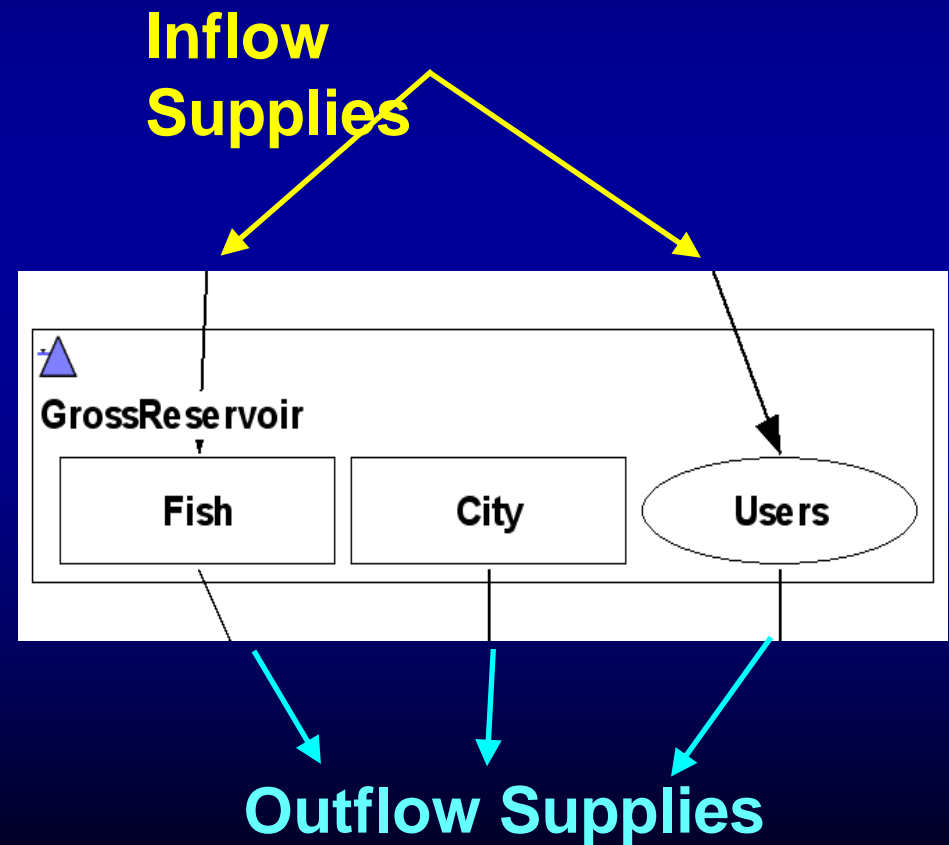
- Purpose: Distribute physical water on simulation objects to the accounts
- Methods are on the object and apply to all accounts
- Categories
  - Gain Loss: allocate physical gains and losses
  - Slot Inflow: allocate local inflows
  - Reconciliation: match accounting and physical systems
- Two ways to specify the methods
  - Compiled: Simple methods or basin specific
  - User Defined: Written in RiverWare Policy Language (RPL)

# Slot Inflow Example

## ➤ Physical

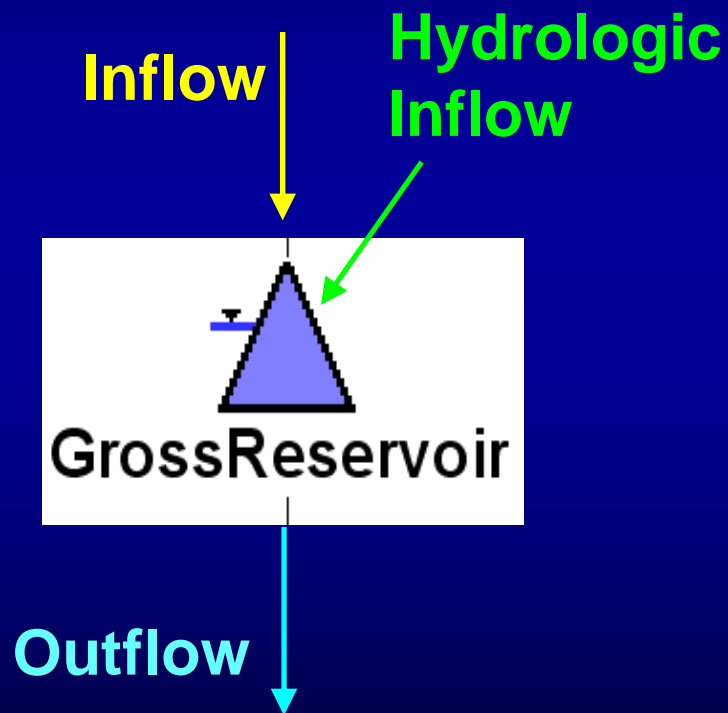


## ➤ Accounting

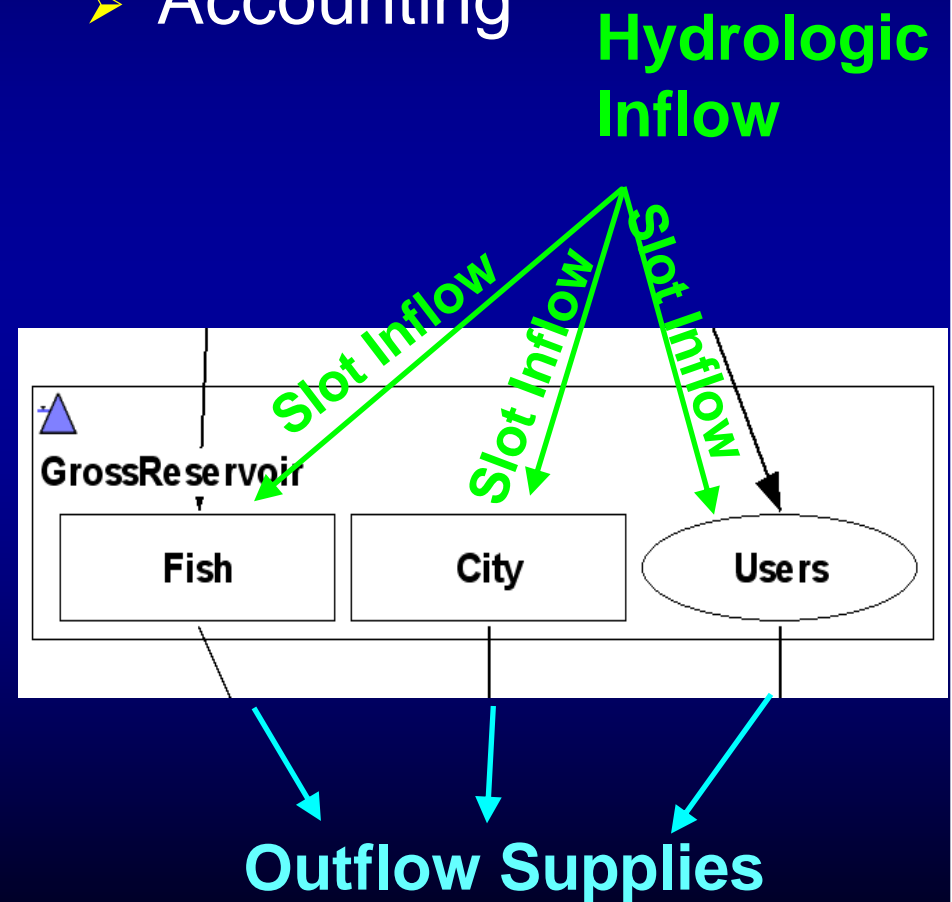


# Slot Inflow Example

## ➤ Physical



## ➤ Accounting



# Slot Inflow Example (cont.)

The image shows two overlapping software windows. The background window is titled "Method Set Editor - 'Object-level Accounting Met...'" and contains a table of methods. The foreground window is titled "Open Object - GrossReservoir" and shows a dropdown menu for "Selected Method".

**Method Set Editor - "Object-level Accounting Met..."**

Name	Priority	On	Type
Confl PassThrough Slot Inflow		✓	Category
Pipe Junction Pass Through Slot...		✓	Category
Pipe PassThrough Slot Inflow		✓	Category
Inline Pump Pass Through Slot I...		✓	Category
DistributionCanal PassThrough ...		✓	Category
Storage Account Slot Inflow		✓	Category
<b>GrossReservoir Slot Inflow</b>	<b>1</b>	✓	<b>Method</b>
Storage Account Gain Loss		✓	Category
Reservoir Reconciliation		✓	Category
Control Point Pass Through Slot...		✓	Category
Instream Flow Reference Level		✓	Category
Water User Reconciliation		✓	Category

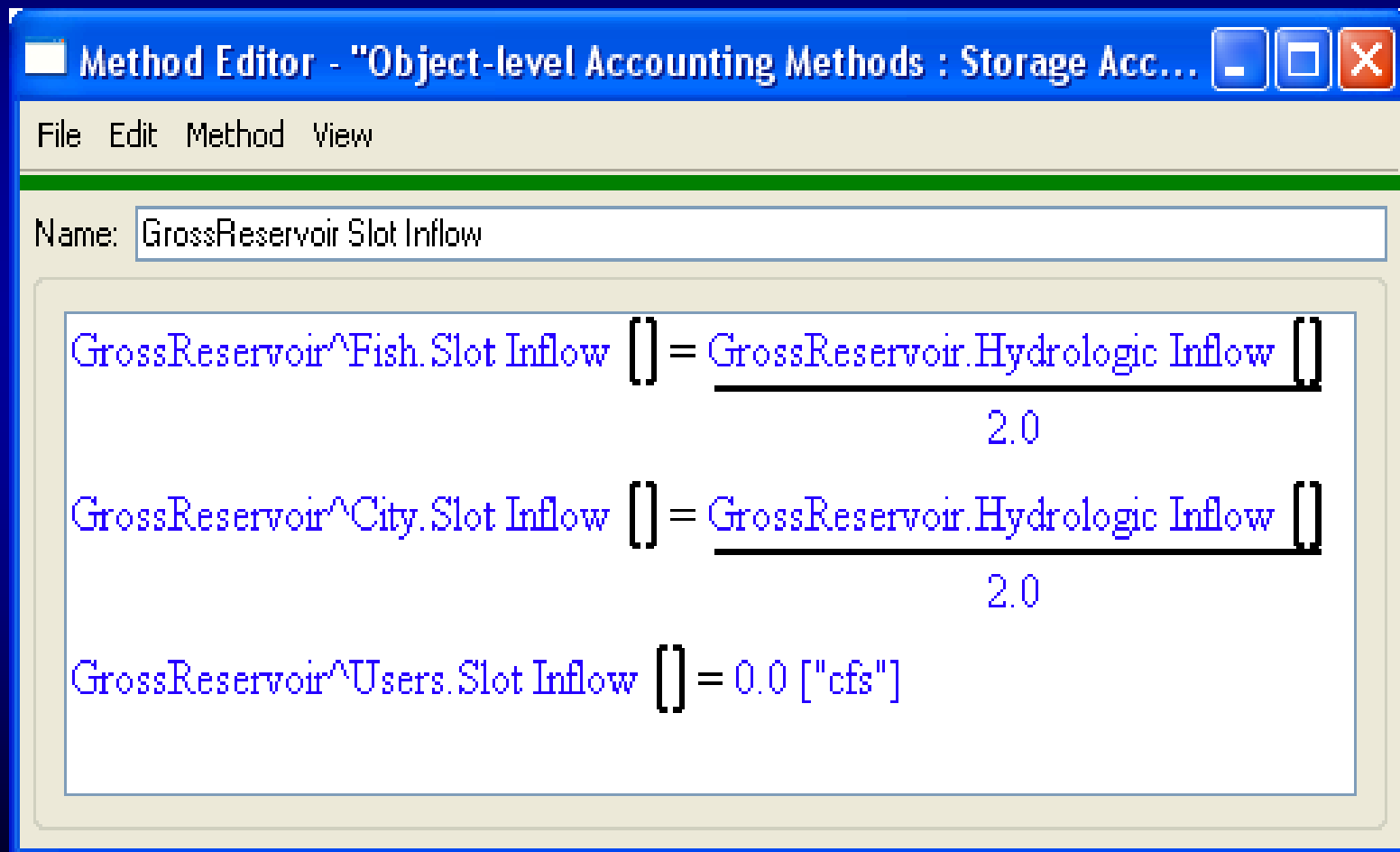
**Open Object - GrossReservoir**

Object Name: GrossReservoir

Selected Method: GrossReservoir Slot Inflow

- No Accounting Inflow Calculation
- Zero Slot Inflows
- Heron Inflow Calculation
- Pooled Account Slot Inflow
- Donner Inflow
- Prosser Uncomm
- GrossReservoir Slot Inflow**
- No Uncertainty
- No Loss Calc
- GrossReservoir Slot Inflow

# Slot Inflow Example (cont.)



The screenshot shows a software window titled "Method Editor - 'Object-level Accounting Methods : Storage Acc...". The window has a menu bar with "File", "Edit", "Method", and "View". Below the menu bar, there is a text field labeled "Name:" containing the text "GrossReservoir Slot Inflow". The main area of the window contains three equations, each with a blue text label on the left and a blue text label on the right, both enclosed in double square brackets. The equations are:

$$\text{GrossReservoir}^{\text{Fish}}.\text{Slot Inflow} [] = \frac{\text{GrossReservoir}.\text{Hydrologic Inflow} []}{2.0}$$
$$\text{GrossReservoir}^{\text{City}}.\text{Slot Inflow} [] = \frac{\text{GrossReservoir}.\text{Hydrologic Inflow} []}{2.0}$$
$$\text{GrossReservoir}^{\text{Users}}.\text{Slot Inflow} [] = 0.0 \text{ ["cfs"]}$$

# Use Rules to Control Accounting

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- Rules can set supplies – may cause the account to solve
- Many predefined functions specific to Accounting

# Reconciliation

- Total physical releases/storage does not have to equal accounting releases/storage
- Matching the accounting system to the physical system is up to the user using:
  - Object Level Accounting Methods
  - Rules
- Check using Object Account Summary

Object Account Summary - Sample Reservoir

File Edit View TimeStep I/O Config Adjust

Single Object: Sample Reservoir Select Object ...

Columns:  Acct Slots  TimeSteps

Account Types:  Storage  InstreamFlow  Diversion  PassThrough

Account Slot Entity: Storage

Accounts (3 of 7)  List All Accounts

Sum	Ord	Object	Account	Type	Water Type	Water Owner
<input checked="" type="checkbox"/>	1	Sample Reservoir	S Contractor1	Stor	SanJuan	Contractor1
<input checked="" type="checkbox"/>	2	Sample Reservoir	S Contractor2	Stor	SanJuan	Contractor2
<input checked="" type="checkbox"/>	3	Sample Reservoir	S Contractor3	Stor	SanJuan	Contractor3
<input type="checkbox"/>	4	Sample Reservoir	S FederalSanJuan	Stor	SanJuan	NONE
<input type="checkbox"/>	5	Sample Reservoir	S RioGrande	Stor	RioGrande	NONE
<input type="checkbox"/>	6	Sample Reservoir	S StorageAccount0	Stor	NONE	NONE
<input type="checkbox"/>	7	Sample Reservoir	S StorageAccount1	Stor	NONE	NONE

Select All Accounts Set Selection ↑ ↓ Set Order

Value: 2485.00495868 acre-feet Scroll: December 31, 1995

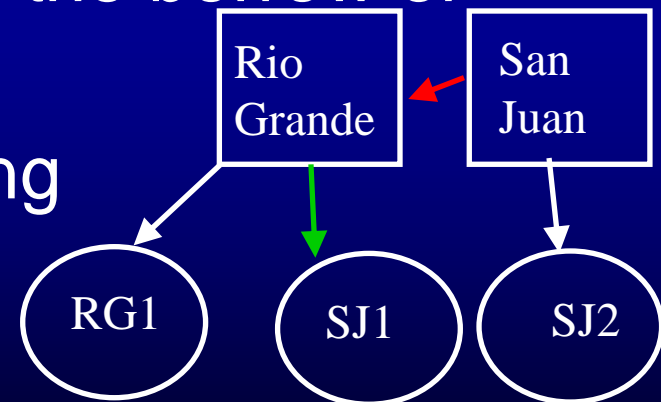
	Sample Reservoir -- SUM Storage	Sample Reservoir ^Contractor1 Storage	Sample Reservoir ^Contractor2 Storage	Sample Reservoir ^Contractor3 Storage
	acre-feet	acre-feet	acre-feet	acre-feet
12-31-1995 Sun	6500.00	2000.00 I	2000.00 I	2500.00 I
01-01-1996 Mon	6480.17	1996.03 A	1992.07 A	2492.07 A
<b>01-02-1996 Tue</b>	<b>6464.30</b>	<b>1990.08 A</b>	<b>1988.10 A</b>	<b>2486.12 A</b>
<b>01-03-1996 Wed</b>	<b>6449.30</b>	<b>1982.15 A</b>	<b>1982.15 A</b>	<b>2485.00 A</b>
01-04-1996 Thu	6433.43	1976.20 A	1980.17 A	2477.07 A

Show empty Slots

3 Slots  
6 values: Sum 12913.60 -- Ave 2152.27 -- Min 1982.15 -- Max 2486.12 -- Range 503.97 [acre-feet]

# Water Exchanges

- Track water exchanges and transfers
- **Borrow** - a supply to an account or a user input
- **Payback** - an outflow (supply) from an account
- In the exchange utility, the debt is updated whenever a new value is set in the borrow or payback
- Rules can access the debt using predefined functions





### Exchange Configuration

File System

Exchange Name:

**Borrow Supply**

Select Supply

Input Borrowed Amounts

**Payback Destination Supply**

Select Destination

No Destination

**Payback Sources**

Demand Name	Legal Loss (decimal)
Fish to Farmers Exchange Payback	0.10

**Units**

User Units:  Scale:

Format:  Precision:

### Exchange Balance -- Fish To Farmers

File Edit View TimeStep I/O Accounting Adjust

Exchange:

Value:  acre-ft Scroll:

	Borrow Supply acre-ft	Exchange Source Balance acre-ft	Payback-1 Debt acre-ft	Payback-1 Supply acre-ft
02-27-2005 Sun	9.92 R	218.18 m	242.42 m	
02-28-2005 Mon	9.92 R	228.10 m	253.44 m	
03-01-2005 Tue		210.25 m	233.61 m	19.83 R
03-02-2005 Wed		192.40 m	213.77 m	19.83 R
03-03-2005 Thu		174.55 m	193.94 m	19.83 R
<b>03-04-2005 Fri</b>		156.69 m	174.10 m	19.83 R
<b>03-05-2005 Sat</b>		138.84 m	154.27 m	19.83 R
<b>03-06-2005 Sun</b>		120.99 m	134.44 m	19.83 R
03-07-2005 Mon		103.14 m	114.60 m	19.83 R
03-08-2005 Tue		85.29 m	94.77 m	19.83 R
03-09-2005 Wed		67.44 m	74.93 m	19.83 R
03-10-2005 Thu		49.59 m	55.10 m	19.83 R
03-11-2005 Fri		31.74 m	35.26 m	19.83 R
03-12-2005 Sat		13.88 m	15.43 m	19.83 R
03-13-2005 Sun		0.00 m	0.00 m	15.43 R
03-14-2005 Mon		0.00 m	0.00 m	
03-15-2005 Tue				
03-16-2005 Wed				

Show empty Slots

Borrow Supply : FishToFarmerExchange  
 Payback-1 Debt : Fish To Farmers.Fish to Farmers Exchange Payback.Debt  
 Payback-1 Supply : Fish to Farmers Exchange Payback

Fish To Farmers.Source Balance  
 3 values: Sum 416.53 -- Ave 138.84 -- Min 120.99 -- Max 156.69 -- Range 35.70 [acre-ft]

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- **Accounting Class Outline**
- Recent and Upcoming Enhancements

# Accounting Class Outline - Day 1

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- Overview of accounting system
- How accounting works
- Run and view an accounting model
  - Navigate accounting system using new accounting workspace (also through simulation workspace)
  - Become familiar with elements of accounting system
  - Run, observe, and analyze model output
- Building an accounting model

# Accounting Class Outline - Day 2

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- Rules and Accounting – Strategies and features
- “After-the-fact” Accounting model: Use rules to specify accounting releases and diversions from simulated flows
- Advanced RBS: Accounting Driven Simulation
- Water Rights Allocation

# Accounting Class Outline - Day 3

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- Group/Interactive Exercise
  - Start with existing simulation model
  - Create accounting system according to specifications
  - Mix of white board session and work on the computer
  - Write rules to implement accounting policy
- Status: Still under development ~85% done  
Test run soon!

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# Recent Enhancements

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- Exchange dialogs re-implemented
- Convergence on Supply slots
  - Supplies between 2 multi-slot: Convergence is changed to “None” – NOT editable
  - Slots on ends of Supply have “Percent Change” – Value IS editable
  - Result: solution will converge, rules that set supplies may need modification

# Recent Enhancements (cont.)

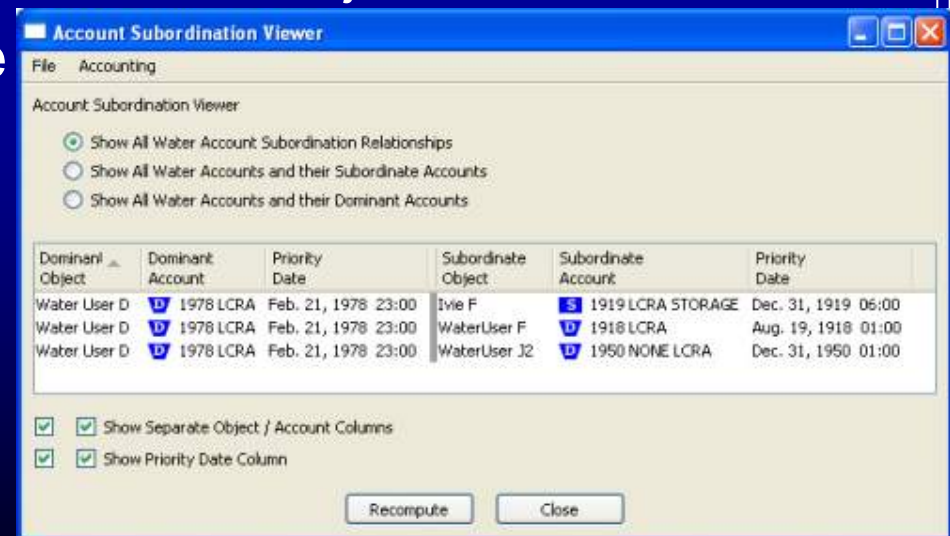
## ➤ New RPL Functions

- AccountAttributes
- ObjAcctSupplyByWaterType-RelTypDestType
- ObjectFromAccountName
- ObjectsFromAccountType

- ObjectsFromWaterType
- SourceAccountAndObject
- SupplyAttributes
- GetAccountFromSlot
- GetObjectFromSlot

## ➤ Documentation

## ➤ Subordination Viewer





# Upcoming Enhancements

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- **New Accounting Controller**
  - Current inline controller executes accounting methods after Rules and Physical simulation
  - New controller will execute accounting first – design and details are unknown
- **Enhanced exchanges: develop a mechanism to execute both physical and accounting parts of exchanges**