Integrated Surface and Ground Water Modeling using RiverWare

Examples from New Mexico

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Outline

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Motivation

- **Ground water systems play increasingly important roles in surface water management**
- **Uses and Issues:**
  - Supplemental and primary water supplies
  - Augmentation plans and exchanges
  - Conjunctive management
  - Water quality considerations
  - Impacts on Operating Agreements, Treaties, Compacts, ESA.
  - Etc.

Modeling Objectives

- **Ground water use has varying degrees of impact on surface water systems**
  - Base flows, spring flows, tributary inflows, reach gains and losses may be impacted by aquifer pumping rates, timing, and location relative to surface water components.
- **Simulation of GW/SW relationships**
  - Physical processes
  - Institutional “feedback” – How much interdependency is there between management of surface and ground water systems? How are physical processes affected?

Surface Water / Ground Water Simulation Options

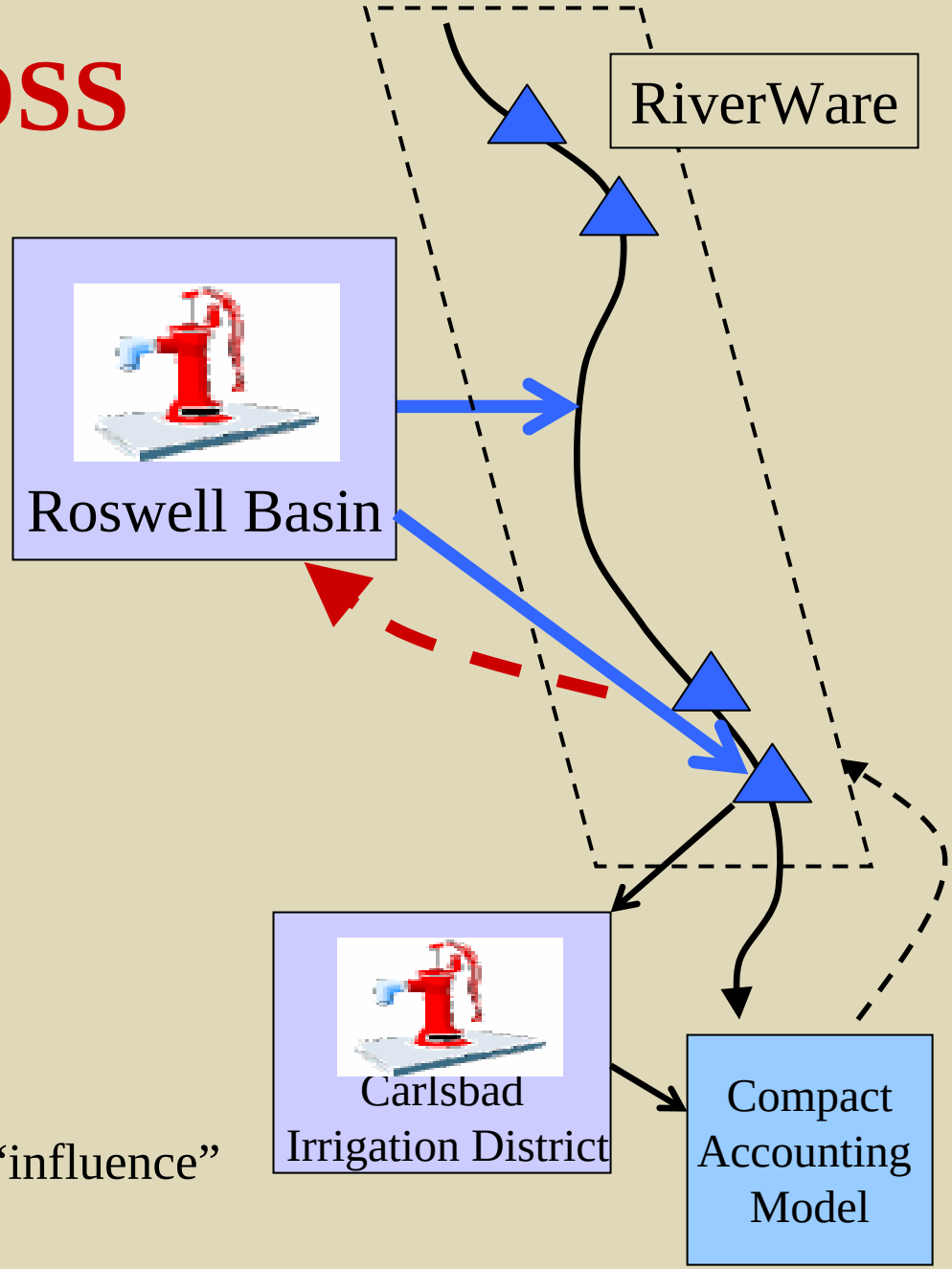
- **Existing GW Object in RiverWare**
- **RiverWare / MODFLOW Linkage**
- **Response Functions (within RiverWare)**
- **New GW Methods in RiverWare (Stay Tuned…)**

Linking RiverWare and Modflow: Pecos River Adjudication Settlement

- **Within Roswell Basin Modflow Model:**
  - Land / GW Rights Retirement and Transfer
  - Augmentation Well Pumping a function of Surface Water Supply conditions (Carlsbad Project, modeled in RiverWare), constrainted by monthly, annual and 5-year limits.
- **RiverWare:**
  - Carlsbad Project Operations driven by surface water supply, irrigation water demands, Pecos River Compact requirements.
  - Augmentation water supplies from Roswell Basin could provide as much as 50% of annual Carlsbad Project Allotment

Pecos River DSS

- **"Baseline" base inflows from Roswell Basin drive first iteration**
- **RiverWare simulates Carlsbad Project water supply**
- **Project allotment drives augmentation pumping in Roswell Basin**



Thoughts on Pecos River DSS – RiverWare / Modflow Coupling

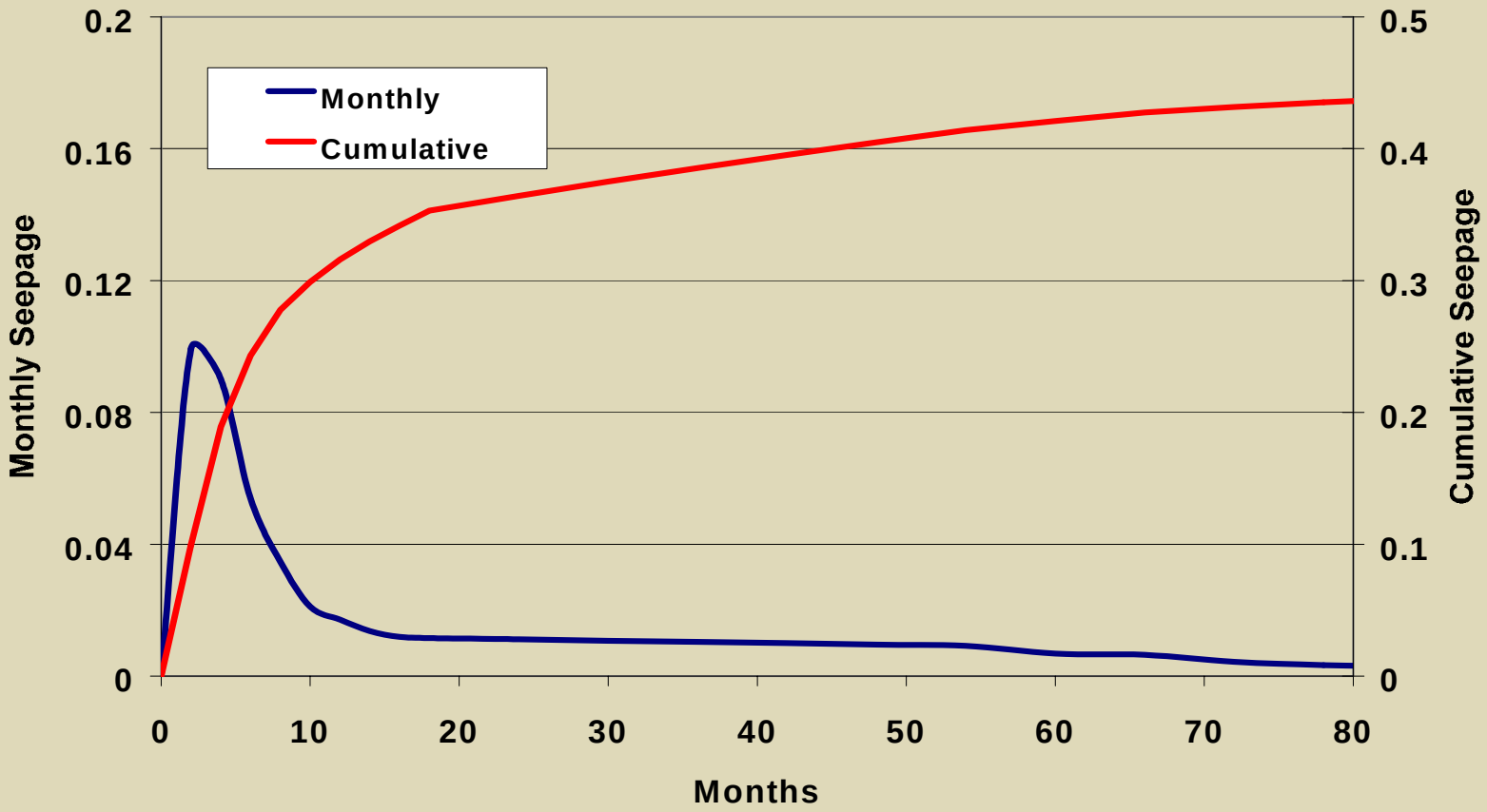
- **The Good (Why it works):**
  - Simulation of GW aquifer using physical process model
  - Sensitivity of Project to baseflow changes is low
  - Impact of augmentation water on Project operations is essentially linear (carryover being an exception)
  - Result: Iterations between models are minimal
- **The Bad (What can go wrong):**
  - No guarantee of “convergence” - depending on rules and well field constraints
  - Quality Control: requires a lot of data and model file manipulations
- **The Ugly:**
  - Data I/O can take 10x as long as model runs themselves

Response Functions within RiverWare

- Effects of ground water withdrawals generalized using a unit response function
- Response functions derived from Modflow model implemented via RiverWare rules
- Pumping from aquifer is simulated within RiverWare using ground water object
- Effects of this pumping on river (or drain) seepage is modeled using diversion objects

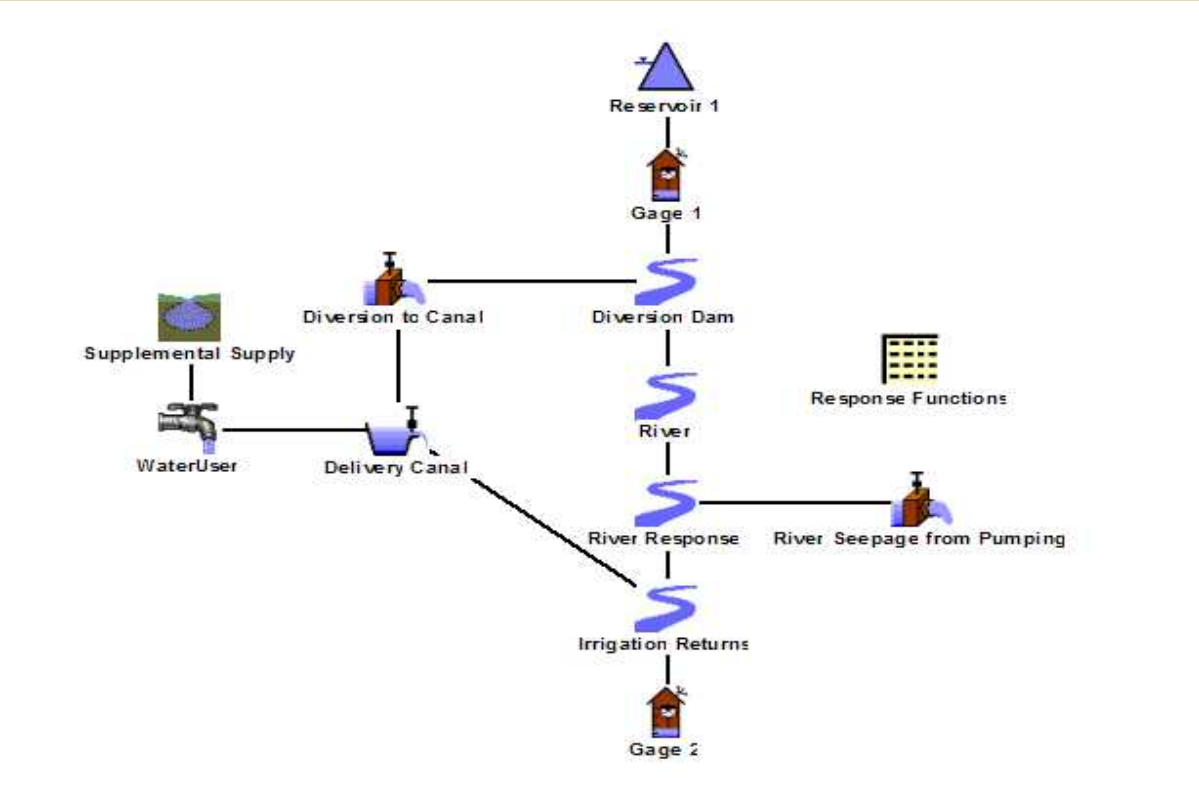
Response Function Implementation

- Unit response function derived from GW model (e.g., MODFLOW)
- Impact of unit withdrawal from aquifer on river seepage



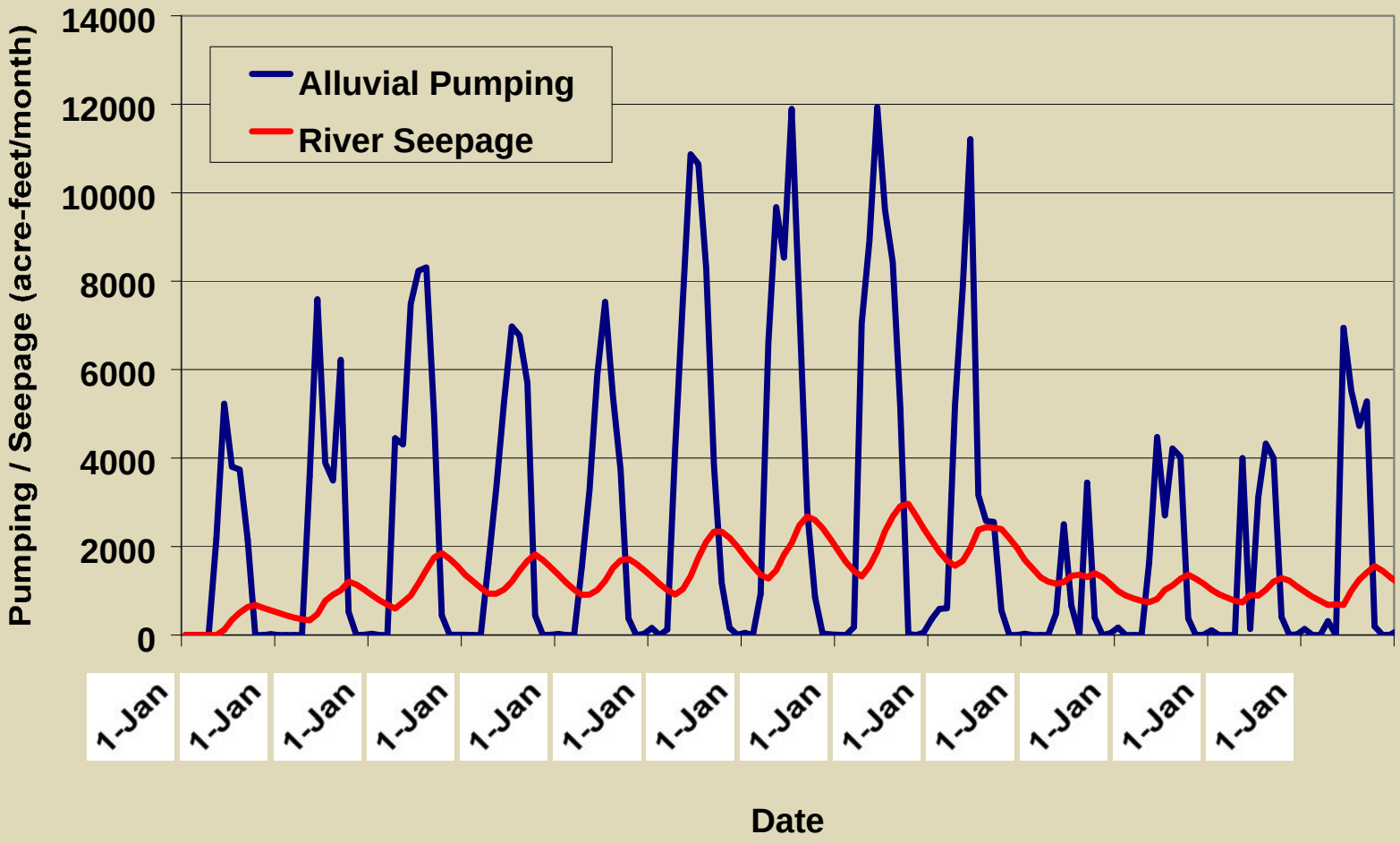
Response Function Implementation

- Response functions derived from ground water model input as tables in RiverWare (36 monthly response coefficients)
- Responses to ground water pumping are simulated using diversions from drains or river reaches



Response Function Implementation

- River Seepage from Response Function / Pumping convolution is the “Demand” on the River Seepage Diversion Object



Response Function Implementation

- **The Good (Why it works):**
  - Simulation of aquifer pumping effects “self-contained” within RiverWare
  - No model coupling
  - Data I/O errors minimized
  - Easy to Implement (once you’ve got the response functions)
- **The Bad (What can go wrong):**
  - Nonlinearity can rear its ugly head
  - No head dependency
  - Over-generalization of aquifer behavior
- **The Ugly:**
  - Run time can easily double or triple with a 60 year monthly model using a 36 month response function. Fortunately, most monthly models don’t take too long to run in the first place. (Your mileage will vary)

Summary: Things to Consider

- How complex are feedback mechanisms?
- How many response functions are needed to capture this complexity?
- How sensitive are surface water parameters of interest to changes in ground water hydrology?
- Nonlinearity and head-dependencies are stumbling blocks for response functions
- Data I/O and iteration concerns are stumbling blocks when linking w/ Modflow
- Size matters: Modeling a 10-year response function period in a daily RiverWare model is a bad idea.