RiverSMART: RiverWare Study Manager and Research Tool

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Sustain and Manage America's Resources for Tomorrow

Grants to Develop Climate Analysis Tools to assess the impacts of climate change on water resources and inform management decisions with respect to those impacts.

Under WaterSMART, **Basin Studies** are comprehensive water studies in specific basins to explore options for meeting projected imbalances in water supply and demand.

Such studies require

- projecting future supplies,
- Projecting future demands,
- developing and exploring options and strategies to address imbalances, and
- techniques for assessing the study outcomes.

RiverSMART: RiverWare Study Manager and Research Tool

This project provides and integrates a set of tools that includes recent scientific advances in climate projections, stochastic simulation, operational modeling and robust decision-making, as well as computational techniques to organize and analyze many alternatives.

Supports Studies that…

- Project future hydrologic (supply) scenarios
- Project future demand scenarios
- Address imbalances with options and strategies: alternative
  - Operating policies
  - Infrastructure options
  - Basin transfers, etc.
- Identify and Model Performance Metrics
- Model System with many Supply/demand/options combos of interest
- Have much data to organize and archive
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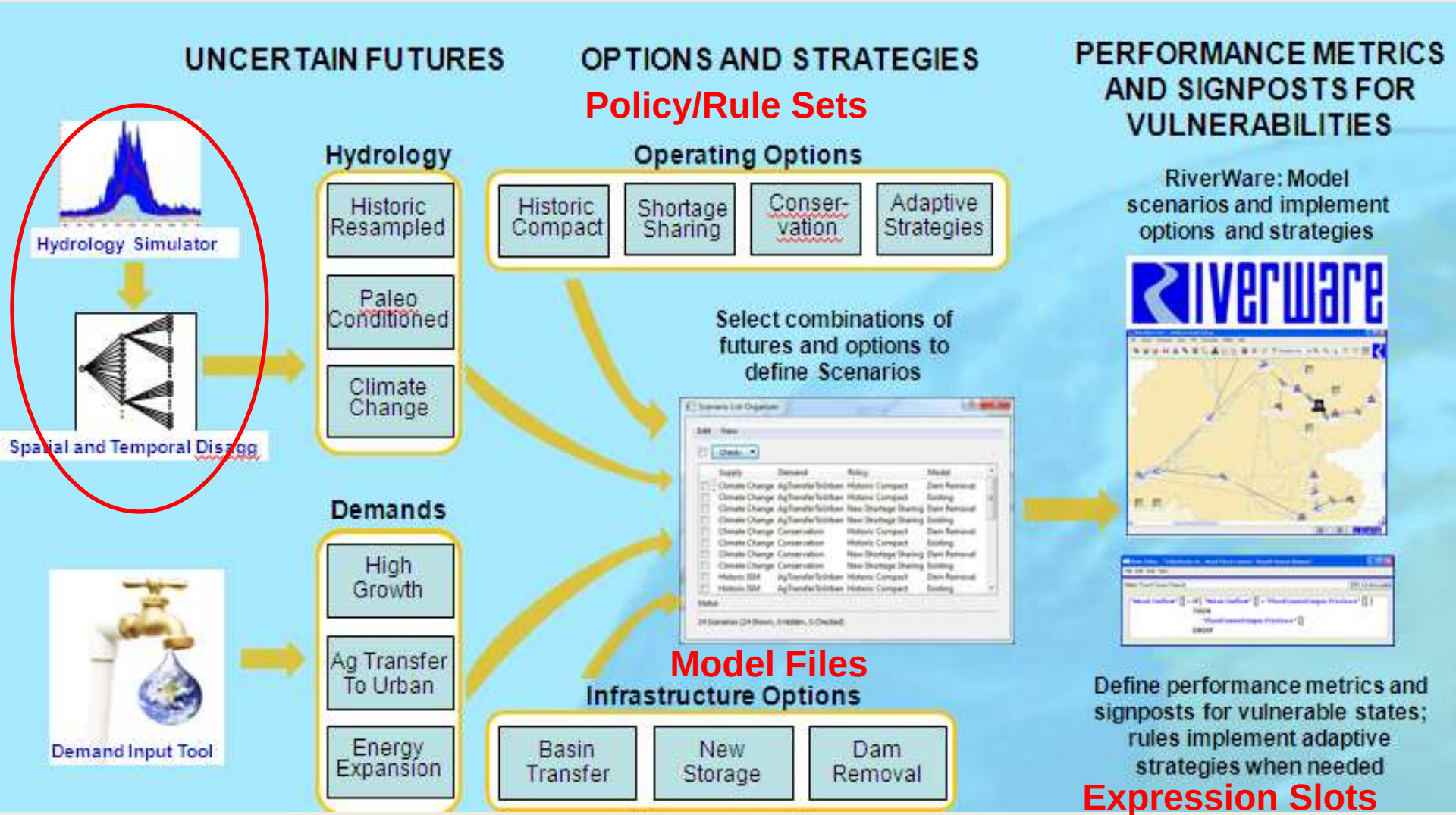
RECLAMATION

Managing Water in the West

Colorado River Basin Water Supply and Demand Study

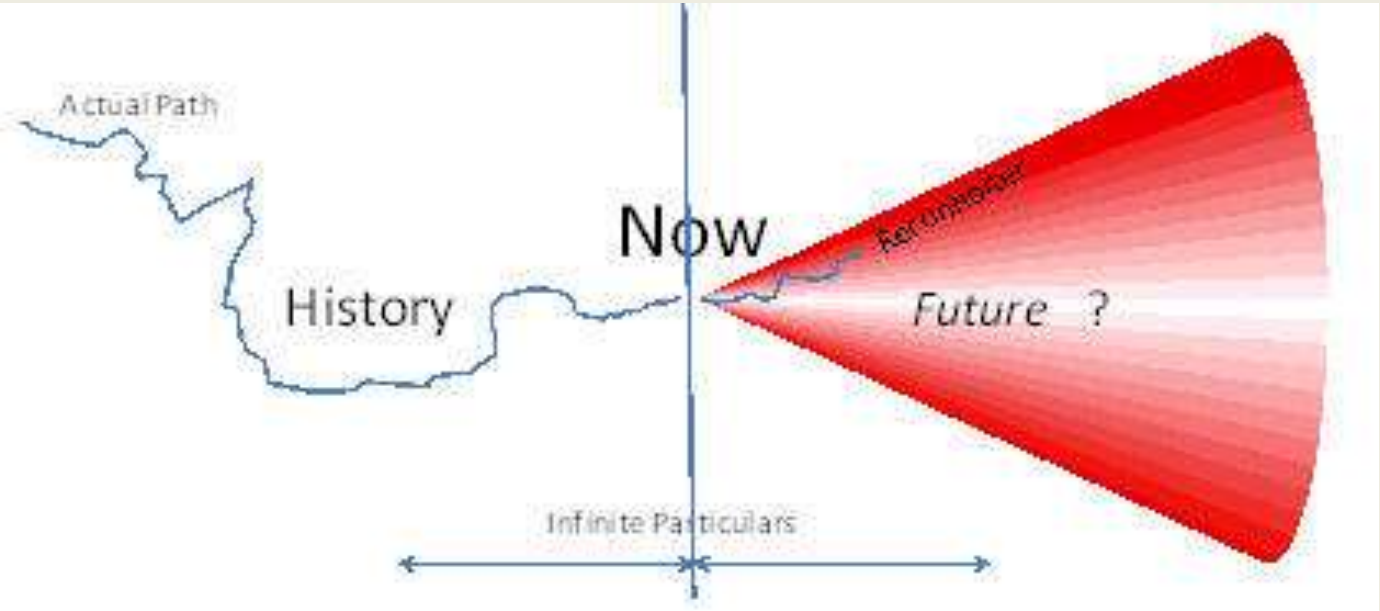
Executive Summary

RiverSMART System Components



Scenario Planning for Uncertain Future

Develop a range of future conditions that go beyond extrapolation of current trends and represent surprising but plausible conditions.



More uncertainties create a larger number of possible futures

Hydrology Simulator

Generate ensembles of single-site annual stochastic hydrology based on historic streamflow record

- 3 Methods and variations
- Spatial disaggregation to multiple sites
- Temporal disaggregation: annual to monthly
- Methods developed in R
- Provided in RiverSMART with GUI
- Methods developed by B. Rajagopalan and students (Prairie, Nowak, Bracken et al.)

Hydrology Simulator

Generate ensembles of hydrology for supply scenarios
Methods developed by B. Rajagopalan and students (Prairie, Nowak, Bracken et al.)

1. **Resample Historic** using non-parametric K-nearest neighbor algorithm (Prairie et al., 2006)

   Variation: change mean over time

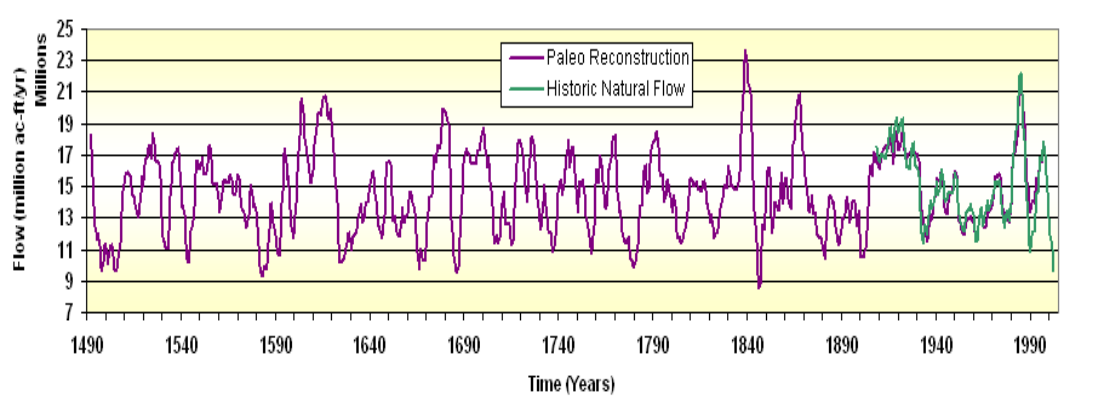
2. **Paleo Conditioned**: resample historic flow record but use sequences found in paleo reconstructed flows via homogeneous Markov method

   - *Paleo data is categorized into 2 or 3 states. Transition probability matrix is developed; probabilities are used as weights in the K-NN resampling process. (Prairie et al. , 2008)*
   - *Paleo PDSI data can be used as a surrogate for reconstructed paleo data*

Hydrology Simulator

3. **Paleo Conditioned with Non-Homogeneous Markov Method**: resample historic flow record but use sequences found in paleo reconstructed flows

   - *Randomly select a window of the paleo record of length equal to trace length and use transition probabilities to condition resampling from historic record*
   - *Optionally favor selection of paleo windows with higher or lower variance*
   - *Optionally resample climate change projection flows conditioned on sequences from paleo record*

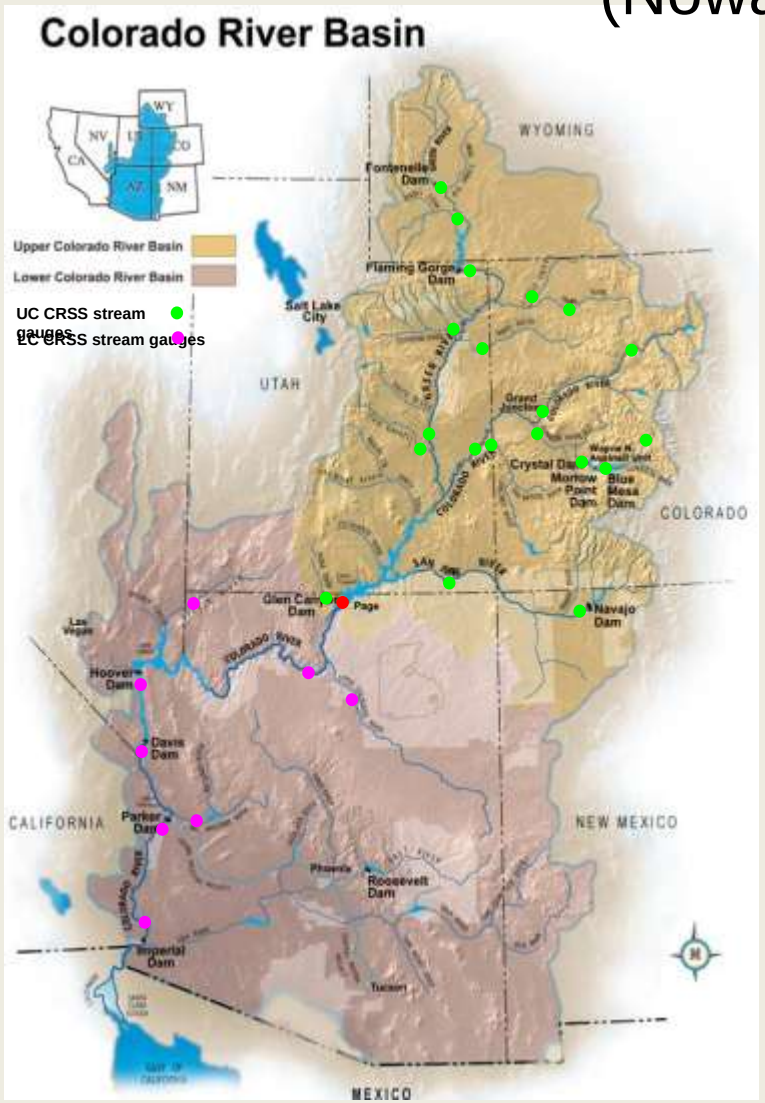


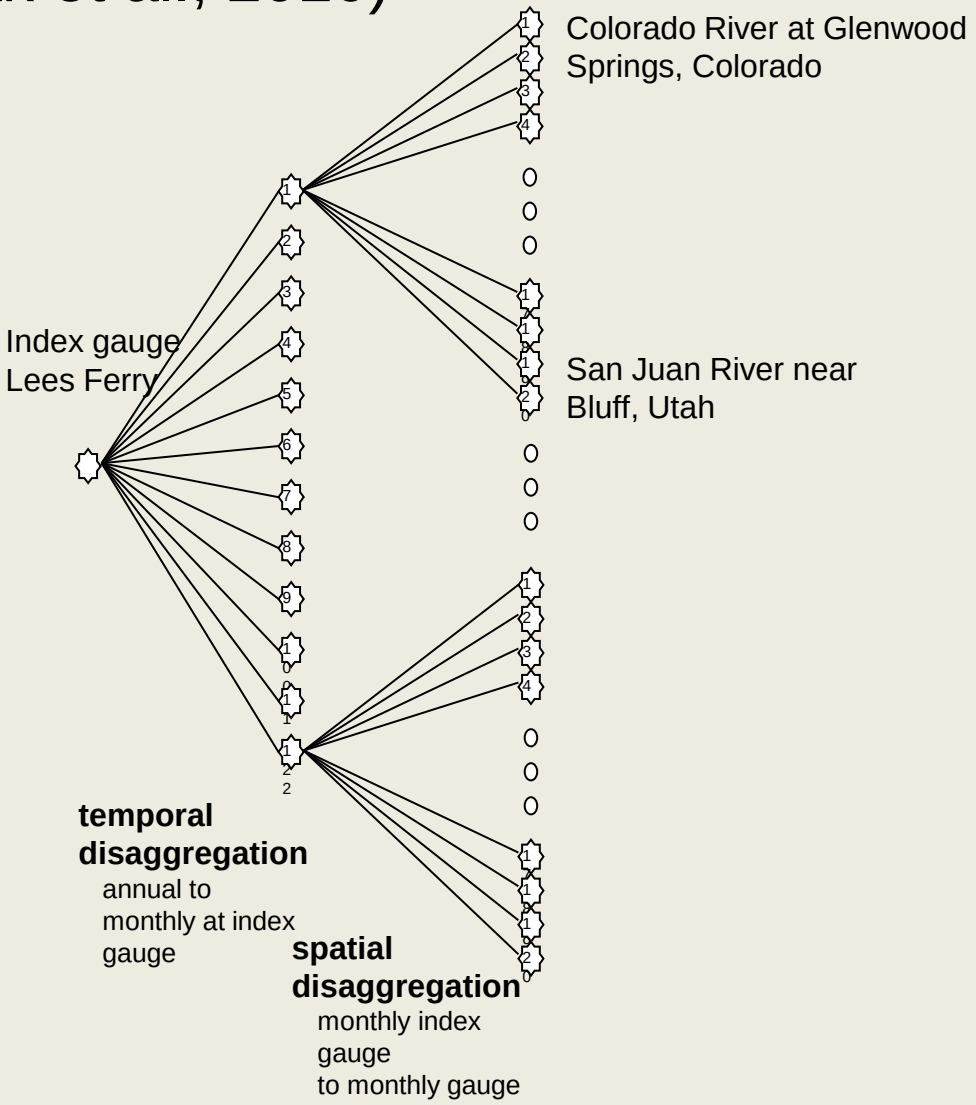
Tree ring reconstructed flows

Direct Paleo - ISM applied to Meko - paleo flow (762-2005) (Meko et al., 2007) 1244 traces

Nonparametric Paleo Conditioned - Meko - paleo conditioned (Prairie, 2006) 125 traces (combines historic magnitudes with paleo sequences)

Disaggregation on Colorado River (Nowak et al., 2010)





Colorado River Basin Supply and Demand Study Supply Scenarios

- **Observed Resampled:** Future hydrologic trends and variability are similar to the past approximately100 years.
- **Paleo Resampled:** Future hydrologic trends and variability are represented by reconstructions of streamflow for a much longer period in the past (nearly 1,250 years) that show expanded variability.
- **Paleo Conditioned:** Future hydrologic trends and variability are represented by a blend of the wet-dry states of the longer paleo reconstructed period (nearly 1,250 years), but magnitudes are more similar to the observed period (about 100 years).
- **Downscaled GCM Projected:** Future climate will continue to warm with regional precipitation and temperature trends represented through an ensemble of 112 future downscaled GCM projections.

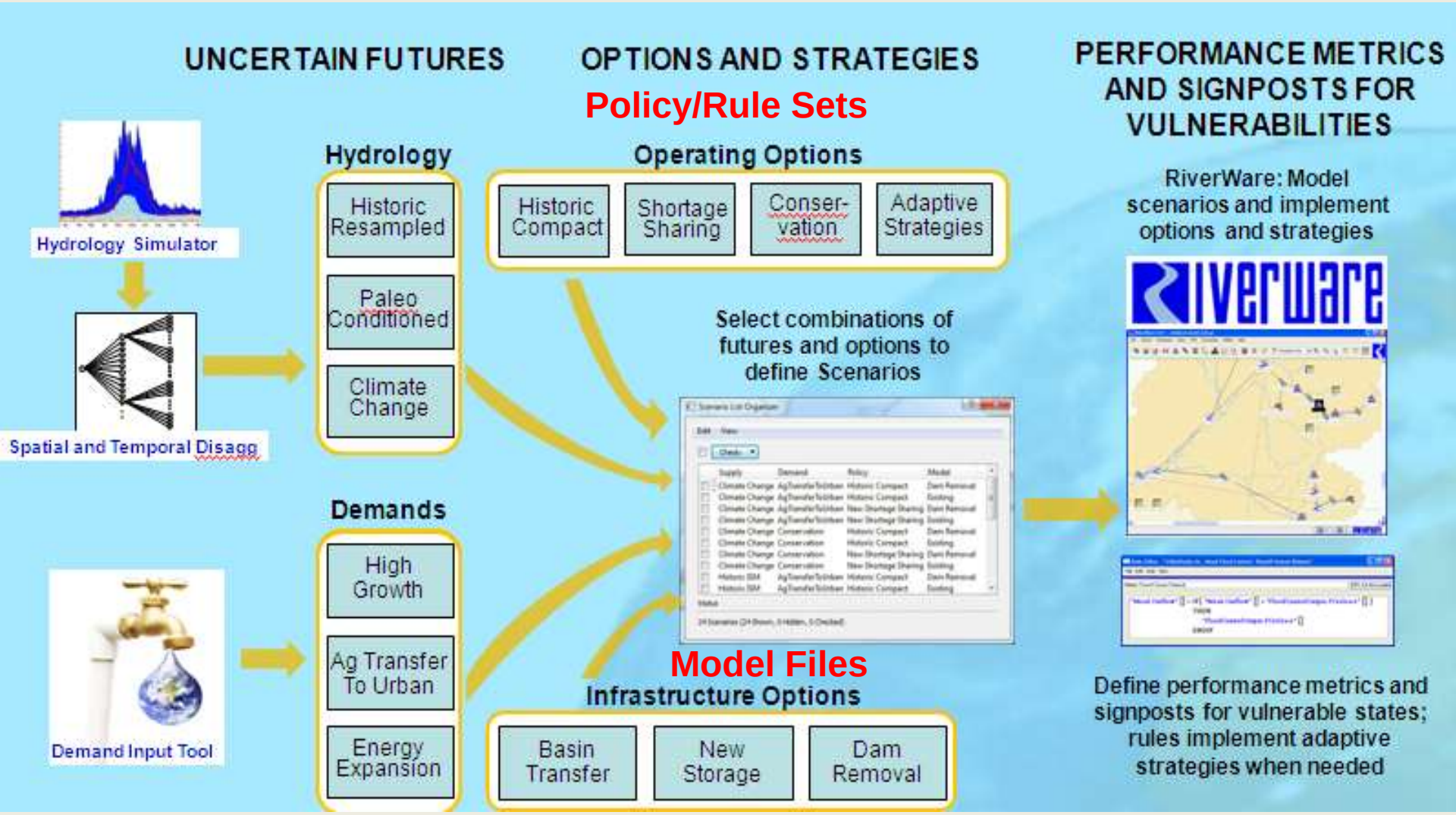
Demand Scenariors: Demand Input Tool (DIT)

Excel-based tool to create and edit new demand scenarios.

- Create or modify specific demands at specific times
- Modify all demands in a political (states or counties) or geographic (subbasin) over time
- Modify all demands in certain sectors (Agriculture, Municipal, Energy, etc)

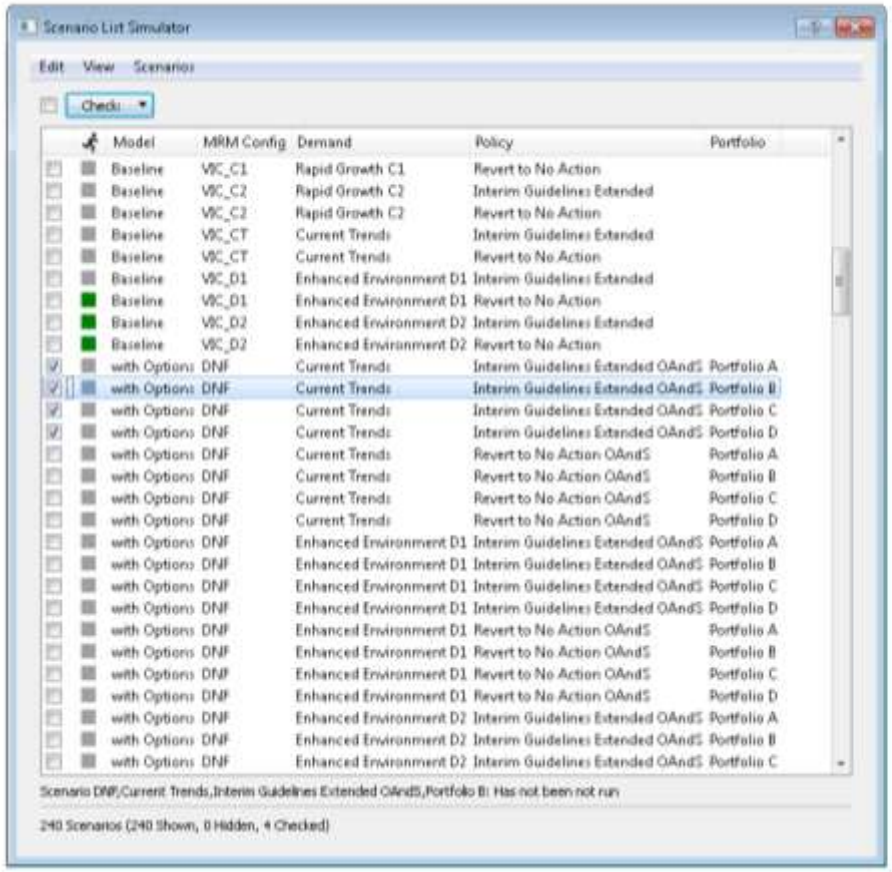
Data generated for automatic import into the RiverWare Operations Model

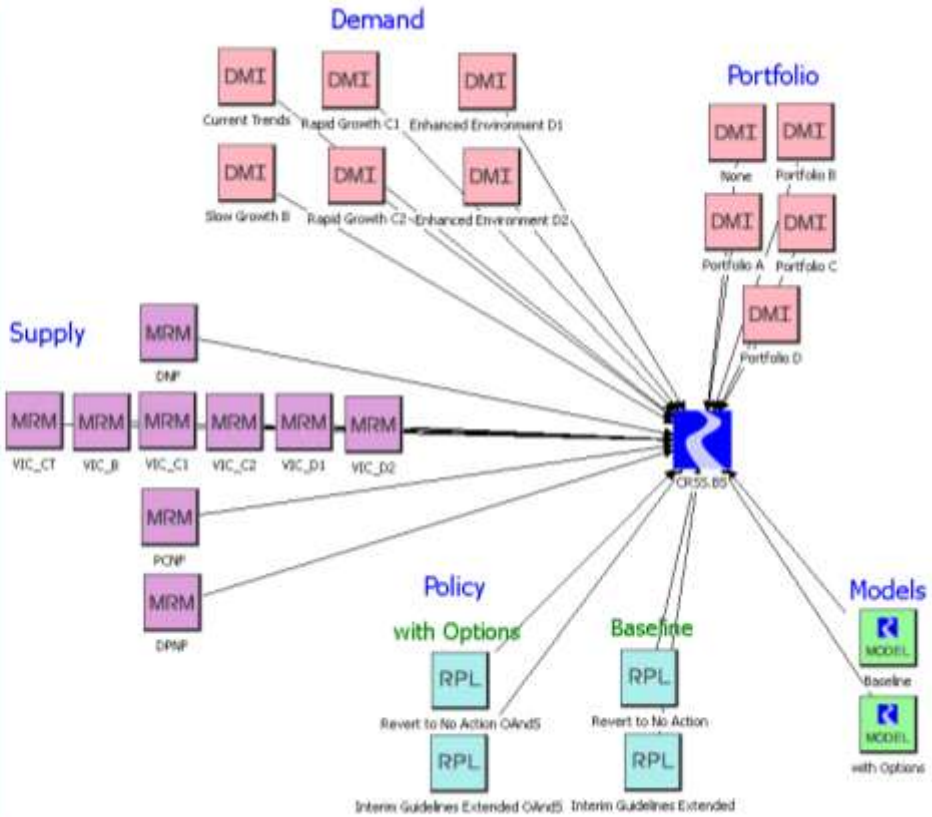
RiverSMART System Components



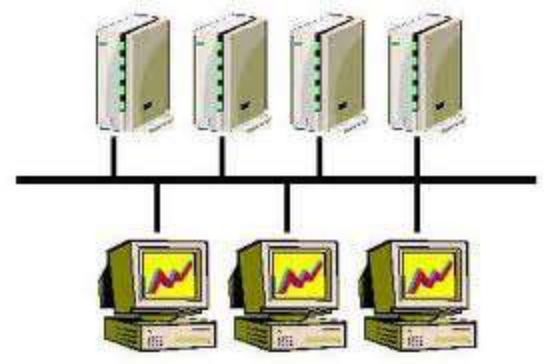
Select Scenarios: combinations of hydrologic and demand projections, operating policies and models (alternative policies and infrastructure)

- Manage input and output for all scenarios
- Automate simulation process
- Can automate generation of results



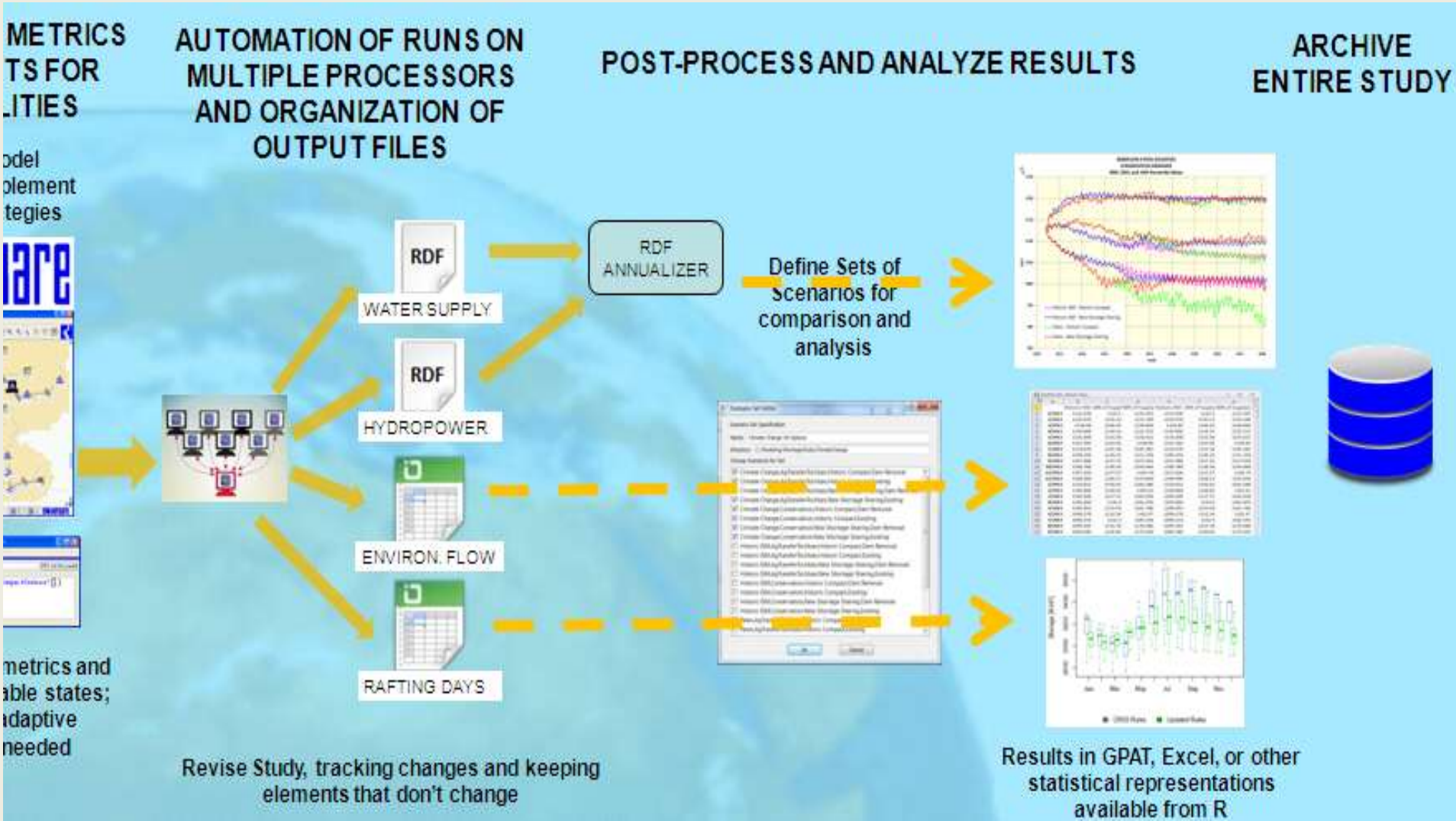


Configure and Execute Study



- Generate all input traces
- Load inputs into the models
- Load policy sets
- Execute runs – use multiple processors and/or multiple computers
- Export data of interest (time series of performance indicators) and organize output
- Send output to analysis tools
- Archive all information (study is repeatable)

RiverSMART System Components



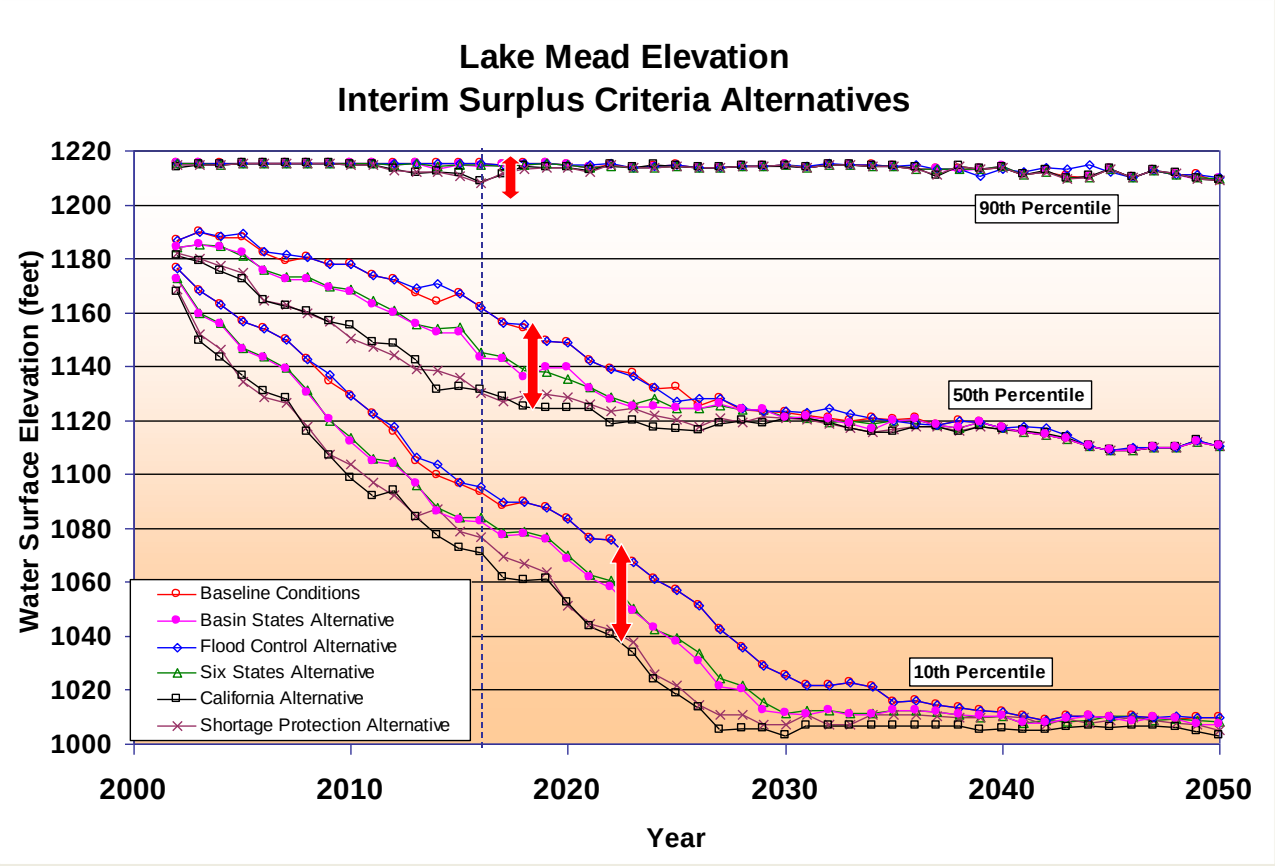
Graphical Policy Analysis Tool (GPAT)

Excel-based Tool for statistical analysis of ensemble output to compare:

- Decision Variables and Performance Indicators

  e.g., storage, P.E., power, flow, risk of shortage

- Compare policies
- See trends over time



Development Status

- Study Manager 1.0 is “released”
- beta testing
- Colorado River Basin Study used some portions
- Support for use of tools for other studies
- Many enhancements desired. Funding in FY14 for continued development