



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

UNIVERSITY OF COLORADO **BOULDER**

# Overview of RiverWare Optimization and Hydropower Modeling

**2023 RiverWare User Group Meeting**

**Tim Magee**

# Comparing Optimization and RBS

## Rule Based Simulation

- Progress through timesteps
  - Execute all rules, then advance timestep
  - Objects dispatch one at a time
  - “Look Ahead” requires explicit logic
- Evaluate a prescribed solution
  - If then rules
- Typical uses
  - System driven by laws, agreements, etc.
  - Many policy rules to follow
  - Long-term and Mid-term planning
- RiverWare Policy Language

## Optimization

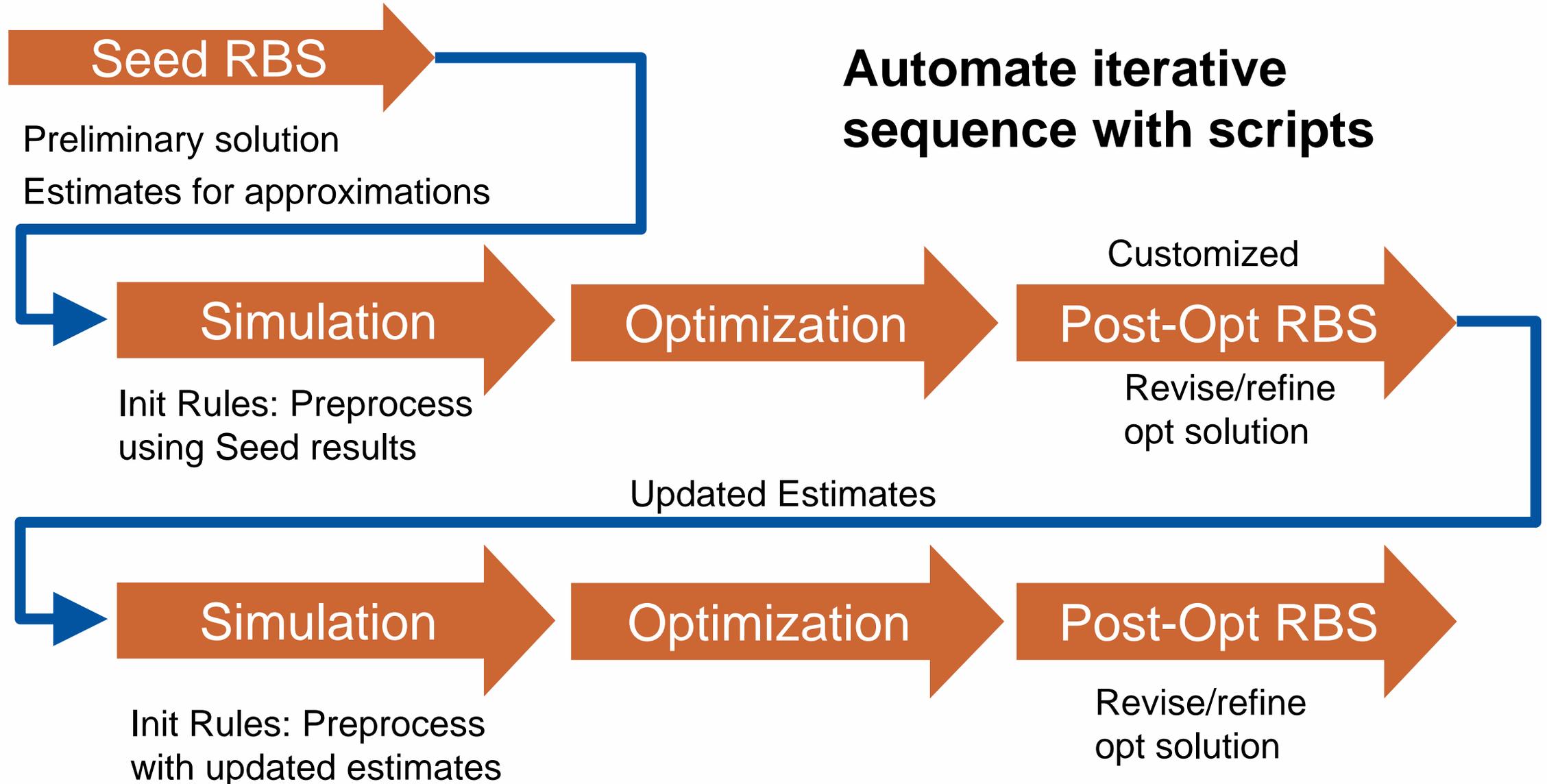
- Global solution in time and space
  - All timesteps and all objects at once
  - Constrain the solution more at each step
- Find the best constrained solution
  - Minimize or Maximize objectives
- Typical uses
  - System driven by system-wide effects and/or looking ahead in time
  - Best use of resources
  - Short-term and Mid-term planning
- RiverWare Policy Language

# Preemptive Linear Goal Programming

- Goals
  - Soft Constraints -> Max satisfaction
  - Minimize and/or maximize objectives
- Preemptive
  - Prioritize goals: high to low
  - Lock in best value at each priority
- Linear (and piecewise linear)
  - Constraints
  - Objectives

Name	Priority
▸ <b>P</b> License Pool Elevations	
<b>G</b> License Max Pool Elevation	1
<b>G</b> License Min Pool Elevation	2
▸ <b>P</b> Minimum Flows	
<b>G</b> Minimum Flow Requirements	3
▸ <b>P</b> Green River Daylight Flows	
<b>G</b> Green River Daylight Flow Restriction	4
▸ <b>P</b> Target Operating Elevations	
<b>G</b> Target Forebay Operating Range	5
▸ <b>P</b> Ending Elevation	
<b>G</b> Ending Elevation Target	6
▸ <b>P</b> Economic Objective Function	
<b>G</b> Maximize Hydropower Revenue	7

# Optimization and Other Controllers



# Hydropower of RiverWare Optimization Users

Hydropower	Installed Capacity (MW)	Generation (GWh)
U.S. Total	102,867	322,390
RiverWare Opt Users	32,514	~113,530
Percent	32 %	35%

# Optimization Enhancements

- Optimization Restore Points
  - Common higher priority goals
  - Create a restore point
  - Alternative sets of lower priority goals
    - Advanced start at the restore point
- Optimization MRM
  - Parallel optimization runs
    - Example: Alternative sets of lower priority goals
- Statistics Library
  - Example: sensitivity analysis on alternative sets  HP value

# Production Cost Models and HP Flexibility

- Production Cost Models (PCM):
  - Minimizing power cost: Generation, Load & Transmission
  - PCMs are hard problems; Can't include many water constraints
- TVA Portfolio Optimization - Iterative
  1. RiverWare calculates extreme generation for all time periods
  2. PCM calculates ideal hydropower from PCM perspective
  3. New RiverWare objective: As Close As Possible to ideal HP
- Research: improving hydropower modeling in LT PCMs
  - Ability of HP to respond to price and respond to load signals

# Optimization Modeling Examples

- Special Operations
  - Promised vs Possible Special Operations
    - High priority vs Low priority
  - 80-90% can be modeled with optimization, some better than Sim
- Occasionally, physical processes are tricky to model
  - Optimization will game the modeling if there is an incentive
  - Example: sloped storage modeling  careful policies
- Transitioning from simulation to optimization: one method
  - Optimize later days, get feedback, add opt days, repeat