

DCDC's WaterSim

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(DCDC)

Phoenix, AZ.

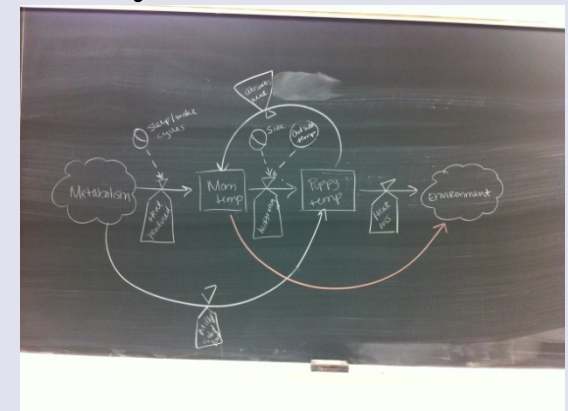


Simulation Models

- *Simulation*: Imitate the operations of a facility or process (via a computer)
- What's being simulated is the *system*
- To study systems we make assumptions/approximations, both logical and mathematical
- These assumptions form a *model* of the system
- If simple enough, could use mathematical methods to get:
 - 1) *Exact information* on questions of interest —*analytical solution*
 - 2) *Approximate information*— *numerical solution*
- A model is a collection of *Hypotheses*

Systems:

- *System*: A collection of entities (people, parts, messages, rivers, urban,...) that act and interact together toward some end (Schmidt and Taylor, 1970)
 - Objectives determine the collection
 - Bounded (physical and logical)
 - Detail often varies
 - Usually a time element – *dynamic* system
- *State* of a system: Variables and their values necessary to describe the system at that time
- *Fluxes*: material movement among states
- *Driver Variables*: impact the rates
- *Auxiliary Variables* (parameters)



Jay Forrester

Classification

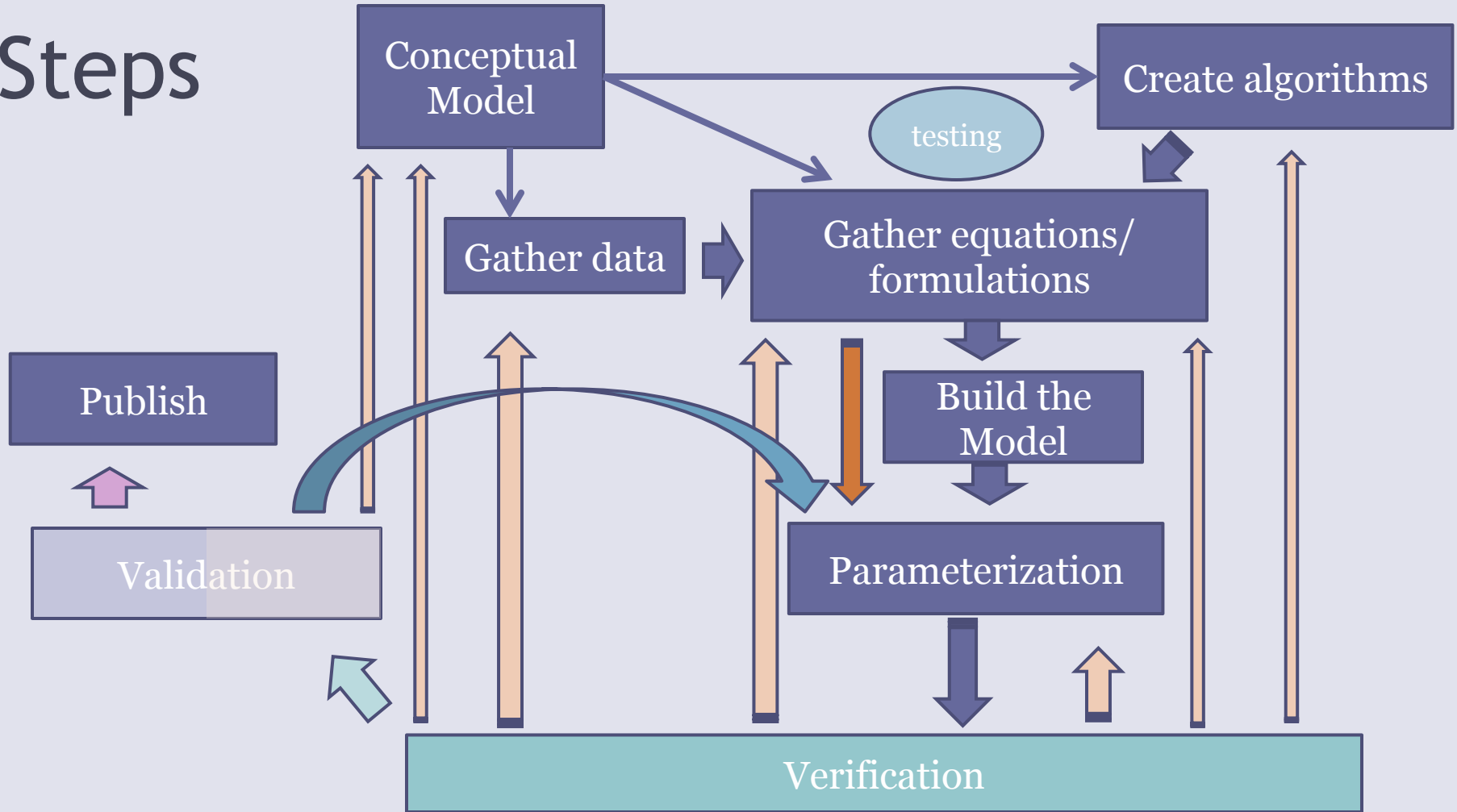
- Classification of simulation models
 - *Static vs. dynamic (steady state vs. time-dependent)*
 - *Deterministic vs. stochastic (initial conditions give similar results vs. probability distributions)*
 - *Deductive vs. Inductive (Based on theory vs. empirical generalizations)*

WaterSim is dynamic, deterministic, and both deductive and inductive.

Some Terminology

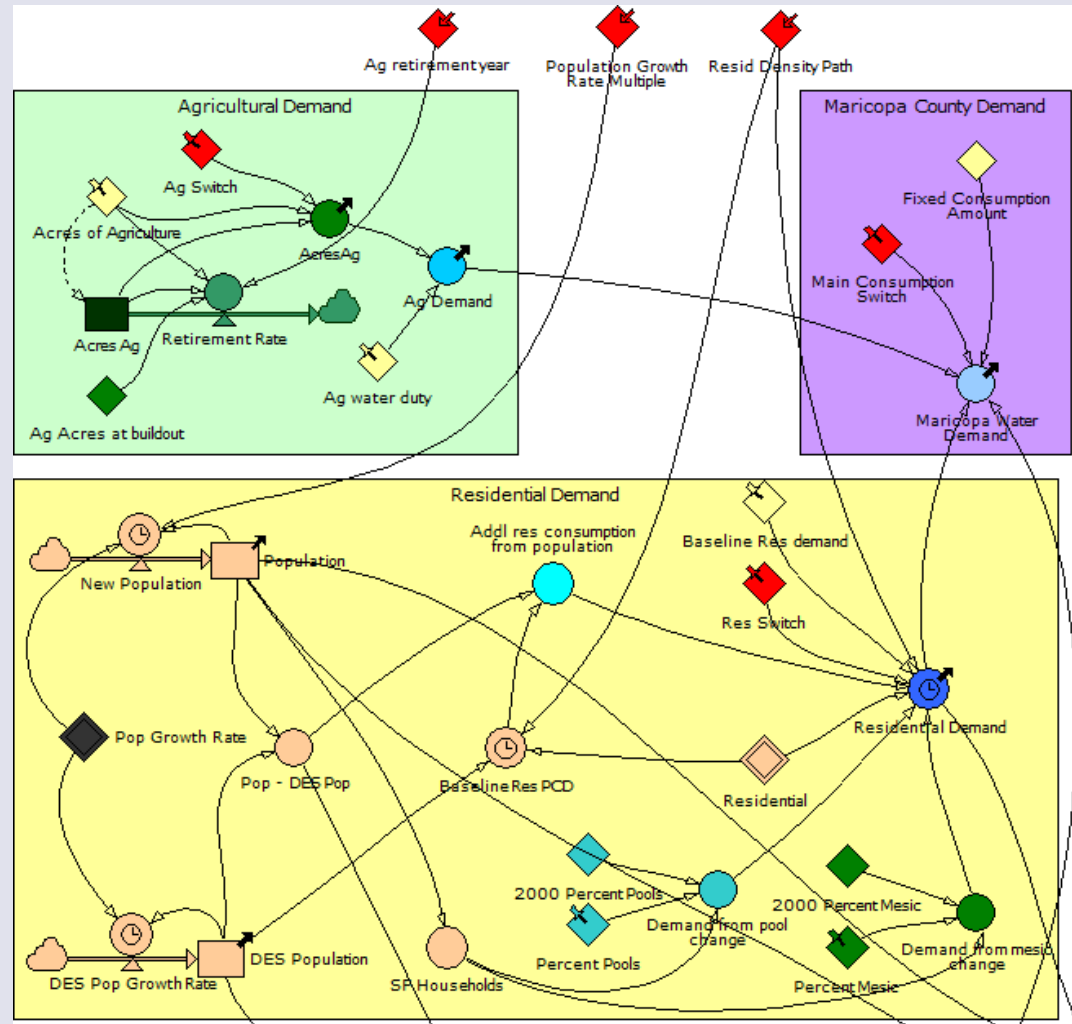
- **Parameterization** : “fit” the model using empirical data-constants, functions, theory, etc. that enable verification.
- **Verification** : Do functions, responses, and outputs trend with reality? e.g. linear increases, curve-linear decreases over time, greater, lessor, etc.
- **Validation** : How well do outputs agree with alternative data? (usually empirical data, but sometimes other model results).

Steps



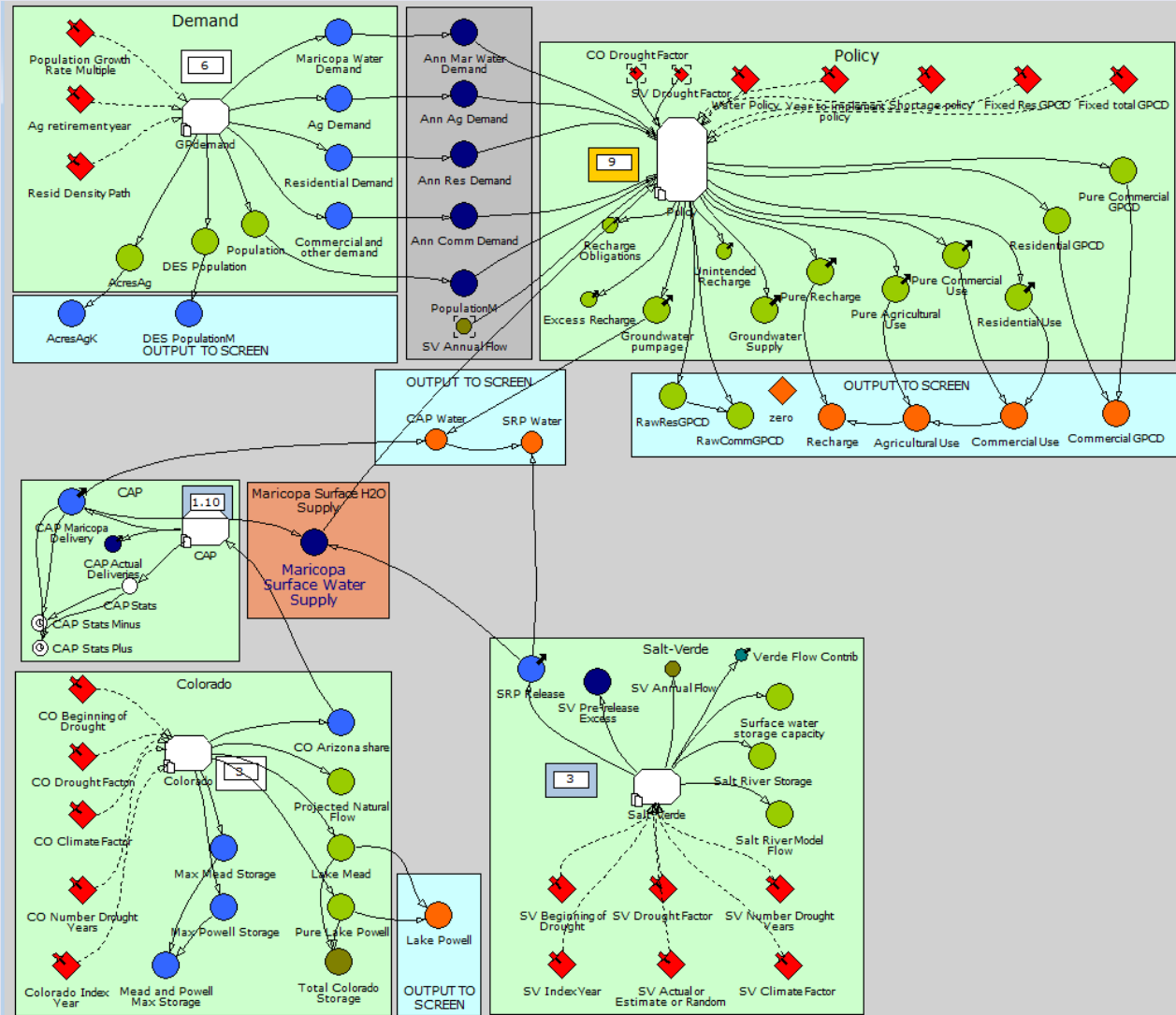
WaterSim 1

- PowerSim®
- County Scale



WaterSim 2

- PowerSim[®]
- County Scale



WaterSim 3

Policy Tra

Policy start year

2020

Total est
per person p

Indoors **78**



toilet 5.3 flushes 3.9 gal/flush



clothes washing 0.4 loads 42.1 gal/load



showers 0.8 10.4 min 1.7 gal/min



faucet 6.7 min 1.8 gal/min



leaks 3.8 drips/sec



other domestic 1.8 gal/day



dish washing 0.1 loads 13.6 gal/load

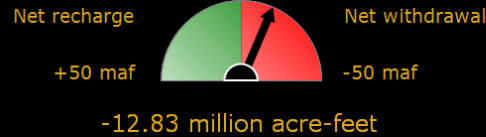
Reset to current demand

Population & Retirement of Agriculture

Phoenix Water Sources

Groundwater Sustainability

Total change, 2006-2030

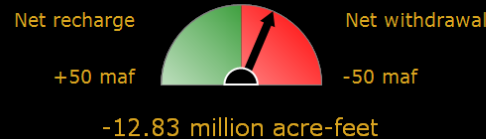


Average change per year, 2026-2030



Save

Total change, 2006-2030



Average change per year, 2026-2030



Scenario summary:

Colorado: 1970-1994 historical period; 100% of average 2006-2030; 100% of historical runoff
 Salt/Verde: 1970-1994 historical period; 100% of average 2006-2030; 100% of historical runoff
 Population: 100% of DES
 Agriculture: buildout by 2069
 Policy: starting in 2020; indoors usage of 78 gpcd; outdoors usage of 146 gpcd



Decision Center
for a Desert City

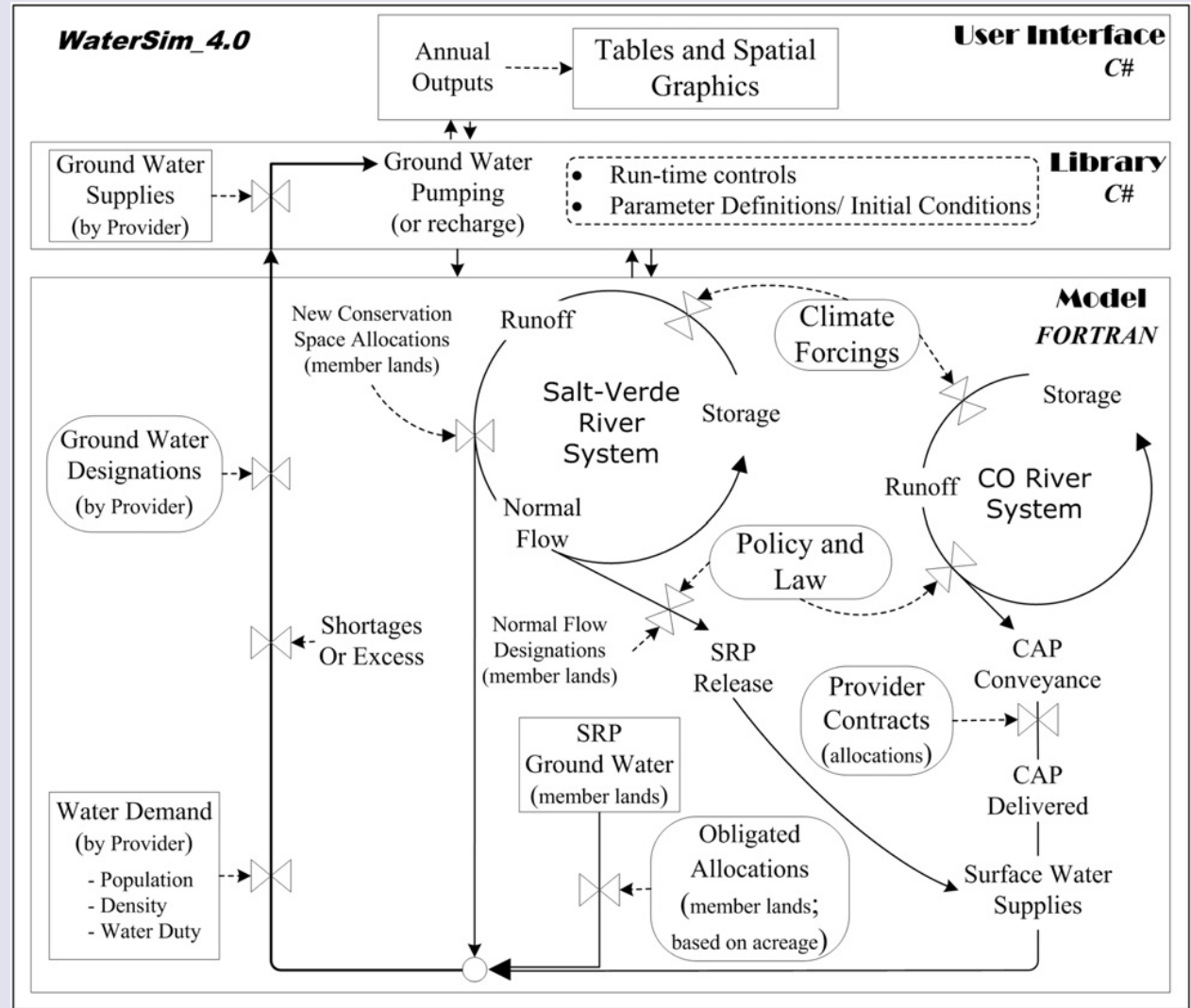
Phoenix, AZ.



ASU GLOBAL INSTITUTE
of SUSTAINABILITY

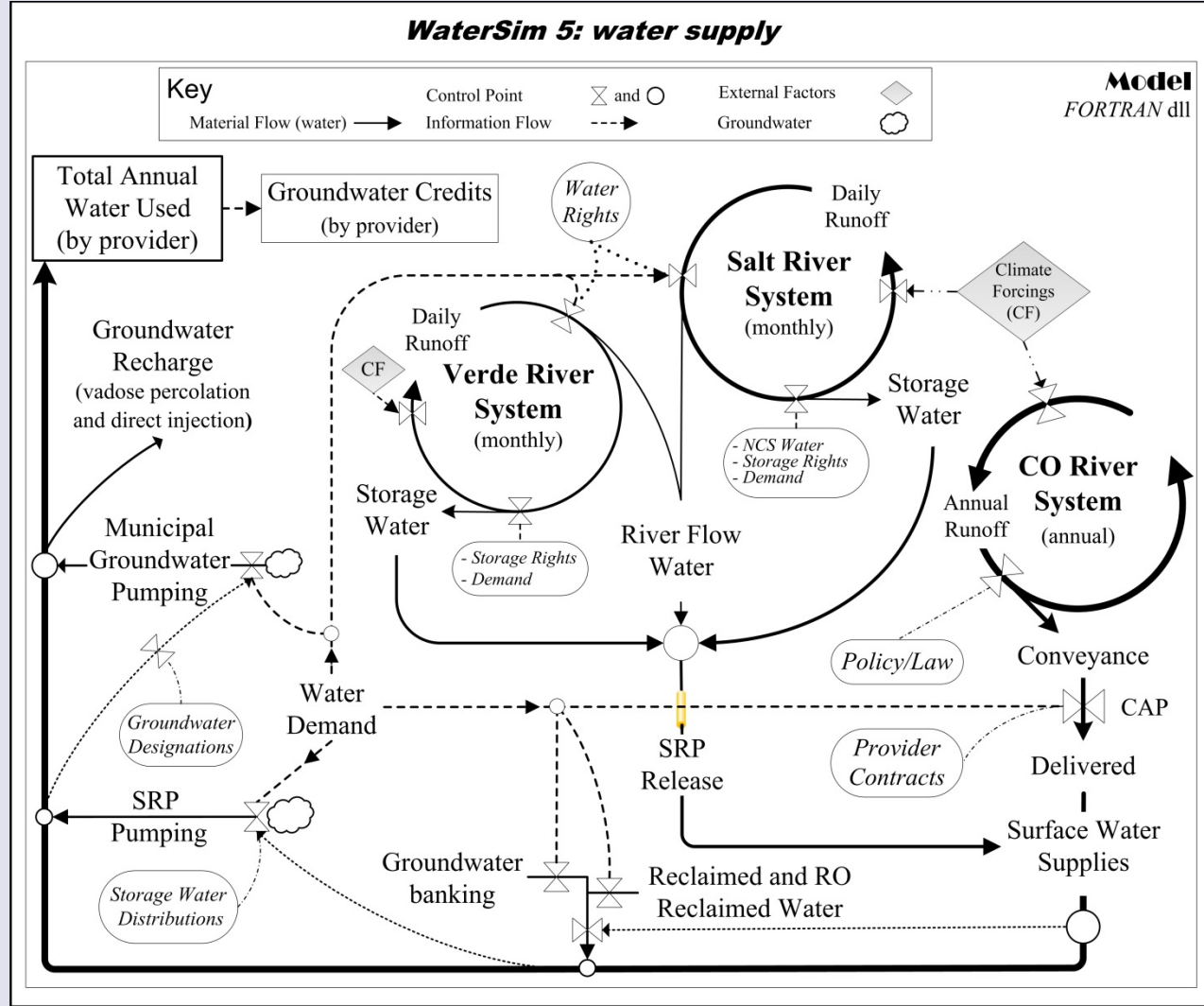
WaterSim 4

Water Supply Model

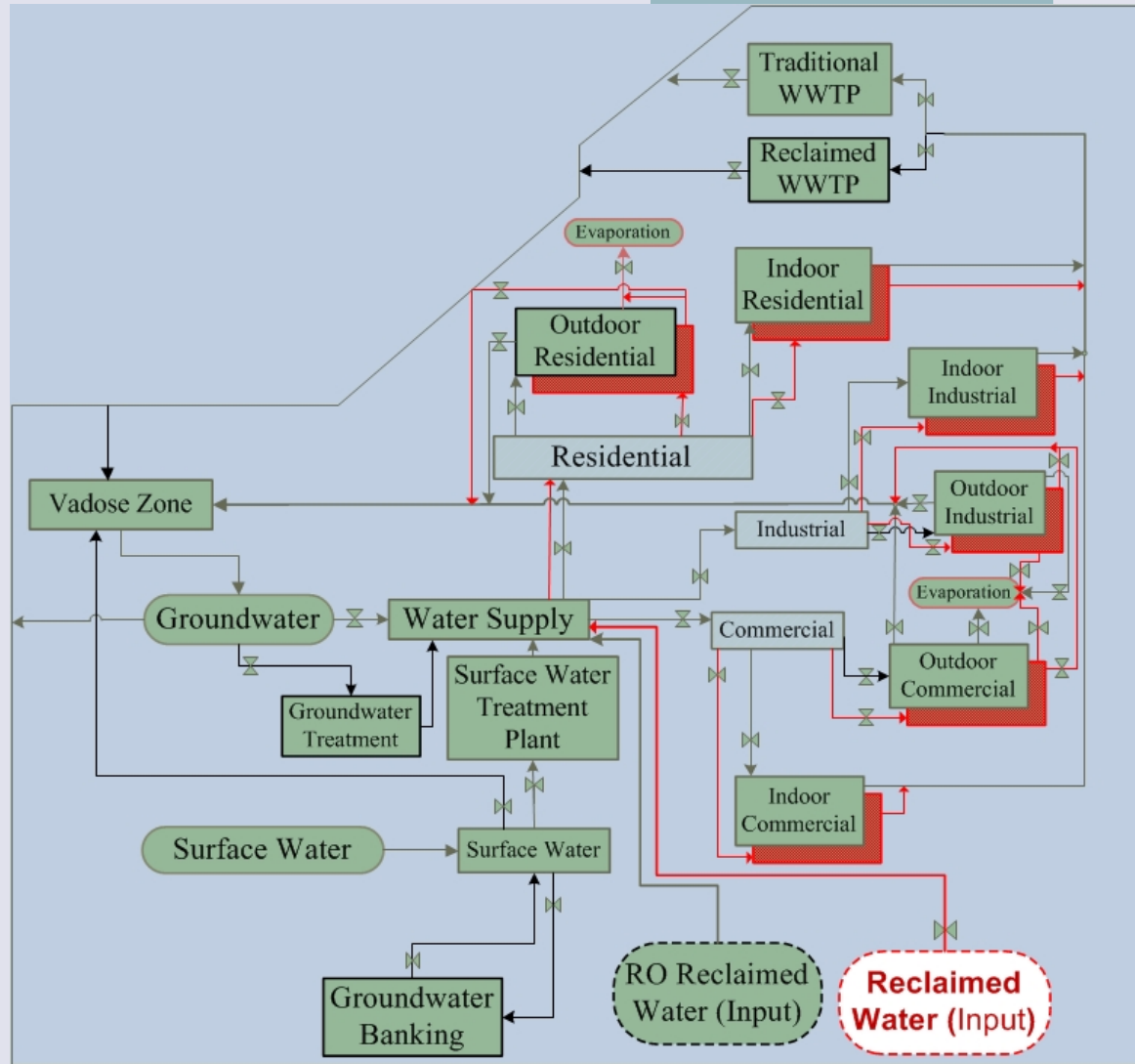


WaterSim 5

Water Demand Model



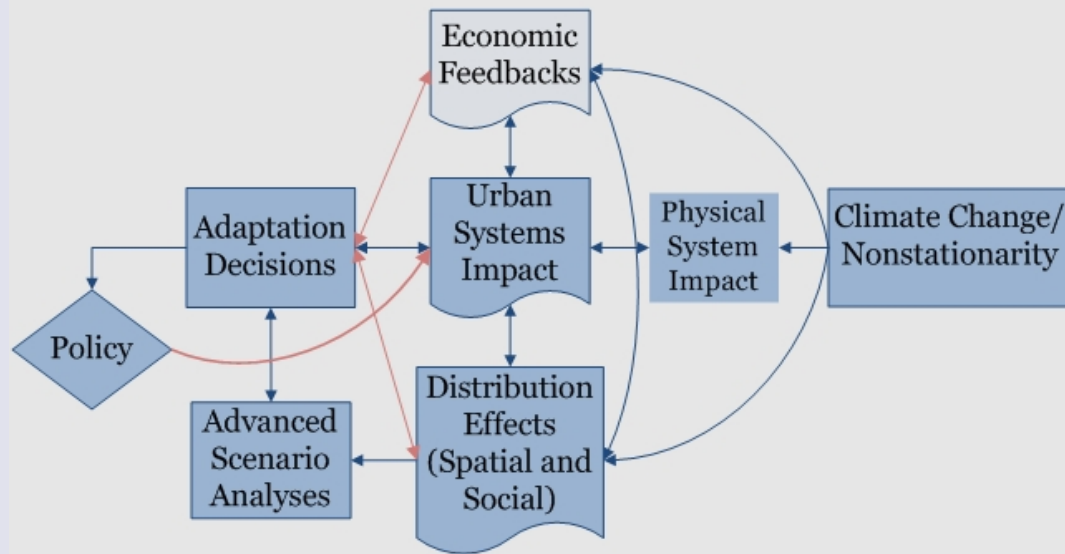
Water Use Network



Alternatives

Outcomes

Uncertainty



DCDC and WaterSim



Policy Levers

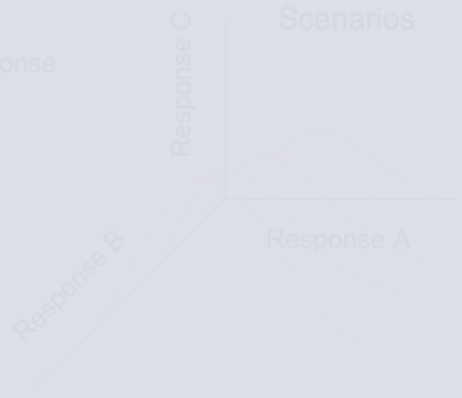
Demand Management

- Municipal Drought Response
- Status Quo Activities
- Growth Management

Supply Management

- Reclaimed Water
- Groundwater
- Water Banking
- Water Exchanges

Scenarios



Phoenix, AZ.



Verification and Validation

Is the structure correct and are the outcomes believable?

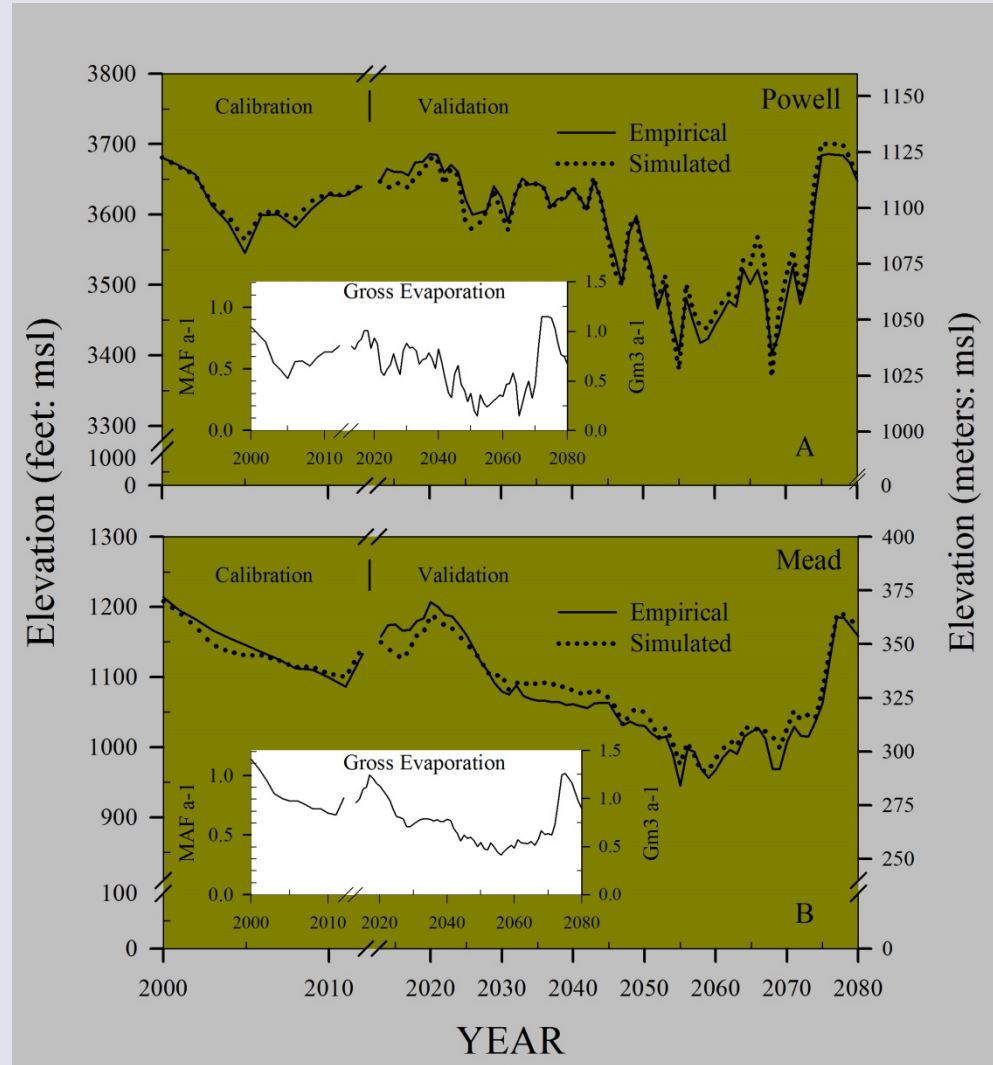
Do the rules and algorithms follow law?

Are the driving variables, levers, and outputs pertinent?

The Model Must Be:

- ✓ Credible
- ✓ Legitimate
- ✓ Salient

Colorado River

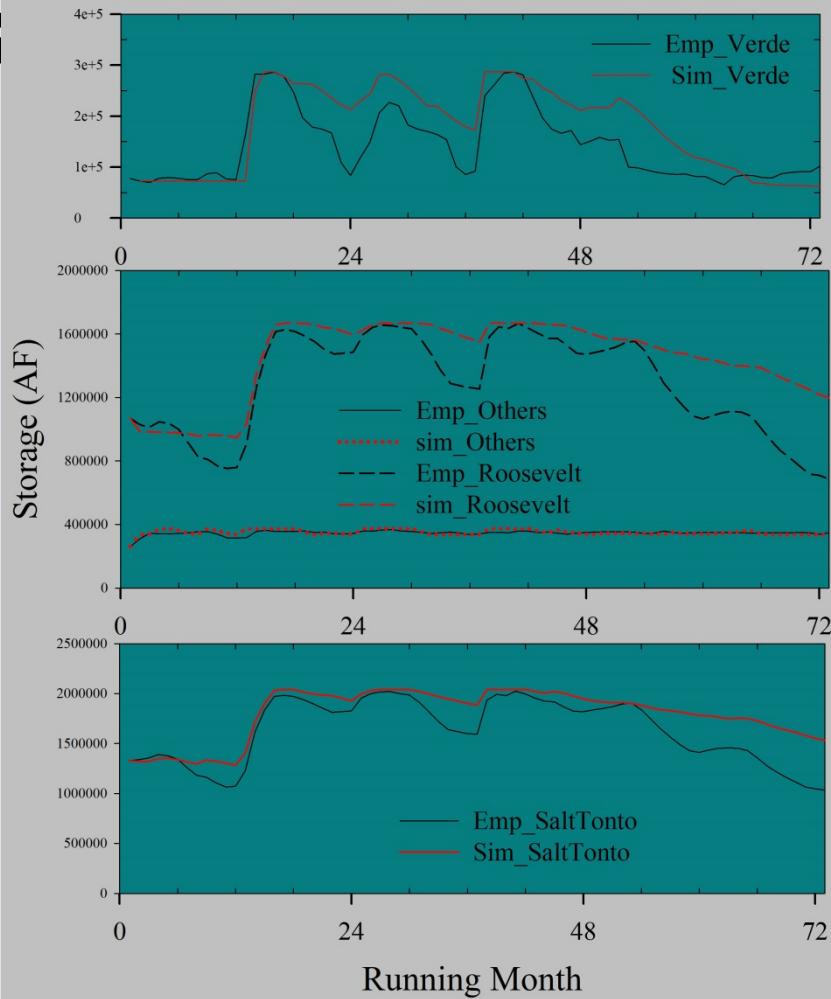


Phoenix, AZ.

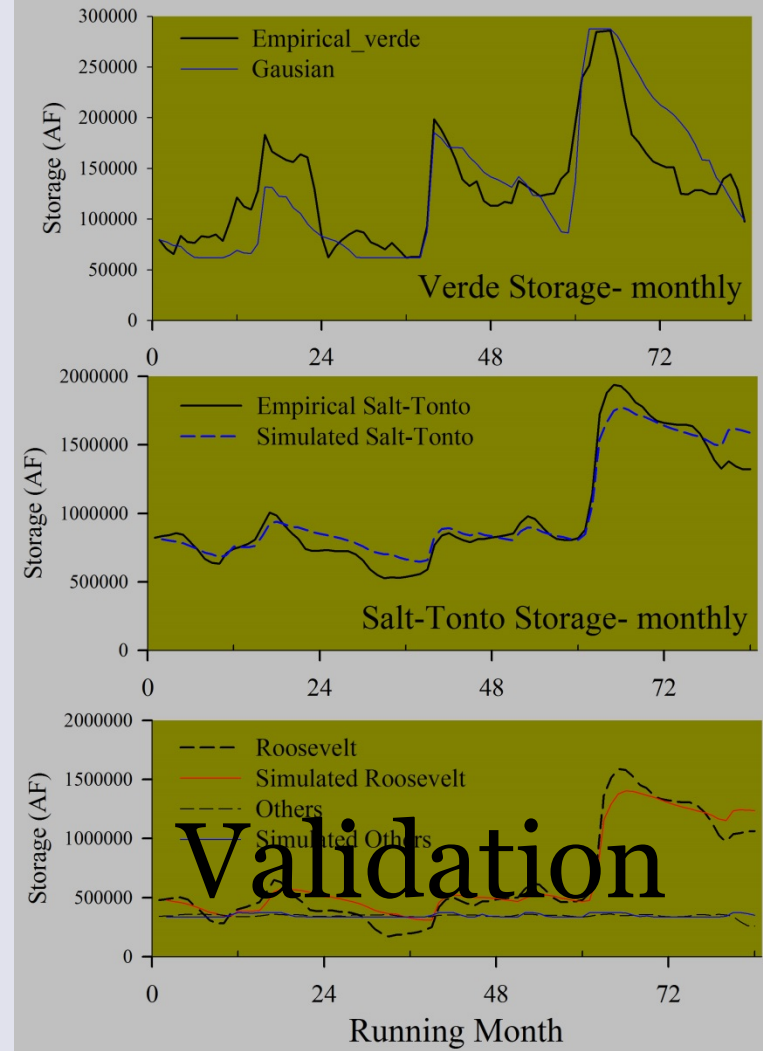


Pa

04.19.13 Validation - Salt-Tonto and Verde Rivers



04.24.13



Water Provider/ Educator Participation

Communication Avenues

A. Stakeholder feedback

- 1) Parameterization
- 2) Policy Options (& metrics)
- 3) Empirical Comparisons

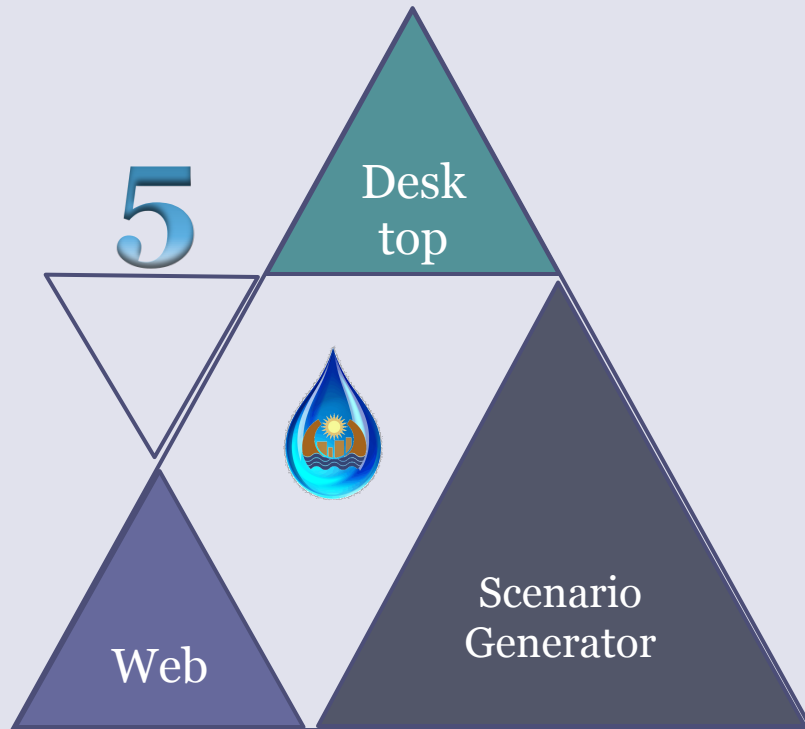
B. Application Interface

- 1) Framework (structure)
- 2) Look and feel
- 3) Visualization of Outputs

WaterSim Base Data for Phoenix

Item	Description	Units	Current Value	NewValue
Use GPCD	The GPCD that will be used if [Provider Demand Option] is set to Value=4.	GPCD	206	
% Effluent to Reclaimed Plant	The percent of Waste water effluent that is sent to a Reclaimed Plant (versus a traditional plant-see figure 1).	%	1	
% Total Wastewater is Usable Effluent	The percent of Waste water effluent that is used and not discharged into a water course (note: if PCEFFREC [below] is set to 100% no waste water is sent to the traditional WWTP and, so, no effluent will be available for partitioning).	%	81	
% Reclaimed to RO	The percent of reclaimed water that is sent to a Reverse Osmosis Plant (thus becoming potable water for direct injection or potable water for use in the next time-step).	%	0	
% RO to Water Supply	The percent of water from Reverse Osmosis Plant that is used for potable water.	%	0	
% Reclaimed to DirectInject	The percent of reclaimed water that is used to recharge an aquifer by direct injection into an aquifer.	%	0	
% Reclaimed to Water Supply	The percent of reclaimed water that is used to meet qualified user demands (non-potable).	%	100	
% Reclaimed to Vadose	The percent of reclaimed water that is delivered to a vadoze zone recharge basin.	%	0	
% Effluent to Vadose	The percent of wastewater effluent delivered to a vadoze zone recharge basin.	%	4	

WaterSim Versions

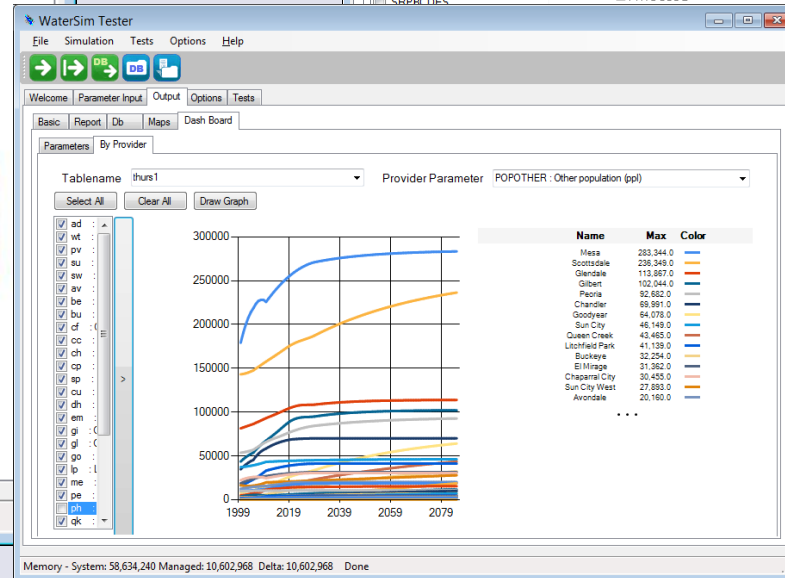
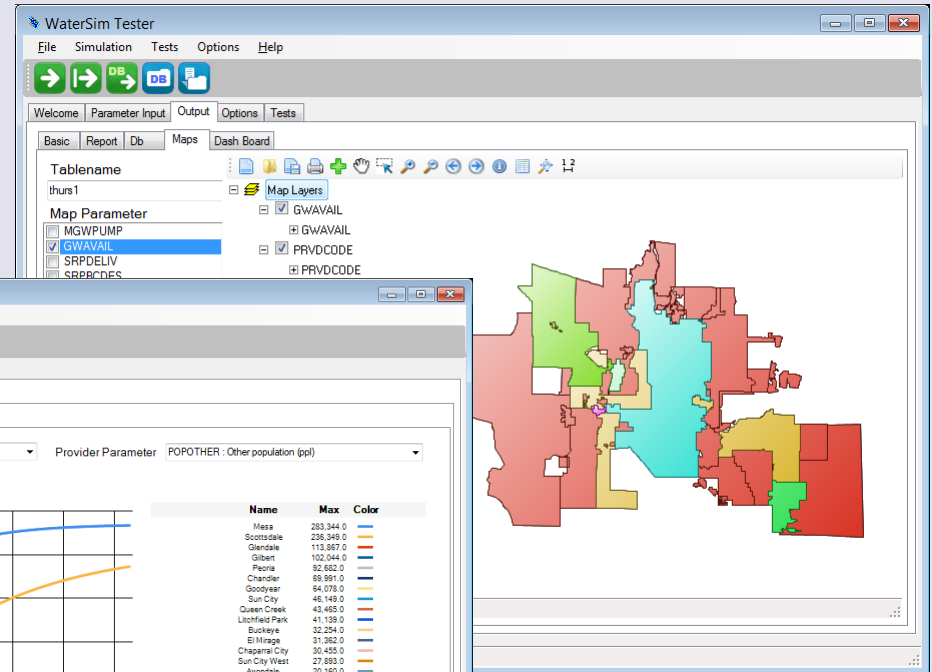


WaterSim is: Evolving water policy and management

- ✓ Physical model of rivers and reservoirs
- ✓ Policy model with management options
- ✓ Urban model with representative city infrastructure

Missing

Desk Top Version



Web Version

Web Beta Version

Decision Center for a Desert City's **WaterSim** Model

WELCOME to Arizona State University DCDC's **WaterSim** Project.



Introduction video (1 minute)

WaterSim is a simulation of water supply and demand for the Phoenix Metropolitan area that integrates information about climate, land use, population growth, and water policy. Adjustable settings allow you to gauge future water-supply conditions in response to climate change, drought, population growth, technological innovation, as well as policy decisions about the nature of the region's built environment, landscaping practices, and recycled water.

WaterSim contains multiple submodels; these submodels work together to simulate the future of our water. Some of the submodels, like the Colorado River shortage sharing agreement, are unchangeable because of legal or natural constraints; others can be adjusted by you. Here are some of the simulation settings that you can adjust:

- Water demand based on population and agricultural use
- Drought conditions on the Colorado River
- Drought conditions on the Salt and Verde Rivers
- The speed at which agriculture can be retired



Browser tabs: dasampso, My ASU - Employe, My ASU - Employe, Inbox (1) - dasam, Dependency Edit

URL: sod04.fulton.asu.edu/projects/watersim/index.php?dashboard=2&id=1346363166257

Lake Mead Water Level

Last year of simulation: 2030
Climate trace: historical river flow data: 1945

Drought Variables: Start Year: 2010, End Year: 2045
Percent Impact on River Run: 50

Browser tabs: My ASU - Employe, My ASU - Employe, Inbox (1) - dasam, Dependency Edit

URL: sod04.fulton.asu.edu/projects/watersim/index.php?dashboard=2&id=1346363166257

Ground Water Credits

Phoenix, AZ.



Scenario Generator

Scenario DB Manager Builder Analyzer

Database Project Help

Scenario Base Builder

Input Parameters Output Parameters Feedbacks (not yet implemented) Ensemble Summary

Select Input Model Parameters

Parameter	Type	Fieldname
<input type="checkbox"/> Colorado User AdjustmentDrou...	Input Base	COUSRSTP
<input type="checkbox"/> Colorado UserDrought Adjustm...	Input Base	COUSRADJ
<input type="checkbox"/> Groundwater Model	Input Base	GWMODEL
<input type="checkbox"/> Ignore AWS Allocation Rule to Li...	Input Base	AWSLIMIT
<input type="checkbox"/> Max % Demand Reclaimed	Input Provider	PCDEMREC
<input type="checkbox"/> Modify Normal Flow	Input Provider	MNFLOW
<input type="checkbox"/> Provider Demand Option	Input Base	DMOPT
<input type="checkbox"/> Provider Off Project Pop Override	Input Provider	POPOVOFF
<input type="checkbox"/> Provider On Project Pop Override	Input Provider	POPOVON
<input type="checkbox"/> Regional % Growth Rate Adjust...	Input Base	PCRRGRW...
<input type="checkbox"/> SaltVerde Historical ExtractionS...	Input Base	SVEXTSTYR
<input type="checkbox"/> SaltVerde HistoricalSVerdeTont...	Input Base	SVSRC
<input type="checkbox"/> SaltVerde User AdjustmentSVer...	Input Base	SVUSRSTR
<input type="checkbox"/> SaltVerde User AdjustmentSVer...	Input Base	SVUSRSTP
<input type="checkbox"/> SaltVerde UserSVerdeTonto Dro...	Input Base	SVUSRADJ
<input type="checkbox"/> SaltVerdeSVerdeTonto Climate ...	Input Base	SVCLMADJ
<input type="checkbox"/> Simulation End Year	Input Base	STOPYR
<input type="checkbox"/> Simulation Start Year	Input Base	STARTYR
<input type="checkbox"/> Surface to Vadose Time Lag in Y...	Input Provider	VADLAG
<input type="checkbox"/> SurfaceWater to Vadose (AF)	Input Provider	PCSWVAD
<input type="checkbox"/> SurfaceWater to WaterBank (AF)	Input Provider	SWWB
<input type="checkbox"/> Use GPCD	Input Provider	USEGPCD
<input checked="" type="checkbox"/> Water From Ag Pumping(AF)	Input Provider	WAGPUMP
<input type="checkbox"/> Water Supply for DirectInject (AF)	Input Provider	USEWSDI
<input type="checkbox"/> WaterBank Source Option	Input Provider	WBOPT

Type of Parameter Change

Percent Change Value List

Value Change

Change Over Range

Colorado Climate Adjustment %

Over Range Base Low Value High Value Steps

20 120 4

Colorado Historical ExtractionFlow Trace Start Year

Value List Base Value Add 1946

1977 Delete 1977

Water From Ag Pumping(AF)

Over Range Low Value High Value Steps

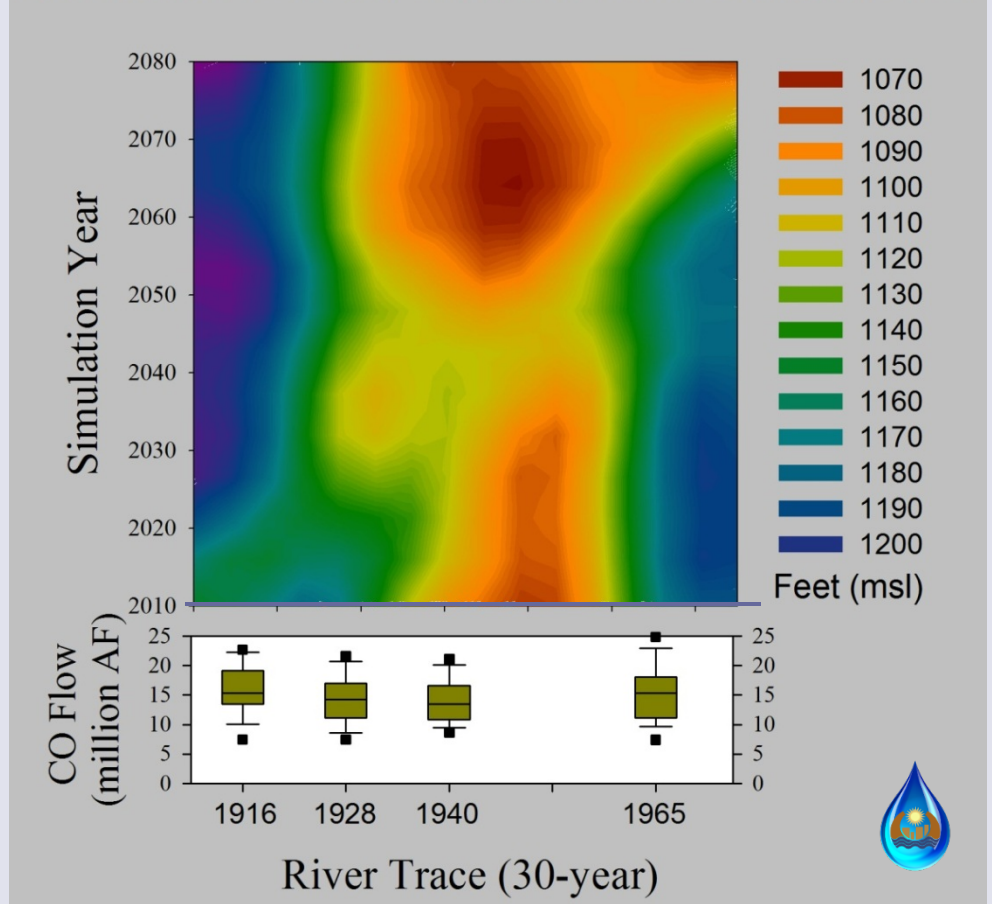
Provider Single 0 0 2

All Providers Phoenix

Sensitivity Analysis

Lake Mead and Shortage Elevations

Lake Mead Elevation: Historical Flows-Colorado River

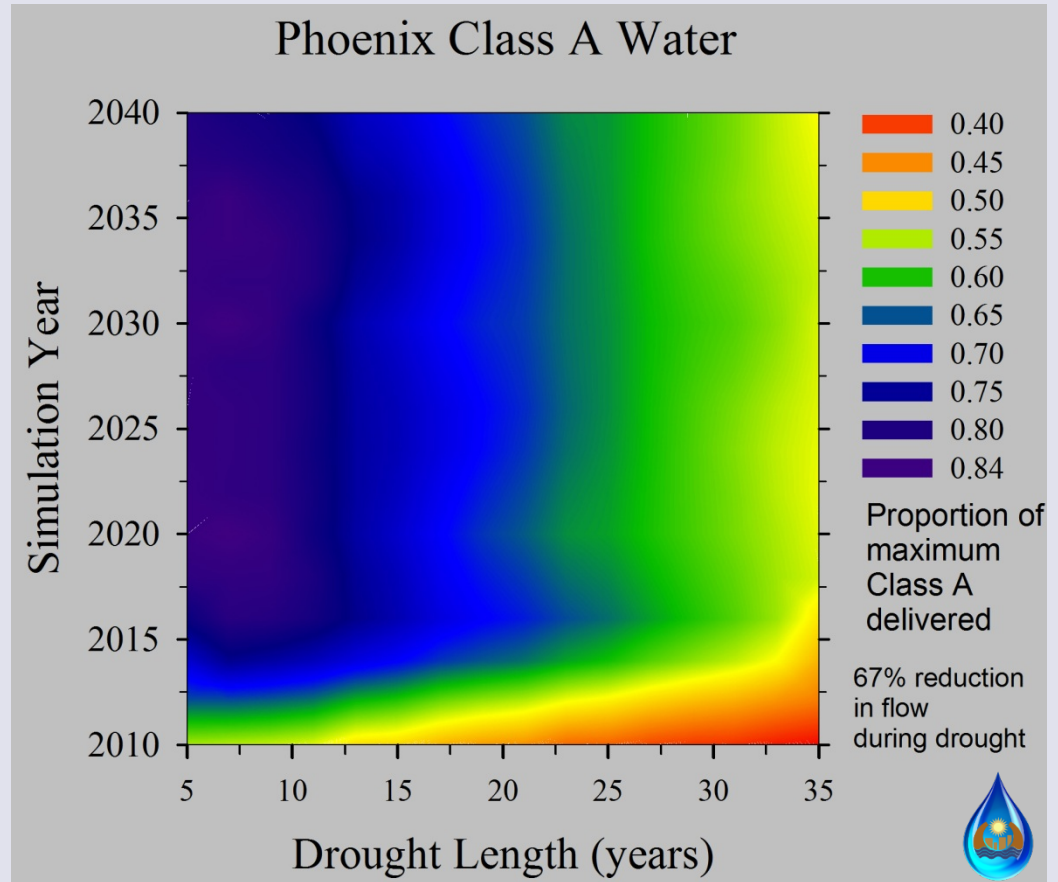


Trigger Points



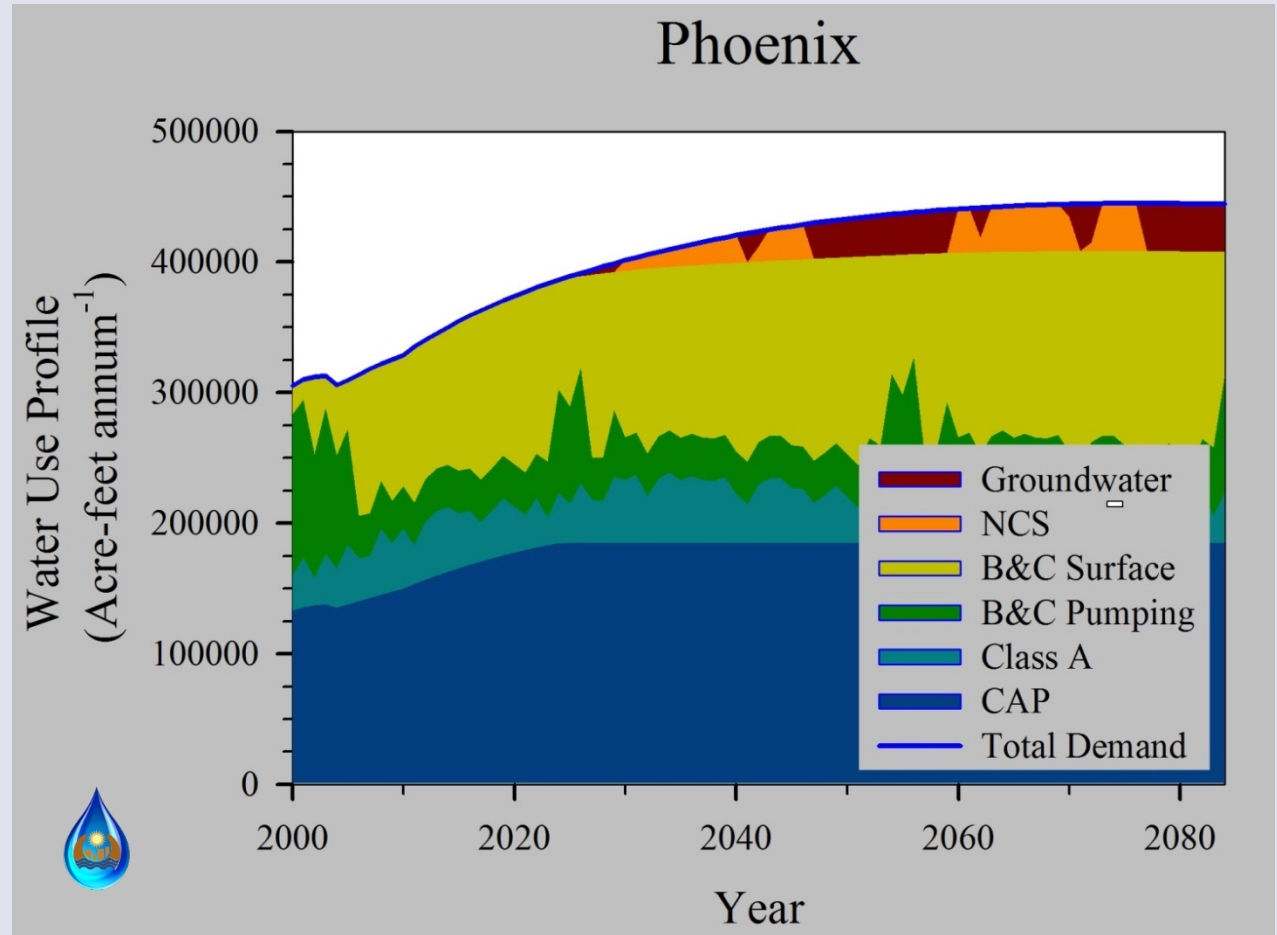
Sensitivity Analysis

Drought and Surface Water



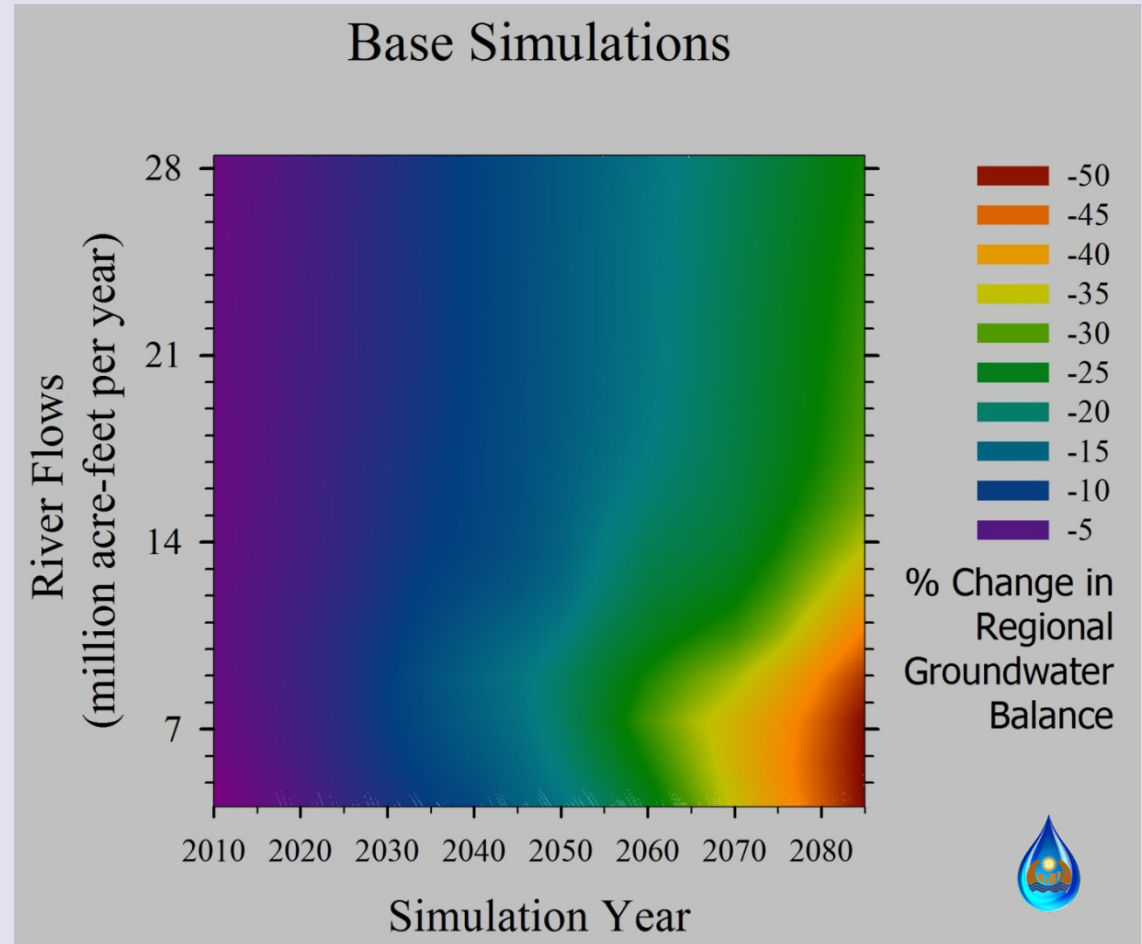
Simulations

Water Profile



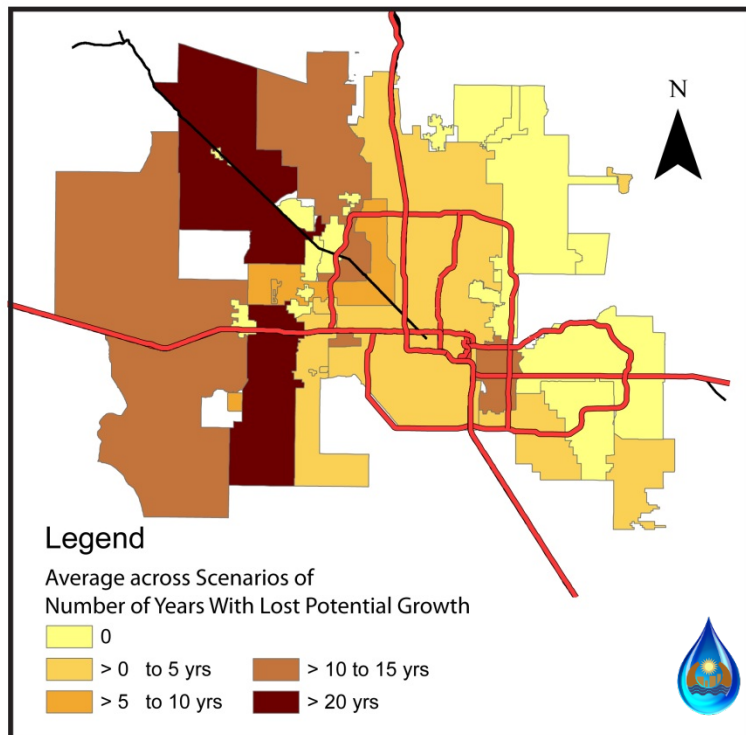
Scenario Analyses

Regional Groundwater



Summary

Average Years With Lost Potential Growth



Open Source Software for:

- 1) Educators
- 2) Researchers
- 3) Water Managers

Future Work:

- 1) Verify Water Provider Inputs (profile data)
- 2) Create Interfaces that Water Managers will use
- 3) Explore Scenarios of Future Water Reality Potentials

**Thank-you for
your attention!**

