Framework for Evaluating a Complex Water Resources System Performance under a Changing Climate

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National Partners in Climate Change Research (WUCA)

Public Water Supply Utilities
Climate Impact Working Group

TAMPA BAY WATER

GRU More than Energy

miamidade.GOV

Peace River Manasota Regional Water Supply Authority

PALM BEACH COUNTY FLORIDA

UF UNIVERSITY of FLORIDA Water Institute

Southeast Climate Consortium

COAPS

Florida Climate Institute

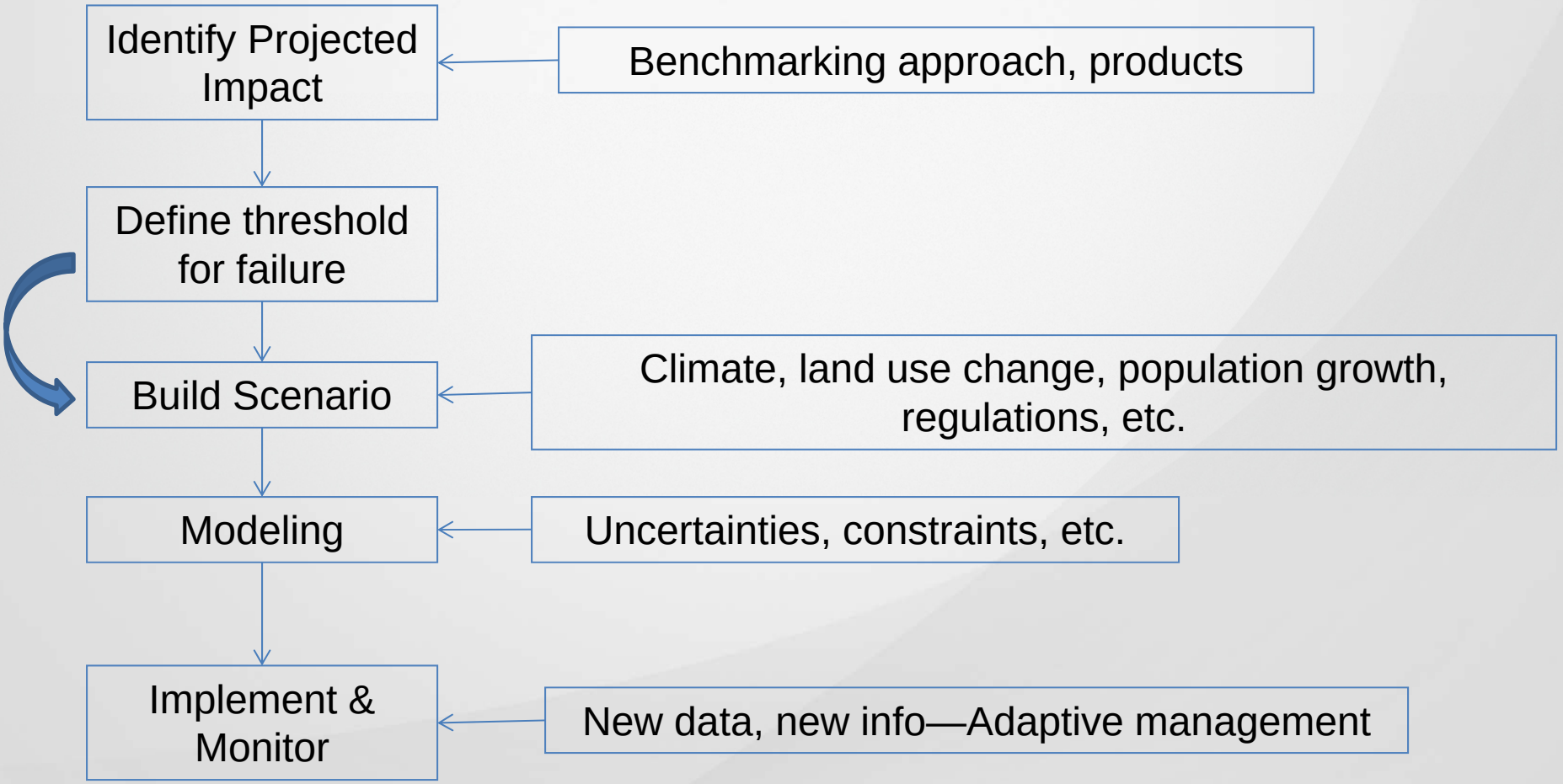
ST. JOHNS RIVER WATER MANAGEMENT DISTRICT

SOUTH FLORIDA WATER MANAGEMENT DISTRICT

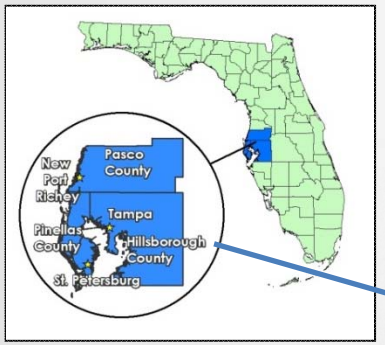
sfwmd.gov

Southwest Florida Water Management District

Framework


Identify Projected Impact
Benchmarking approach, products
Define threshold for failure
Build Scenario
Climate, land use change, population growth, regulations, etc.
Modeling
Uncertainties, constraints, etc.
Implement & Monitor
New data, new info—Adaptive management

Who We are

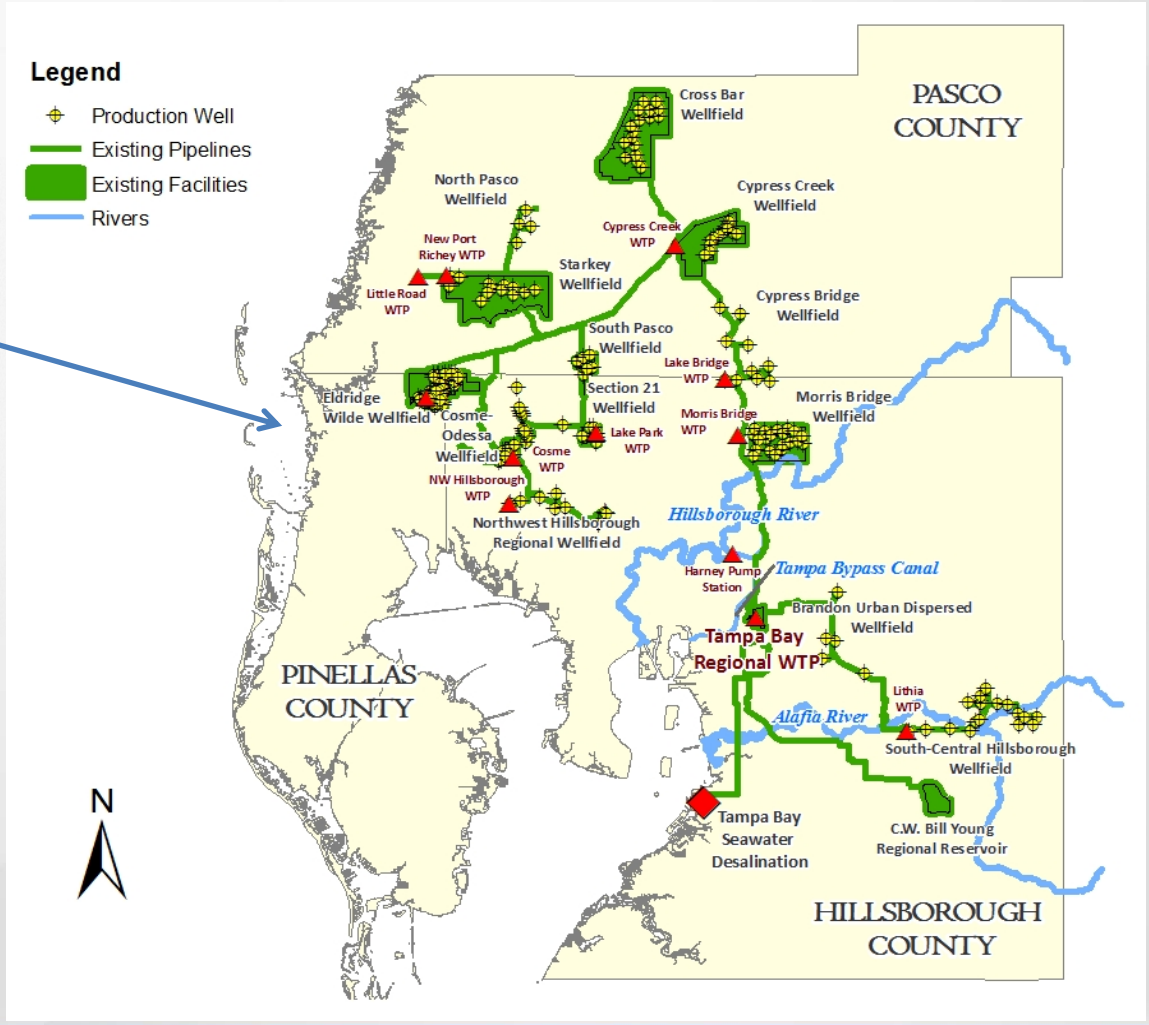


Wholesale drinking water to six governments

2.4 Million Residents

220-250 mgd annual average

Seasonal to multi-year variable climate



Who We are (Cont.)

Desal Water

TAMPA BAY WATER

What you need to know

It has come to this: Officials have imposed the toughest watering restrictions in the Tampa Bay area's history. As the three-year Florida drought continues to drain the Tampa Bay water supply, homeowners and local officials increasingly are turning to water conservation. People want to know what is being done to help, how they can help and when will it end. This special report is the place to check back constantly for news that directly affects you.

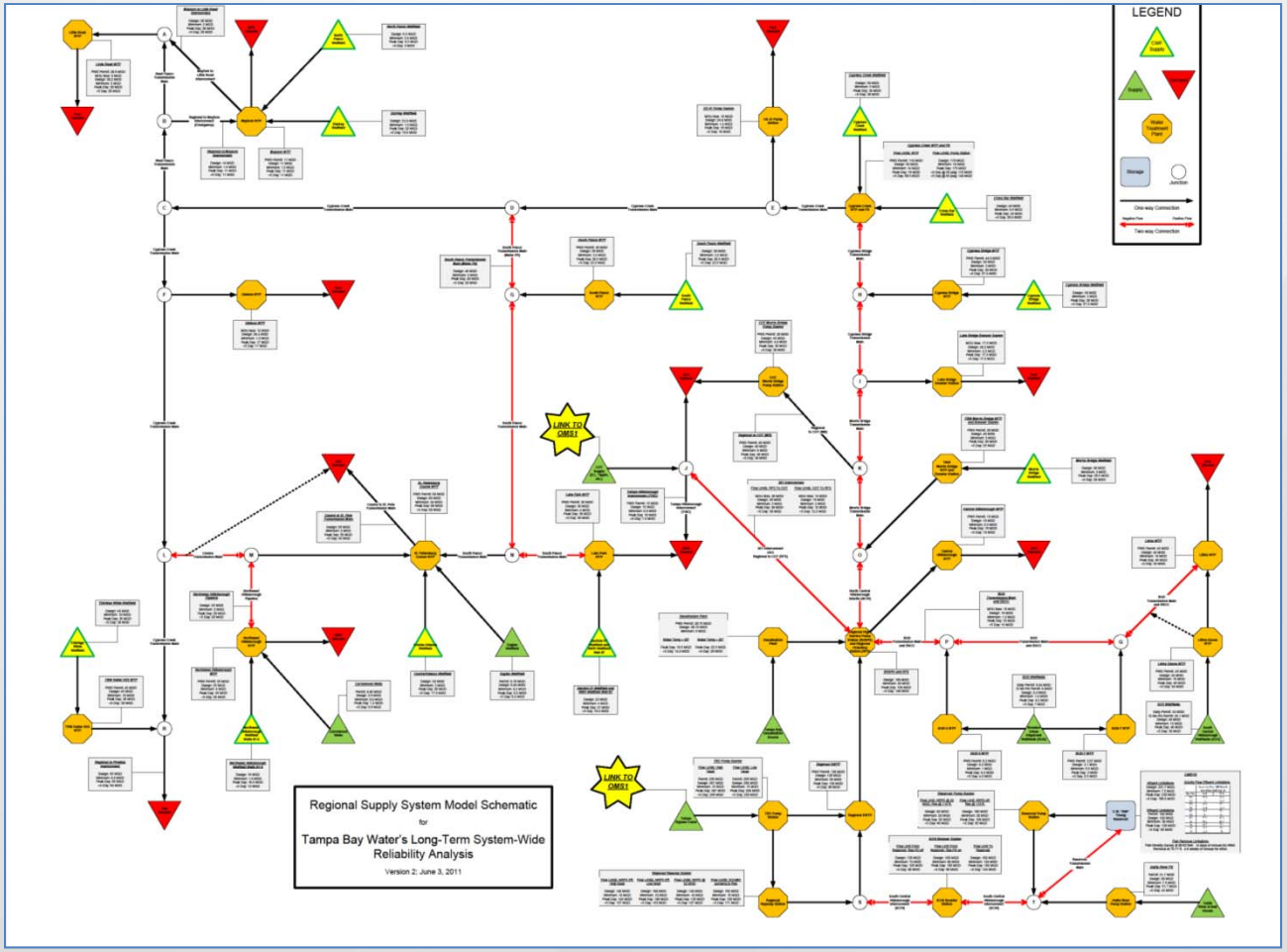
Performance Evaluation under Varying Climatic Condition

Asefa, T., Wanakule N., Adams, A., Shelby, J. and J., Clayton 2012. On the use of System Performance Metrics for Assessing Incremental Water-use Permit, *Journal of Water resources Planning and Management*, in review.

RRV: Definition (Hashimoto et al., 1982)

- Reliability:
  - Describes the frequency or probability of a system in satisfactory state
- Resilience:
  - Describes how quickly a system rebounds from an unsatisfactory state
- Vulnerability:
  - Describes how severe is the unsatisfactory state/or the parameters that caused it

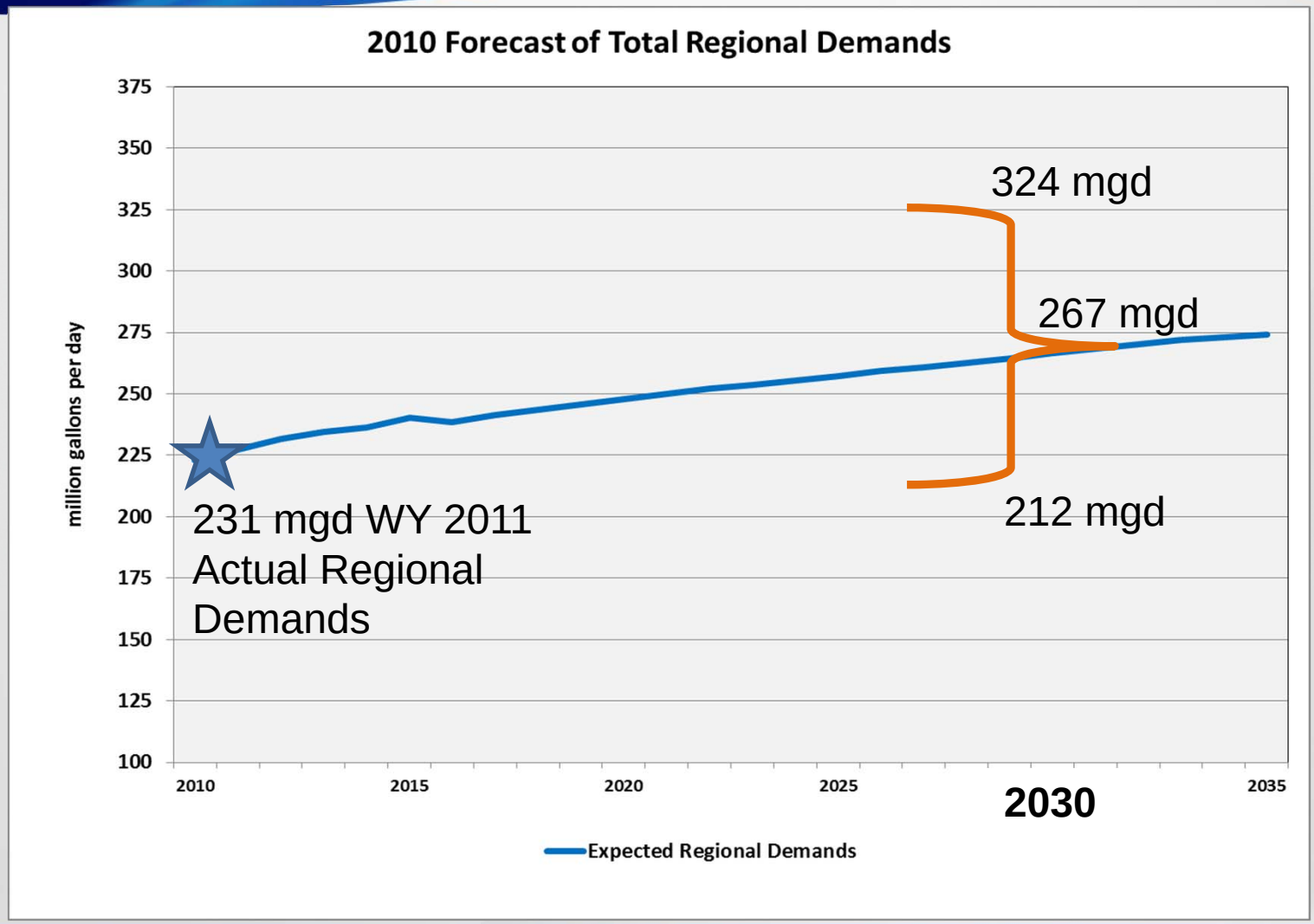
Tampa Bay Water Operational System



Optimization-Simulation Model

- Two models interacting real time, at daily time scale
- Operation Simulation Models (OMS), surface water availability including desal, COT operation
- Optimization Model—solving the pipe flow as an integer-optimization problem

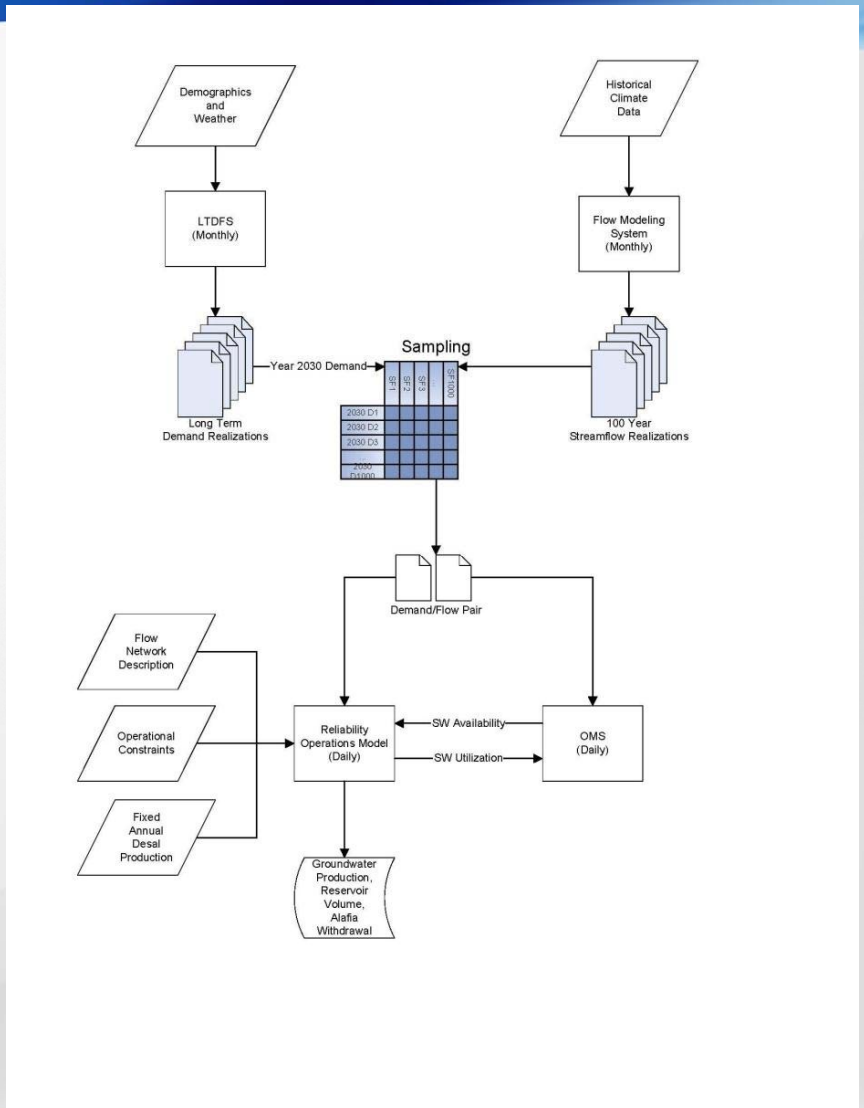
Range of Regional Demands



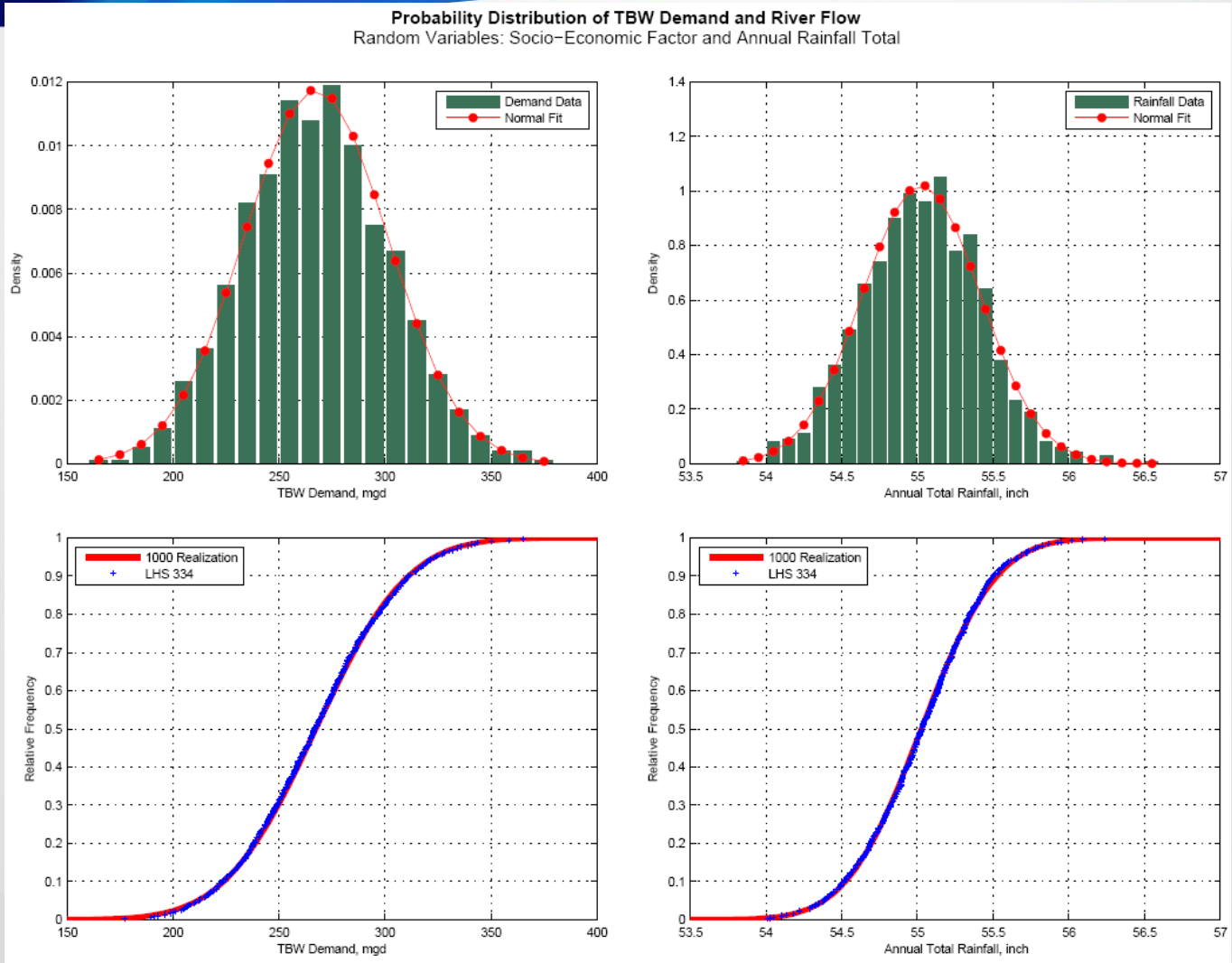
Modeling and Analysis Setup

- AMPL – code for pipe network
- MATLAB – Surface water flow modeling
- Protocol for the two codes to communicate
- Monte Carlo framework

  - 1000 realizations of demands
  - 1000 realizations of streamflow
  - Using sampling created a set of 334 realizations of Demand-Flow pairs



Distribution of Regional Demand for 2030 and Annual Total Rainfall

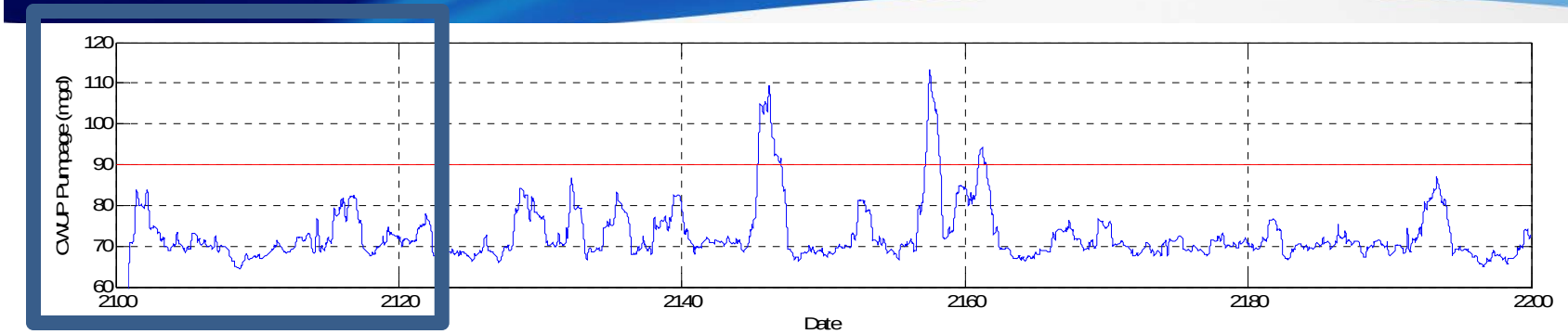


Implementation

- Two Platforms
  - Cloud System: 40-Core HP Proliant DL580 G7 512MB and 1.6 terabyte virtual memory configured to run 32 instances
  - Matlab Distributed Computing system over a cluster of 52 quadcore Proliant BL460c G1 pcs

32 100-year long demand-flow pair optimization takes 5 hours; 4.3days two scenarios presented here.

Example: CWUP above 90mgd



$X_{t(i)}$: Simulated parameter of interest compared with criterion $D_{t(i)}$

$If\ X_{t(i)} \epsilon\ S, Z_{t(i)} = 1\ else\ X_{t(i)}\ \epsilon\ U\ and\ Z_{t(i)} = 0$, the ith reliability is defined as

$$C_{R(i)} = \frac{\sum_{t=1}^{T} Z_{t(i)}}{T}$$

$$C_{V(i)} = max\left\{\sum_{t \epsilon J_j(i)} C - X_{t(i)},\quad j = 1, \ldots N\right\}$$

$$C_{V(i)} = median\left\{\sum_{t \epsilon J_{j(i)}} C - X_{t(i)},\quad j = 1, \ldots N\right\}$$

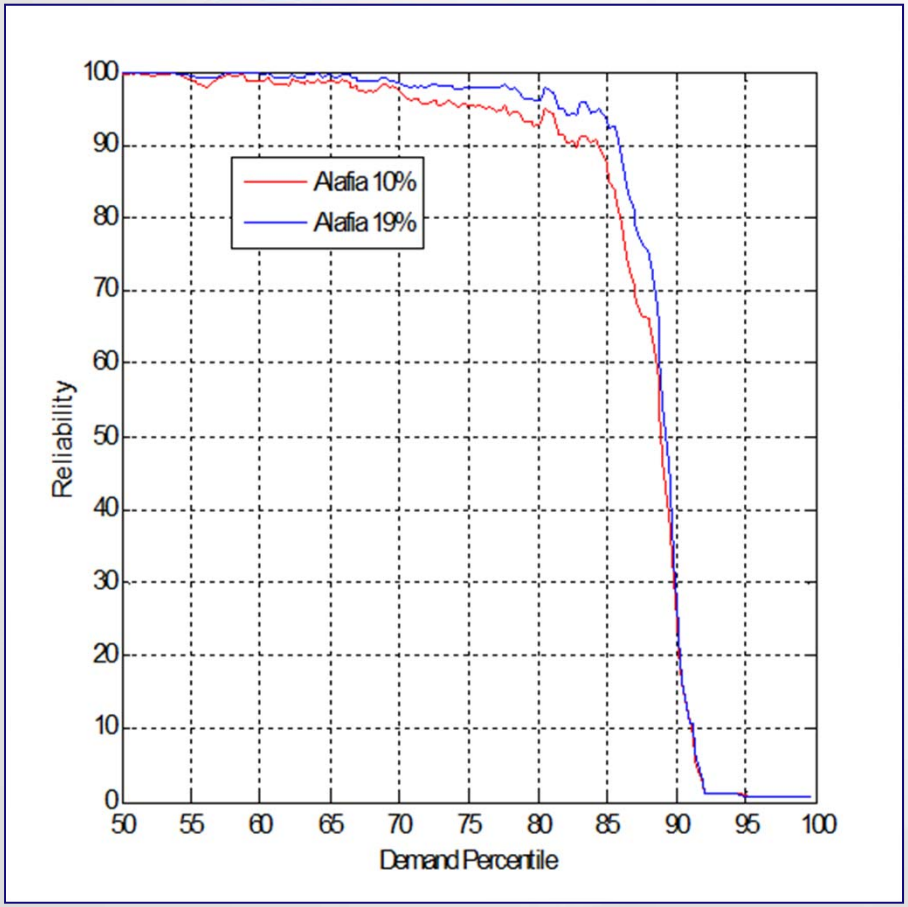
$$W_{t(i)} = \begin{cases} 1 & if\ X_{t(i)} \epsilon\ U \quad and \quad X_{t+1\,(i)} \epsilon\ S \\ 0, & otherwise \end{cases}$$

Then the ith realization resilience is given by

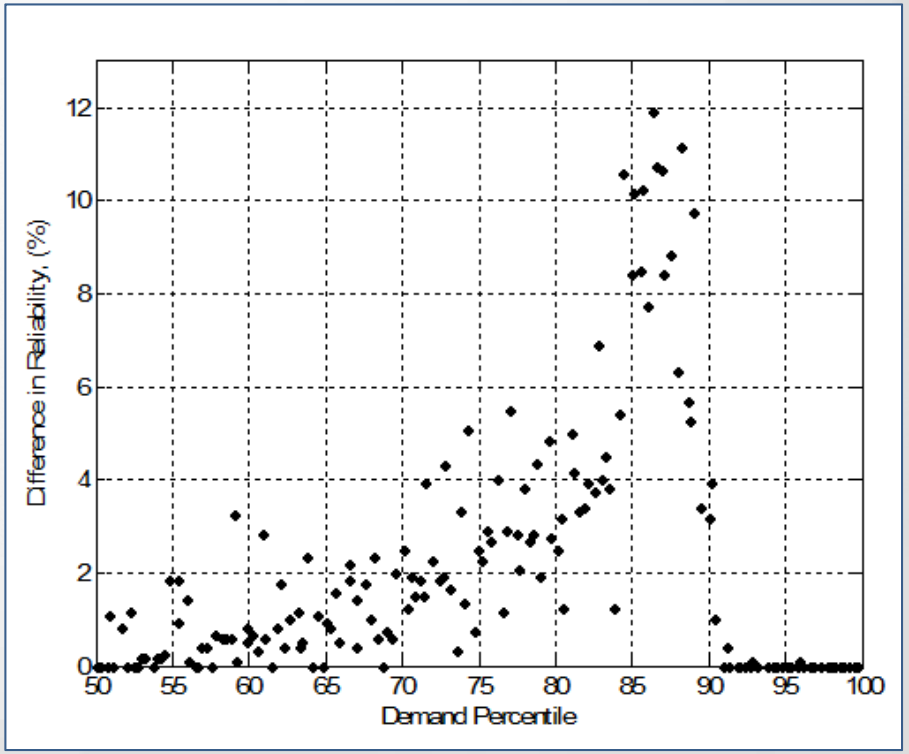
$$C_{RS(i)} = \frac{\sum_{t=1}^{T-1} W_{t(i)}}{T - \sum_{t=1}^{T} Z_{t(i)}}$$

Results

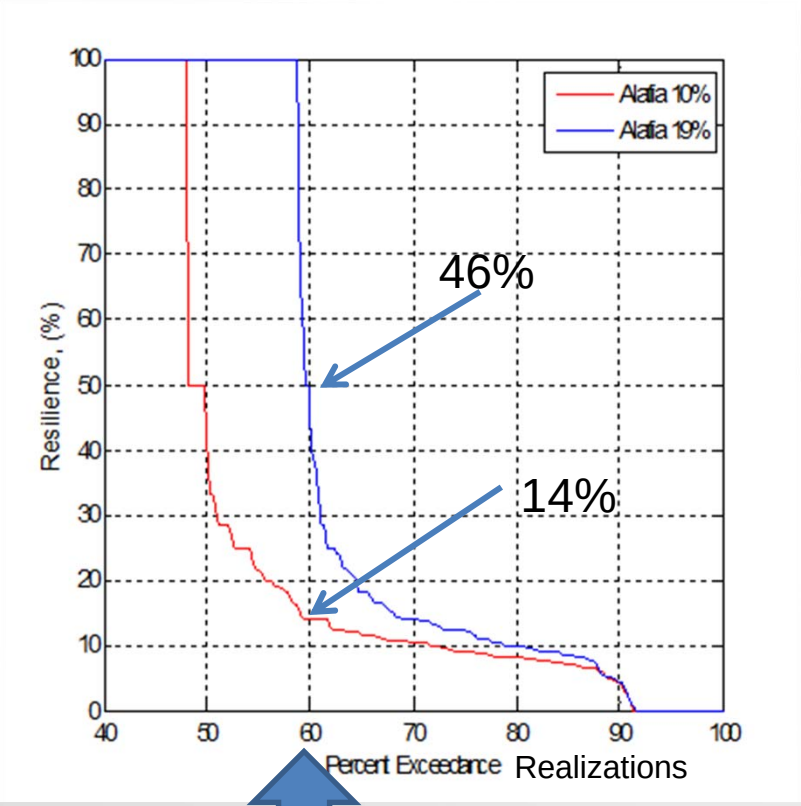
Reliability: Changes in Percent Alafia River Withdrawal

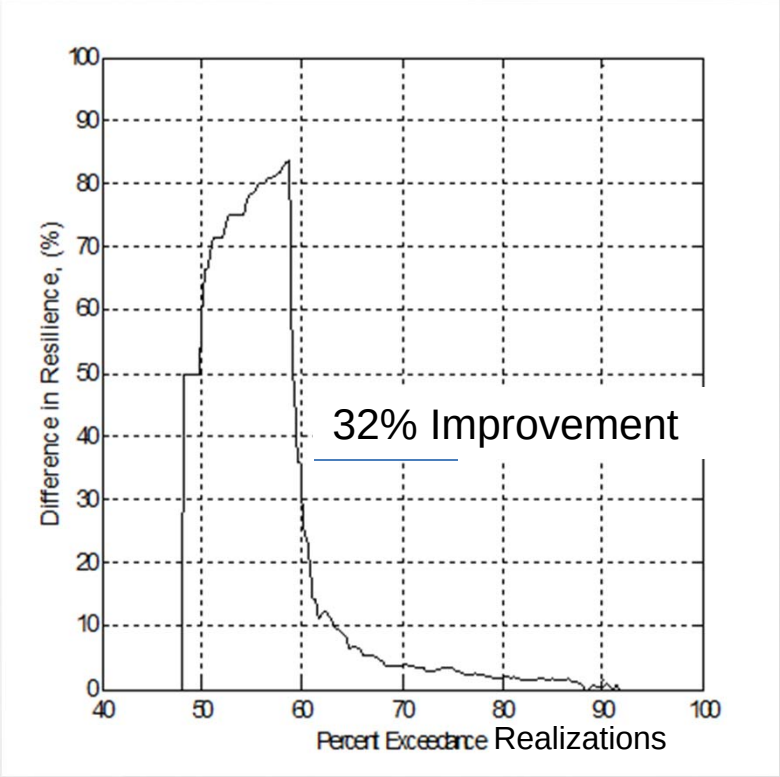


Up to 12% Improvement



Resiliency: Once in an unsatisfactory state, how quickly the system returns to satisfactory state

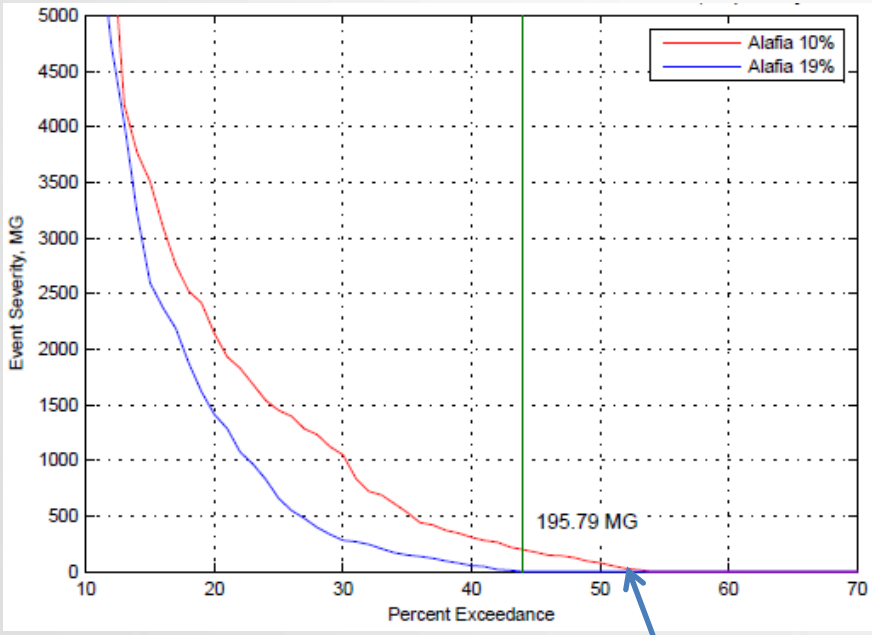




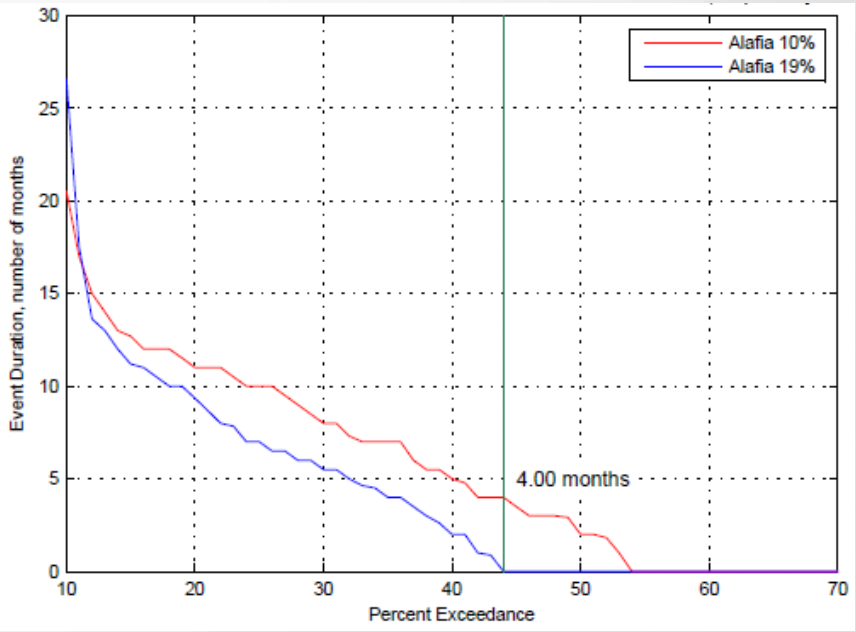
The resiliency of the Regional system improves with the Alafia River withdrawal rate at 19%.

Vulnerability: Measured in terms of reducing CWUP pumpage violations

Quantity

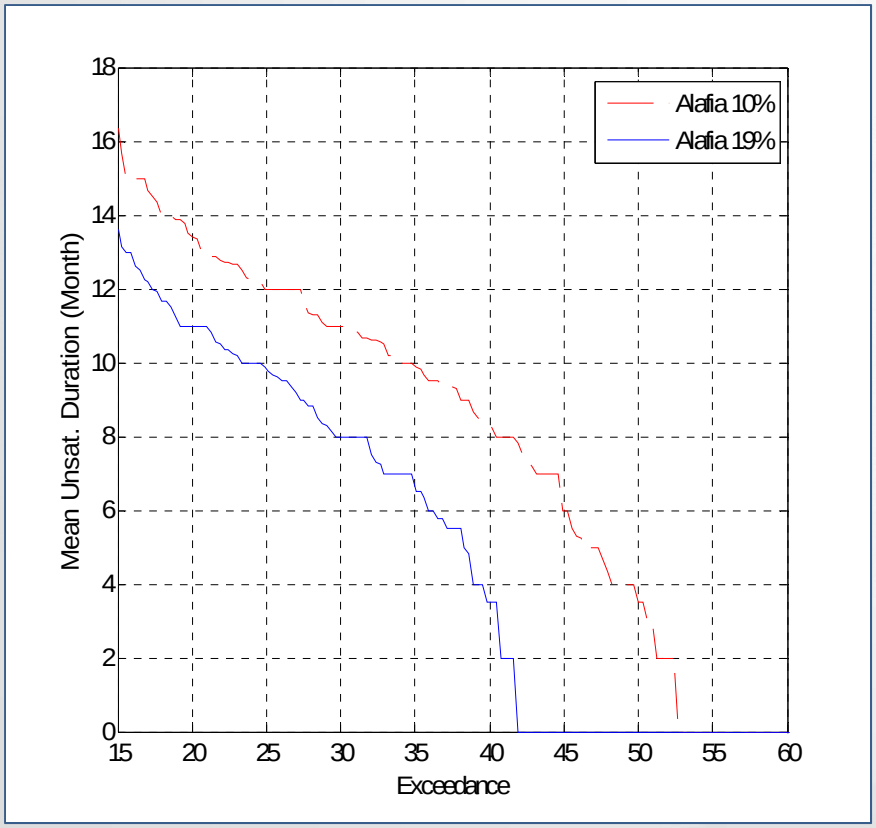


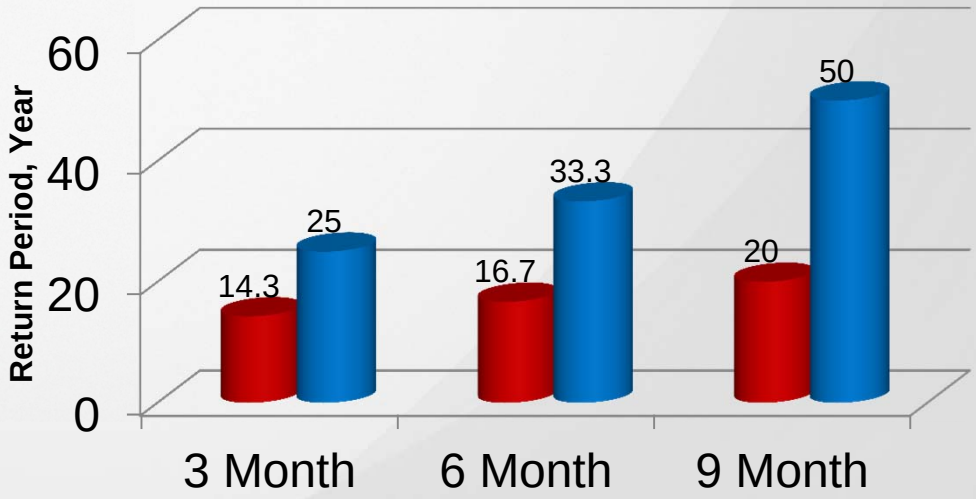
Duration



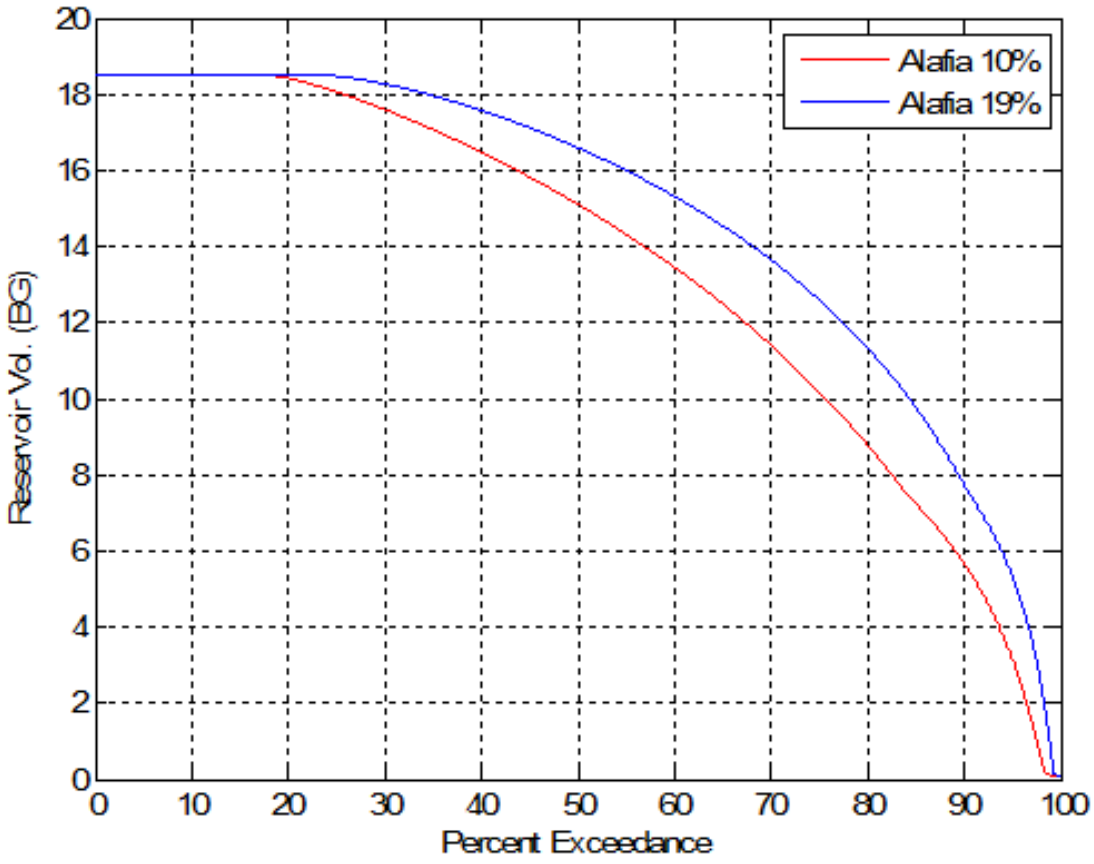
Unsatisfactory states removed from 10% of the realizations

Mean Unsatisfactory Duration, Return Periods





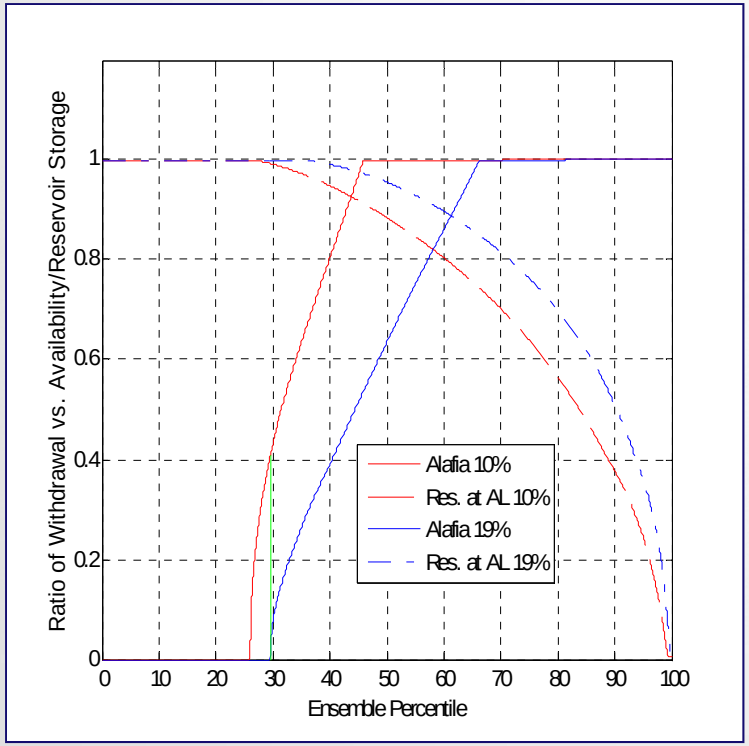
Comparison of reservoir storage

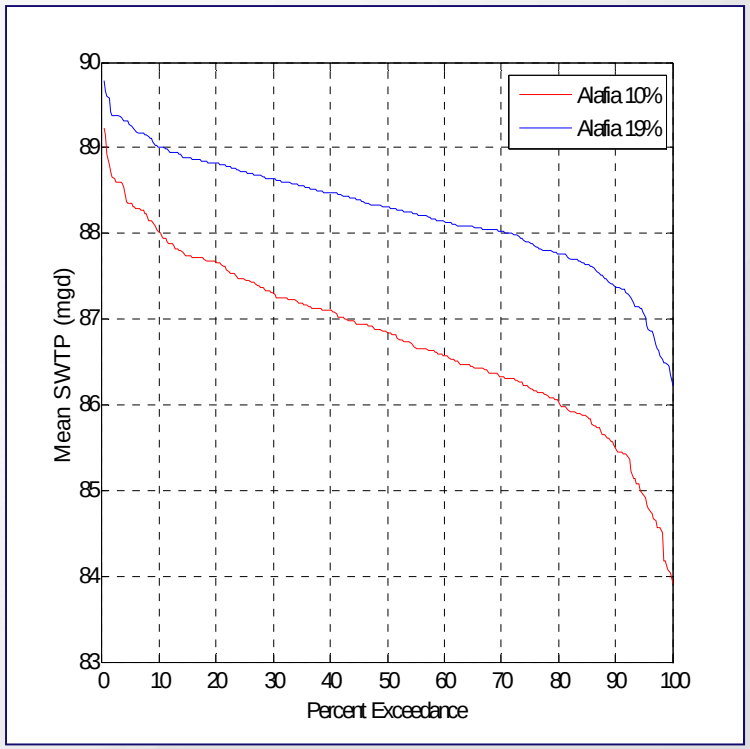


Long-term average reservoir storage	Alafia River Withdrawal Schedule
13.51 BG	10%
14.81 BG	19%

Expected long term increase in storage of 1.3 billion gallons

Utilization and SWTP Production





Conclusions

- Increases long term average Reservoir storage by 1.3 BG
- Increases in system reliability and resiliency
- Reduces magnitude, duration, and return periods of potential violations of wellfield pumping limits

Thank You !

Question ?

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