Tampa Bay Water
Piloting Utility Modeling Applications

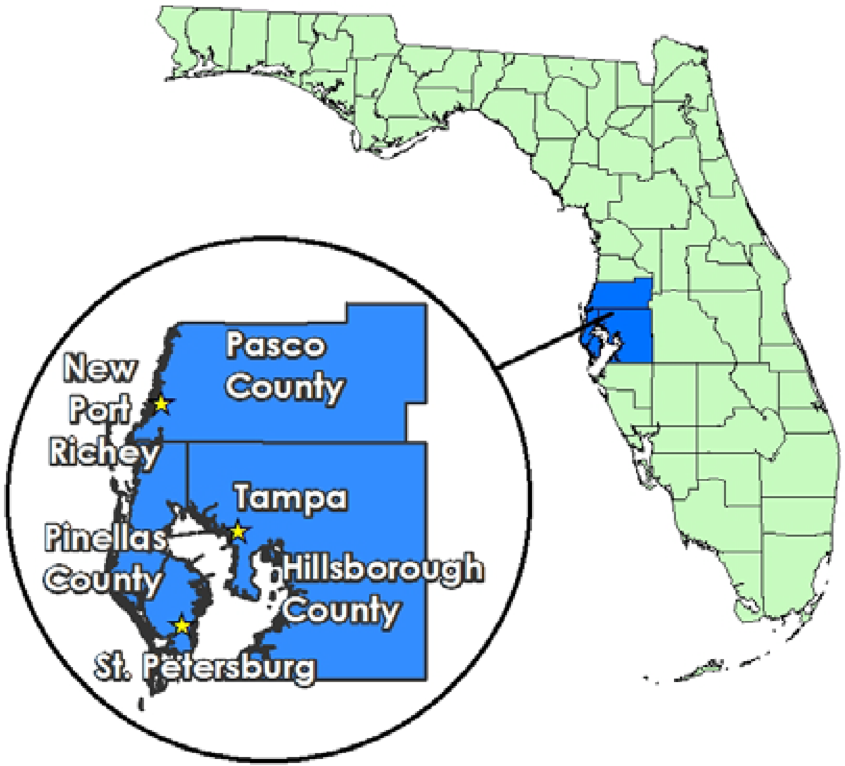
Alison Adams, Ph.D., P.E.
Jeff Geurink, Ph.D., P.E.
Tirusew Asefa, Ph.D., P.E.

Workshop One
December 1-3, 2010
San Francisco

Tampa Bay Water - Public Water Supplier for the Tampa Bay Region

2.4 Million Residents Served

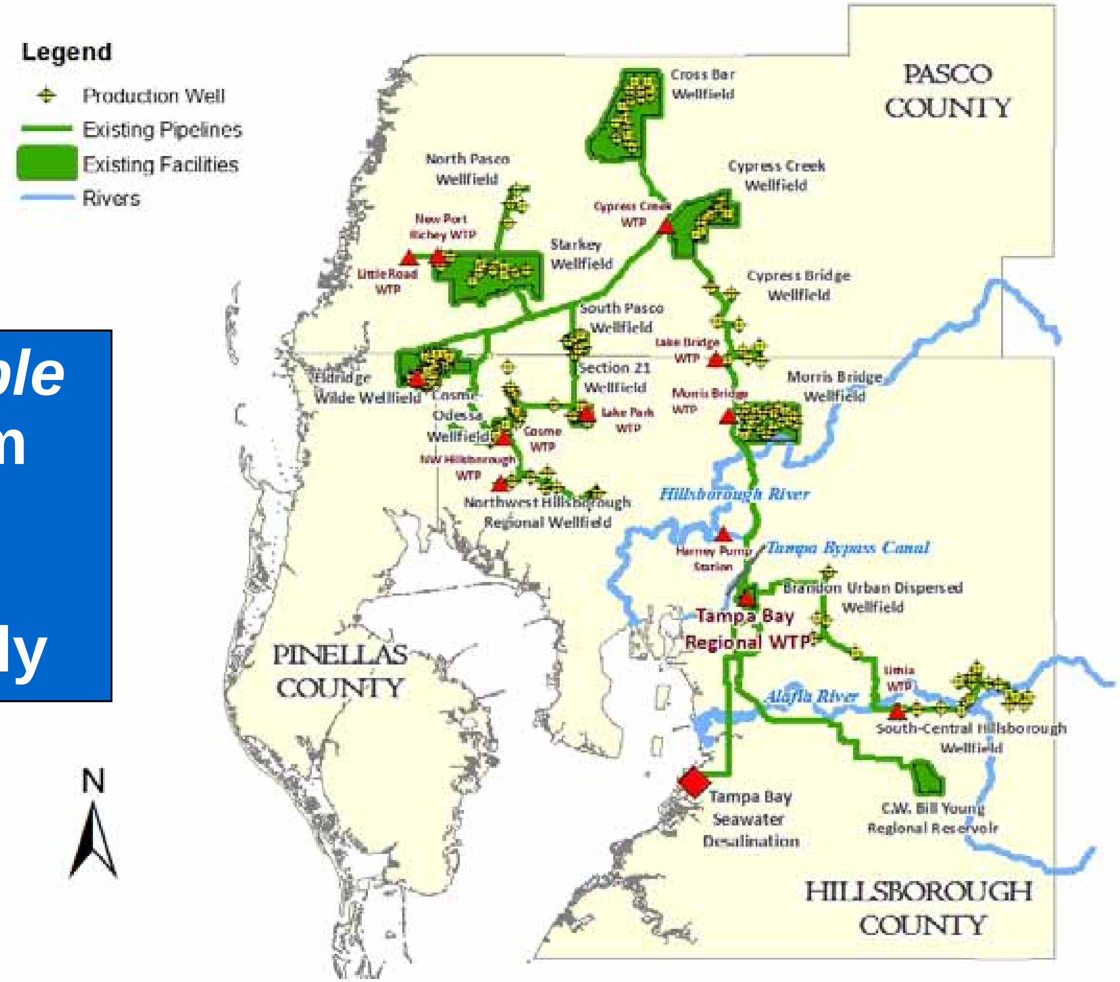
220-250 mgd public supply annual average



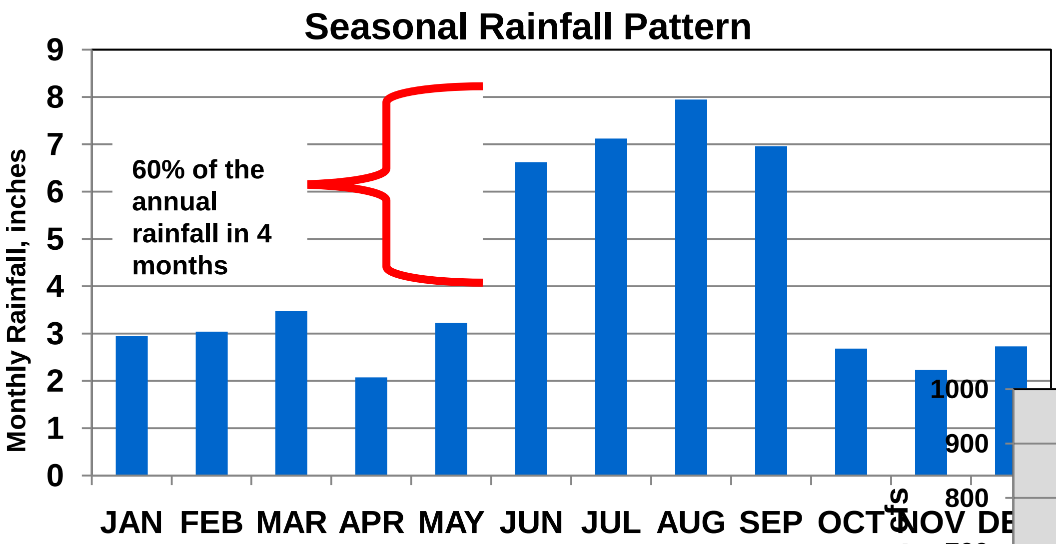
Tampa Bay Water
Multiple Types of Raw Water Sources

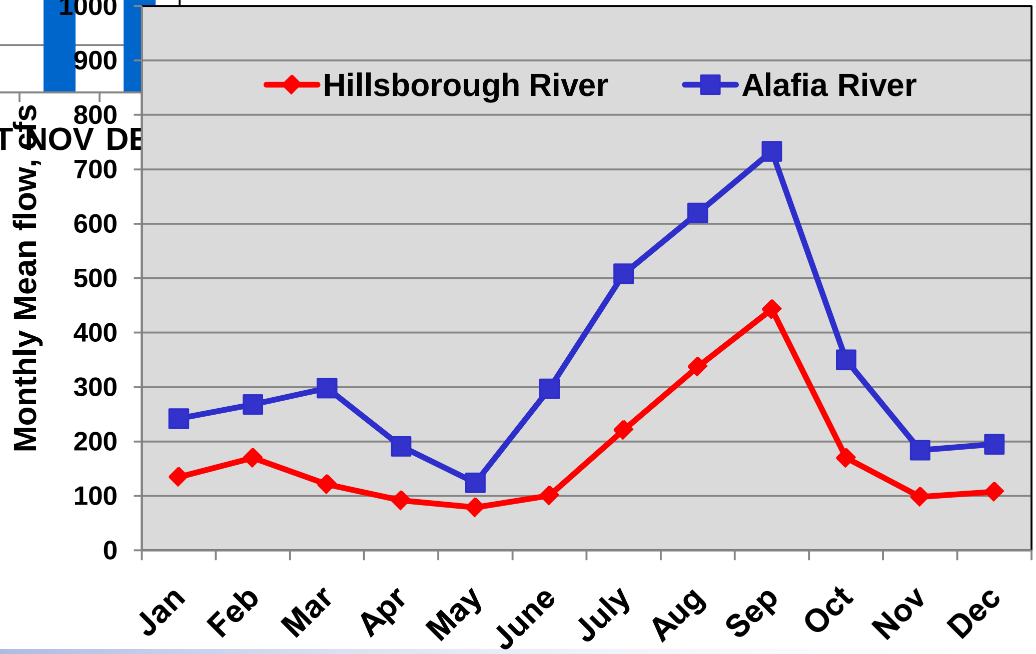
Tampa Bay Water has Developed an Integrated and Diverse Water Supply System

An integrated, *flexible and diverse* system that produces a *sustainable and reliable* water supply



Why Climate Variability is Important to Tampa Bay Water





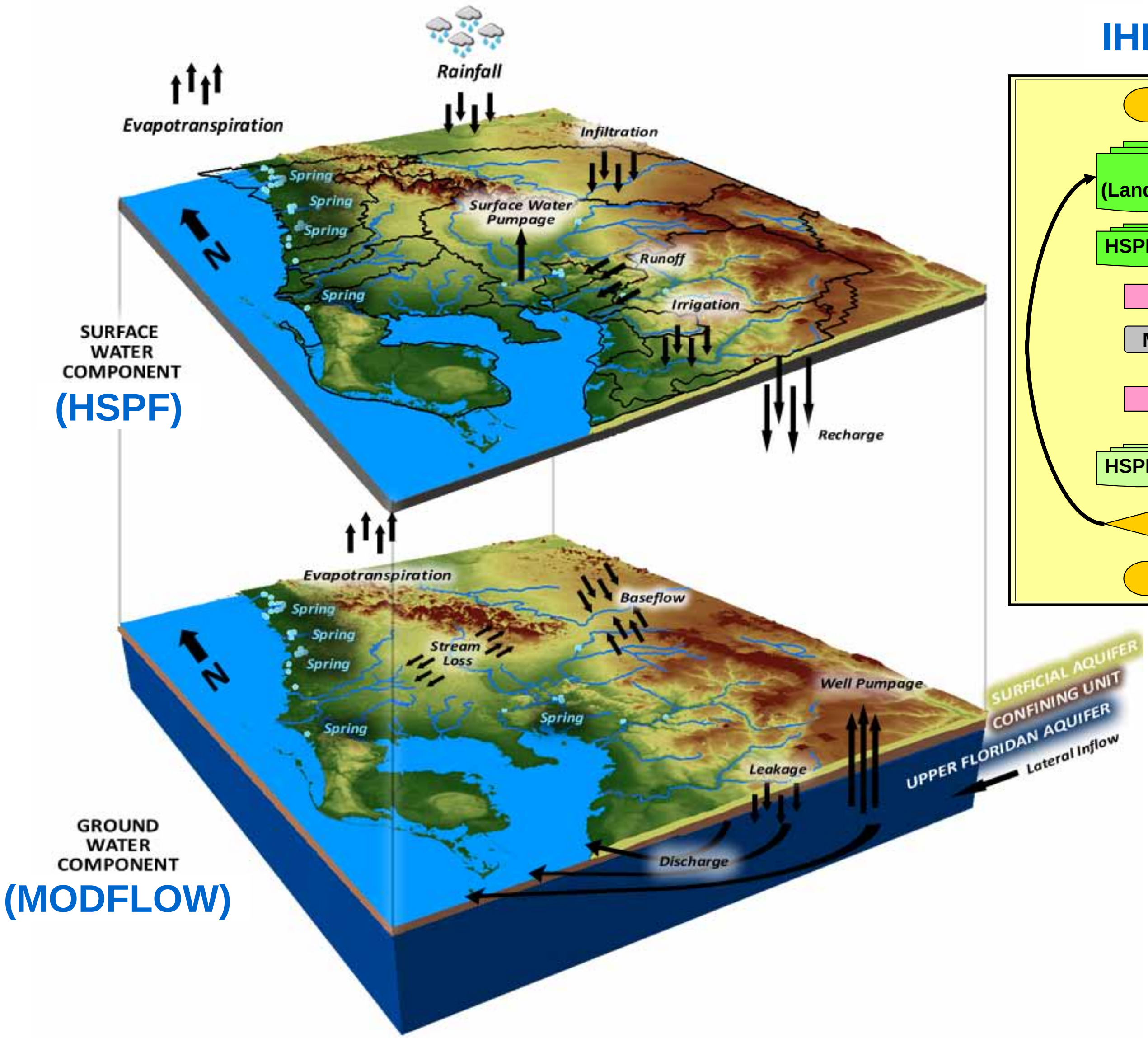
Decision Making Actions Influenced by Climate Factors

- **Long range Planning (5 Years and beyond)**
  - **Demand forecasting / supply availability**
  - **Vulnerability assessments (reliability)**
  - **Long range water supply needs**
- **Operational (Weekly to Annual)**
  - **Weekly forecasting demands and supply**
  - **Monthly / seasonal supply allocation**
  - **Annual budgeting process**

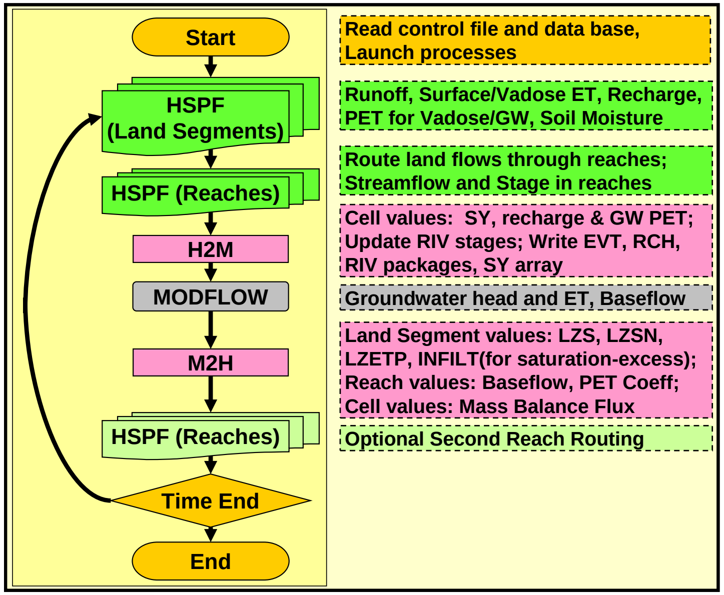
Challenges and Issues

- Acceptance by Board of Directors of vulnerability to climate changes
- Climate ready regulations and regulators
- Making good decisions with uncertainty
- Embracing an adaptive management style of decision making
- Customer acceptance of the agency’s efforts regarding water supply vulnerability

Integrated Hydrologic Model (IHM) Hydrologic Processes



IHM Sequential Integration



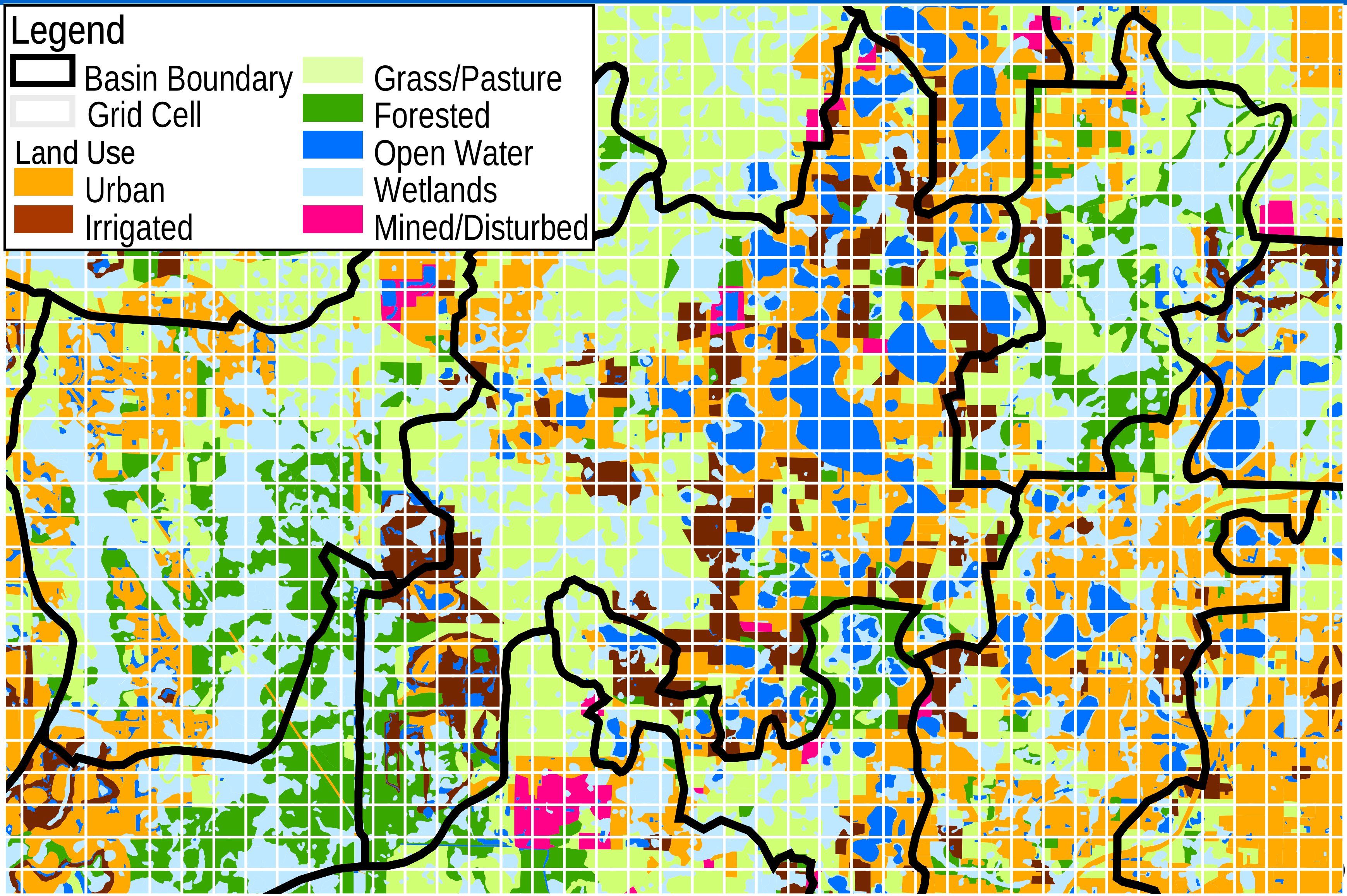
TAMPA BAY WATER

Integrated Hydrologic Model Simulated Processes

Surface-Water Processes	Ground-Water Processes
Non-Integrated	
Rainfall and potential ET input	Lateral flow
Abstraction storages	Inter-aquifer leakage
Interflow storage	Well pumping
Percolation	Confined ground-water storage
Interflow	Spring flow
Abstraction evapotranspiration	
Irrigation flux	
Surface-water diversions	
Level-pool reach routing	
Integrated	
Vadose zone storage	Recharge
Infiltration & redistribution of infiltration	Flow exchange water bodies ↔ ground water
Overland flow	Unconfined ground-water storage
Vadose zone evapotranspiration	Ground-water evapotranspiration
Reach evapotranspiration	

TAMPA BAY WATER

Integrated Hydrologic Model
Surface & Ground Water Interaction



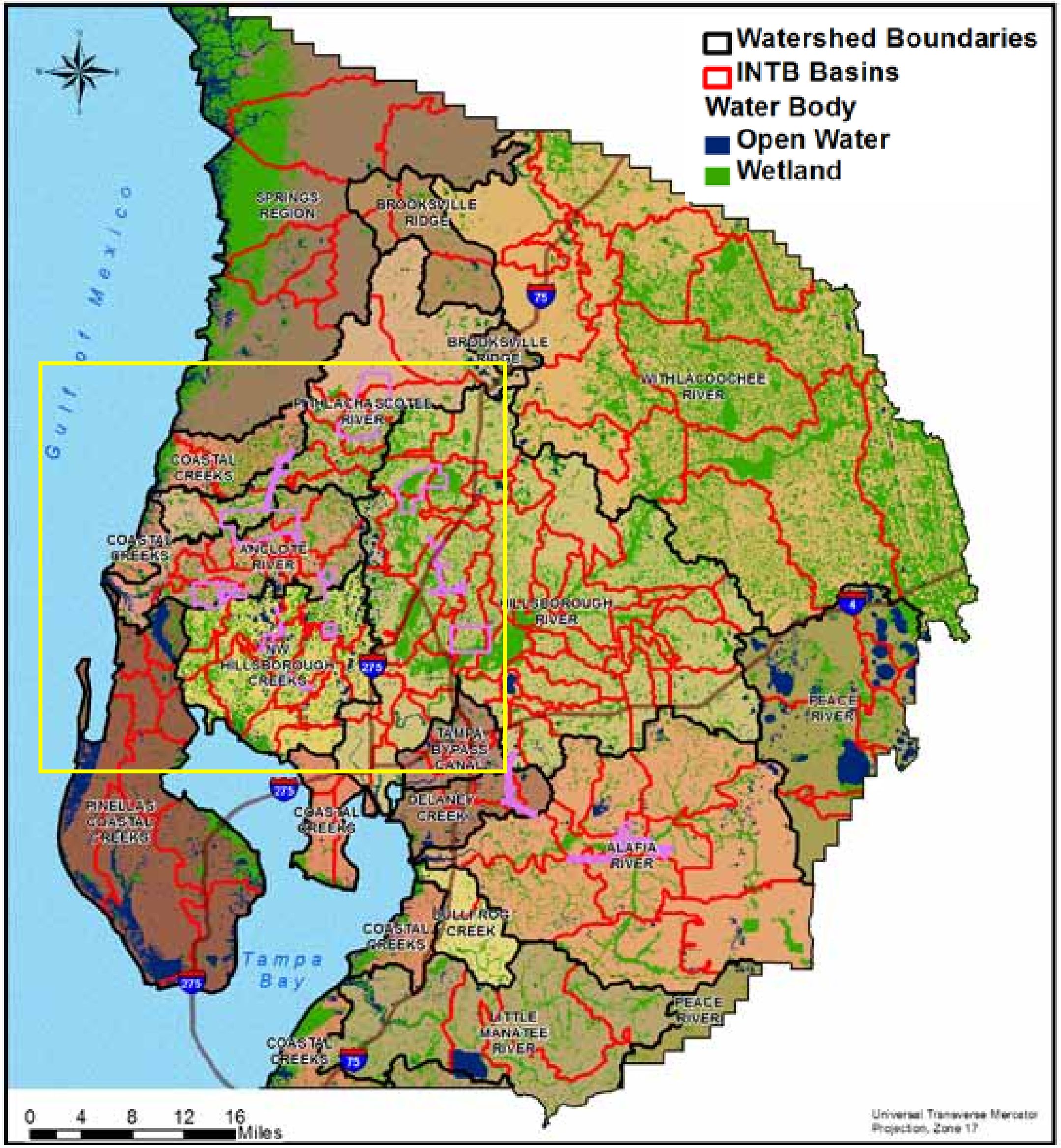
Integrated Northern Tampa Bay Model Surface-Water Component (HSPF)

TAMPA BAY WATER

- Convective Rainfall (4 months)
  - 60% volume / 75% events
  - 1.25-mile event spatial scale
- 65% of basins with 2 mile radius
- Rain input: 300 gauges, 15-min.
- Potential Evapotranspiration
  - minor spatial variation
  - 5x seasonal variation

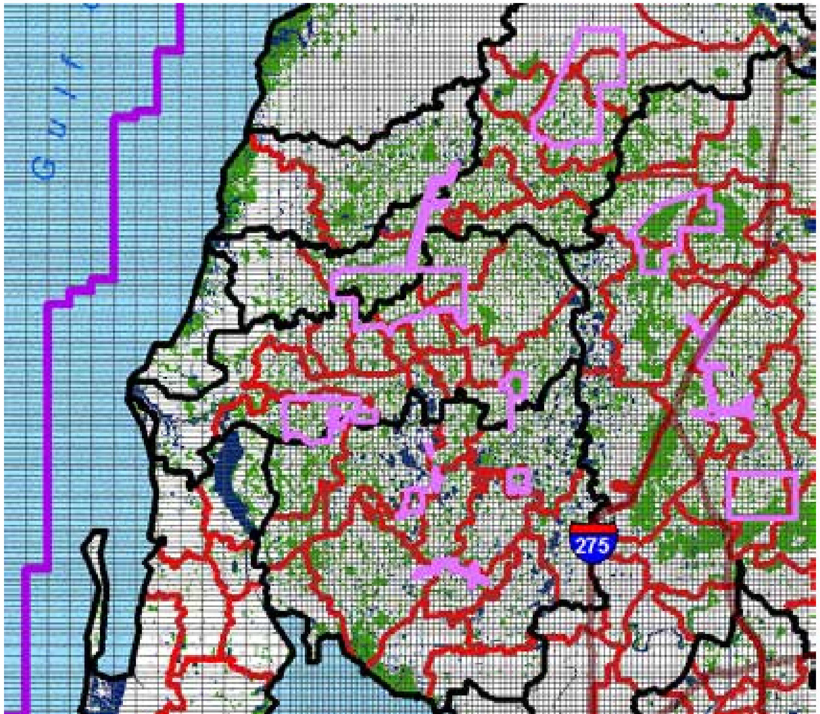
Average Annual Budget 1989-98

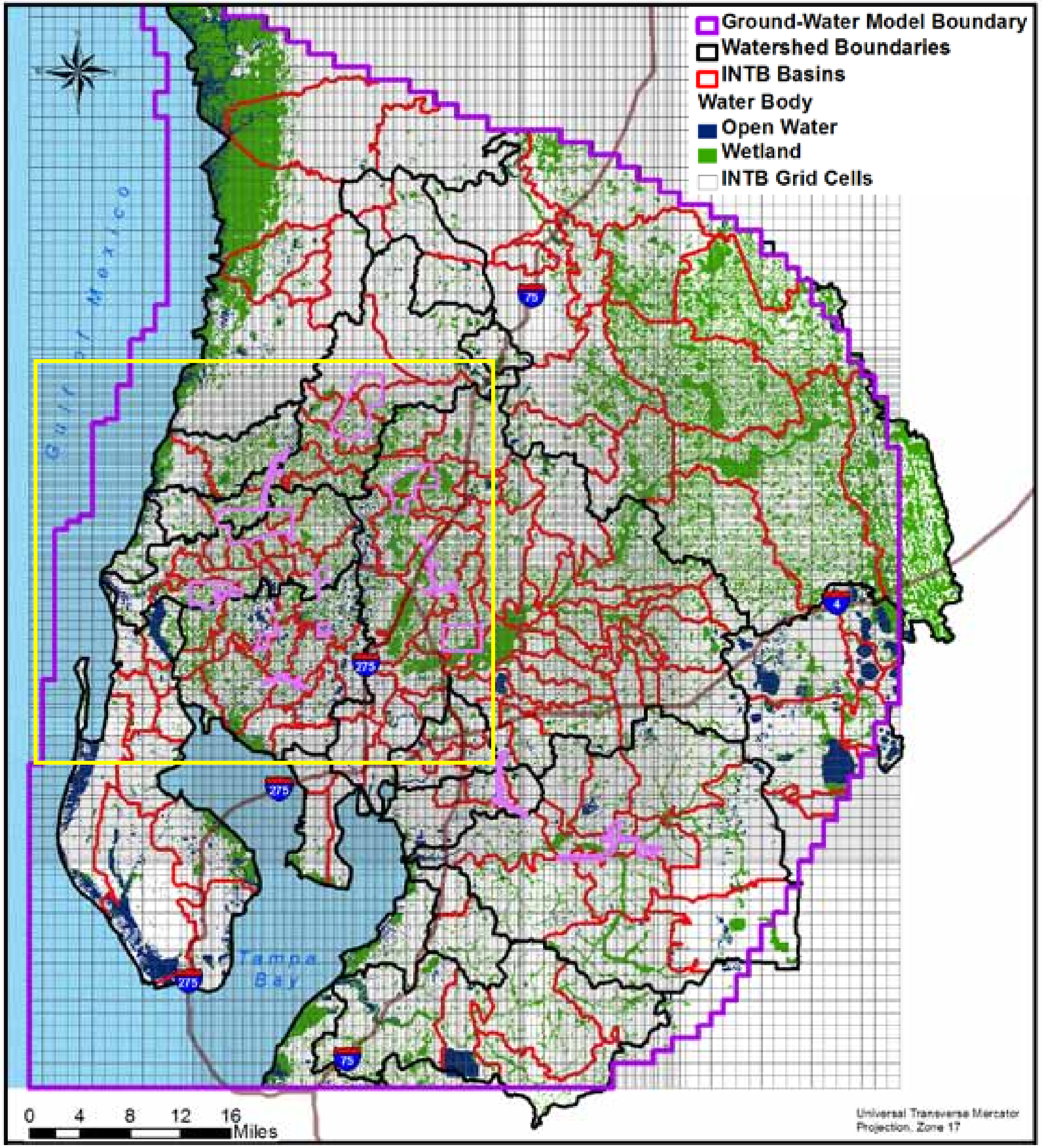
Budget Term	Percent	Flux (in/yr)
Evap. & Transp.	69	38.0
Stream & Spring Q	21	11.0
Well Pumping	5	3.0
GW Flow to Gulf	3	1.5
SW Pumping	1	0.5
Other GW Outflows	1	0.5
Total	100	54.5



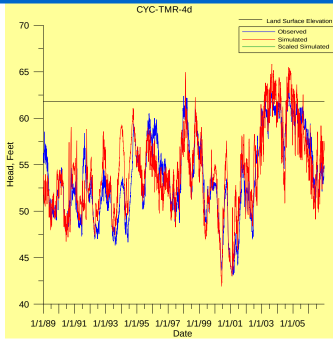
Integrated Northern Tampa Bay Model Ground-Water Component (MODFLOW)

- Ground-Water Component
  - 95,000 active nodes
  - ¼ to 1-mile cell dimension
  - 85,000 water-body units
  - 8700 production wells
- Ground-Water Temporal Scale
  - Sub-daily computation
  - Daily stress changes





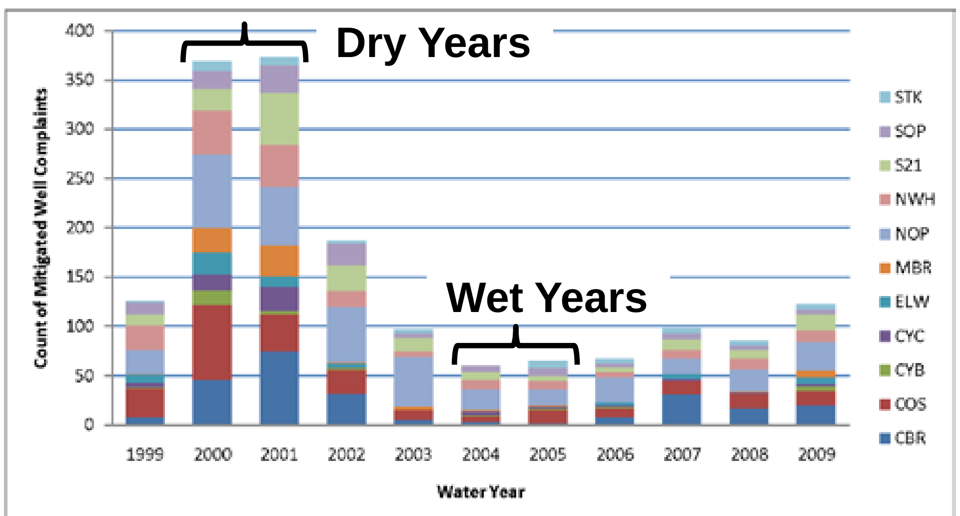
INTB Calibrated Model & Climate Data Informed Decisions

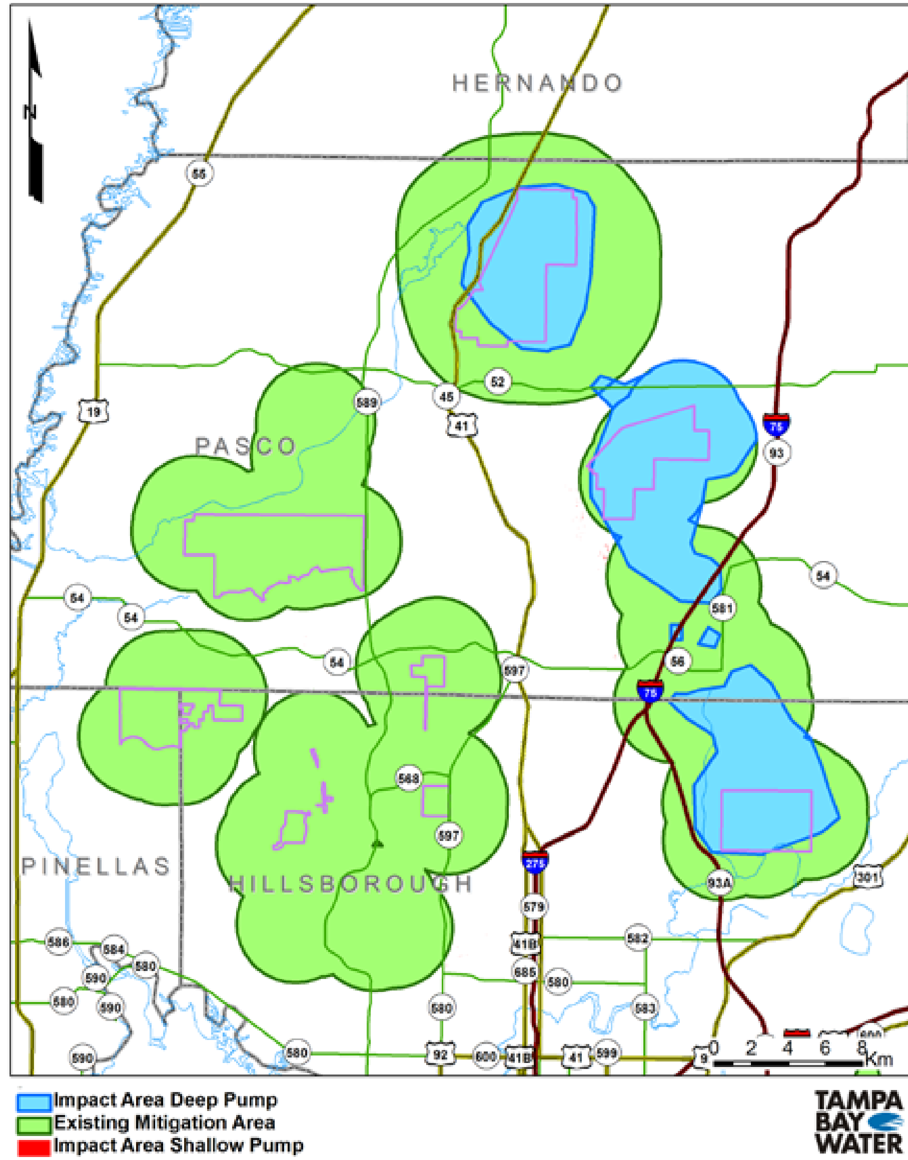


- **Regulations**
- **Operations**
- **Estimate ground water safe yield**
  - **Climate and pumping variability**
  - **Regulation, infrastructure, mgmt constraints**
- **Understand & compare uncertainty**
- **Adaptive management strategies**
- **New source assessments**

Support Regulatory Requirements Define Drawdown & Assess Impacts

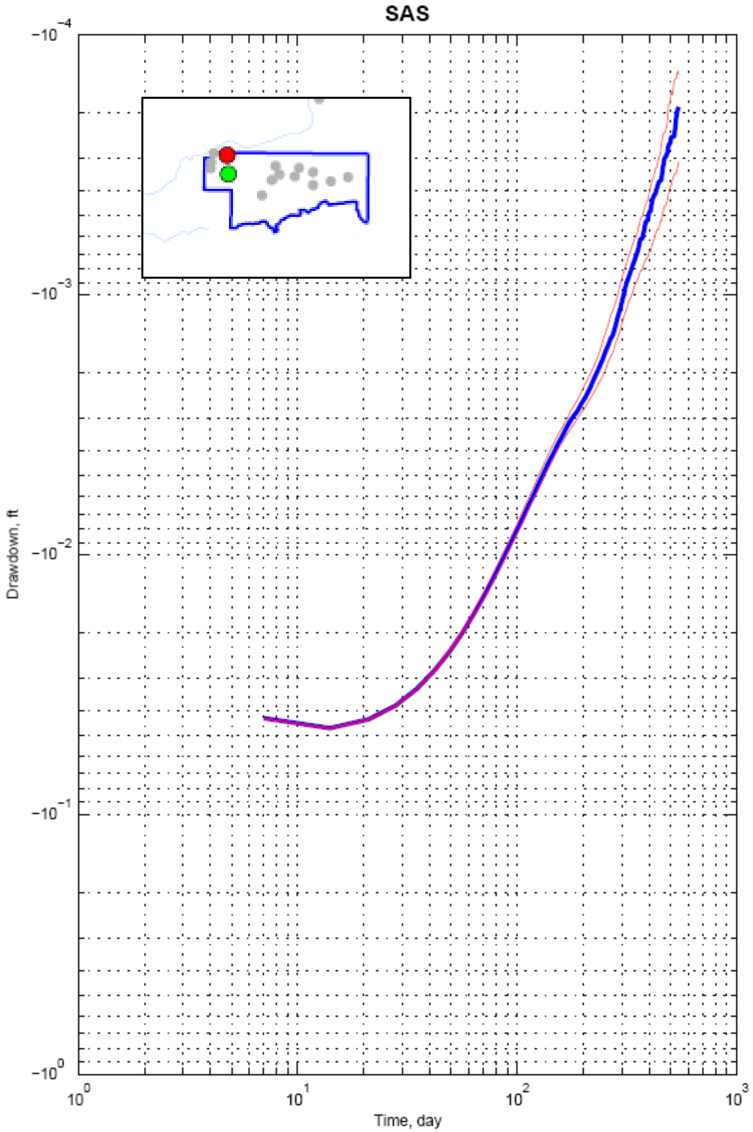
- **Protection of other well owners**
- **Single regulatory scenario for rainfall & pumping (worst case)**
- **Regulations & regulators not ready for climate variability assessments**
- **Historical well mitigation has depended on rainfall magnitude**

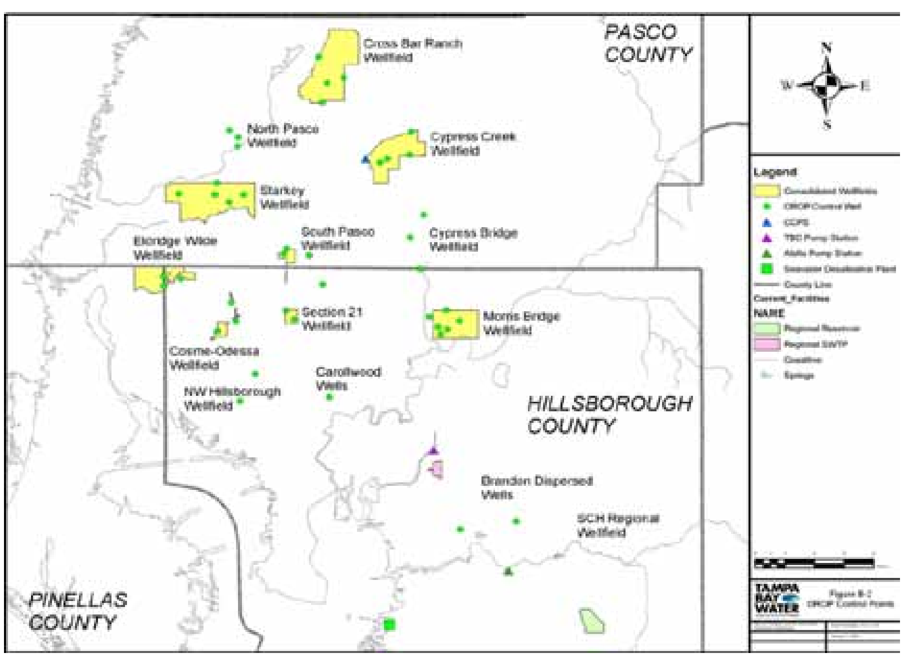




Optimize Well Pumping Distribution Unit Drawdown Response (Per 1 MGD)

- Drawdown response for 1 MGD well rate
- Temporal and spatial convolution defines total drawdown over time & space
- Historical climatic variability captured with 1000 rainfall realizations
- Ensemble median drawdown response

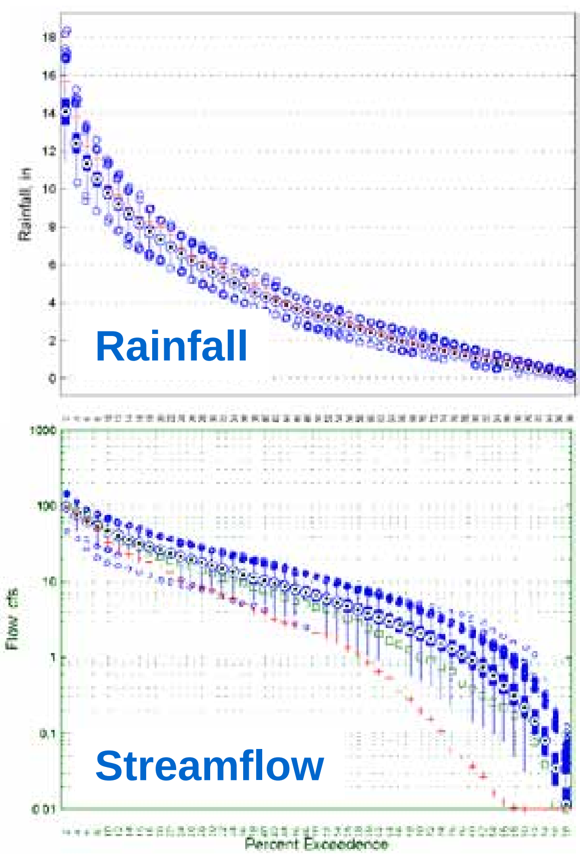


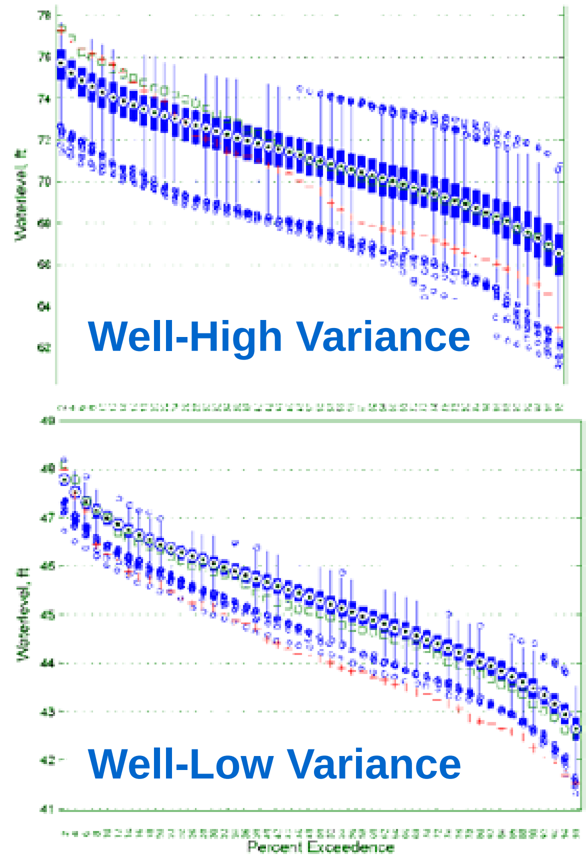


Ground Water Safe Yield
Variability in Climate and Well Pumping

- **Regulatory protection metrics**
  - **Wetlands & lakes (levels)**
  - **Streams & springs (flow)**
- **Variability in climate and pumping**

- **1000 rainfall realizations, 20 yrs**
- **Uncertainty in levels and flows**
- **Water-supply system reliability**





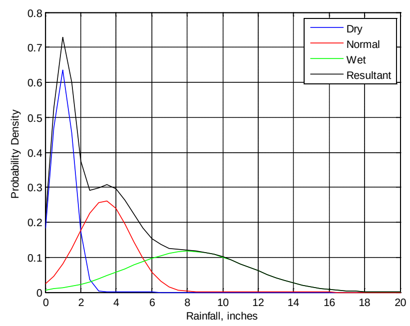
Tampa Bay Water's Statistical Models

Weekly Ensemble Stream Flow Forecast Models

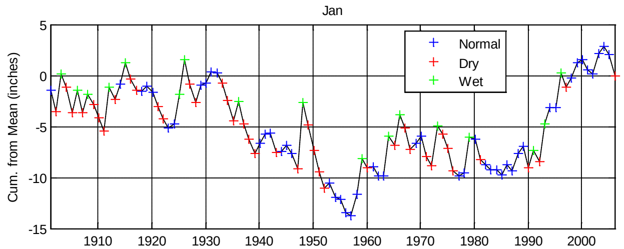
- Artificial Neural Network Based on Generalize Likelihood Estimation (GLUE)
- Driven by recent weather, river flows, and groundwater levels
- Input supply availability to Weekly Operations Model

Seasonal Stream flow Models

- Multivariate regression
- Rainfall based on HMM
- Three month to annual
- Conditioned on recent weather

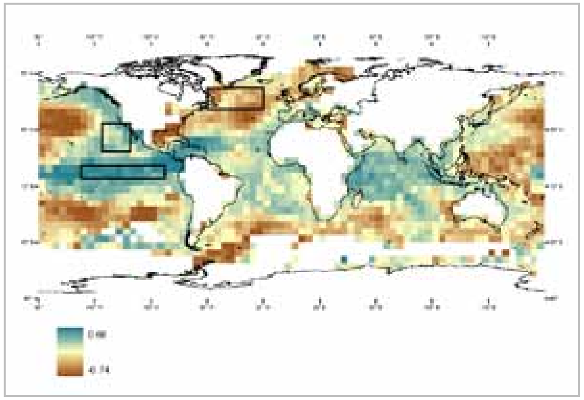


	Dry	Normal	Wet
Dry	0.43	0.34	0.23
Normal	0.14	0.70	0.16
Wet	0.72	0.18	0.10

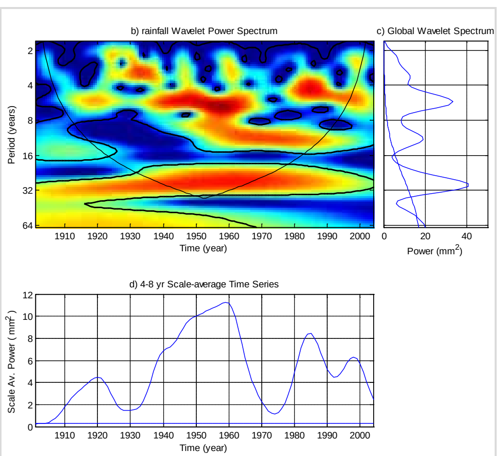


Central Florida Rainfall: “a Multi-scale Climatic Signal Measurement Device”

1



2



3

ENSO

JFM

	La Nina	Neutral	El Nino	MarProb
Wet	0	45	55	**21**
Normal	17	48	35	**45**
Dry	61	36	3	**34**
MarProb	**28**	**43**	**28**	100

AMO Filter

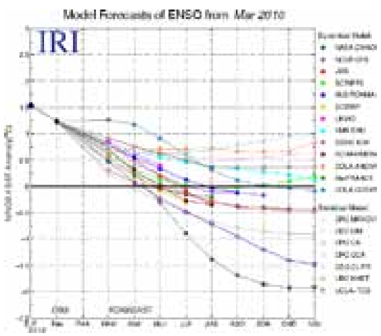
Cold Phase

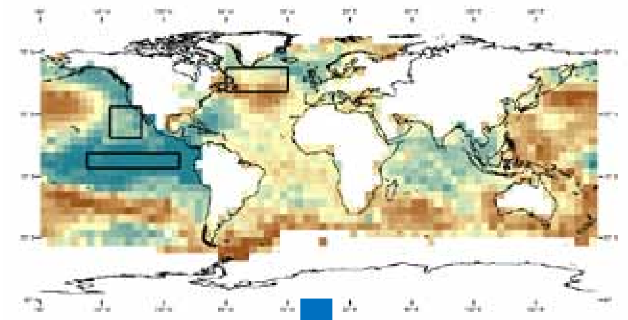
	La Nina	Neutral	El Nino	MarProb
Wet	0	22	78	**8**
Normal	23	41	36	**21**
Dry	82	9	9	**10**
MarProb	**15**	**11**	**13**	39

Warm Phase

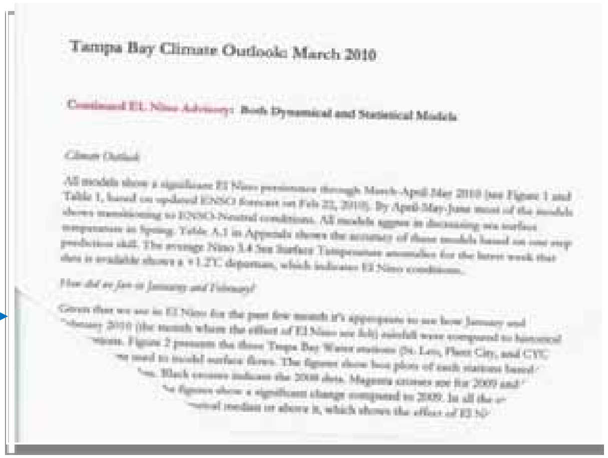
	La Nina	Neutral	El Nino	MarProb
Wet	0	58	42	**11**
Normal	12	56	32	**24**
Dry	52	48	0	**24**
MarProb	**12**	**31**	**15**	58/59

Tampa Bay Water's Seasonal Outlook





	Below Normal	Normal	Above Normal
DJF	65	35	0
JFM	85	12	3


Tampa Bay Climate Outlook: March 2010

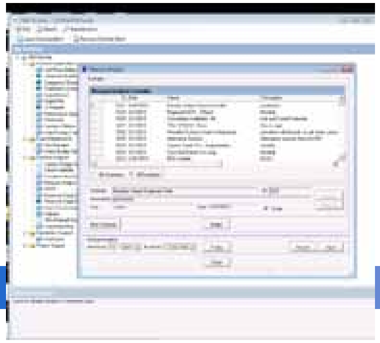
Continued EL Nino Advisory: Both Dynamical and Statistical Models

Climate Outlook

Climate Outlook
&
Real time observation

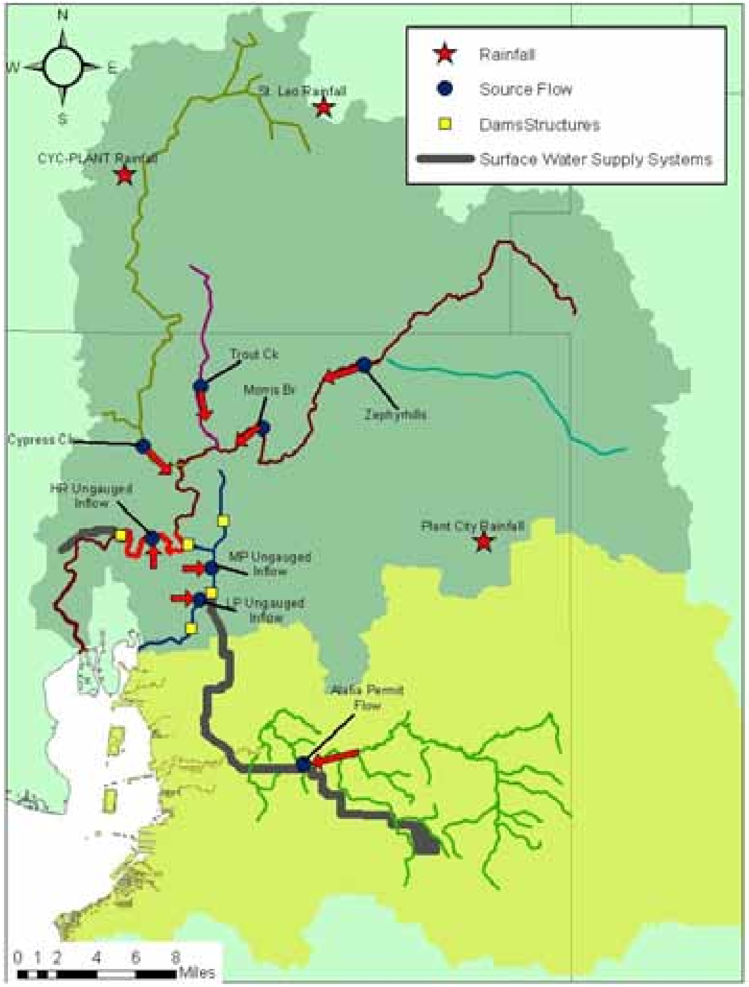
Conditional Markov Rainfall Model

Rainfall / Runoff Model



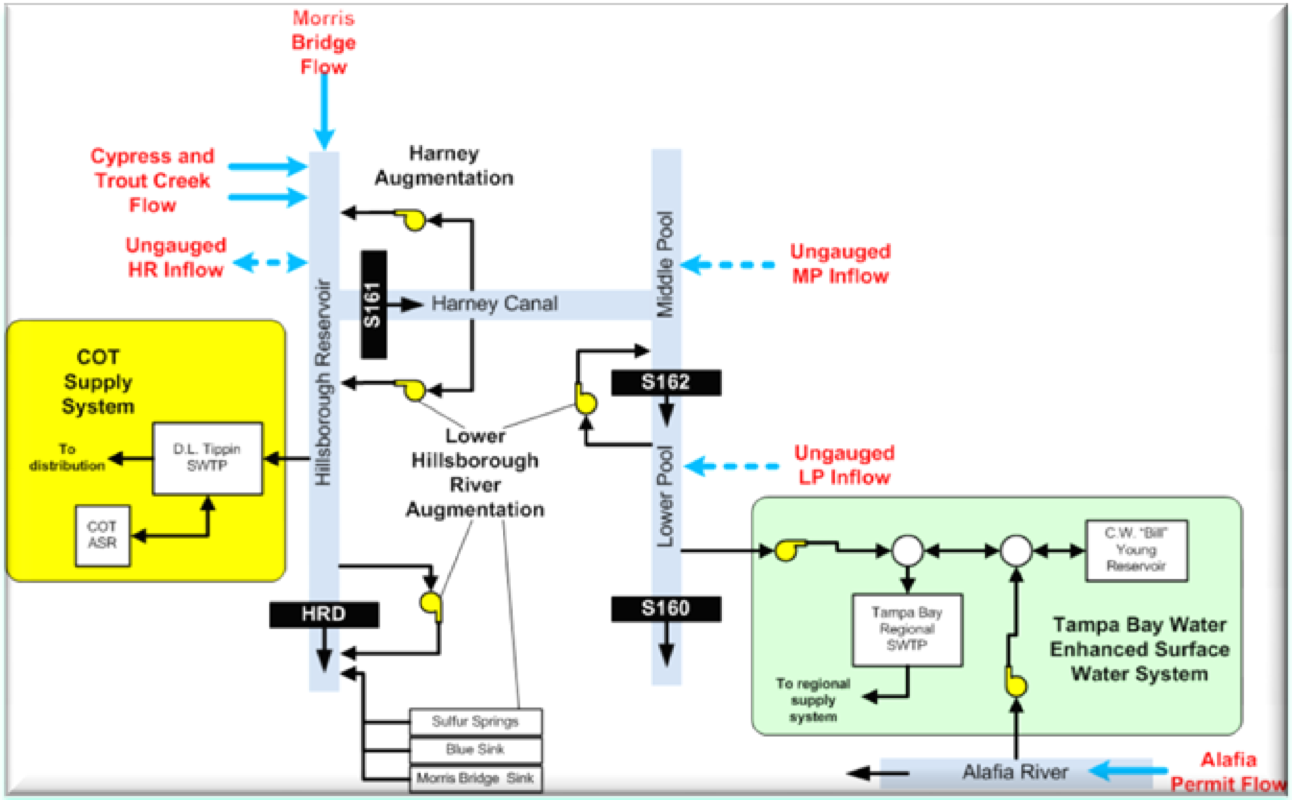
Long-range Rainfall/Runoff Simulation Models

- **Three rainfall stations**
  - **Two 106 years one 30 years, some 30 miles apart, 1095 square mile watershed**
- **Same model structure but two parameter set**
  - **(October through May, and June through September)**
- **Lag 0 through 3 rainfall as wells as lag 4, 12 month cumulative**
- **Non-parametric residual resample to account process uncertainty**
- **Monthly to Daily disaggregation**
  - **Conserve volume, intra and inter month daily flow continuity**



Operational Modeling System

Daily Ensemble Flow Simulations



Resilience, Reliability, and Vulnerability (RRV) Analysis

- **Currently uses seasonal Hidden Markov rainfall models (based on 106 years of data)**
  - **Future climate scenarios could replace this**
- **Analyze scenarios based on specific reliability and vulnerability measures**
- **For each scenario, 1000 ensembles of 300yrs long daily simulations**
- **Uses distributed computing over 64 Computer cluster**
  - **a 2.5 day cluster run would have taken over 120 days on a single 8GB PC**

Thank you

Questions?