

# Community Water Deficit Index (CWDI) - A Tool for Forecasting Drought in the Southeastern U.S.

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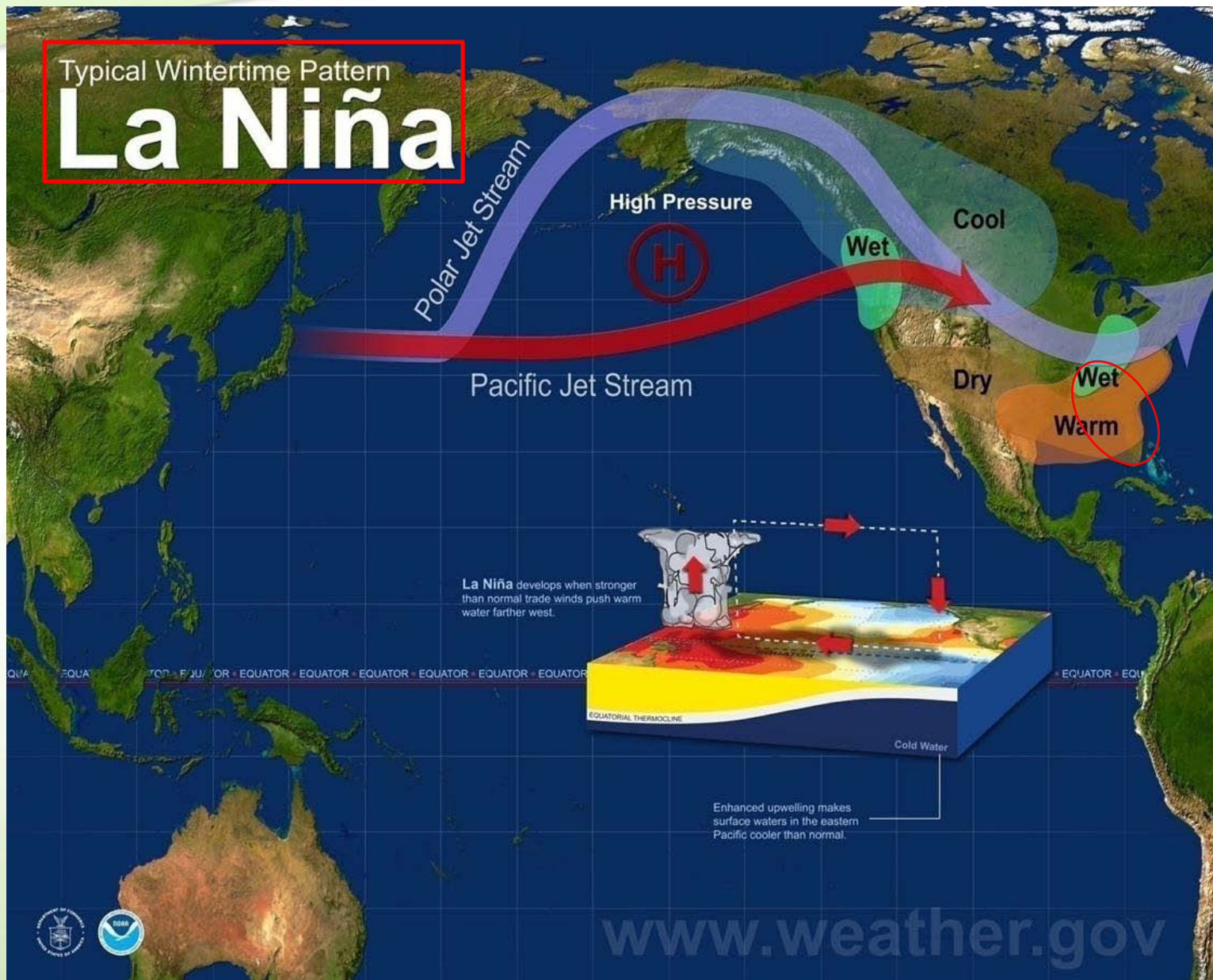
# INTRODUCTION

- Droughts have significant climatic as well as socio-economic impacts.
- Persistent US drought may be linked to persistently cool eastern tropical SSTs and warm North Atlantic SSTs.
- Climatic variability as well as increased consumptive use of water may lead to future water supply problems in the Southeast.



Typical Wintertime Pattern

# La Niña



## Tasks – Presentation Outline

Impact of  
ENSO on  
precipitation  
and  
streamflows in  
Alabama

Development of  
CWDI for drought  
forecasting in small  
to mid-size  
communities of the  
Southeast US

Impact of  
climate on  
municipal  
water demand –  
Value of this  
information

### Outcomes

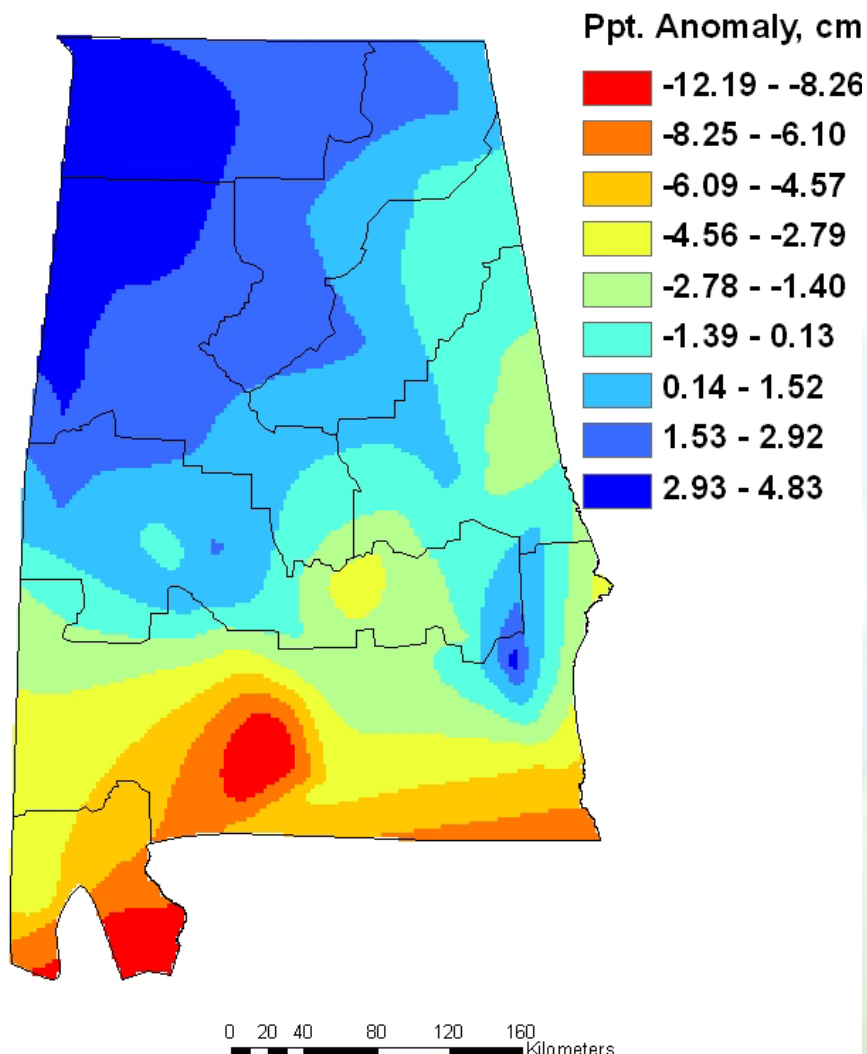
1. Anomaly maps/statistical properties
2. CWDI/ Web-based tool
3. Value of drought information/ Alternative policies

## Assessment of ENSO Conditions in Alabama

- Studied teleconnections between ENSO indicators and monthly rainfall / streamflow
- Investigated potential for forecasting rainfall and streamflow several months ahead using:
  - Serial correlations in rainfall and in streamflow (statistical properties of each variable)
  - Lag correlations between ENSO indicator and streamflow
- Developed precipitation anomaly maps for the state

## Precipitation Anomaly Map

DJFMA\_LN



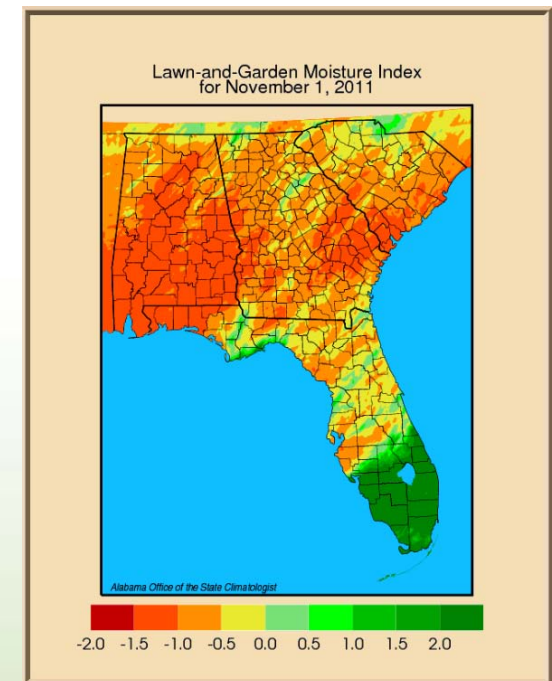
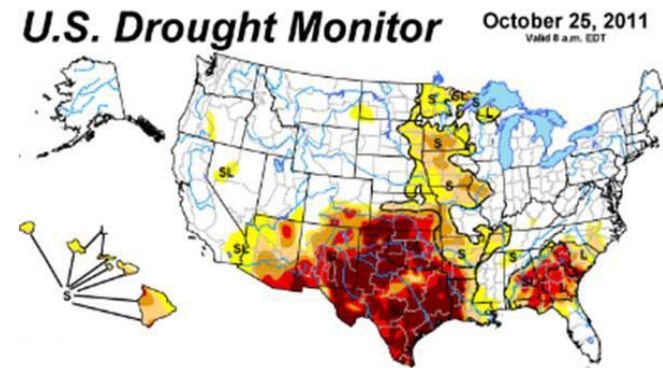
- Significant relationship between Niño 3.4 index, precipitation and streamflow during winter months.
- Dry conditions during winter months in the South tend to be associated with La Nina.

## Also....

- Urban water use
  - Potential evapotranspiration and rainfall best explains changes in residential water use attributable to climate
  - Drought conditions subject the municipal water systems to
    - Increased demands and decreased supplies
    - Pose serious risk to the performance of the system
  - Such fluctuation in climatic conditions may cause short term failures in the system

## Available Drought Indices

- Currently available drought information (US Drought Monitor, Lawn and Garden Moisture Index, etc. are not specific to municipal water systems)
  - High spatial variability of the rainfall in the Southeast
  - Supply and demand balance not considered
  - Do not forecast



## Important Considerations – Drought Index

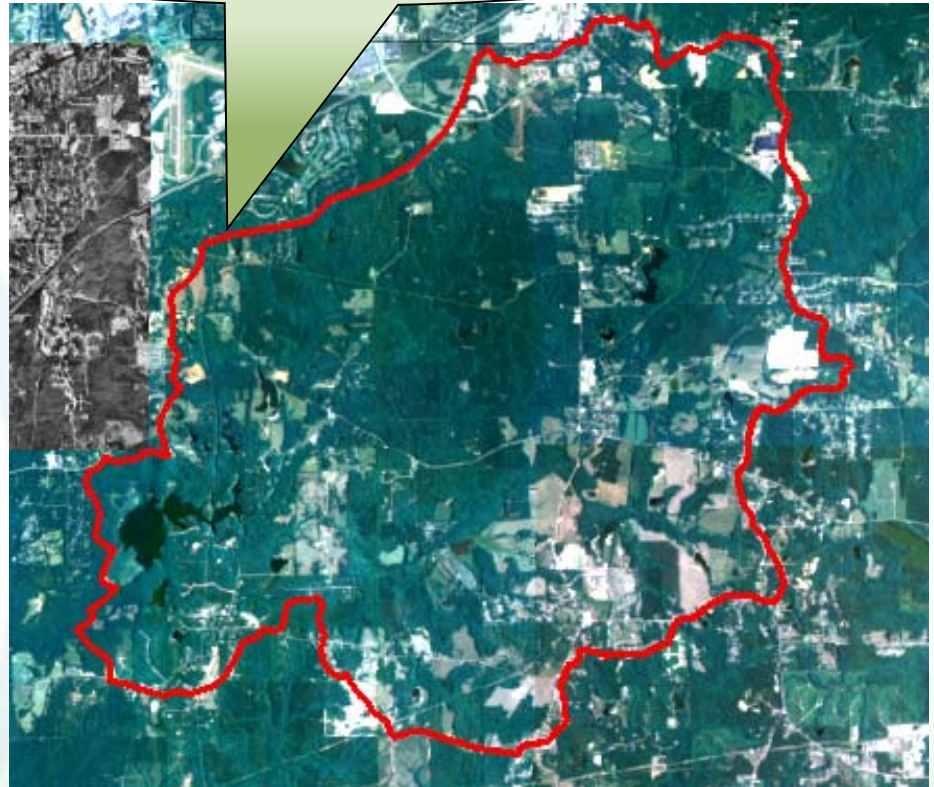
- Suitability for drought types of concern
  - Hydrological Drought
    - Effects of periods of rain shortfall on surface and subsurface water supply
    - Lag behind meteorological and agrometeorological droughts
- Include aspects of water demands, water supplies, drought vulnerabilities
- Data availability and consistency
  - Readily available?
  - Trustworthy?
- Clarity and validity
- Readily-understood and scientifically-sound
- **Temporal and Spatial sensitivity**

## Vision

- Develop a web-based CWDI for water managers of small to mid-size communities in the region
  - Water supply
  - Seasonal water demand
  - High spatial resolution
    - The communities are of relatively small size
  - Provides an easy to use web-interface – help in decision making
  - **Drought Forecast**
    - 3-4 months in advance

## Features

Delineated Supply Watershed



- User just needs internet access
- Delineate supply and demand watersheds
- Provide population, historic water usage data etc.
- No advanced knowledge required

# Basic Principles

## Supply and Demand Water Balance

### ➤ Inputs

- Runoff from the supply watershed (Curve number method)
- Baseflow
- Precipitation
- Additional water supply sources (purchased water, groundwater, etc.)

### ➤ Outputs

- Total water withdrawal (demand)
- Evaporation
- Mandatory discharge

## CWDI Model

- Curve Number Selection: Based on the season (dry or growing) and the Antecedent Moisture Condition (AMC)
- Evapotranspiration: Most important component
  - Dynamic demand - irrigation of lawns and golf courses
  - Dependent on climate
  - Dynamic demand is given by:

$$W_d = [(PET(t) - AET(t))] * IrrigatedArea$$

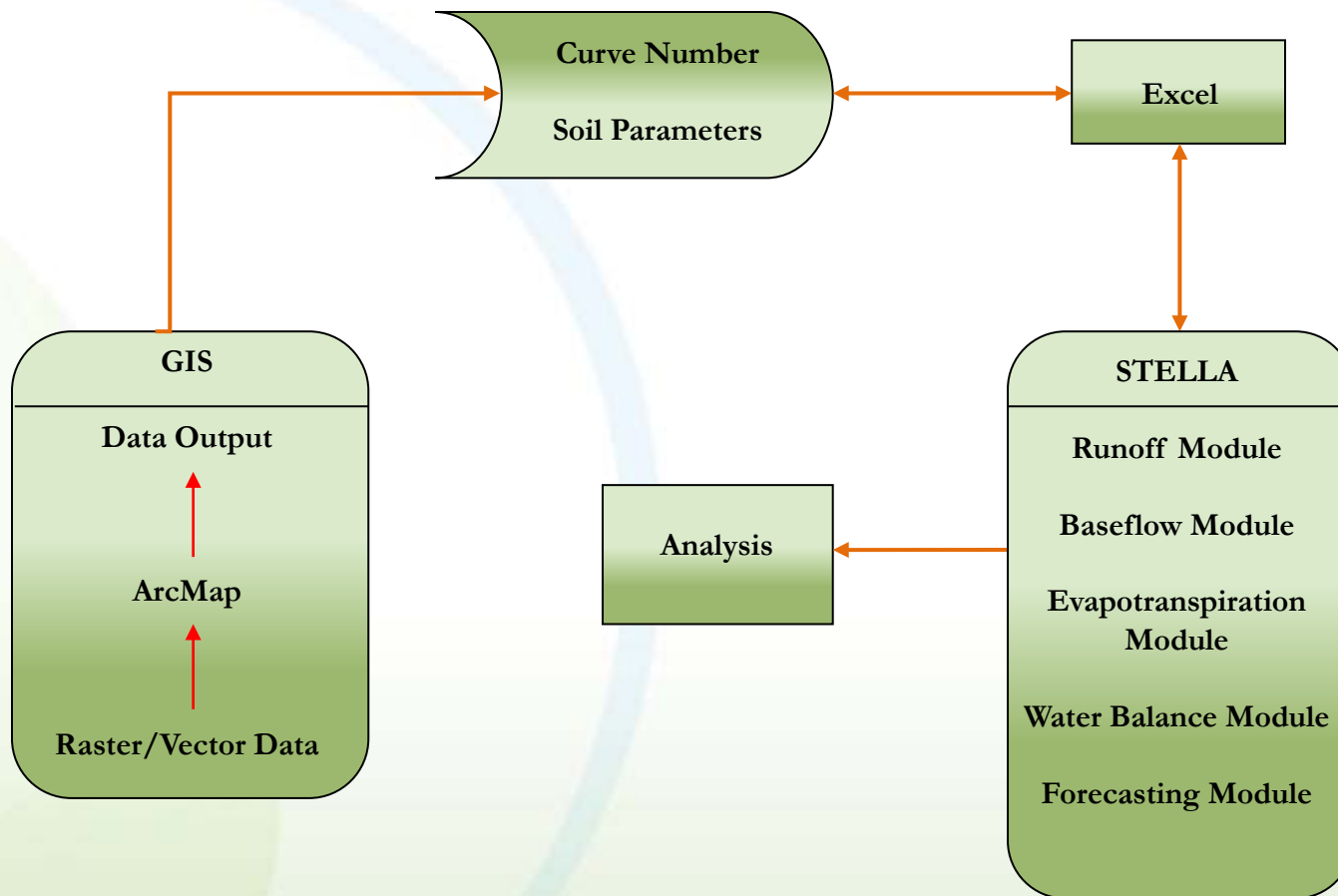
- Static Demand: Depends on population
- CWDI: Estimated as

$$CWDI = \frac{S}{S_d} - 1$$

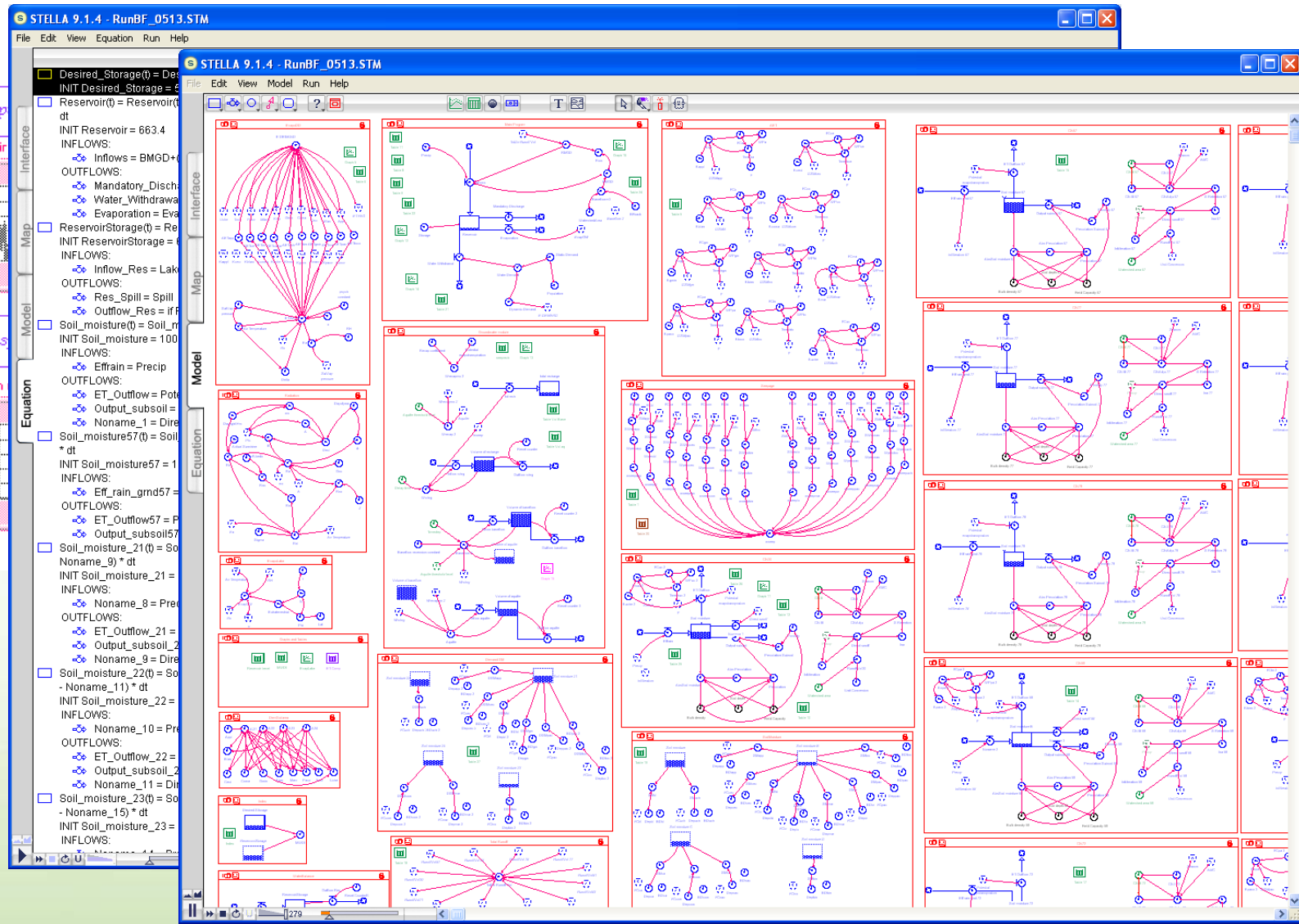
If  $CWDI \leq 0$ , => Drought

If  $CWDI > 0$ , => No Drought

# Model Framework



# CWDI Model in STELLA



Weather Imp

Evapotrans

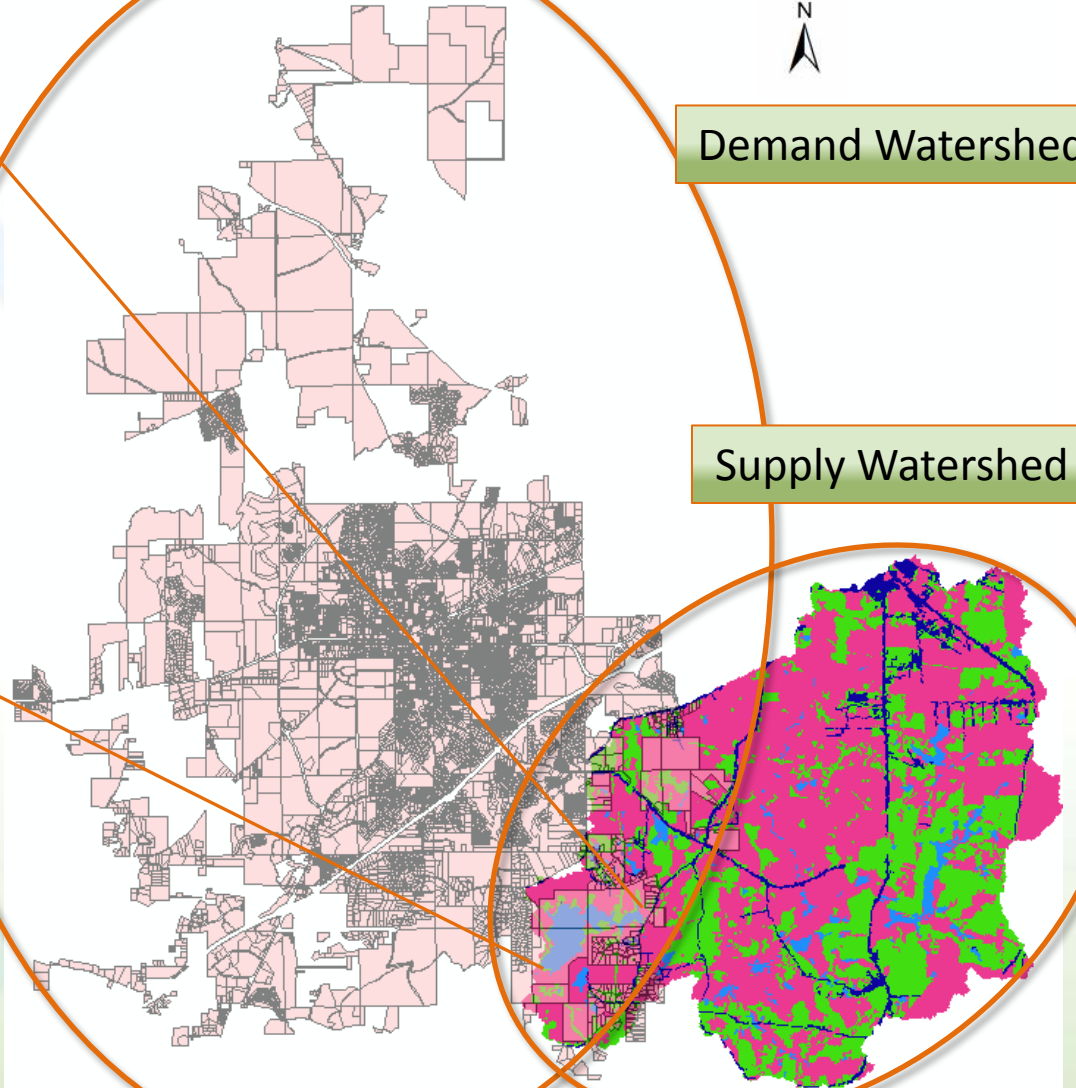
# Case Study 1 – City of Auburn



Lake Ogletree

Demand Watershed

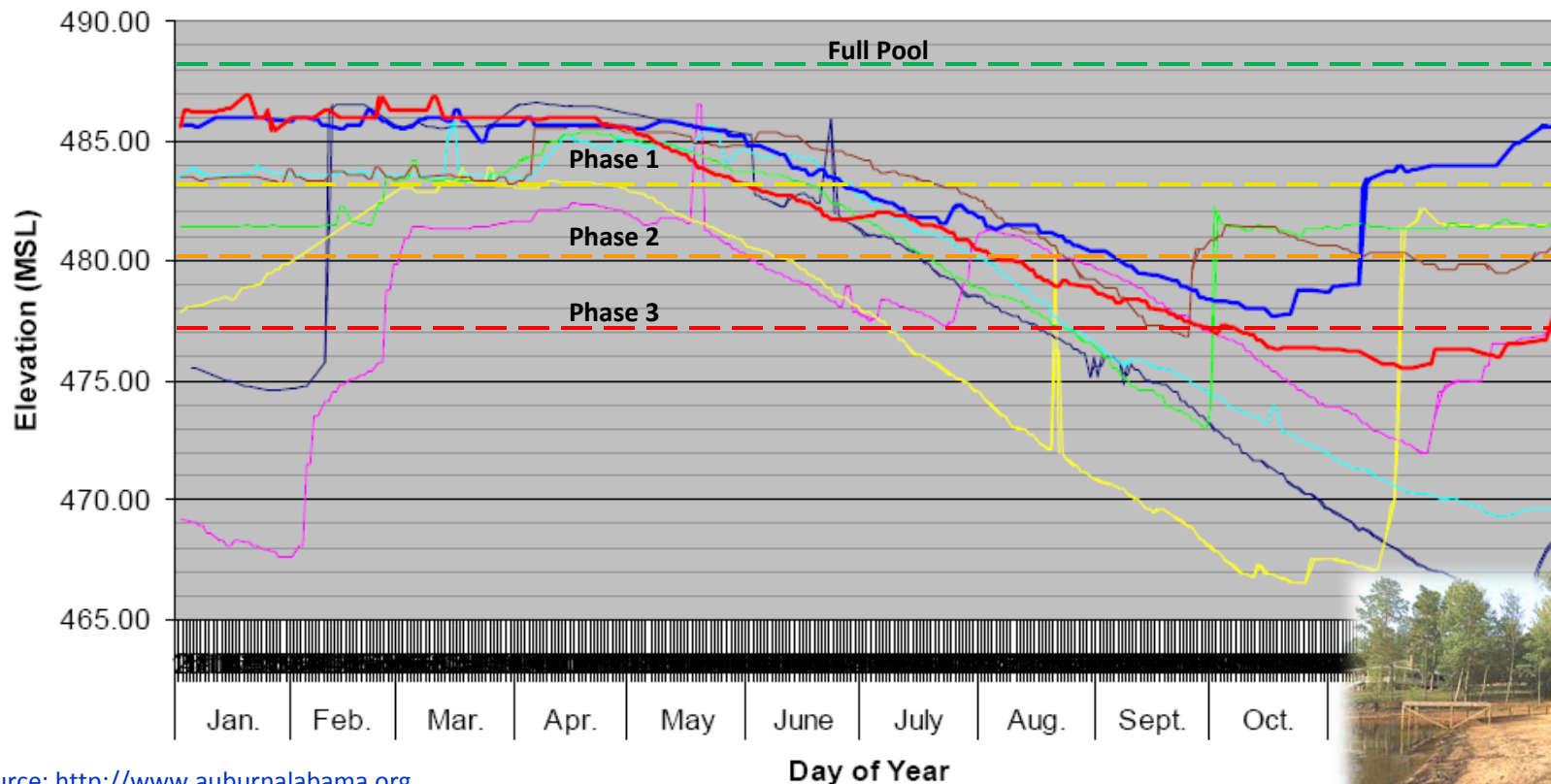
Supply Watershed



- Current average usage for the water system - 6 MGD
- Current water supply capacity - 11.6 MGD
- Can purchase up to 3.6 MGD from Opelika Utilities. (used only at certain times during the year)

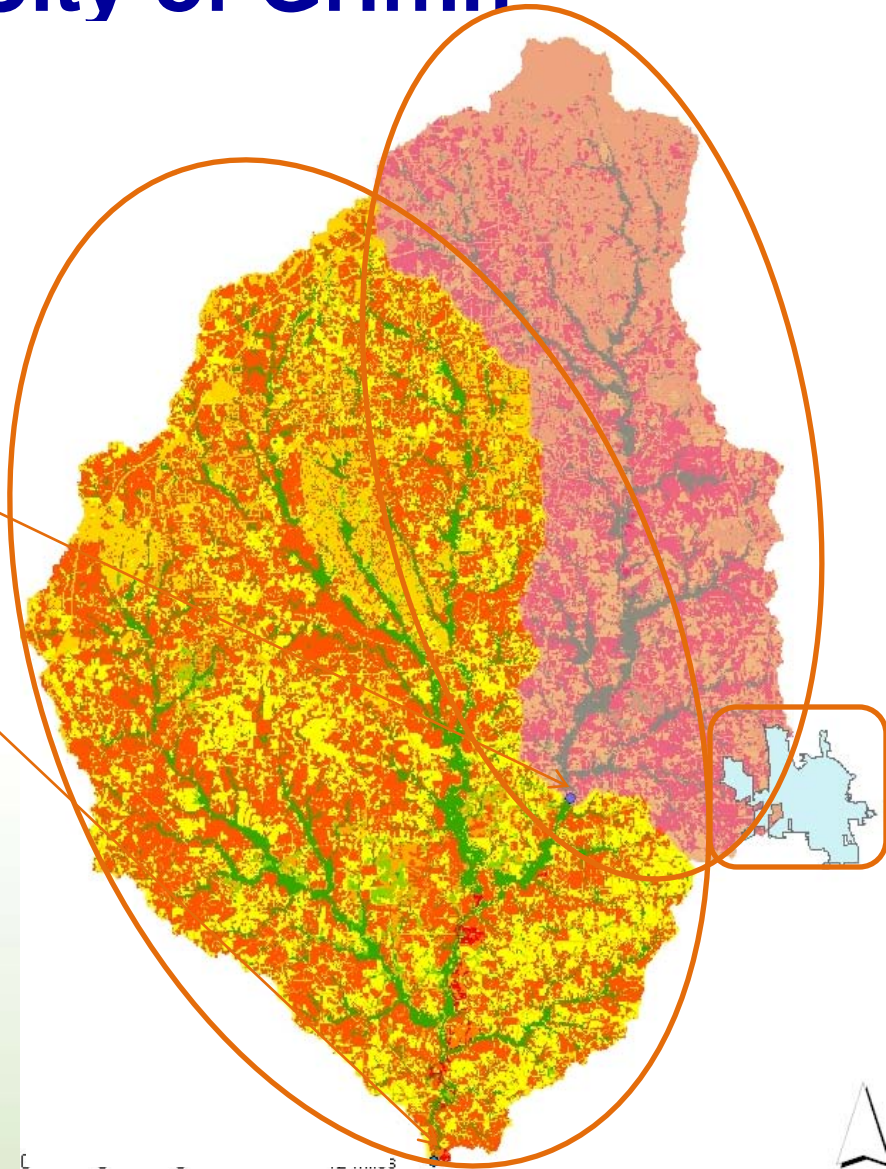
# Why Climate Variability is Important to City of Auburn?

Historic Lake Level (Comparative Drought Years)

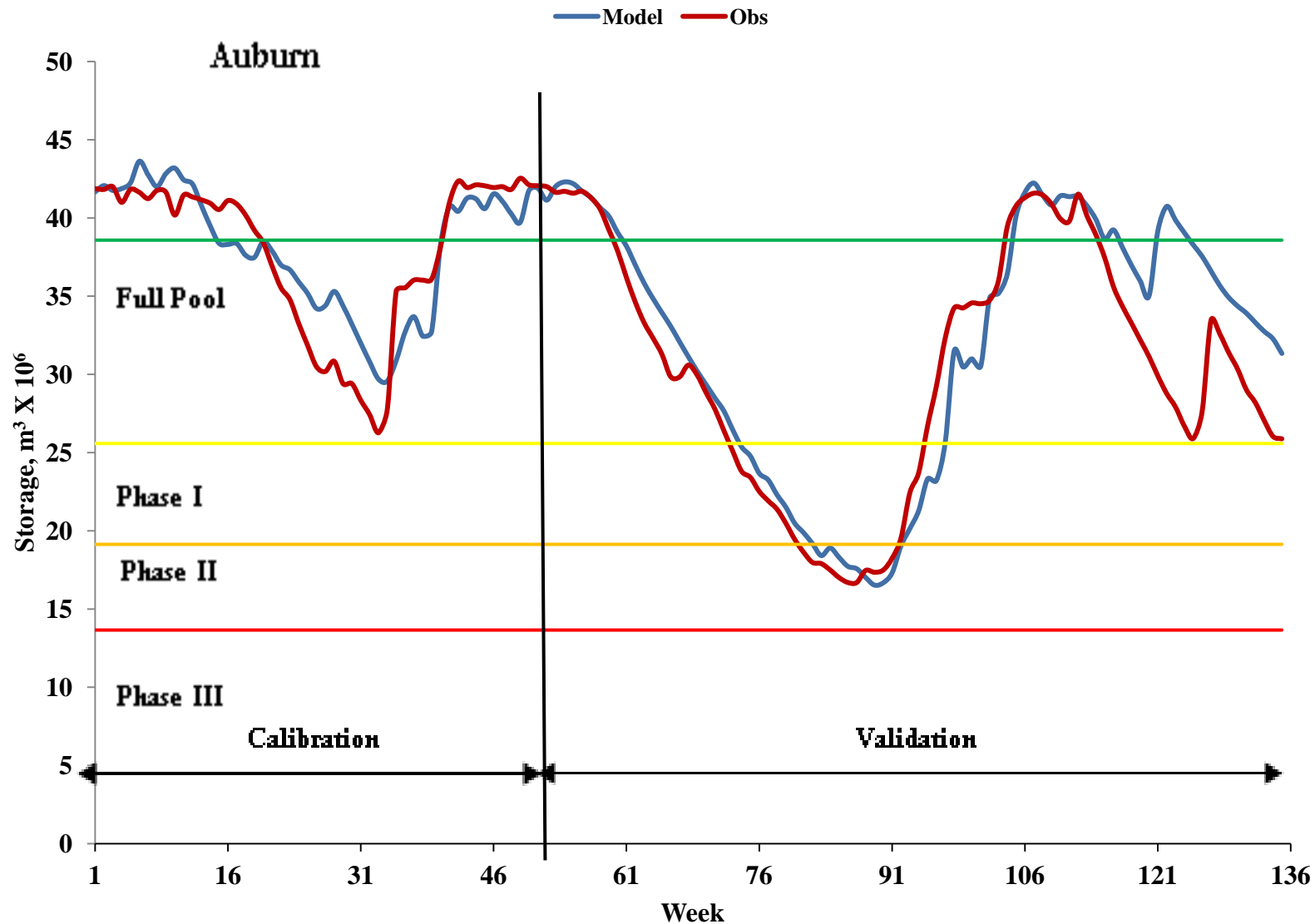


## Case Study 2 – City of Griffin

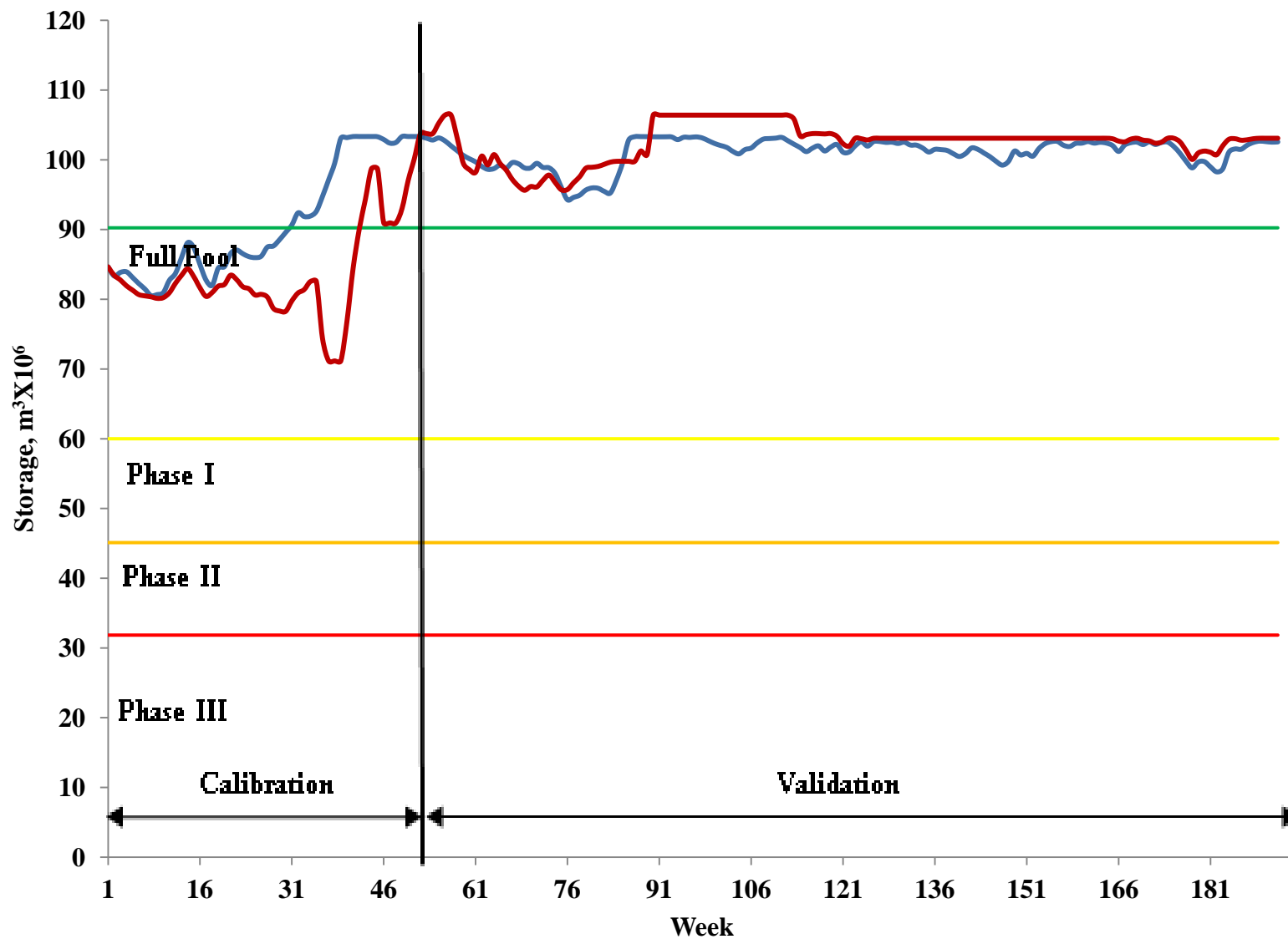
- 2 withdrawal points on Flint river
  - Griffin (13.2 MGD)
  - Molena (50 MGD)
- 7 customers
  - 80000 people
  - City of Griffin
  - Wholesale customers
- 24.5 Mgd capacity



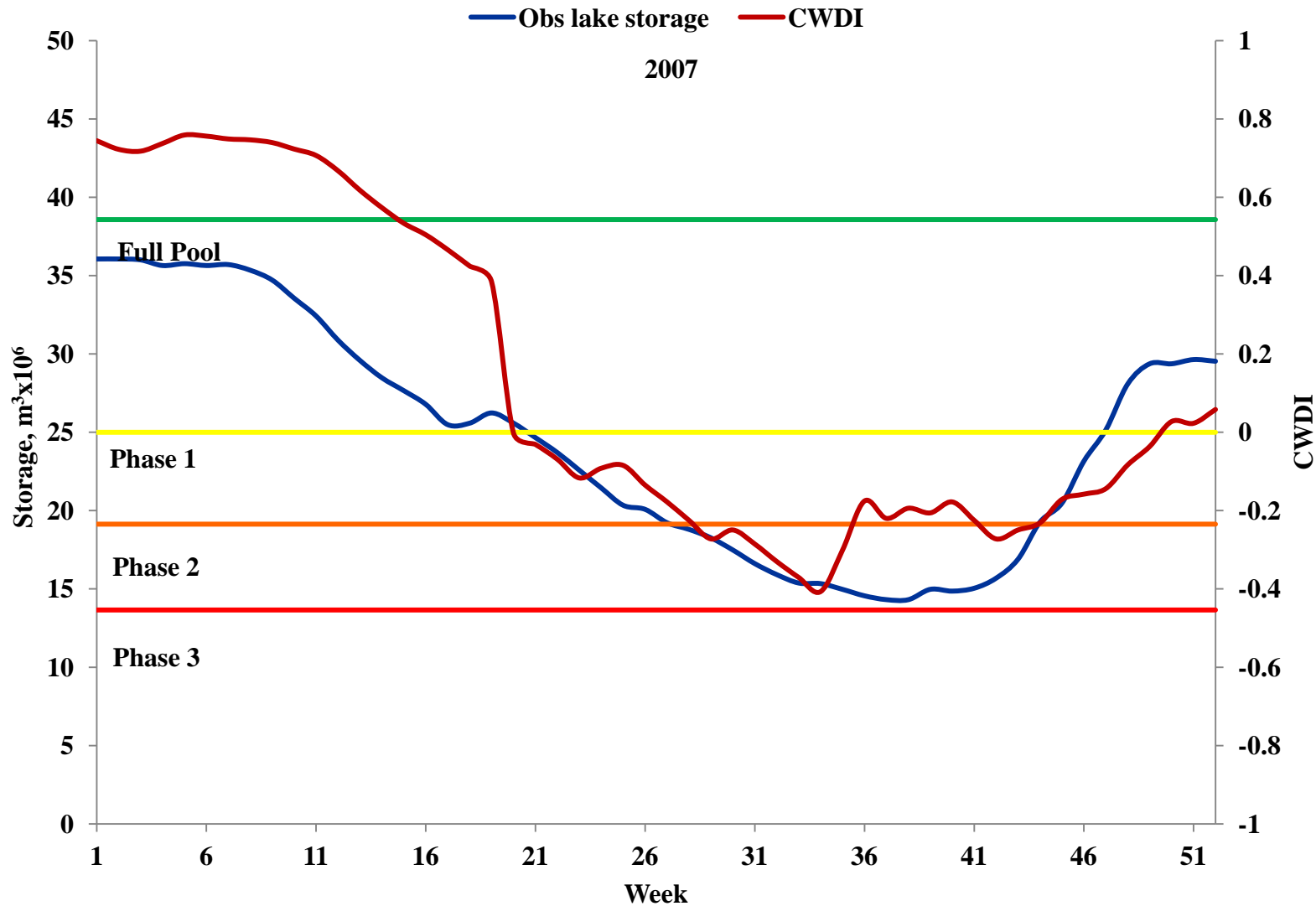
# Validation - CoA



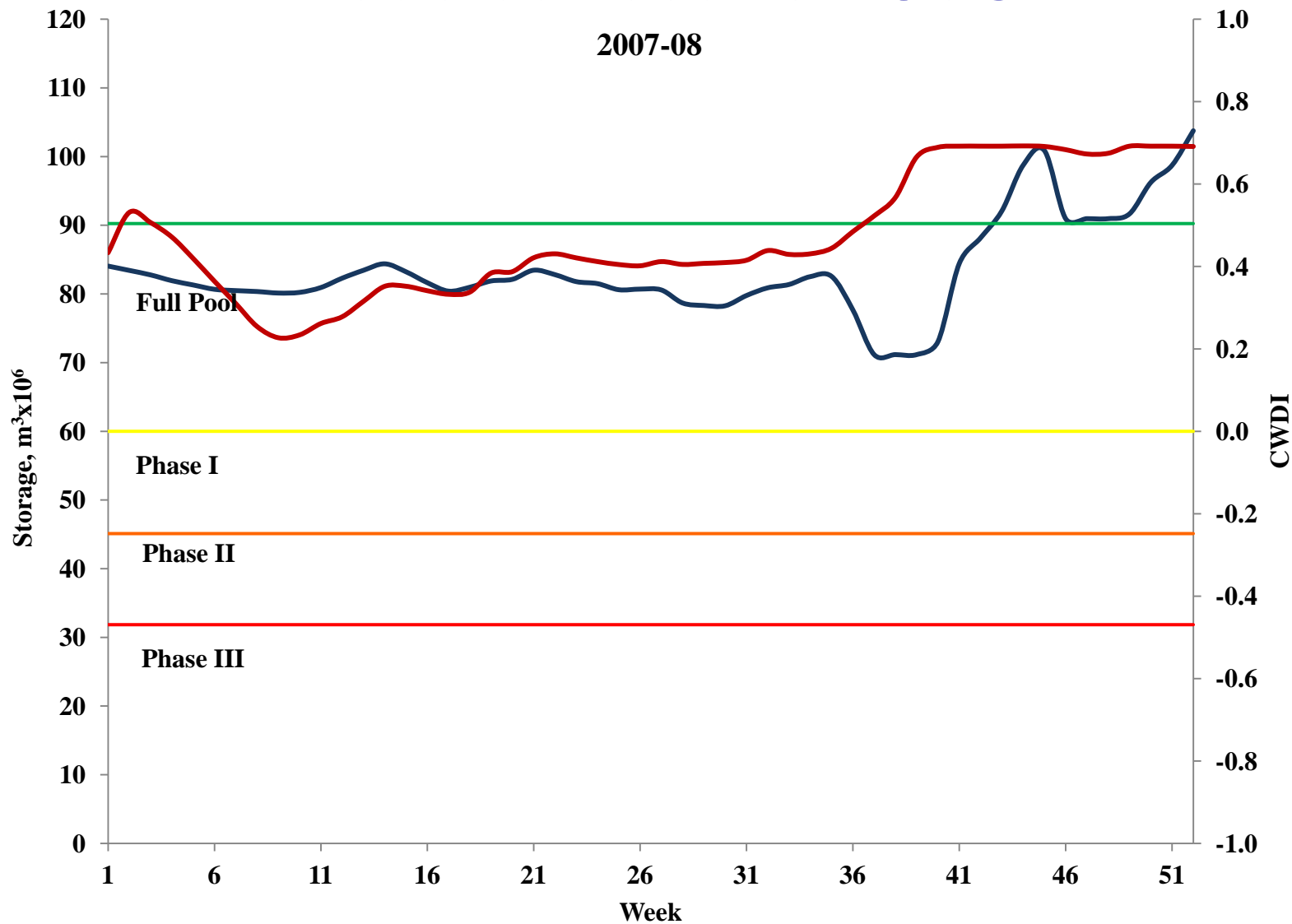
# Validation - CoG



# Modeled results - CoA

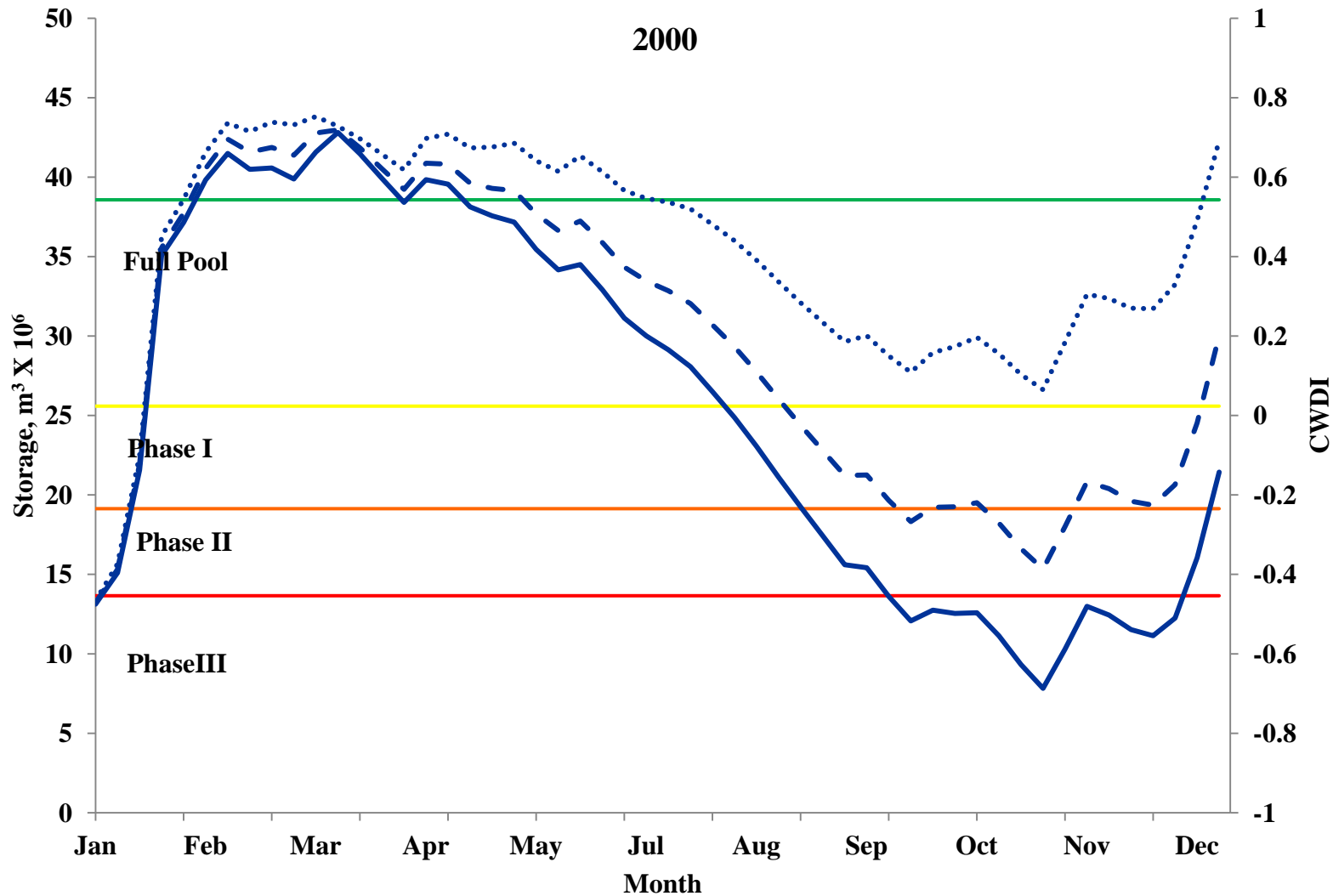


# Modeled results - CoG



# Scenario Analysis

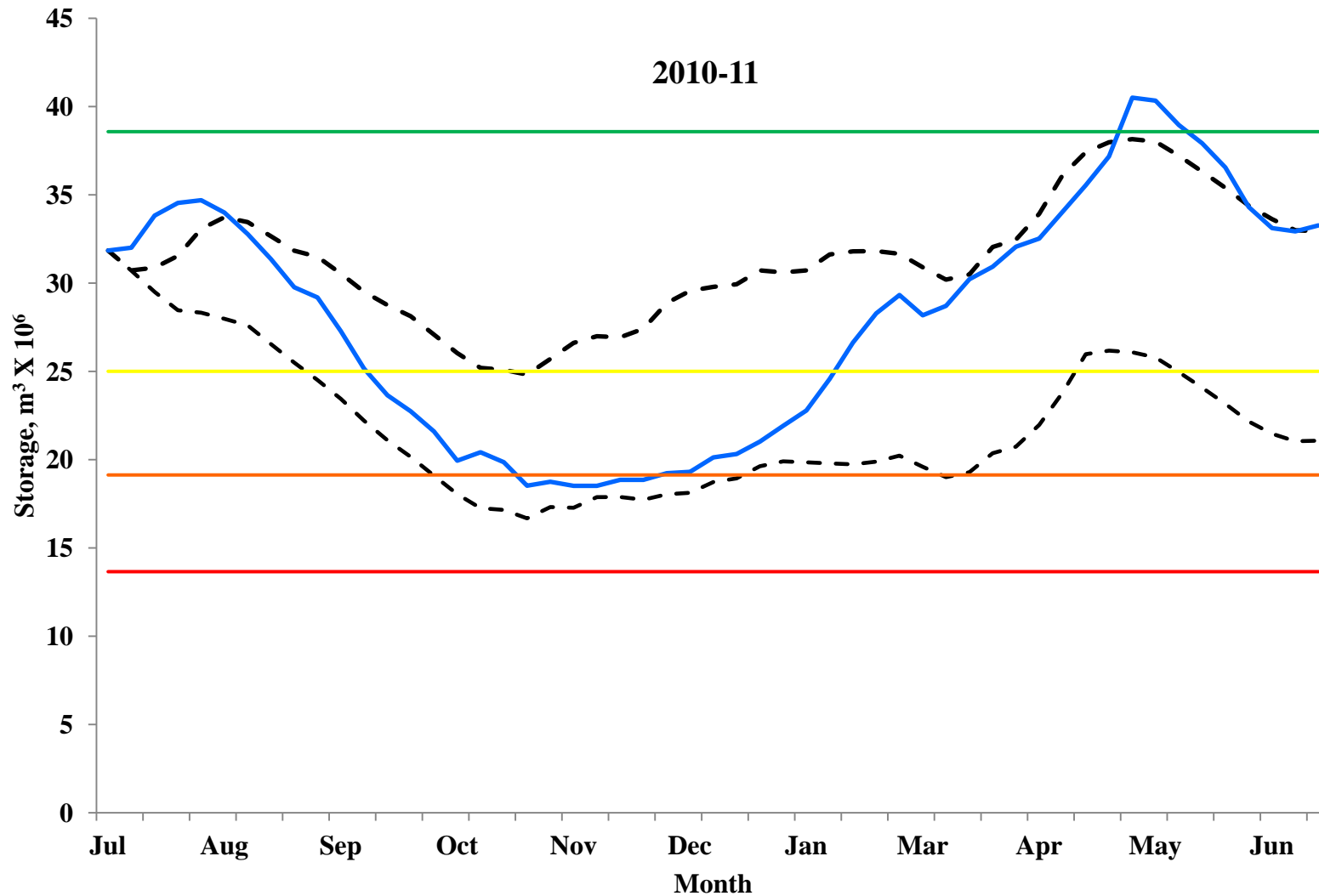
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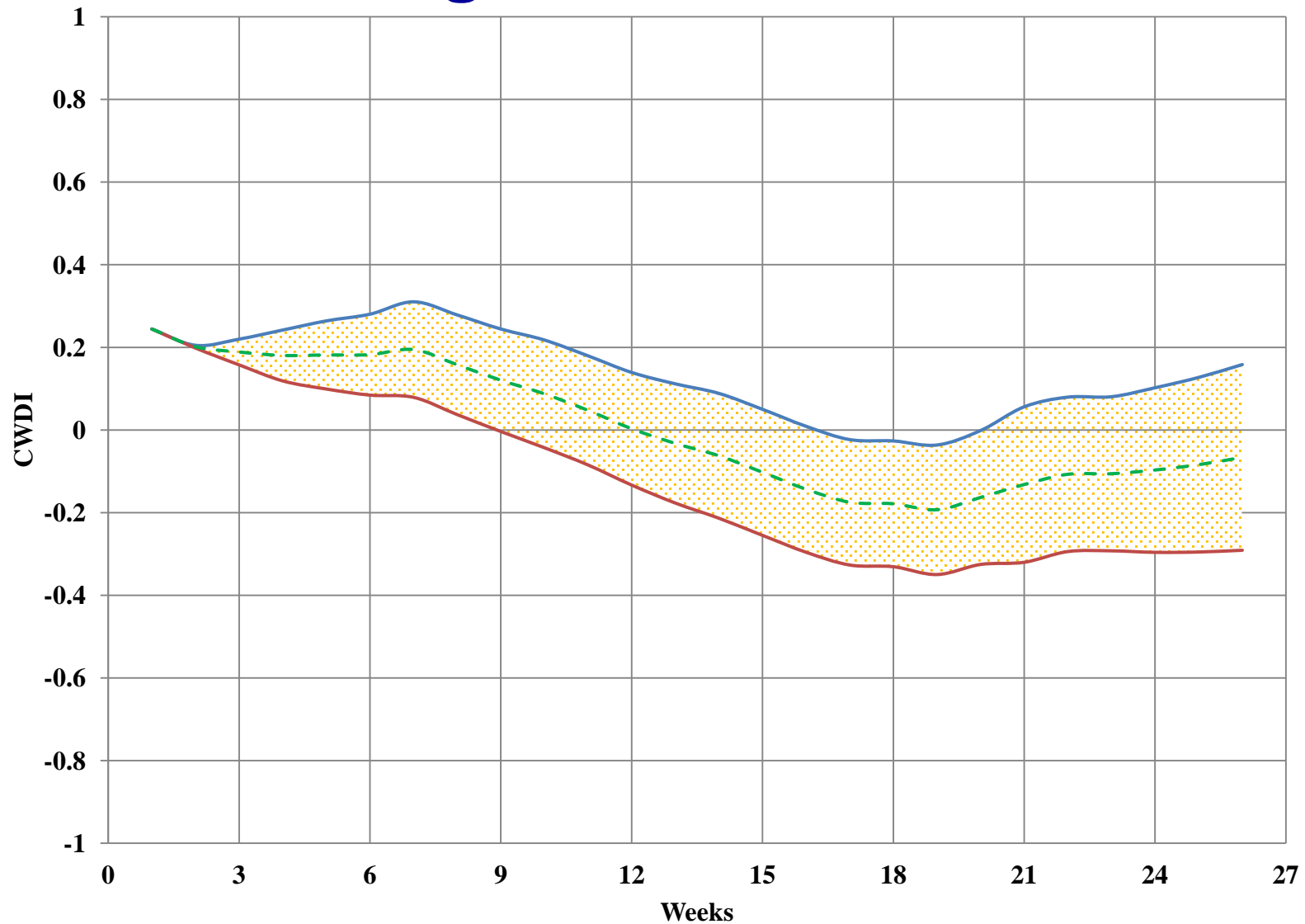


# Drought Forecasting

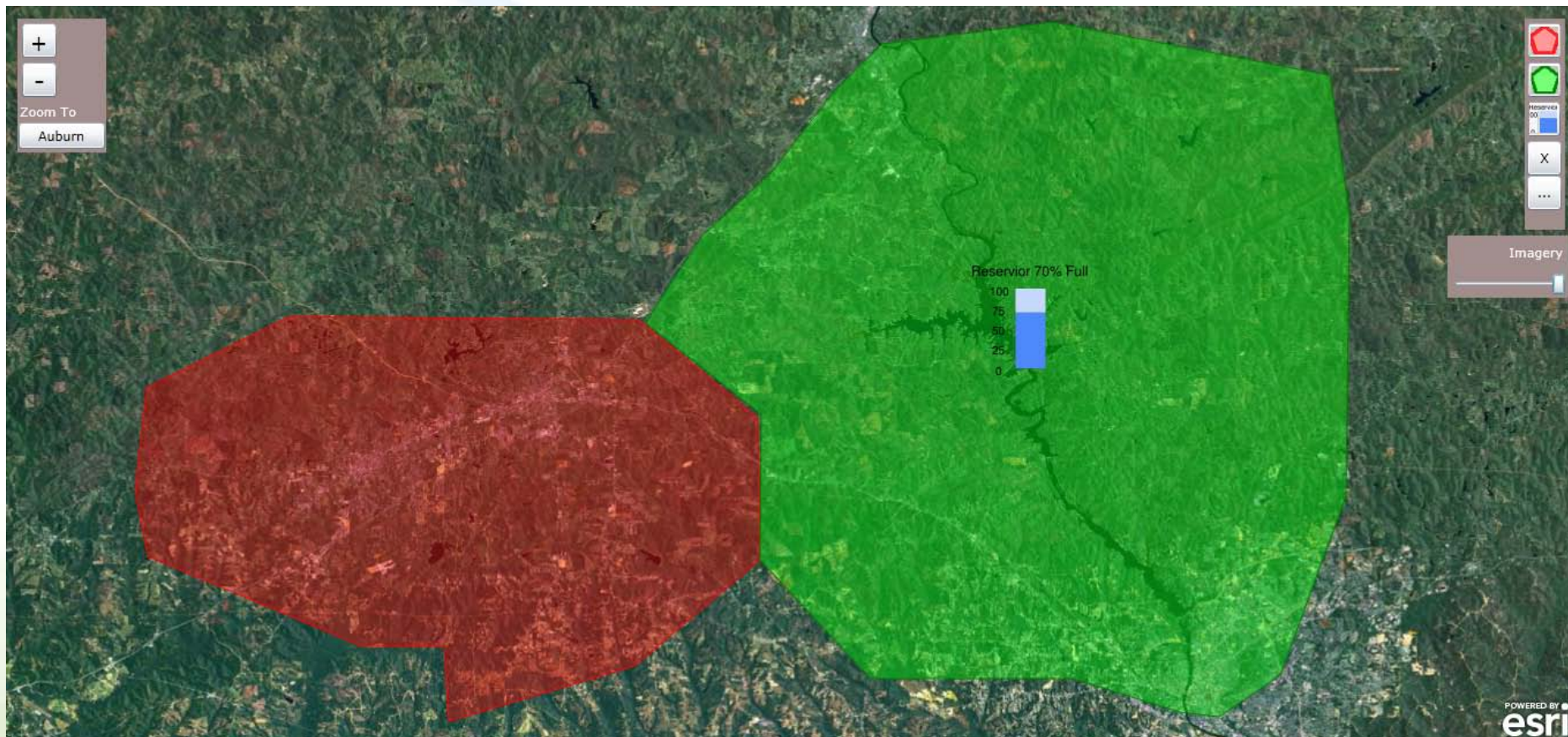
- - Ensemble forecast    — Observed



# Drought Forecast-CoA



# Web based CWDI – Initial Stage



## Value of Drought Information

- At onset of droughts, main drought management strategies are:
  - Water restrictions
  - Short-term emphasis on leakage control measures
- Additional drought management strategies are:
  - Water conservation measures (e.g. dual flush cisterns, use of grey water for garden watering)
  - Design and installation of roof catchment systems
  - Require greater public and political awareness of community's water resources

## Value of drought information

- Impact of climate variability signal (ENSO) on water demand
  - Multiple linear regression approach to predict per capita water demand. Predictors are:
    - Daily precipitation
    - Daily max. temperature
    - One day lag variable to account for temporal persistence in time series of water use
  - Considerable accuracy in predicting water use with  $R^2$  values ranging from 0.62 – 0.84
    - Negative relationship with precipitation
    - Positive relationship with temperature and lag. variable

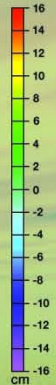
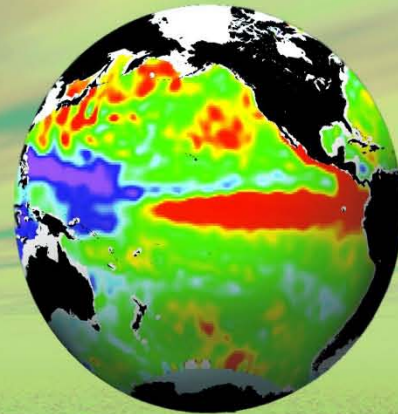
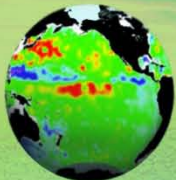
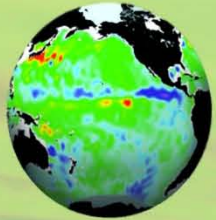
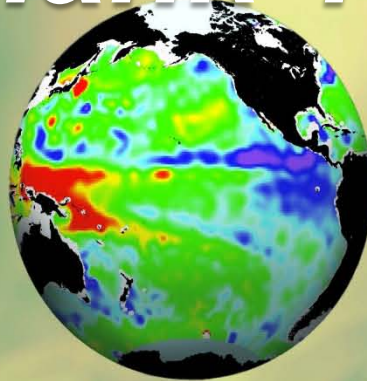
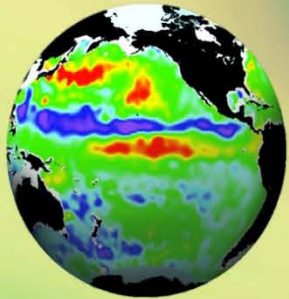
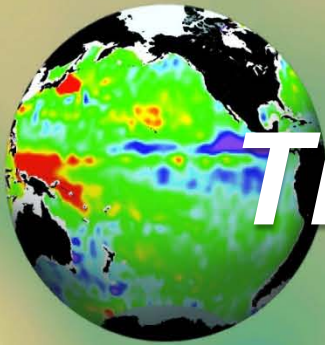
# Value of drought information

- Work in progress
  - Use and effectiveness of municipal water restrictions
  - Use of CFSRR dataset to run the model in past and quantify the value of CWDI information for stakeholders.
  - Knowledge of drought forecast allows mitigation of negative impacts
  - Survey – Jessica Bolson
    - Policy implications
    - Conservation measures etc.

## Conclusions

- Need of drought information for small to mid-size communities in ENSO related climate variability prone Southeastern US
- CWDI: drought forecasting
  - Data available
  - Reliable
  - Consistent
- Results will improve as the data keeping of communities/ water managements improve
- Drought forecast information has considerable value since demand is impacted by climate variability.

*Thank You*



*Questions*