Resiliency and the Energy-Water Nexus

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RD&D Needs For Energy System Climate Preparedness and Resilience
IEA Committee on Energy Research and Technology

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EPRI: Born in a Blackout

Founded in 1972 as an independent, non-profit center for public interest energy and environmental research

New York City, The Great Northeast Blackout, 1965

Our Members…

- 450+ participants in more than 30 countries
- EPRI members generate approximately 90% of the electricity in the United States
- International funding of nearly 25% of EPRI's research, development and demonstrations

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Outline

I. EPRI approach to resiliency

II. Power sector water use and availability

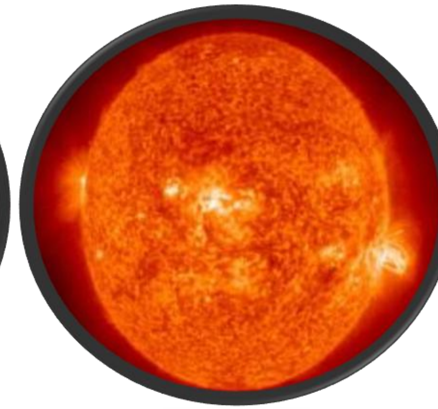
III. EPRI modeling tool: “Water Prism”

EPRI's approach to Resiliency

Physical Security

Weather Events

Cyber Security



Solar Storm

A Comprehensive Risk Informed System Resiliency Plan
Hardening, Recovery, Survivability

Resiliency
External Events

- Earthquakes
- Flooding
- High winds
- Extreme temperatures
- Snow loading
- Fire
- Drought

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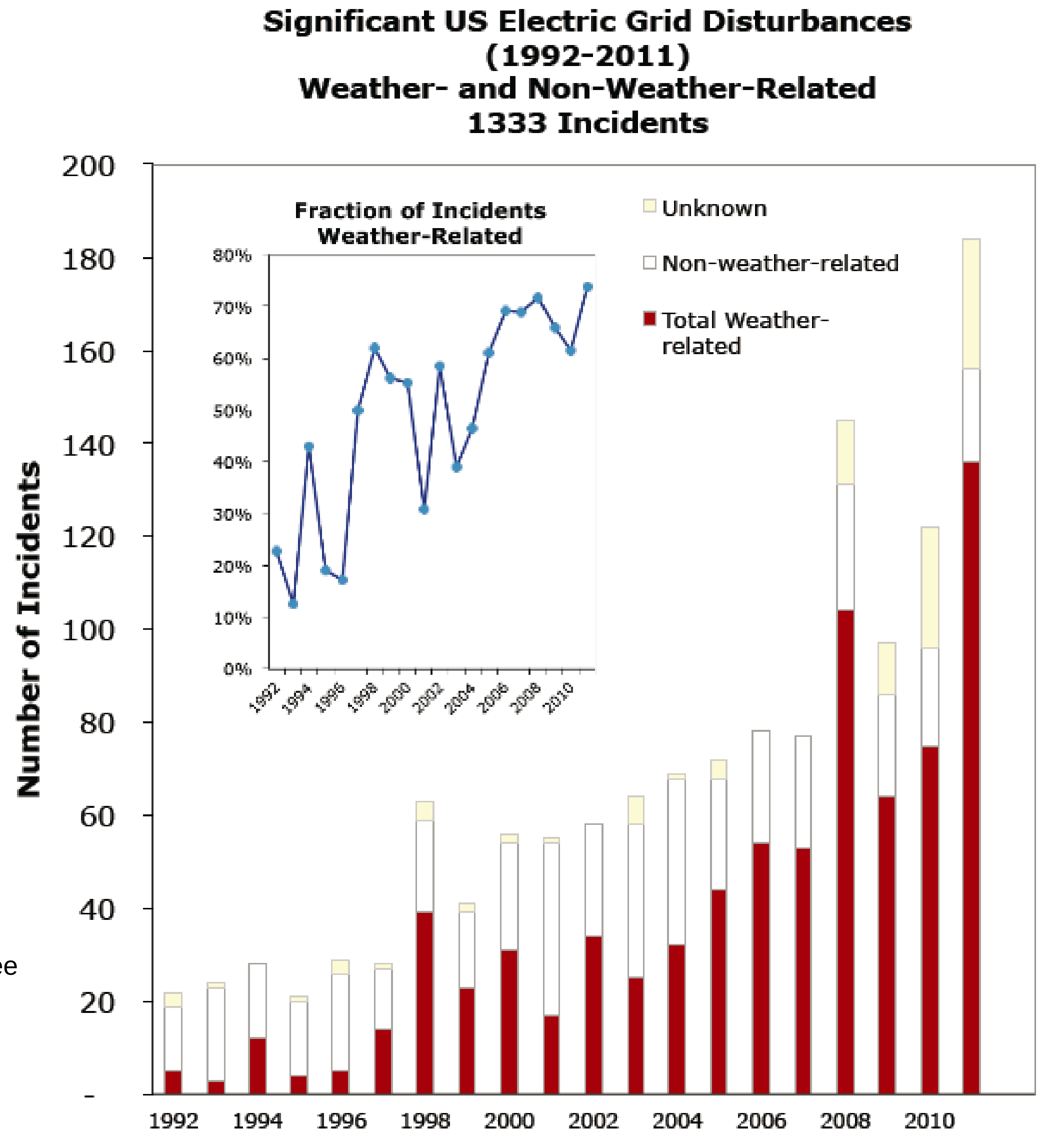
Resiliency
Increasing Number of Service Interruptions

- Increase in the frequency and severity of weather events
- Heightened customer expectations

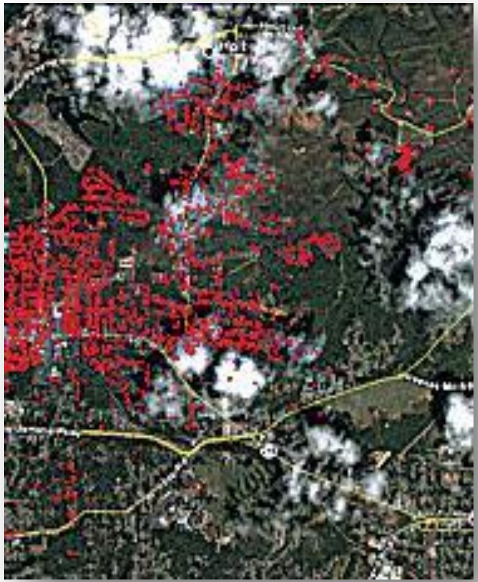


Source: Electric Grid Disruptions and Extreme Weather. See http://evanmills.lbl.gov/presentations/Mills-Grid-Disruptions-NCDC-3May2012.pdf.

Resiliency

Improving Recovery Time

Using UAVs for damage assessment



Integrating OMS and GIS with AMI systems

Enabling the field workforce and consumers

Technologies to Enhance Situational Awareness

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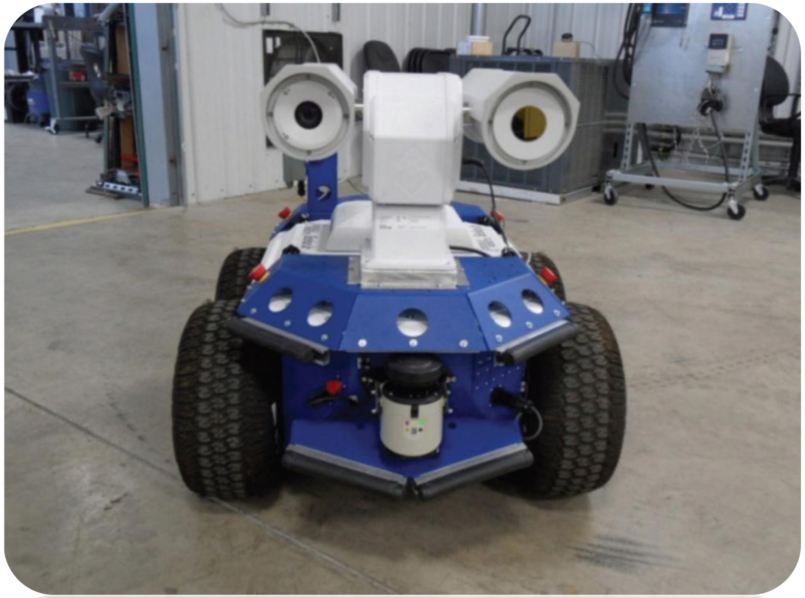
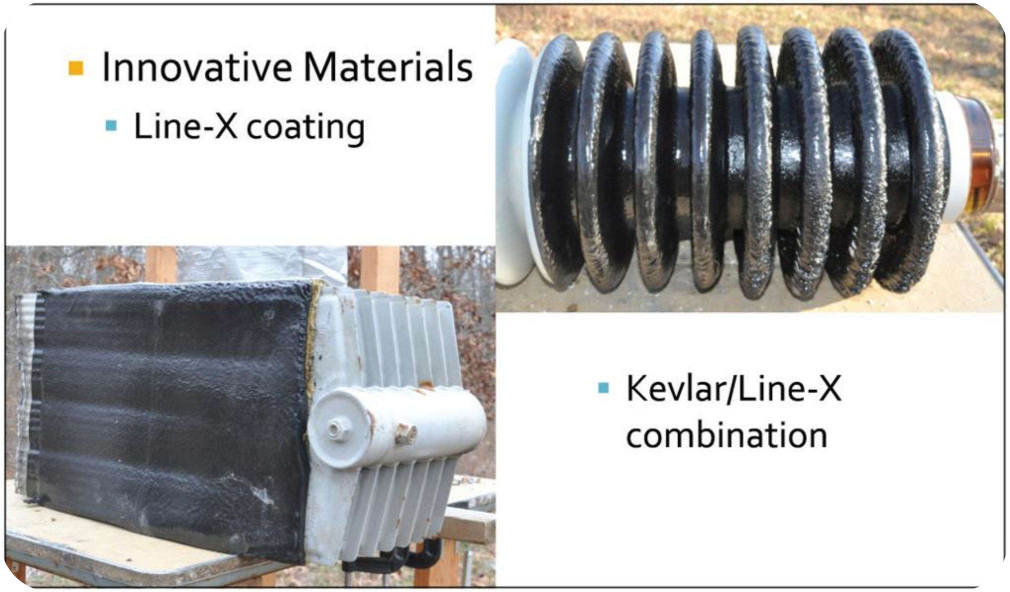
Resiliency
Technology to Improve Physical Security



Substation Robot
Online Infrared and Visual Camera



Explosive Protection & Coatings
Courtesy: University of Kentucky

Resiliency
Vegetation Management

Challenge

- Reducing impacts from weather-related outages
- Trees never stop growing!
- Are practices more aggressive?
- Is data analysis working?
- Costs and benefits - $3k/mile or $25k/mile?

EPRI R&D

- Alternative approaches – New ideas to test and analyze
- Improved tree trimming schedules to keep rights-of-way clear
- Selective Undergrounding
- Reinforcing Overhead Distribution

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Resiliency
Grid Modernization

- **Using distribution automation**, **automated service restoration**, **outage management systems**, **automated metering**, and other smart grid technologies to improve resiliency
- Make communications networks and other smart-grid components more robust during extreme events.

Resiliency
Health & Safety

Challenge

- Identify, quantify and understand physical and chemical stresses on the workforce
- Tools and data for assessing injury trends, exposures and potential occupational risks.

EPRI R&D

- Identify knowledge gaps required to evaluate additional data requirements.
- Address critical issues associated with hazard identification, assessment and control.
- Integrate data and practices from across the industry to inform individual company decision making.

Ability to quickly respond dependent on trained, reliable workforce

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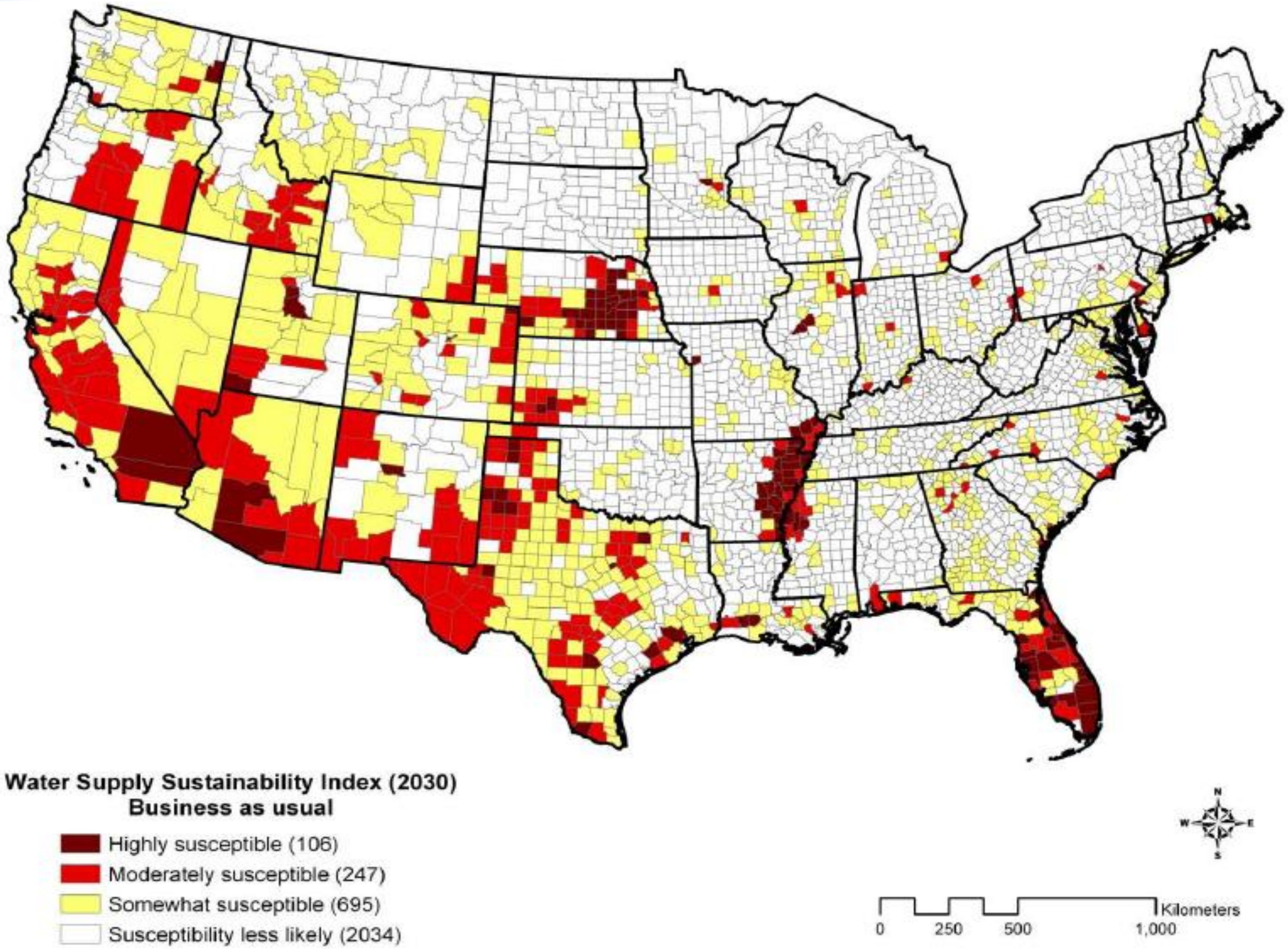
Big Picture

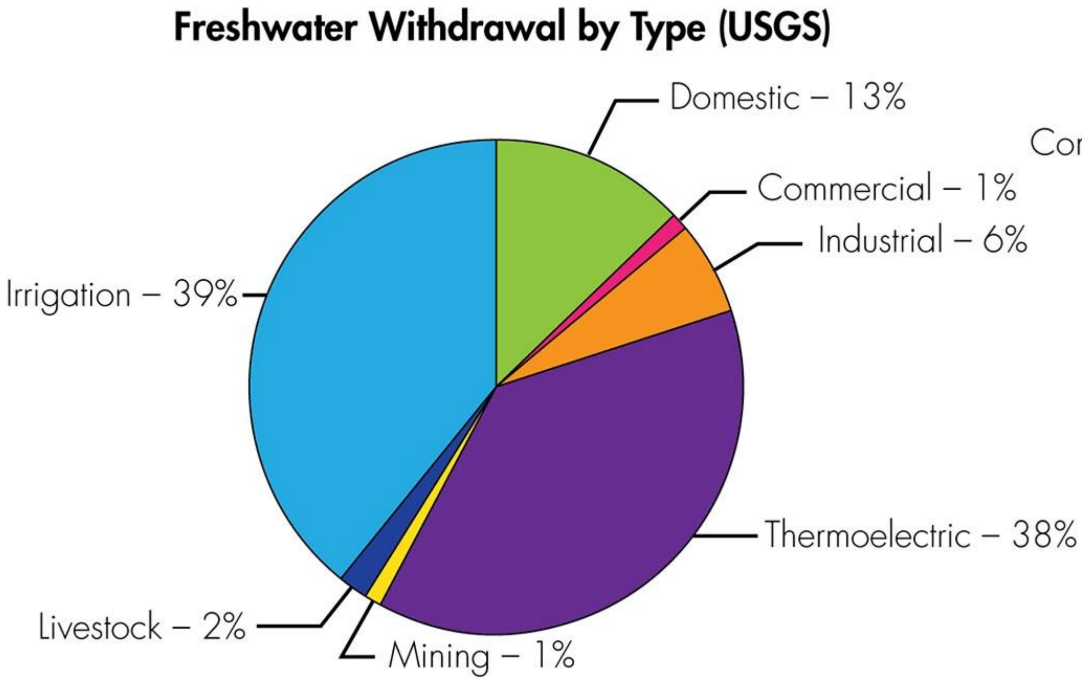
- Drivers
  - Fast growing demand for clean, fresh water
  - Population growth
  - Increased concern for environmental protection and enhancement
  - Unknown impacts of climate variability
  - Many regions showing vulnerability to water shortages
- Challenges
  - Water resource management requires broad stakeholder consensus
  - Social and economic vitality depend on water and electricity availability
  - Demand for both are increasing and are inter-related
  - Energy/water sustainability is a real and high priority issue

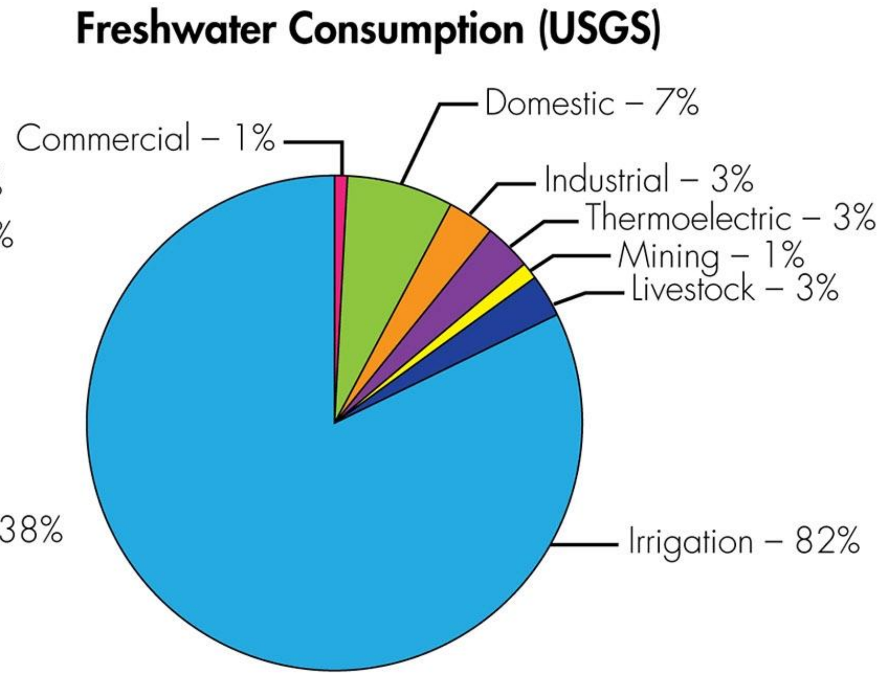
Water Sustainability Outlook for the US



Reference: "Water Use for Electricity Generation and Other Sectors: Recent Changes (1985-2005) and Future Projections (2005-2030)" , EPRI Report 1023676

Freshwater Withdrawal and Consumption





Sources: EPRI, USGS

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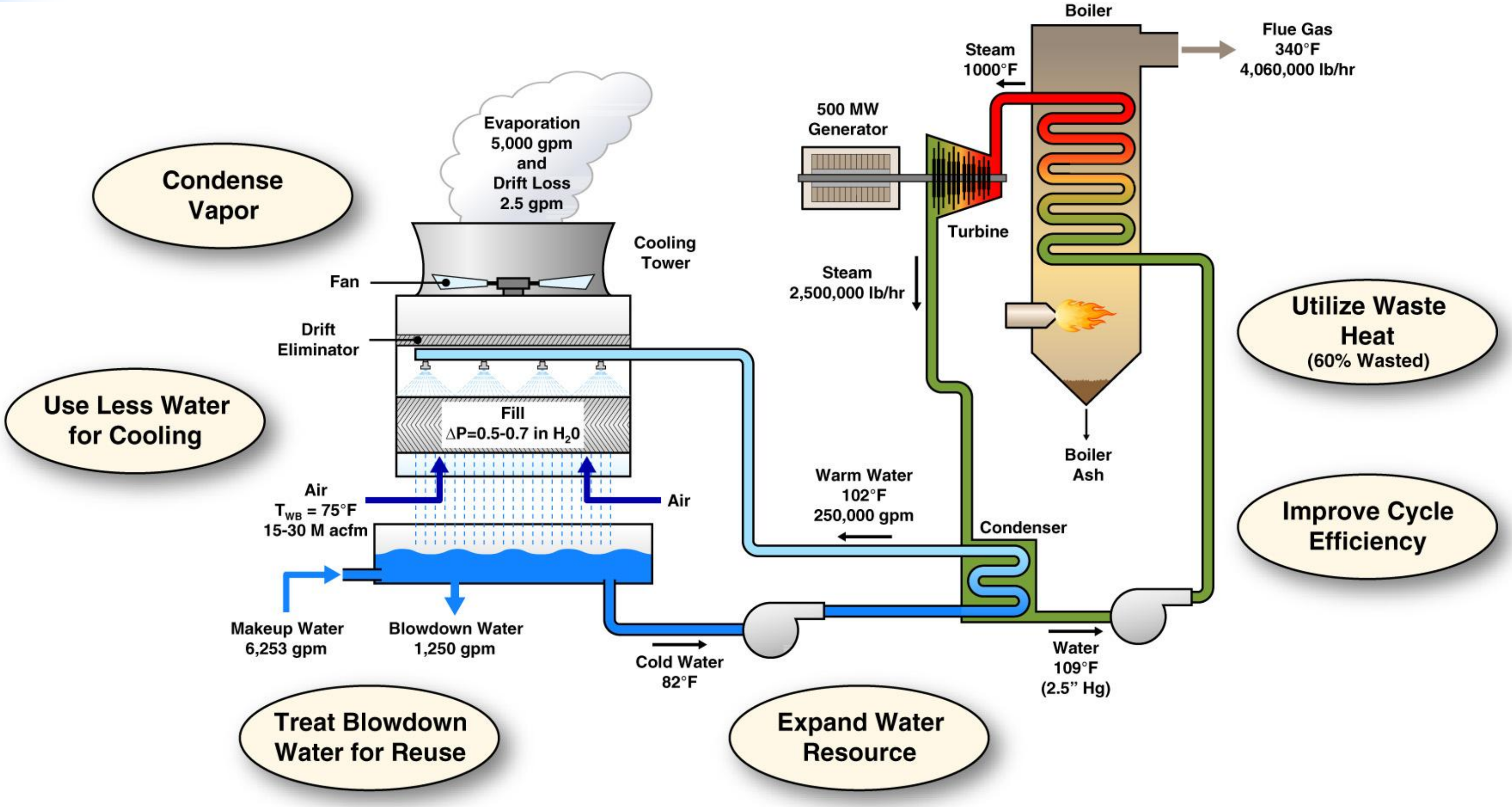
Opportunities for Power Plant Water Use Reduction

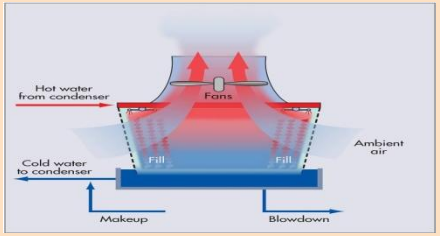


<u>Research Priorities</u>: Advancing cooling technologies, novel water treatment and waste heat recovery concepts to improve efficiency and water use

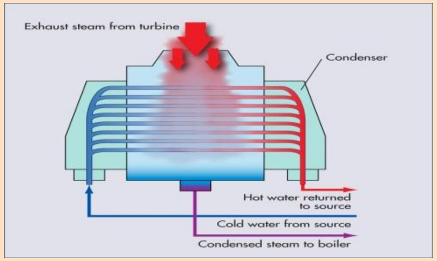
What Cooling System Options are Currently Deployed in the Industry?

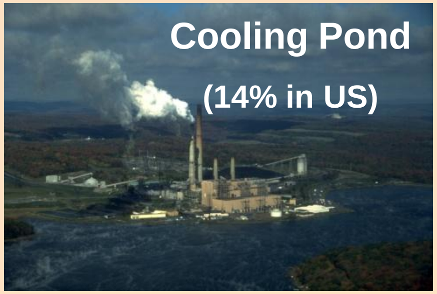
Water Cooling

Cooling Tower (42% in US)



Once Through Cooling (43% in US)

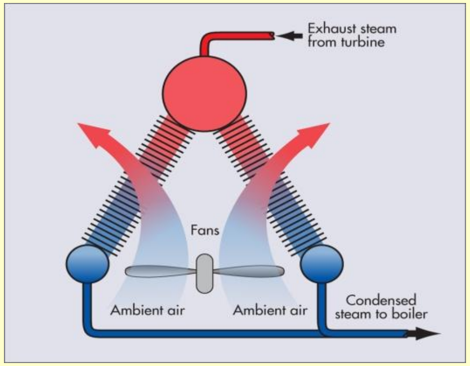




Air Cooling

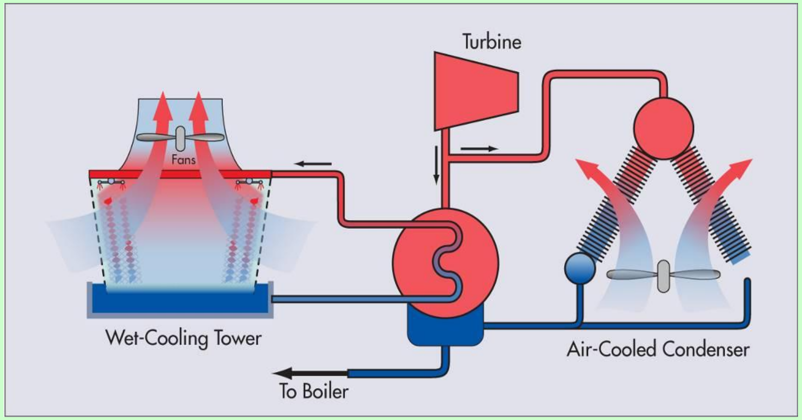
Air Cooled Condenser

(1% Usage in US)



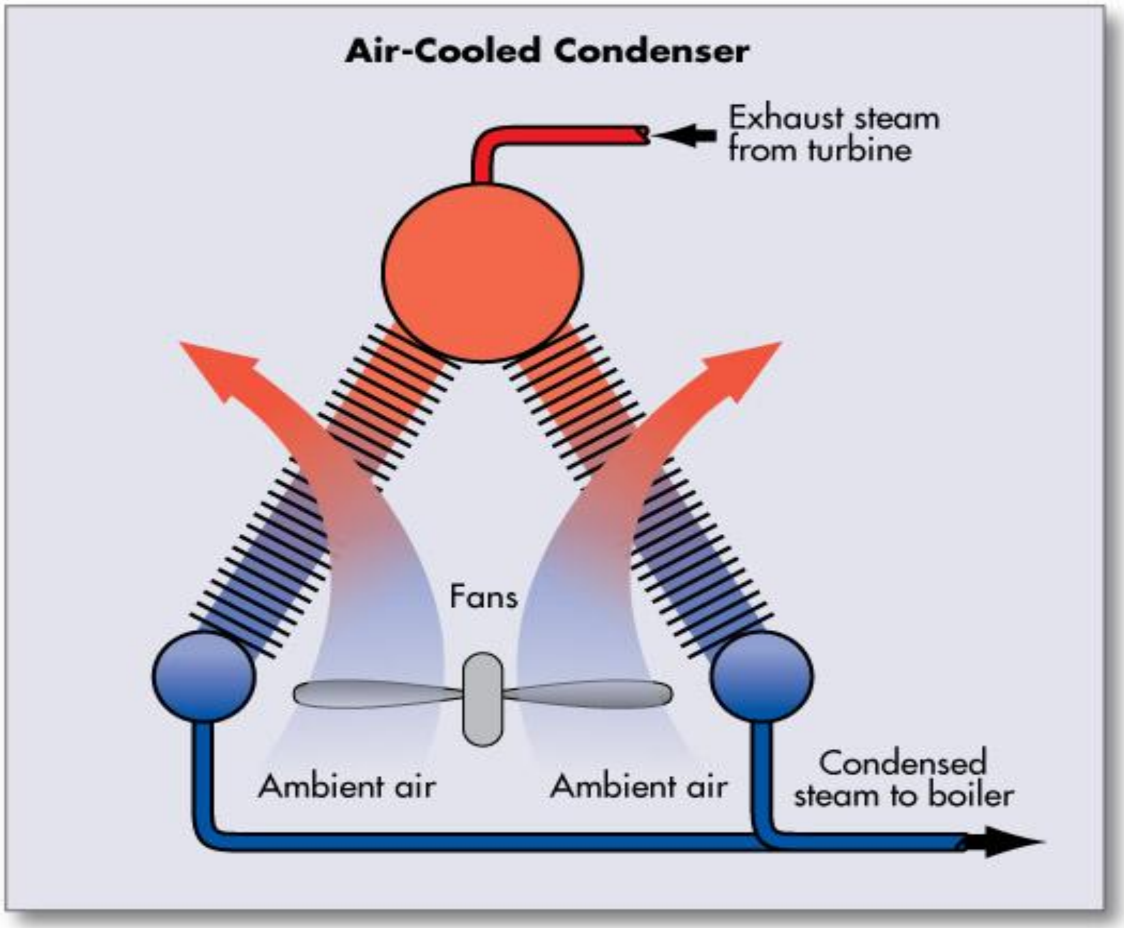
Hybrid Cooling

(<1% in US)



Trend Continues Towards Increased Cooling Tower Use

Dry Cooling



Matimba 6x665MW Coal

Courtesy of Eskom

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Bighorn---530 MW Combined-Cycle with ACC

Issues with Dry Cooling:

- Cost
- Size
- Hot weather penalty
- Wind effects

Technology Innovation
Key Advanced Cooling Projects

- Waste Heat/Solar-Driven Green Adsorption Chillers for Steam Condensation (Collaboration with Allcomp)
- Thermosyphon Cooler Technology (Collaboration with Johnson Controls)
- Advanced M-Cycle Dew Point Cooling Tower Fill (Collaboration with Gas Technology Institute)
- Heat Absorption Nanoparticles in Coolant (Collaboration with Argonne National Laboratory)
- Hybrid dry/wet cooling to enhance air cooled condensers (Collaboration with University of Stellenbosch / So. Africa)

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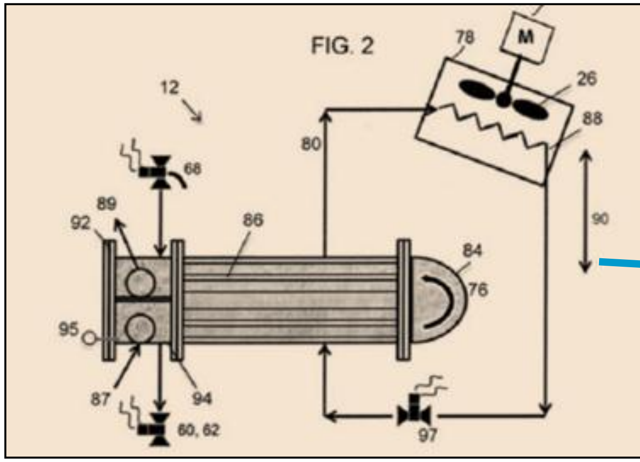
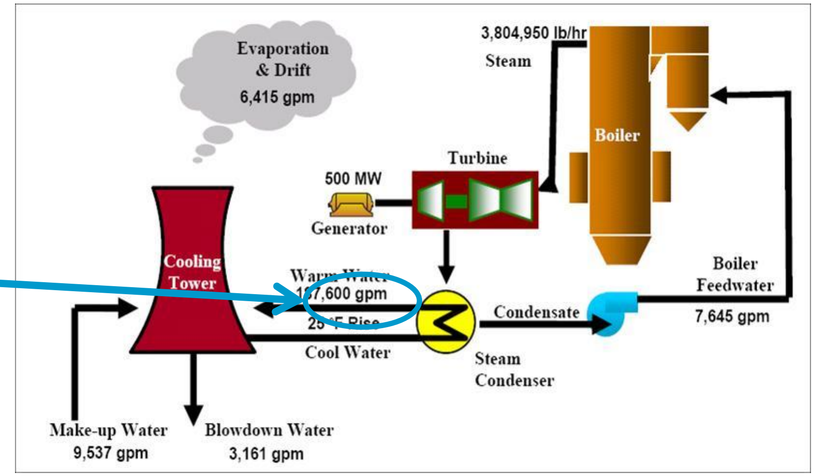
Thermosyphon Cooler Technology (Collaboration with Johnson Controls)





Project Scope

- Feasibility evaluation of a hybrid, wet/dry heat rejection system using Thermosyphon coolers
- Compare in multiple climates to standard cooling tower systems, all dry systems using ACC's, and hybrid systems using parallel ACC's
- Determine most effective means to configure and apply the thermosyphon coolers

Key Potential Benefits

- Potential annual water savings > 50%
- Compared to ACC, full plant output is available on the hottest days
- Ease of retrofitting
- Reduced operating concerns in sub freezing weather
- Broad application (hybrid, new, and existing cooling systems)

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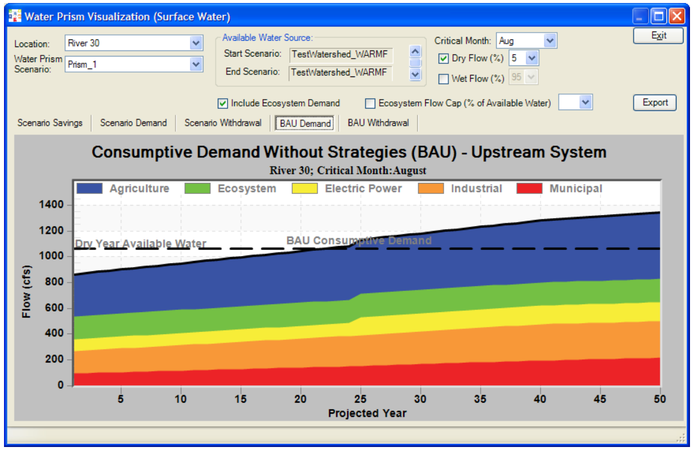
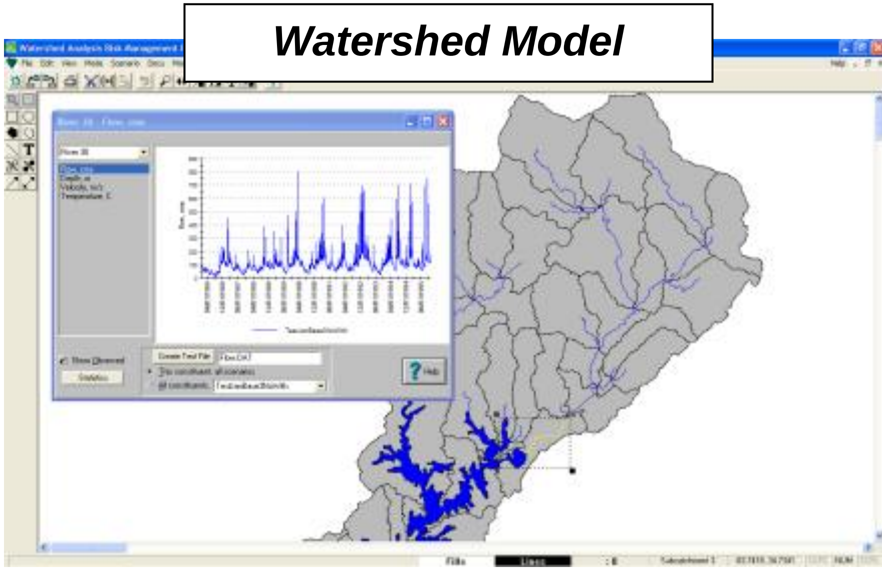
Water Prism Overview

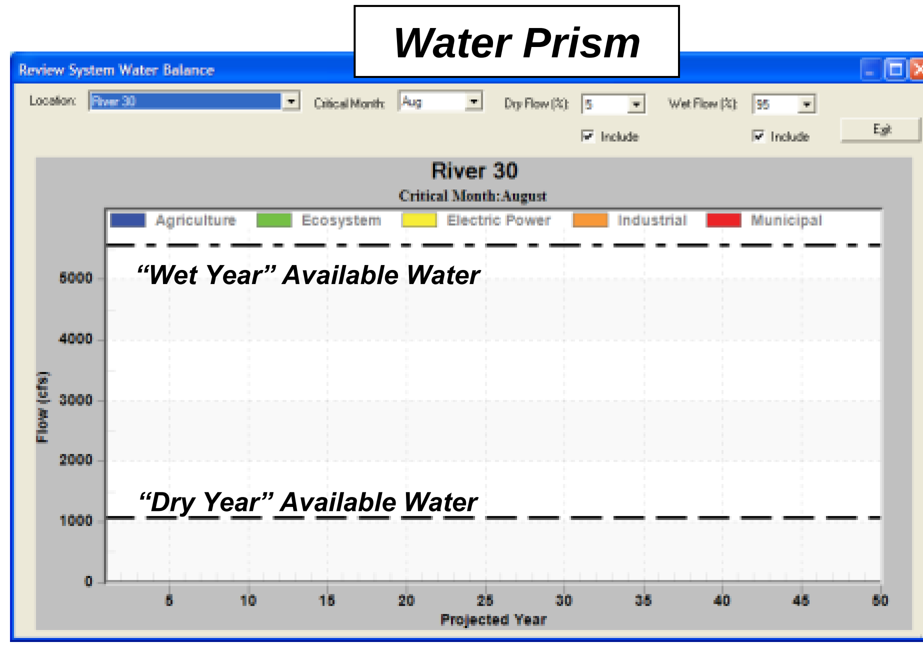
- Watershed-scale decision support system
  - Site and/or retrofit power plants
  - Understand and verify water risks
  - Explore water saving benefits across all sectors
  - Encourage stakeholder collaboration



- Computes system water balance on regional scale
  - Algorithms for rivers, reservoirs, and groundwater
  - Links with underlying watershed models
  - Map based-graphical user interface and database
- Projects consumptive and withdrawal demands for 40- to 50-year horizon
- Explores water saving strategies through scenarios
- Complements other hydrological and short term forecasting models

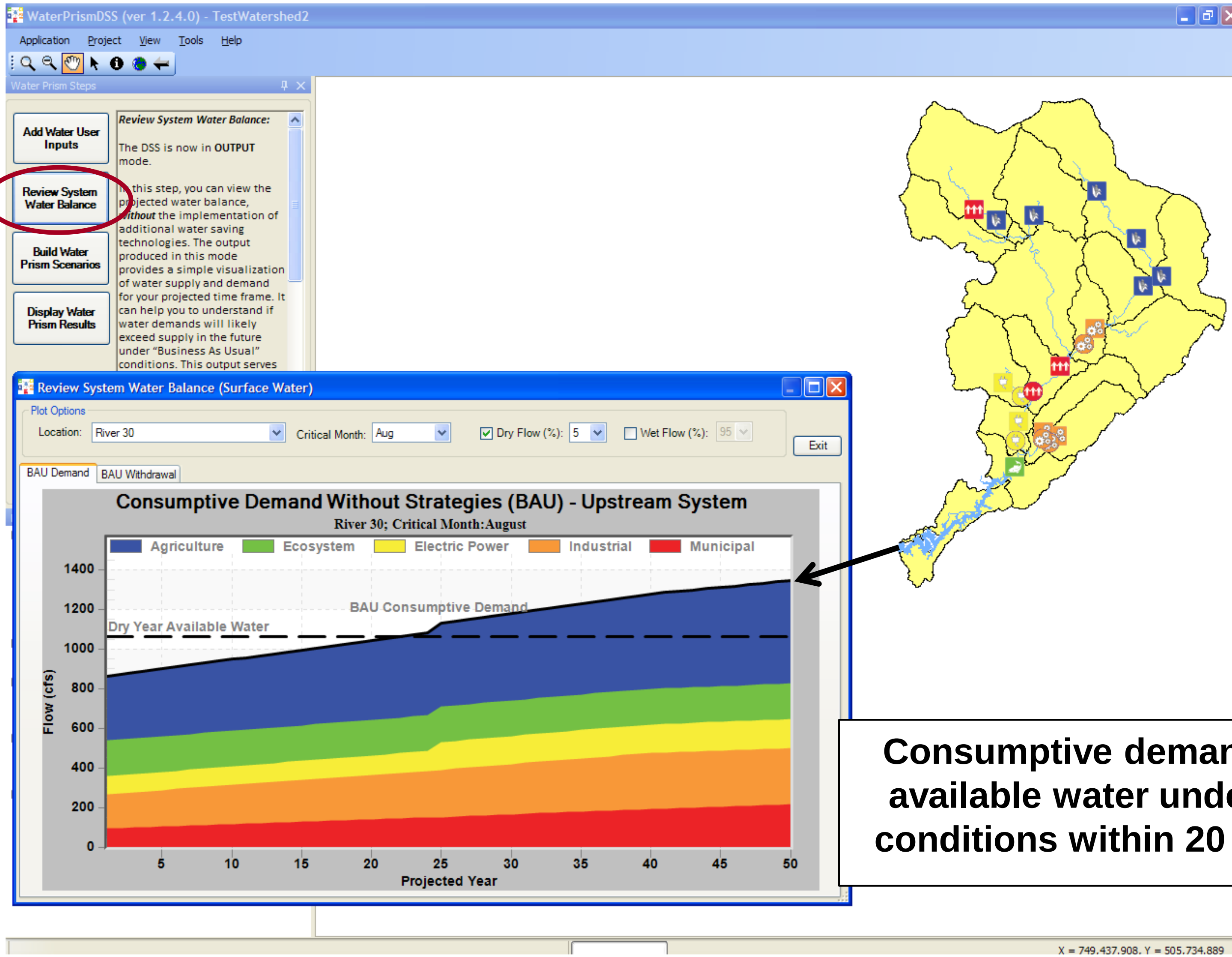
Watershed Model Provides Upper and Lower Bounds of Available Water





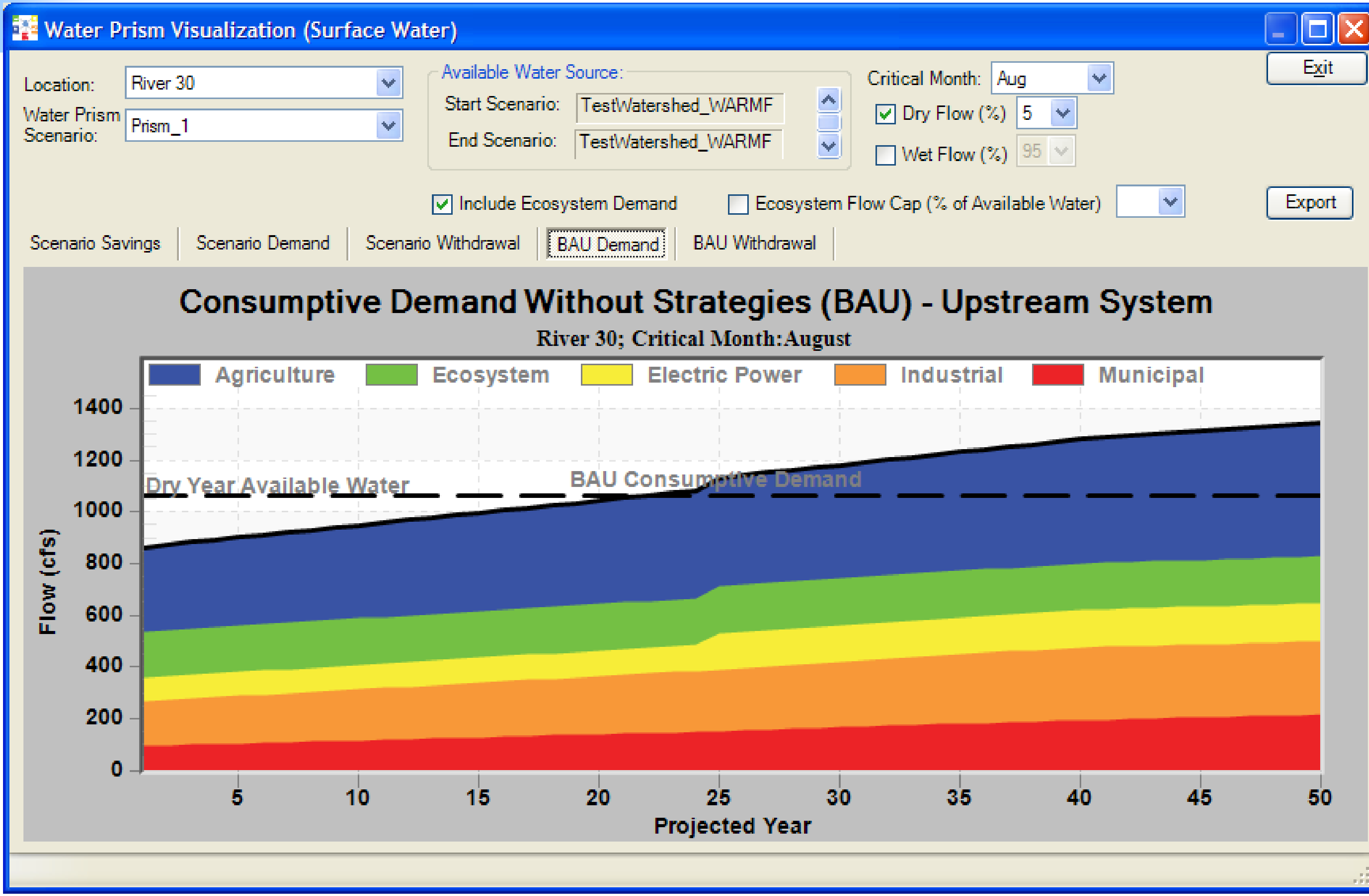
- Historical flows help determine:
  - Typical wet year flows
  - Typical dry year flows
- User defines:
  - Percentile for "wet" and "dry"
  - Critical month of interest
  - Long-term drought

Hypothetical Watershed

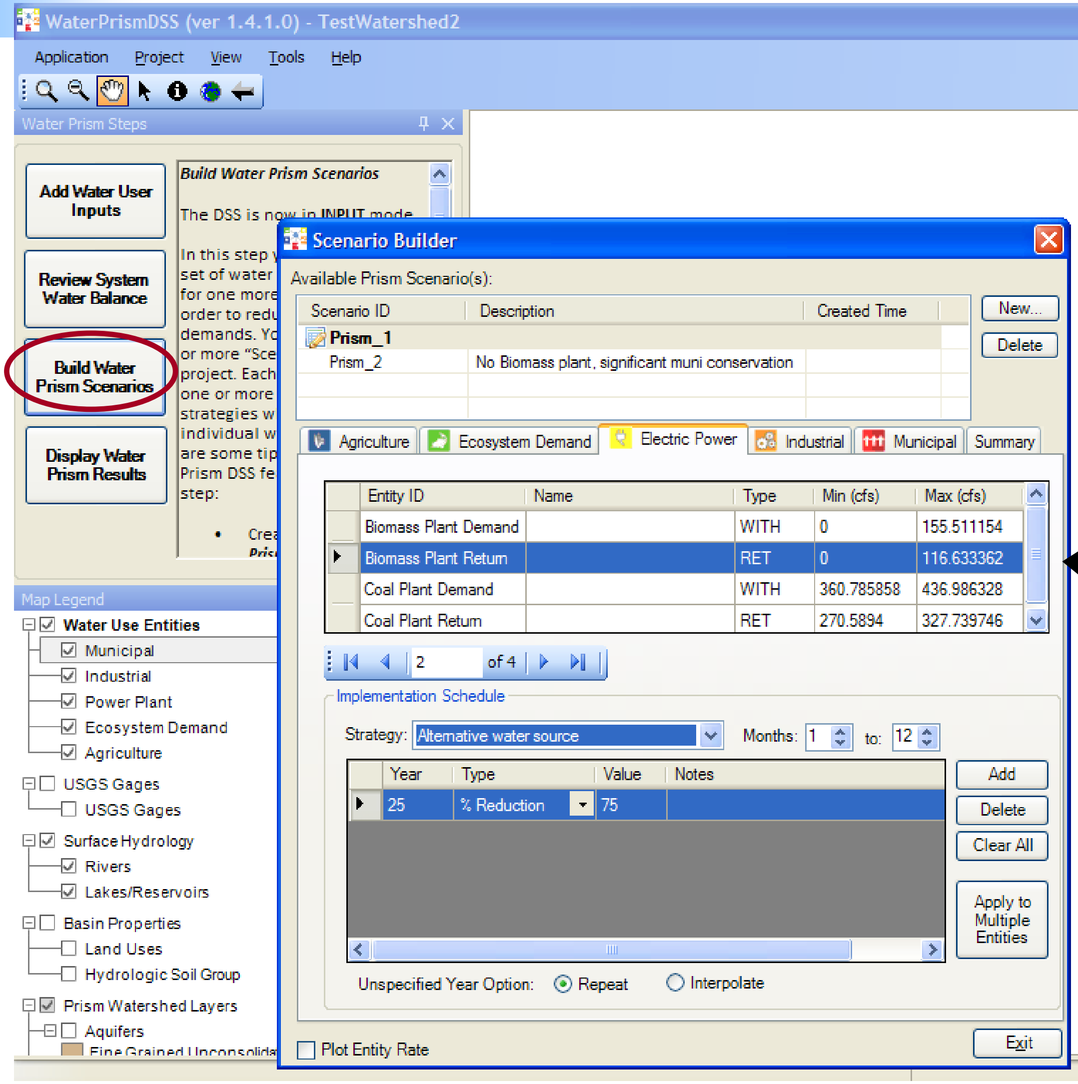


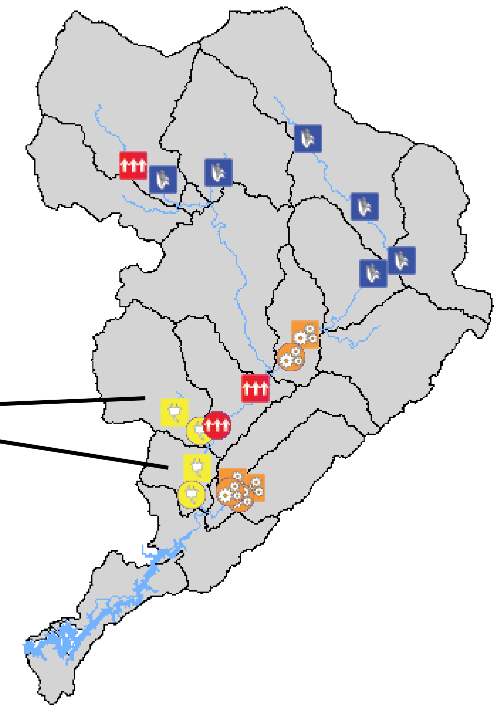
Consumptive demand exceeds available water under dry year conditions within 20 to 25 years

Hypothetical example



Build Water Prism Scenarios: Electric Power

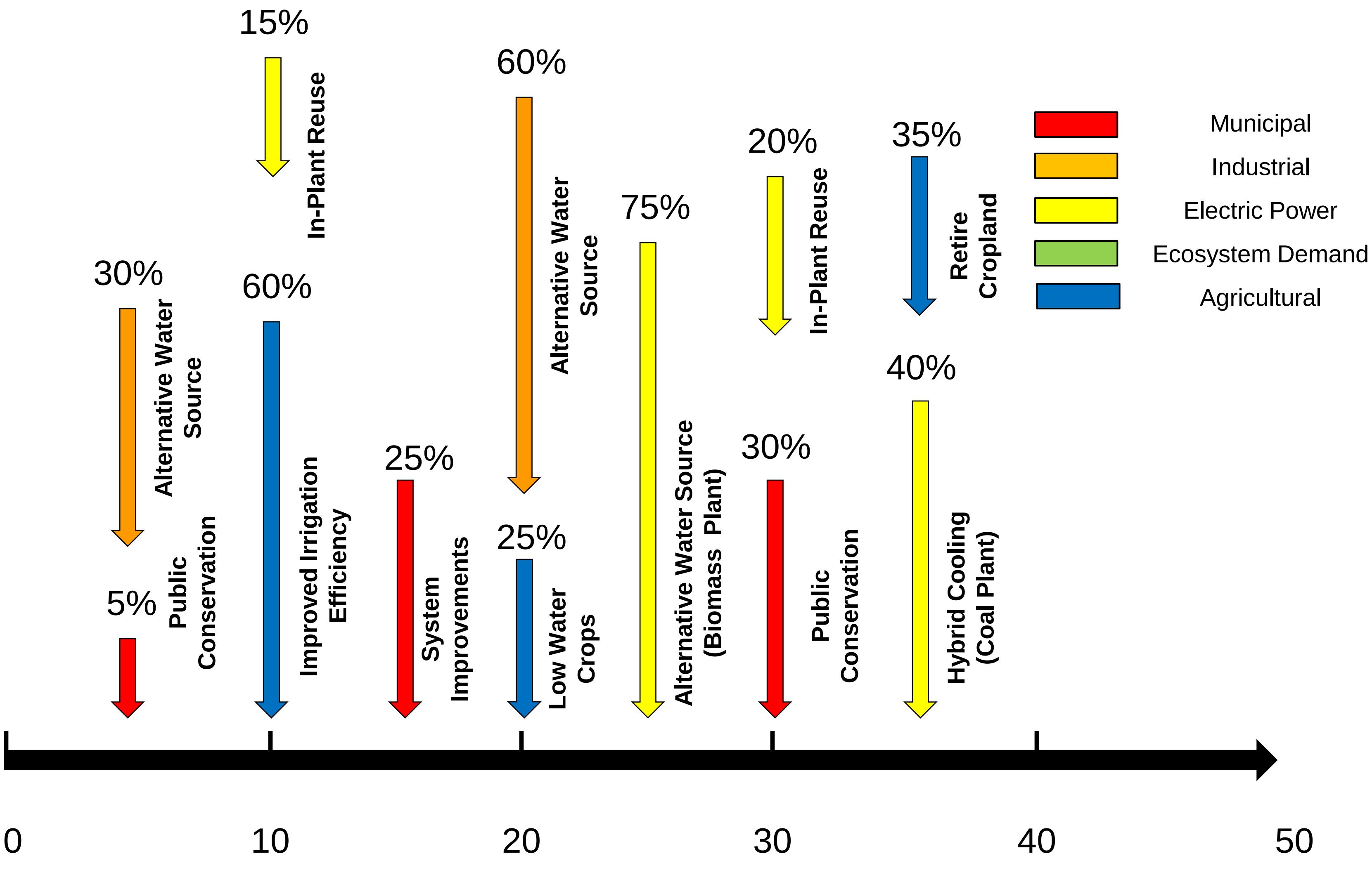




Year 25: alternative water source for new biomass plant

Year 35: convert once-through coal plant to hybrid cooling

Schematic of a Water Prism Strategy Timeline
(Percent Reduction in Water Use)



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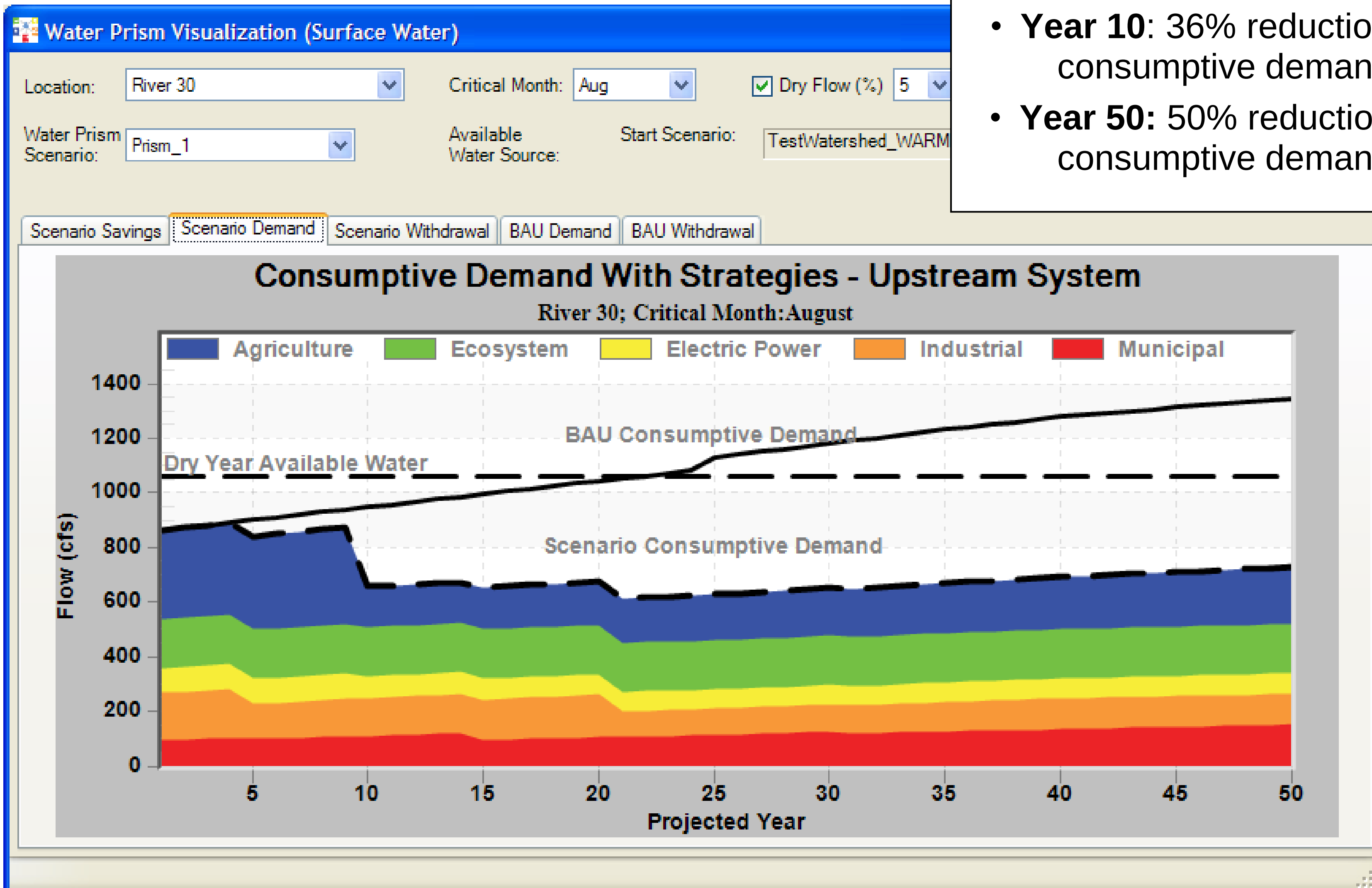
Reduced Demand Risk



Potential Benefits of Water Prism Strategy Implementation

- **Year 10**: 36% reduction in consumptive demand
- **Year 50:** 50% reduction in consumptive demand

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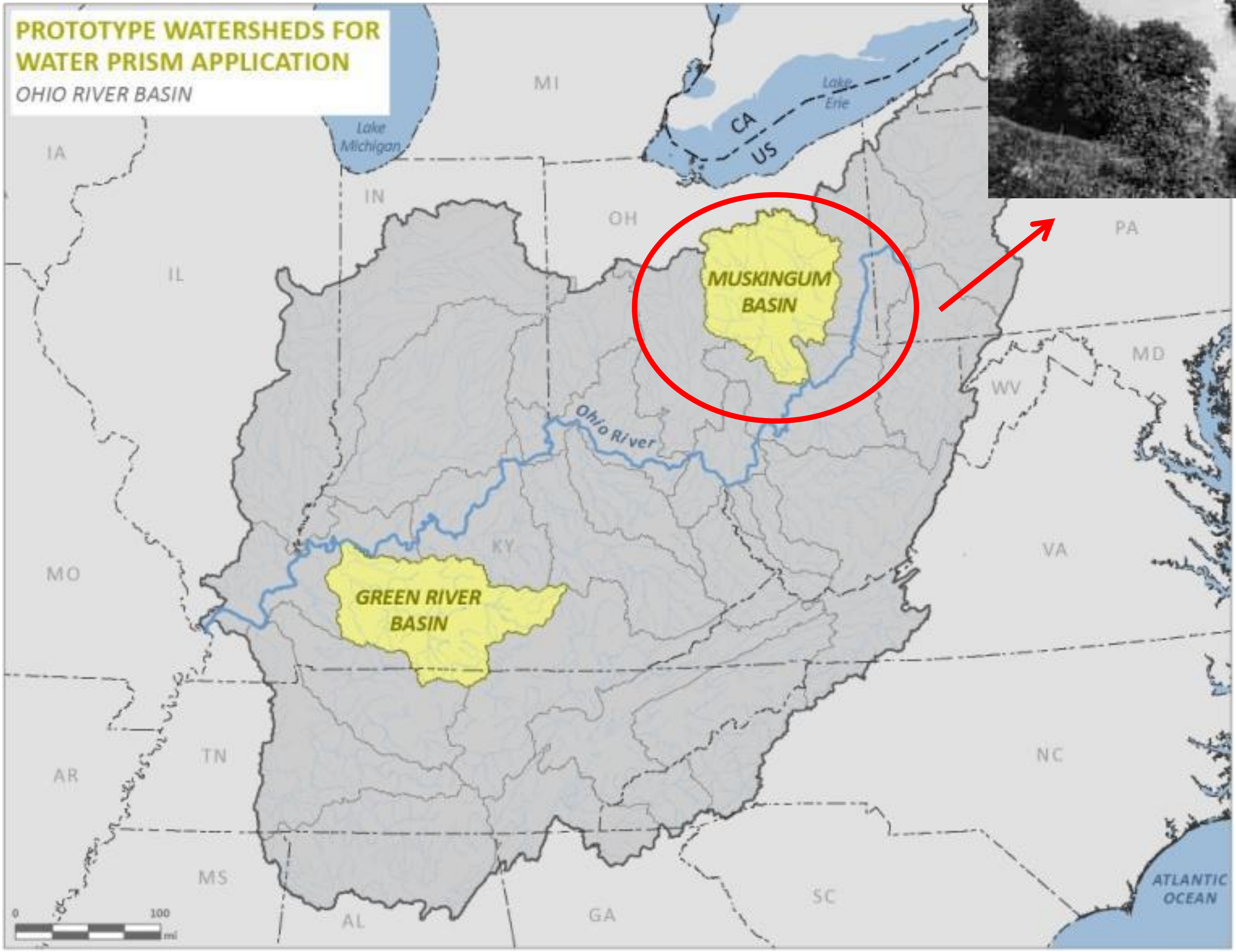
Test Case: Muskingum Basin



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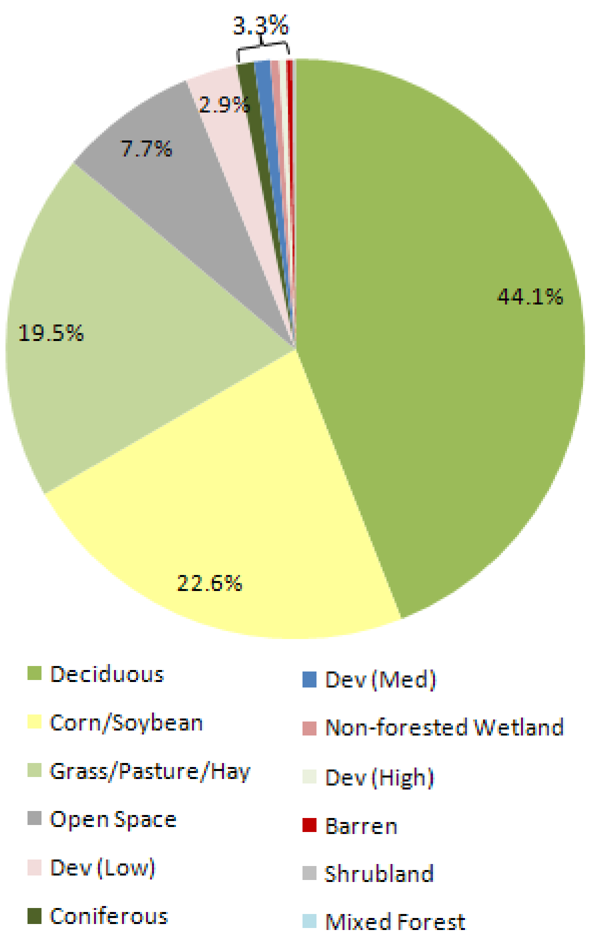
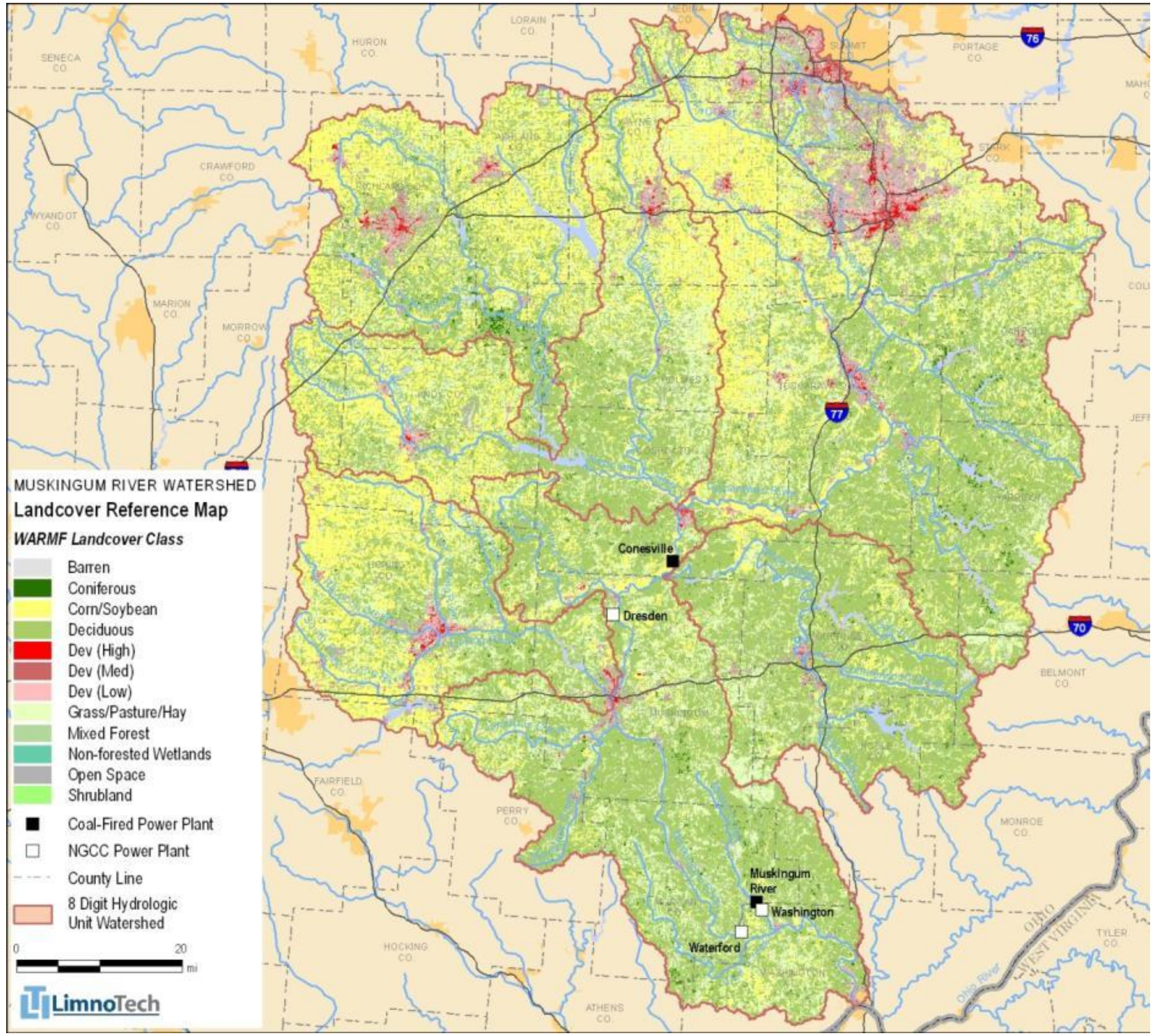
Land Use / Land Cover (2006 NLCD)





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Principal Aquifers

4 Principal Aquifers

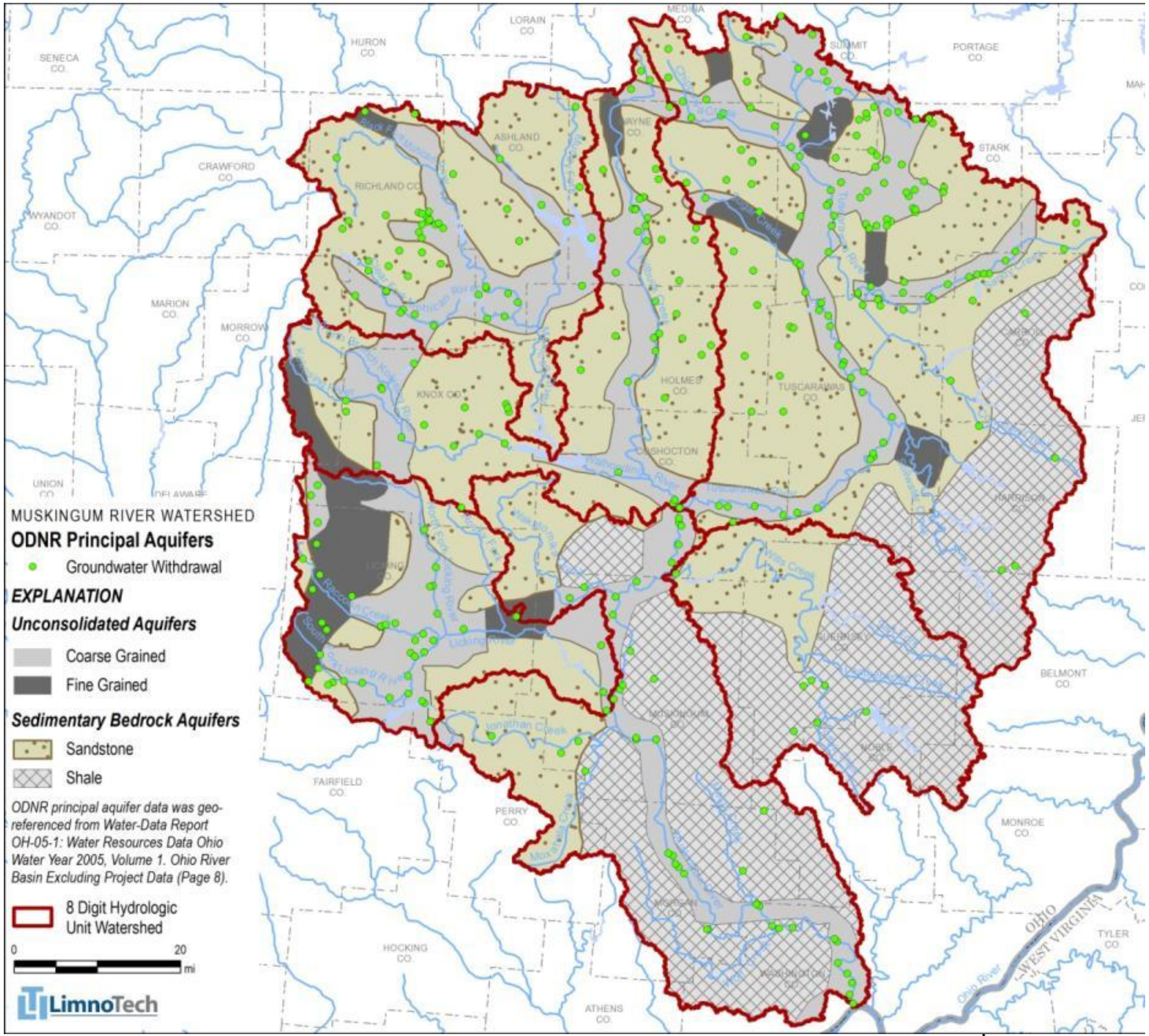
- 389 to 3741 mi^2

Unconsolidated

- Shallow, follows river valleys, high porosity, high yield

Bedrock

- Deeper, low porosity, low yield



Withdrawals and Returns

Surface water withdrawals

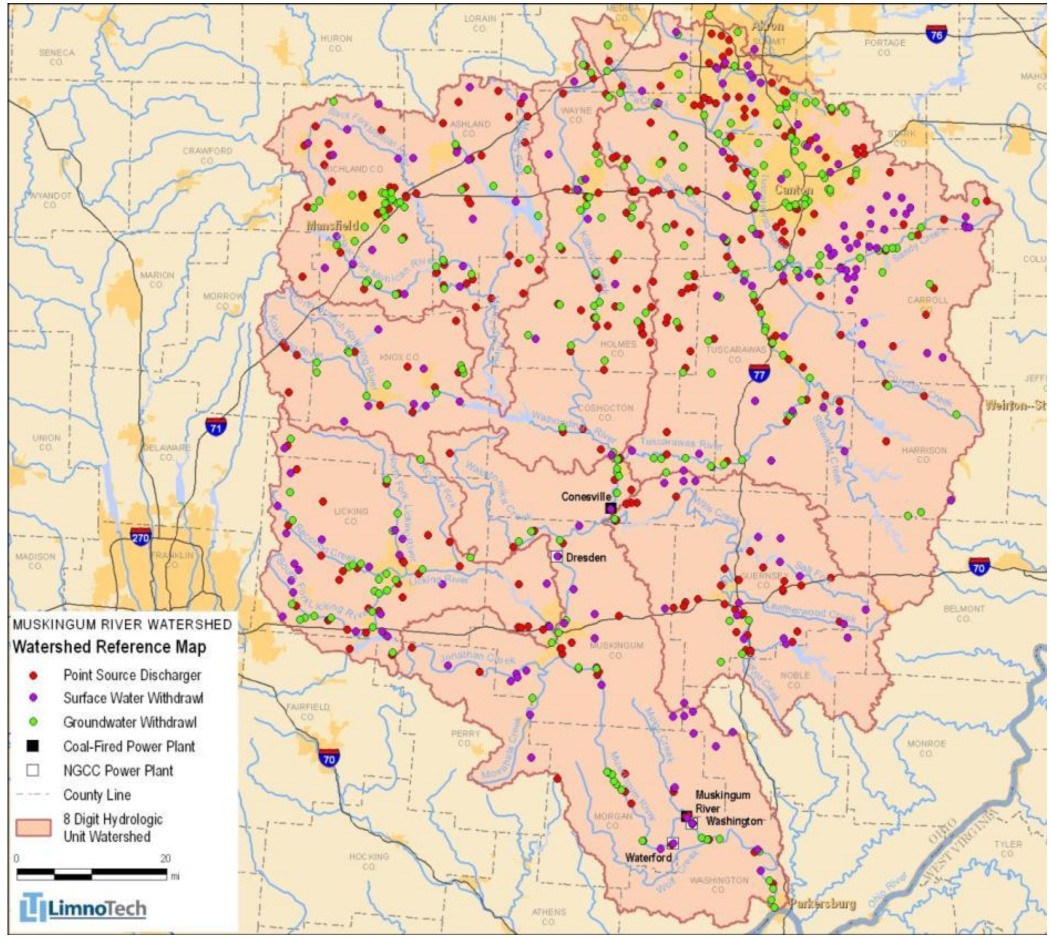
- 174 facilities
- 789 MGD (2009)

Groundwater withdrawals

- 329 facilities
- 131 MGD (2009)

Point source discharges

- 319 stations at 307 facilities
- 915 MGD (2009)



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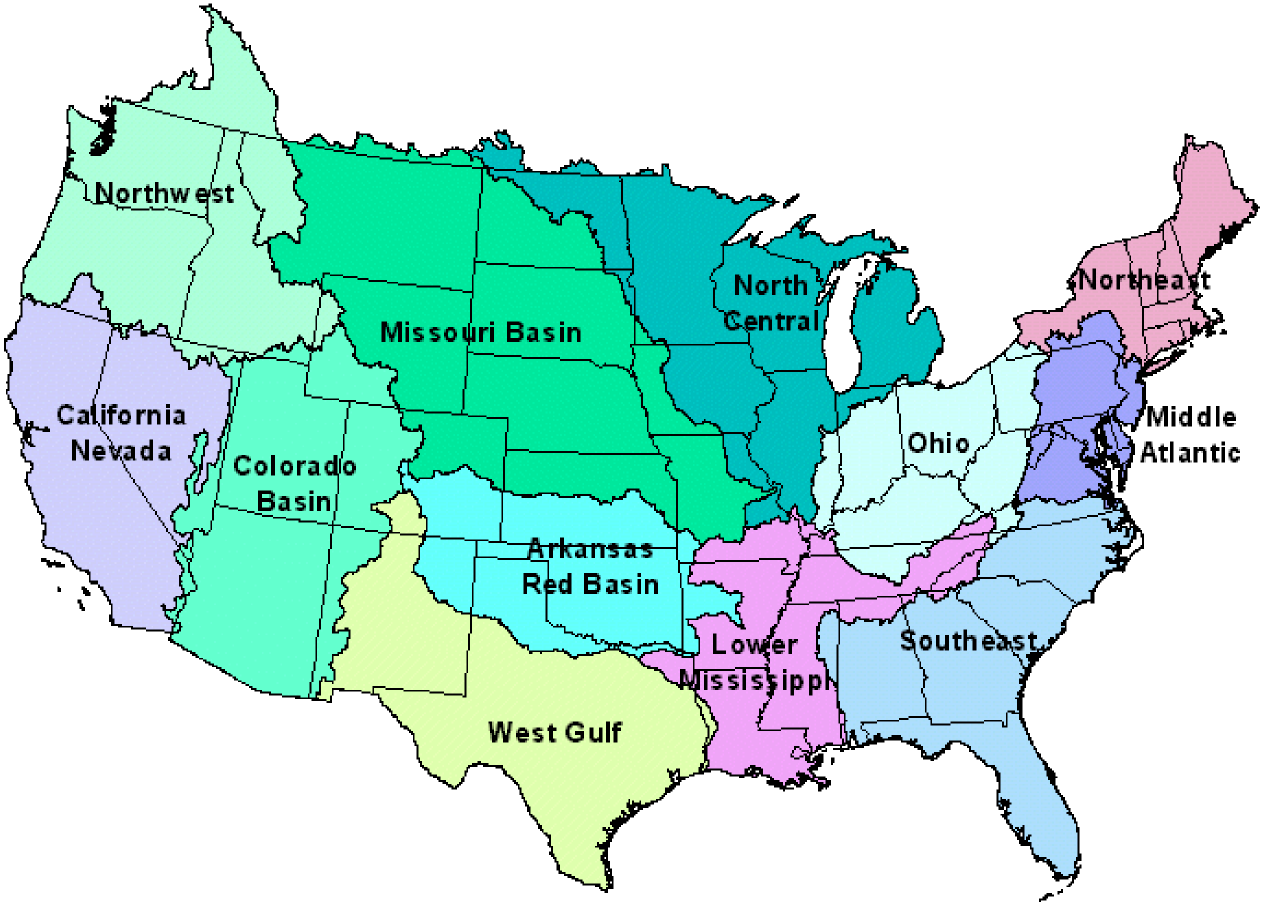
Observations of Muskingum River Basin

- Surface water system is generally "gaining" water from the groundwater system
- Isolated areas with potential water risk during summer months of dry years:
  - Consumptive demand in upper tributary reaches
  - Withdrawal demand near one of large once-through cooling plants
- Most of watershed at relatively low risk for consumptive and withdrawal demands in both groundwater and surface water systems

Water Prism showed generally low water risk and impacts of retirement of once-through units

Nationwide assessment could evaluate risks



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