SAND2013-10265C

Exceptional service in the national interest

Sandia National Laboratories

Integrated Energy-Water Planning in the Western and Texas Interconnections

Vincent Tidwell

Fall Meeting of the AGU

December 9, 2013

U.S. DEPARTMENT OF ENERGY | NNSA

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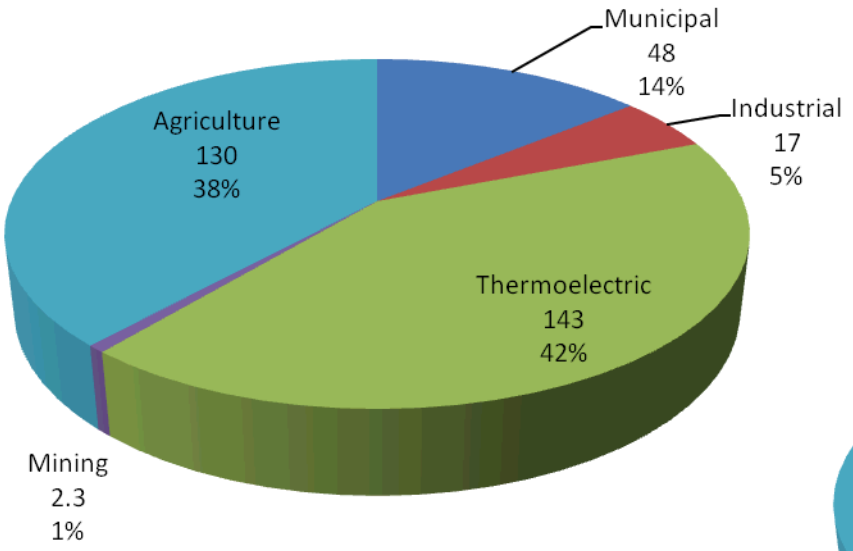
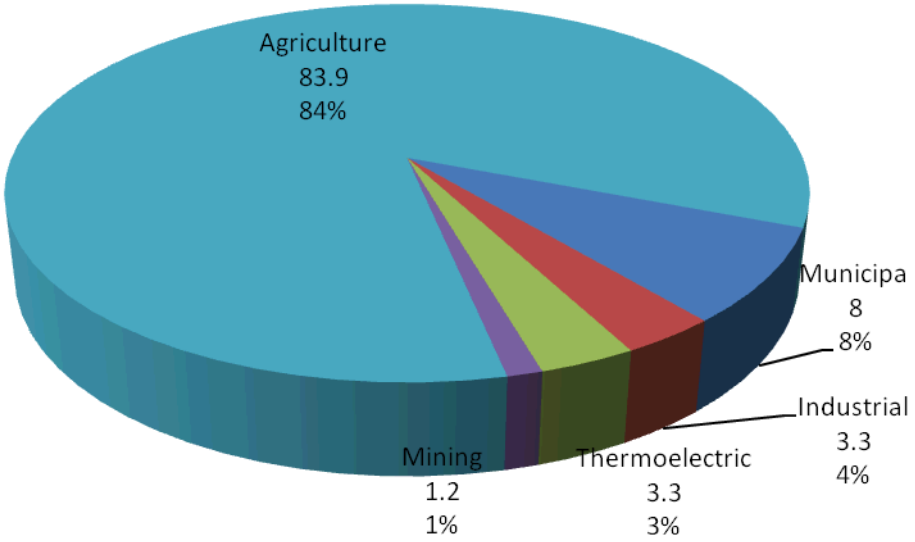
Water for Thermoelectric Power Generation

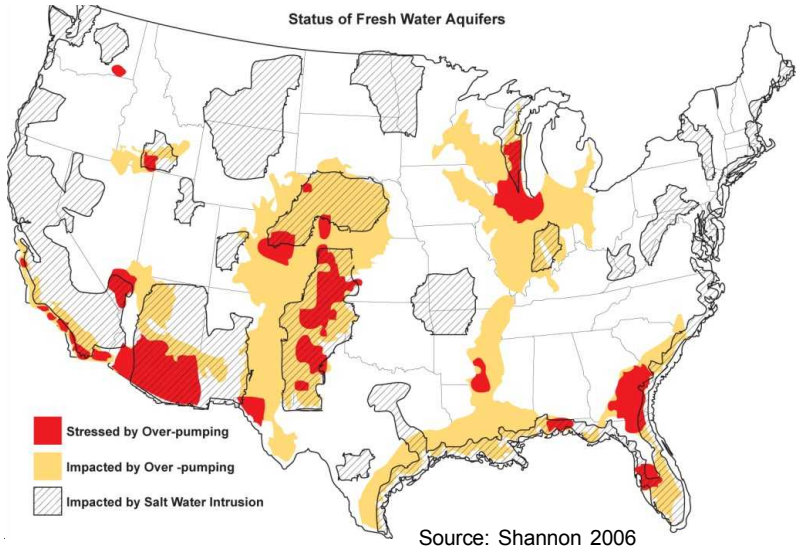
Water Withdrawal (BGD) 2005



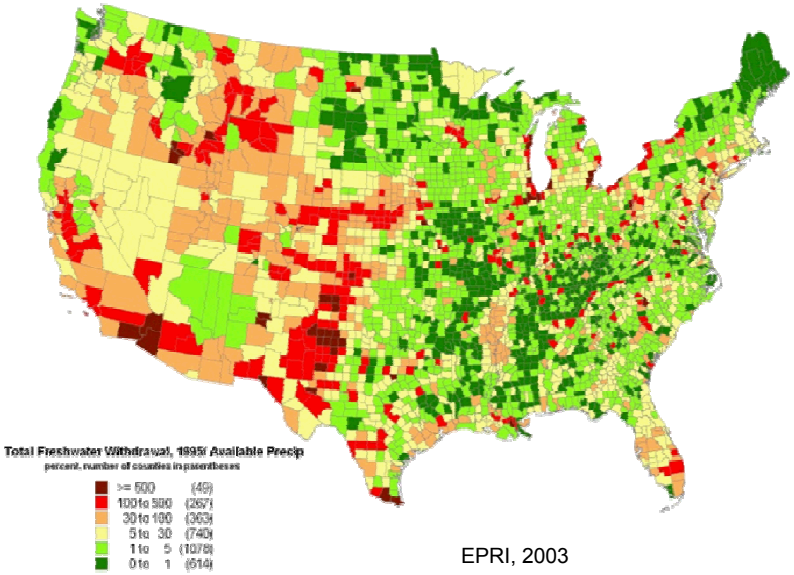
Water Consumption (BGD) 1995



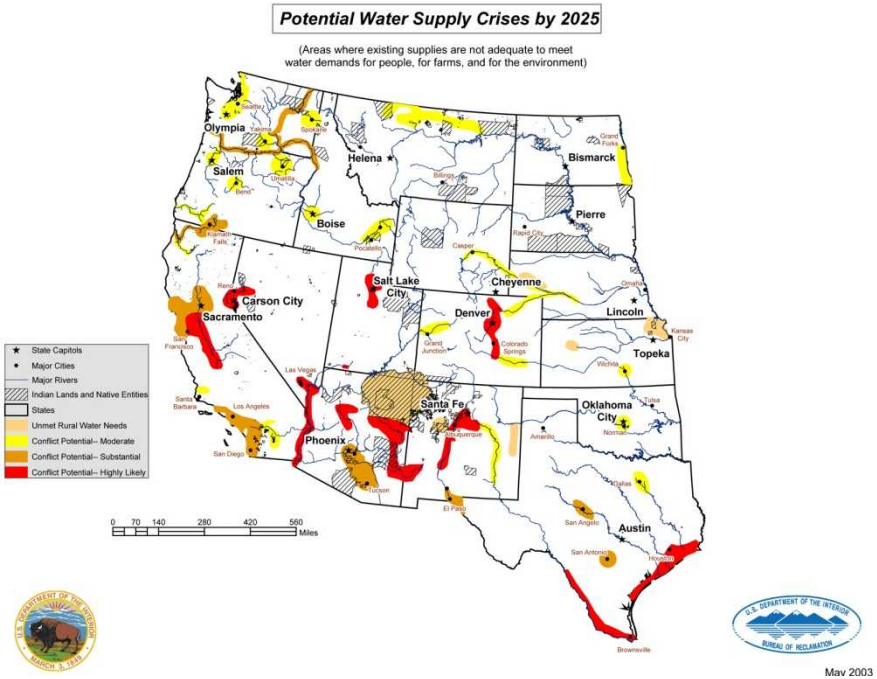
Indications of Water Stress



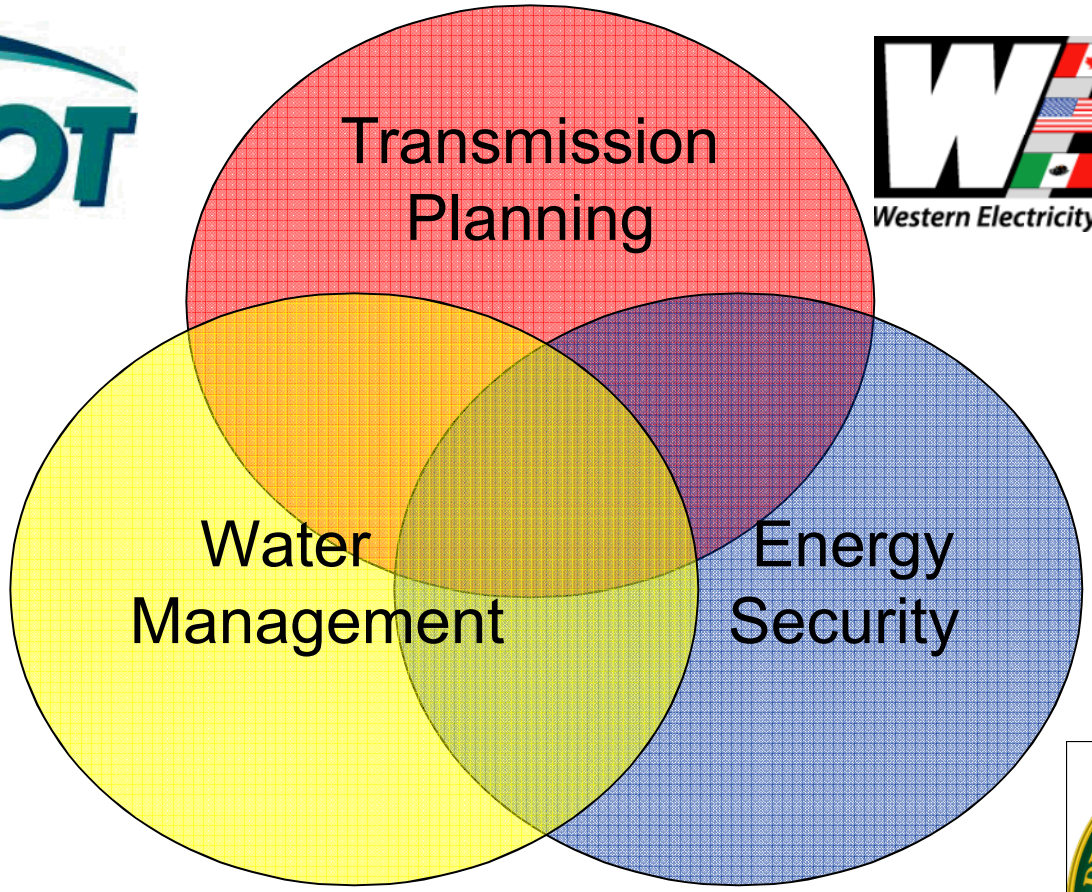
Source: Shannon 2006



EPRI, 2003



Integrated Planning



ERCOT

WECC
Western Electricity Coordinating Council

Western Governors' Association
Serving the Governors of 19 States and 3 US-Flag Pacific Islands

WSWC
Western States Water Council

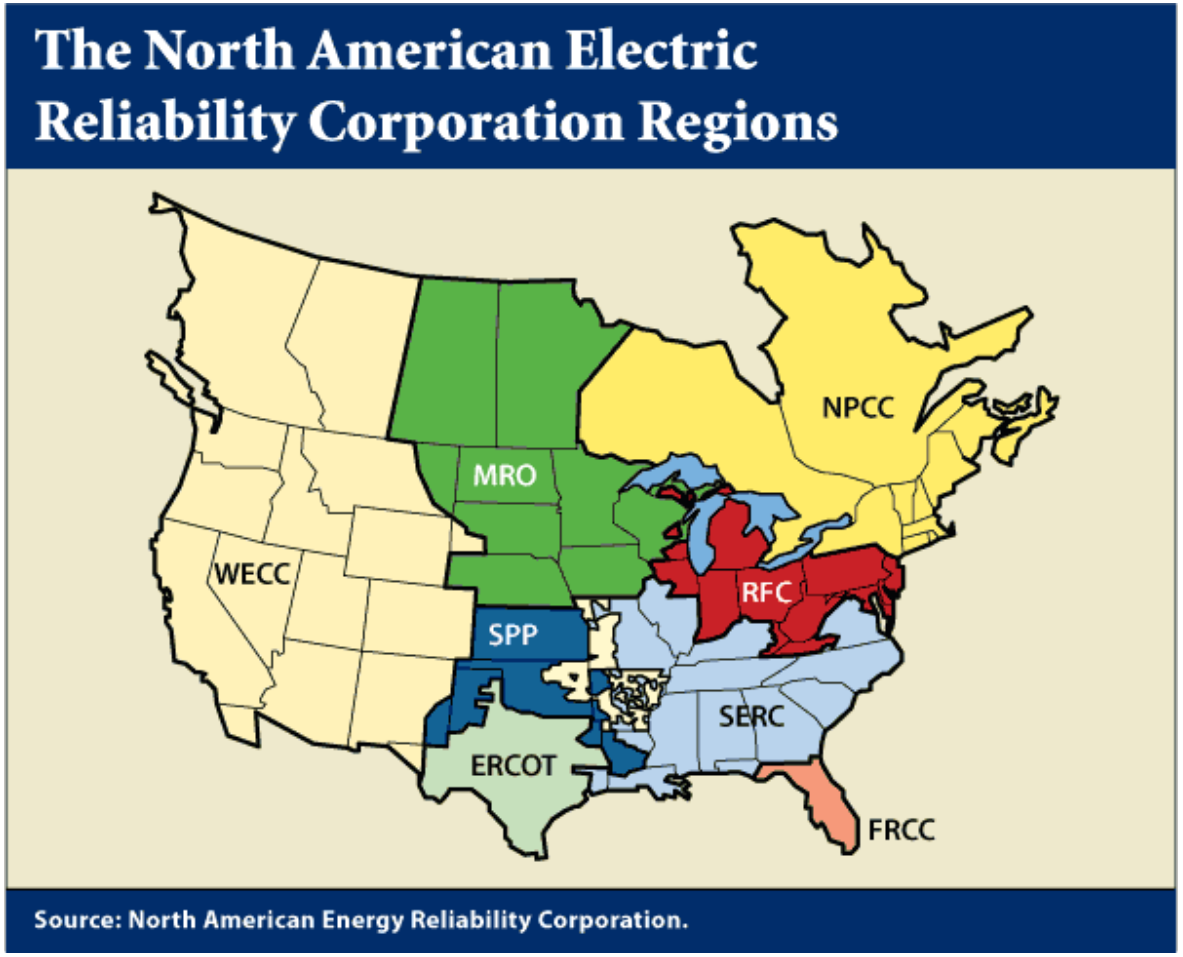
Department of Energy · United States of America

Technical Support Team

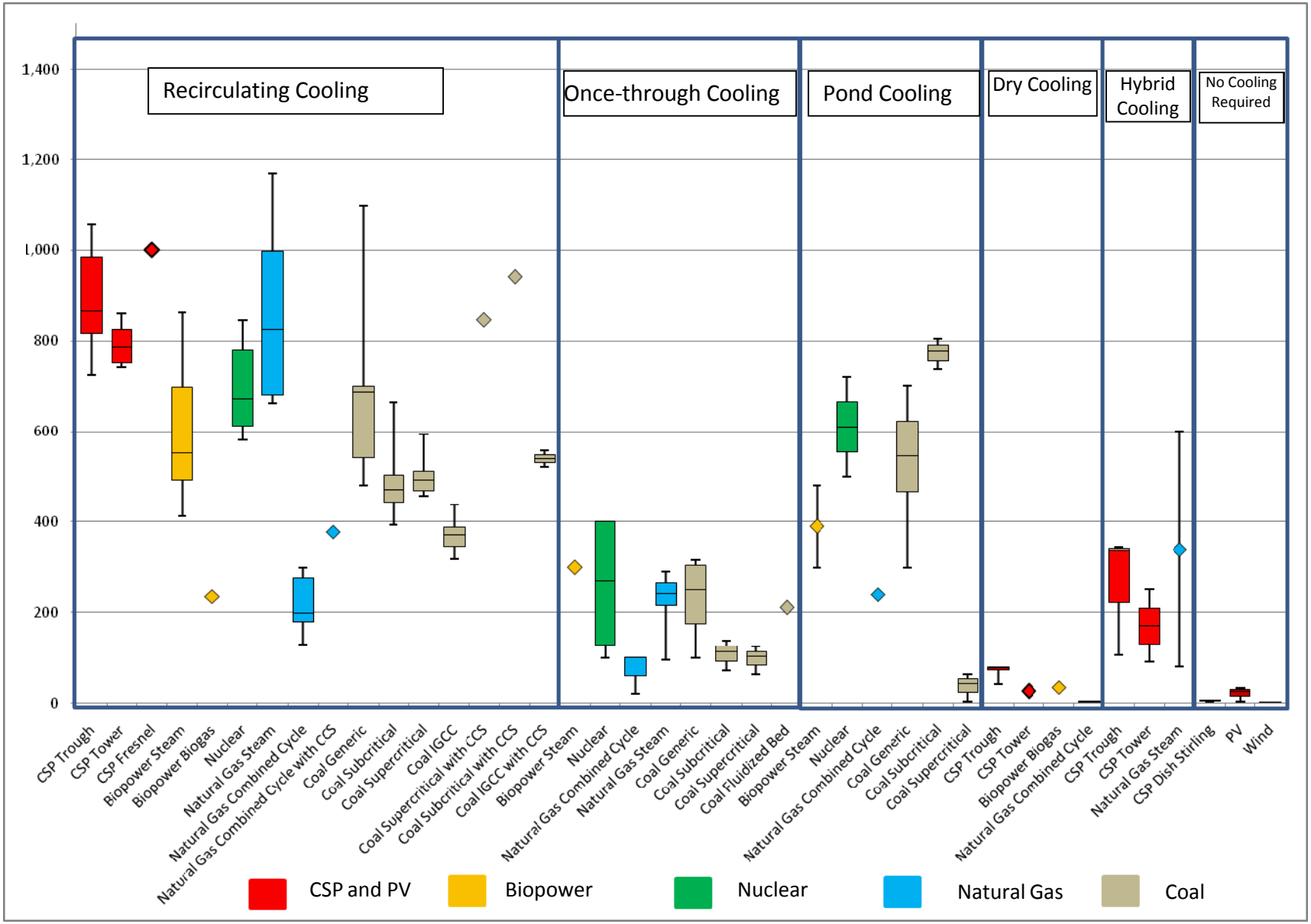
- Sandia National Laboratories
  - Vincent Tidwell
  - Barbie Moreland
  - Howard Passell
  - Katie Zemlick
  - Barry Roberts
- Argonne National Laboratory
  - John Gasper
  - Eugene Yan
  - Chris Harto
- Electric Power Research Institute
  - Robert Goldstein
- National Renewable Energy Laboratory
  - Jordan Macknick
  - Kathleen Hallett
- Idaho National Laboratory
  - Gerald Sehlke
  - Dan Jensen
  - Chris Forsgren
- Pacific Northwest National Laboratory
  - Mark Wigmosta
  - Ruby Leung
- University of Texas
  - Michael Webber
  - Carey King

Transmission Planning

- WECC and ERCOT are conducting long-range transmission planning (20 yrs.)
  - Siting of new power plants
  - New transmission capacity

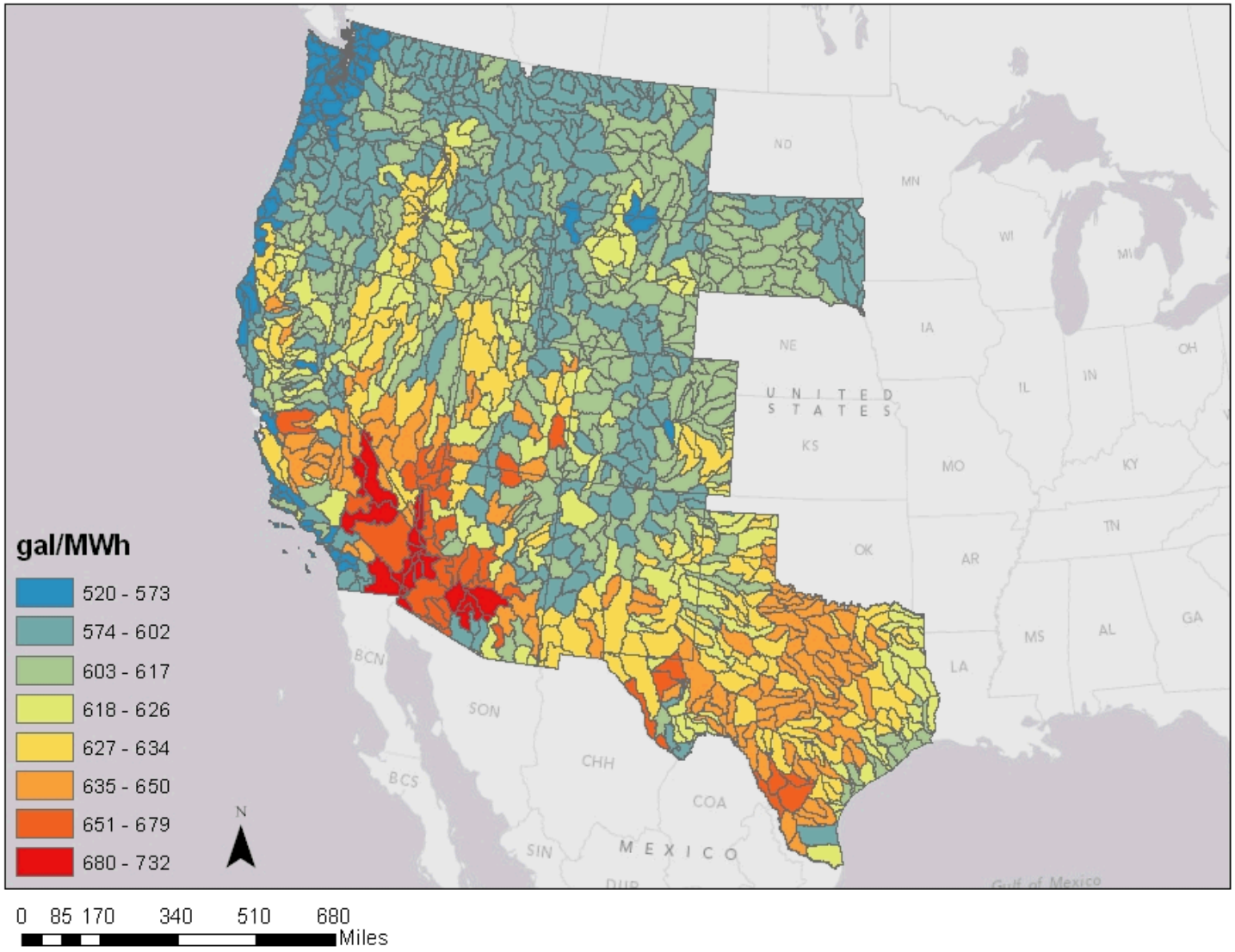


Operational water *consumption* factors for electricity generating technologies



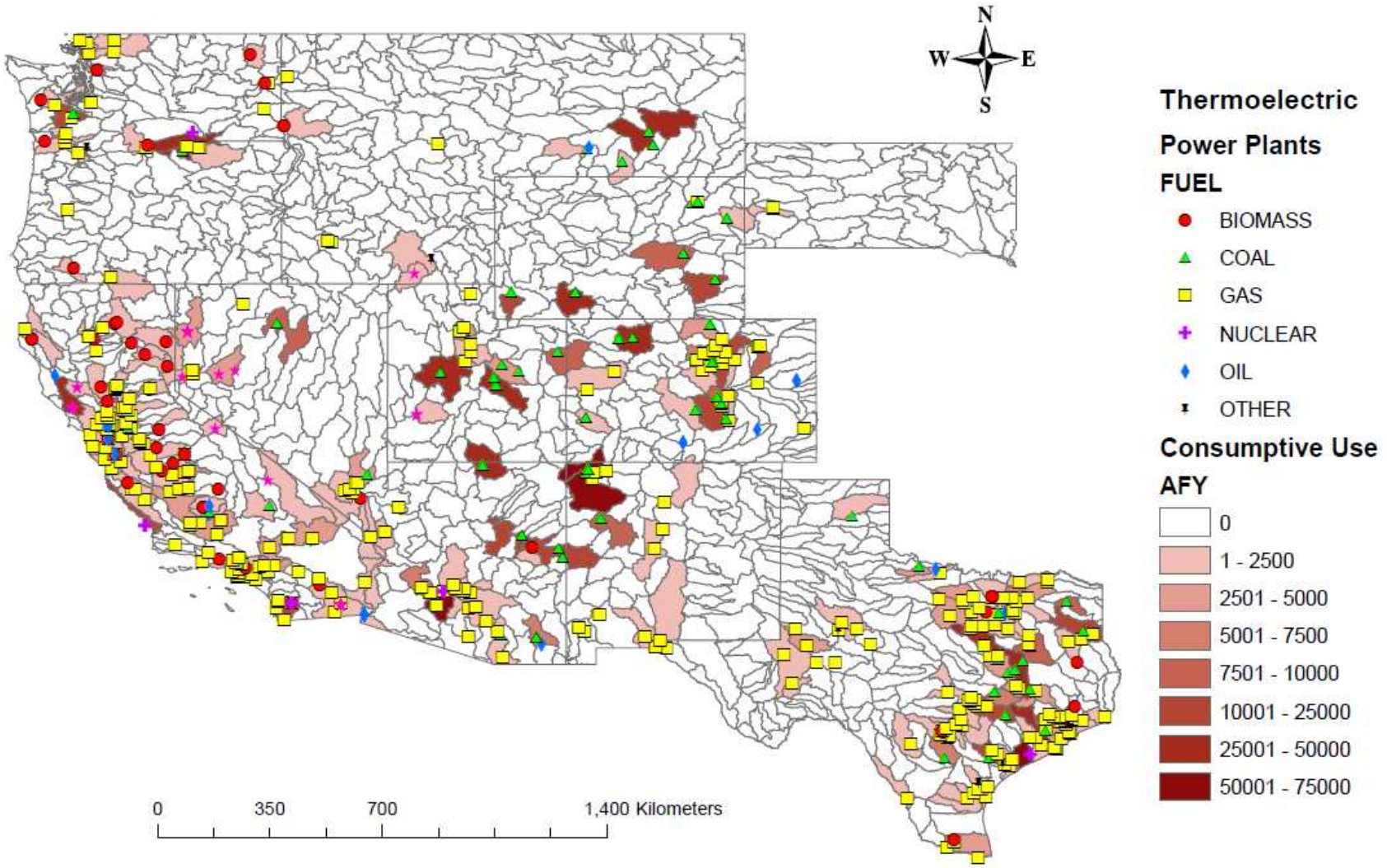
Source: Macknick *et al.* 2011

Coal Plant Water Use (gal/MWh)

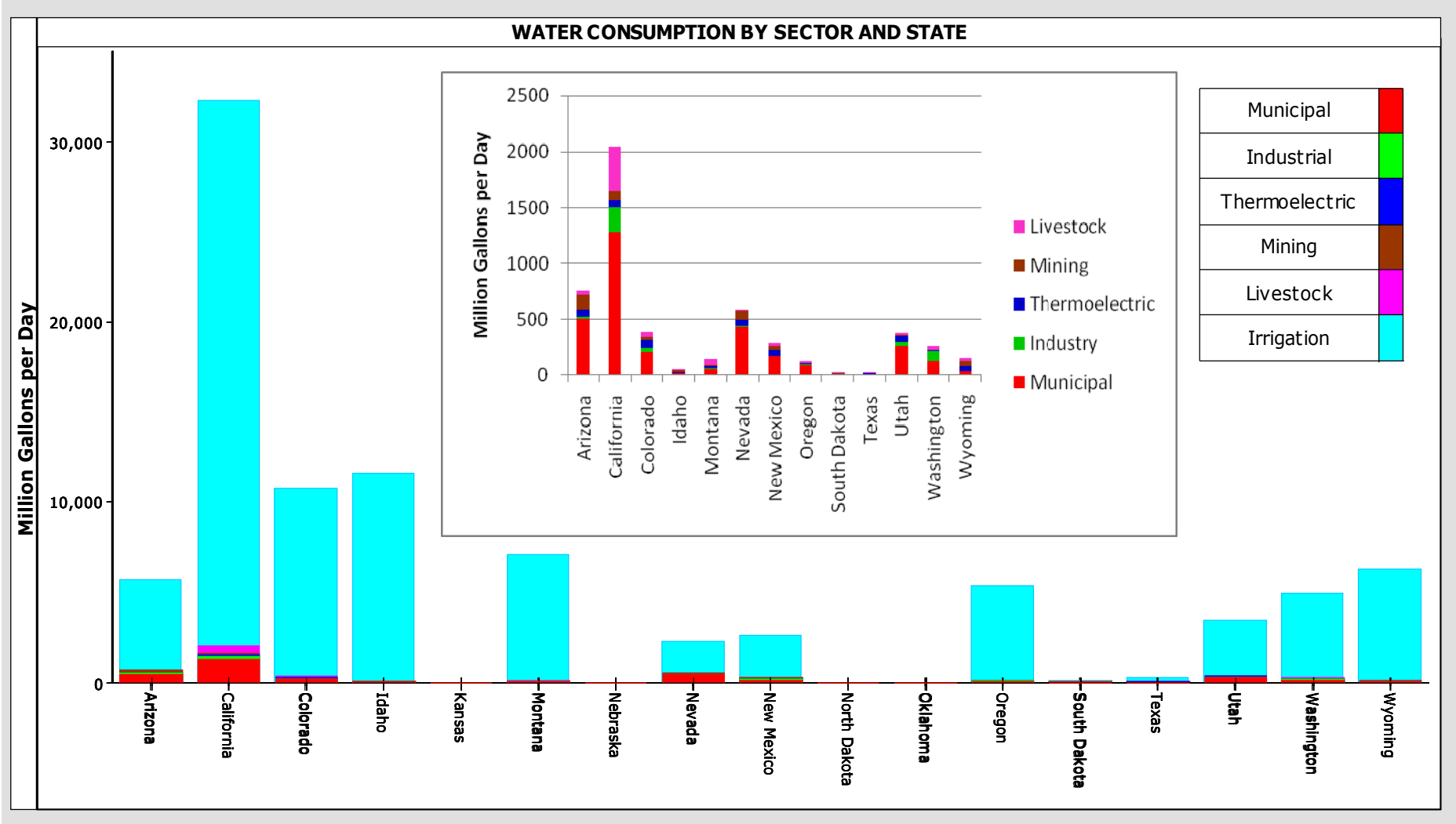


NREL 2012

Thermoelectric Consumptive Use and Power Plants (Current)

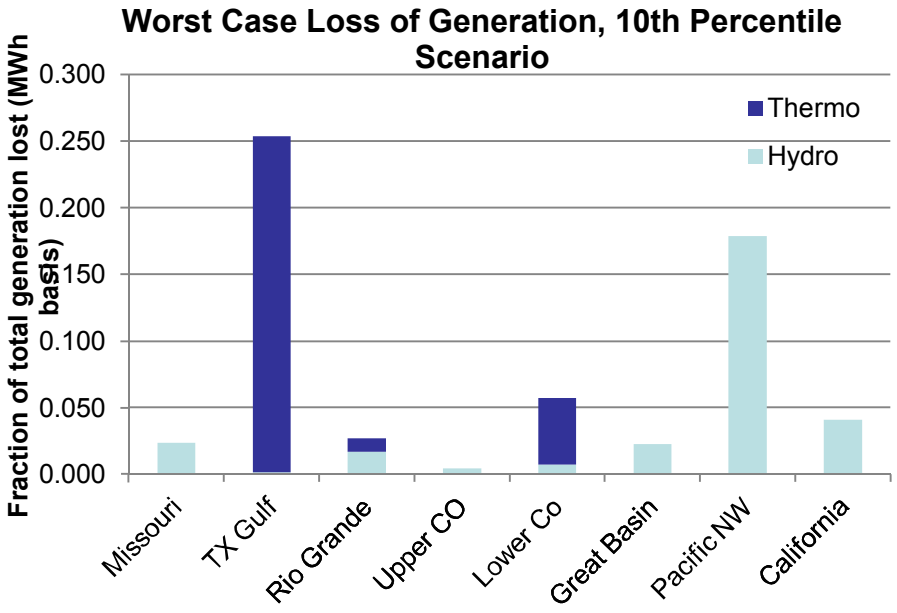


Water Consumption by State and Sector



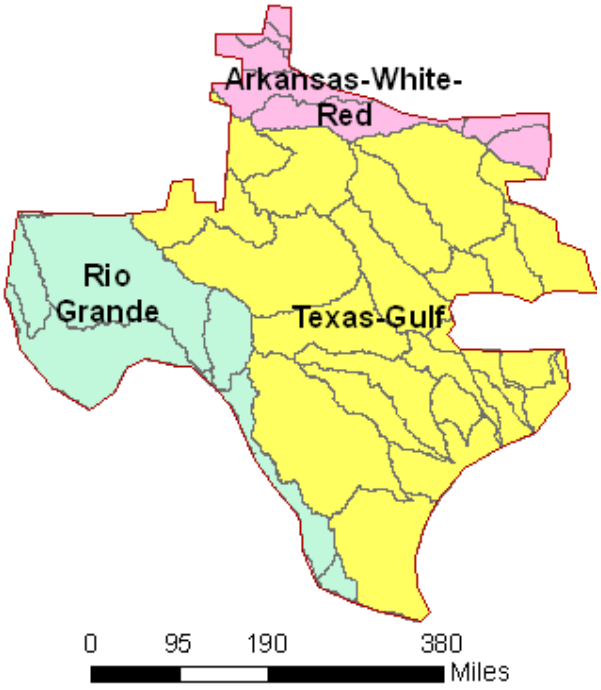
Climate Impact on Existing Plants

	Drought flow vs. recent normal flow (2000-2008)	Drought flow vs. 2010 water demand	Thermoelectric water demand (based on NREL and UT estimates)vs. drought flow	Thermoelectric water demand (Sandia 2010 consumption data)vs. drought flow	Worst case loss of generation from hydro	Worst case loss of total generation from thermoelectric	Total Worst Case Loss of Generation
Missouri	0.67	1.21	0.003	0.005	0.024	0.000	0.024
TX Gulf	0.31	0.66	0.014	0.045	0.002	0.252	0.254
Rio Grande	0.70	0.35	0.000	0.022	0.017	0.010	0.027
Upper CO	0.92	1.31	0.025	0.018	0.004	0.000	0.004
Lower CO	0.77	0.22	0.018	0.048	0.007	0.050	0.057
Great Basin	0.65	1.26	0.006	0.009	0.023	0.000	0.023
Pacific NW	0.74	5.30	0.000	0.000	0.179	0.000	0.179
California	0.65	1.36	0.001	0.001	0.041	0.000	0.041

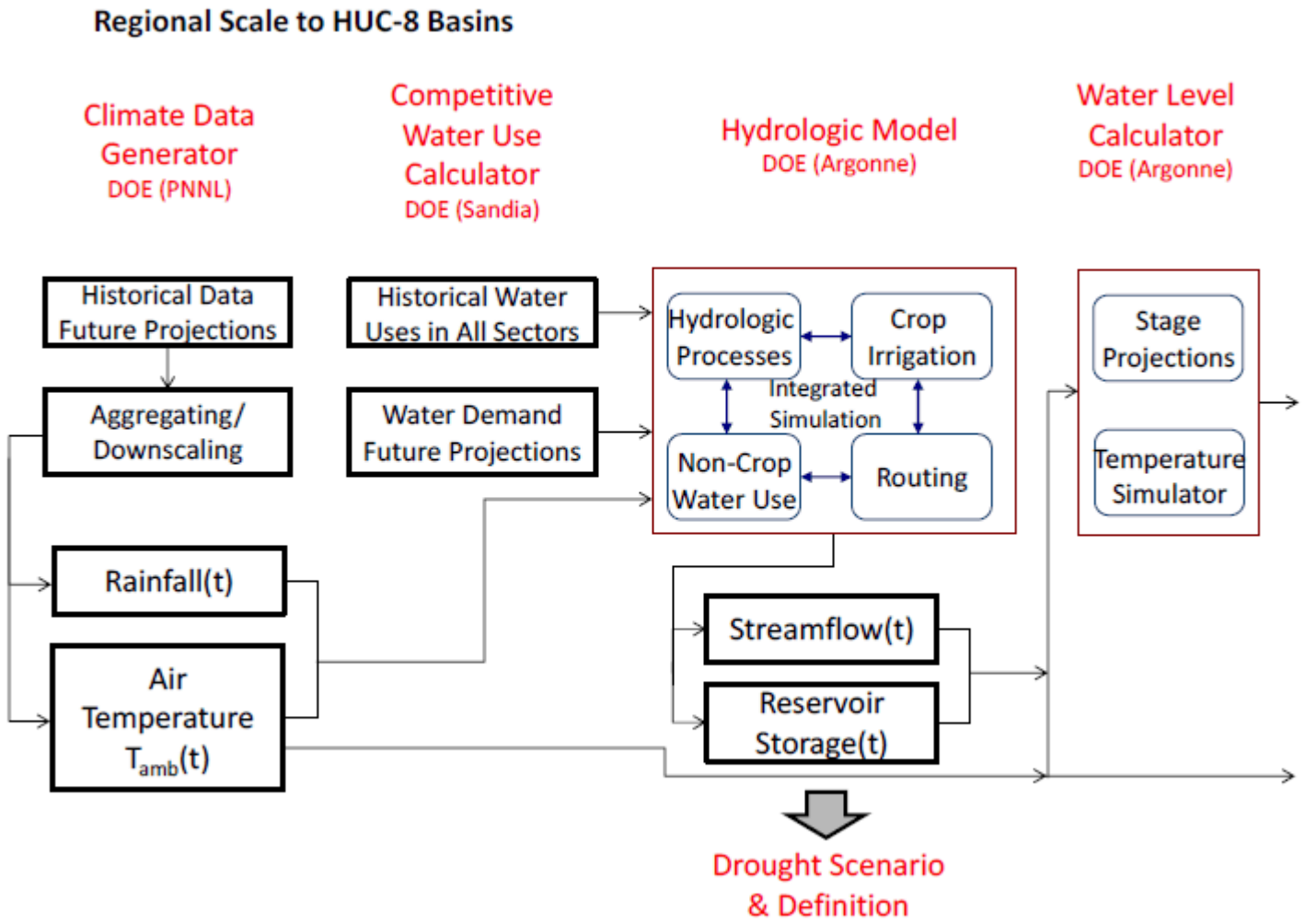


Climate Modeling

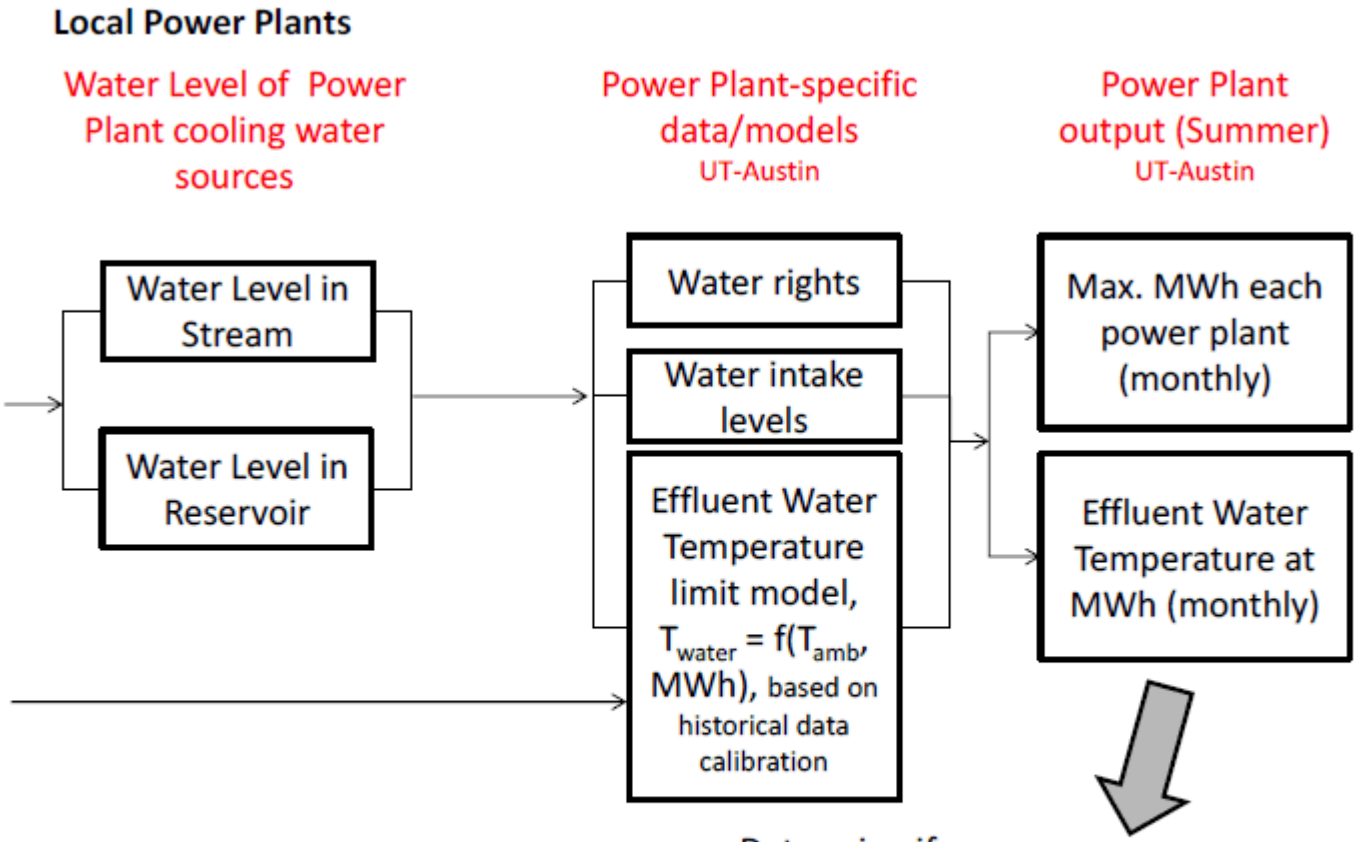
- Texas Gulf Coast
- California
- *Pacific Northwest*



Methods of Analysis (1)



Methods of Analysis (2)



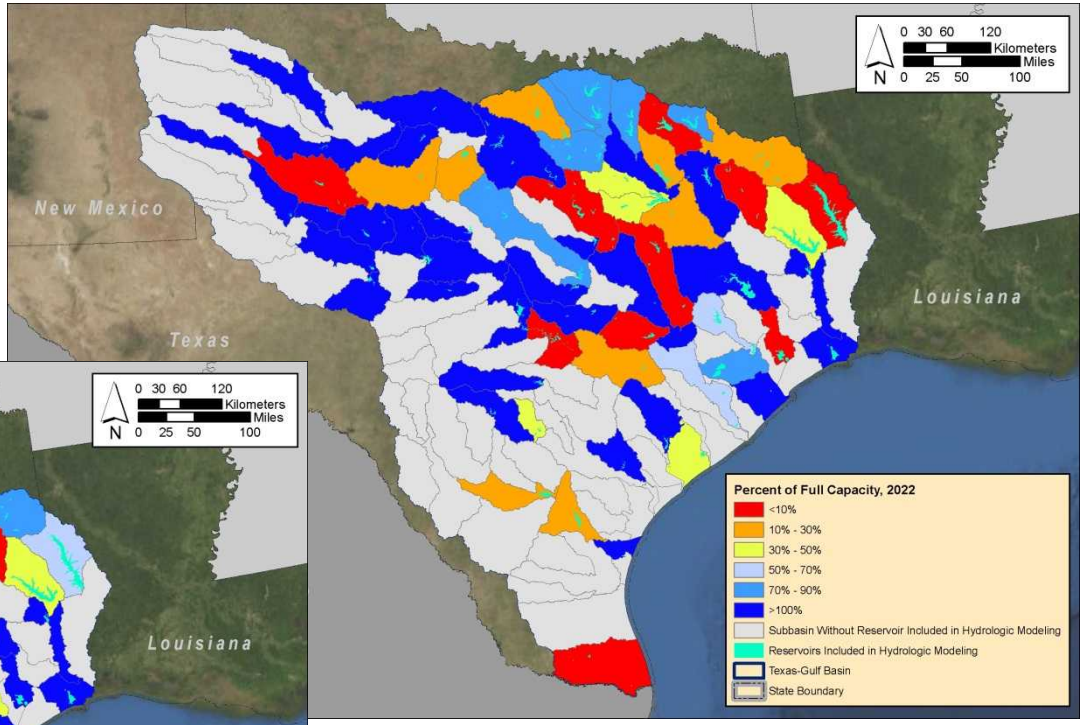
Determine if:

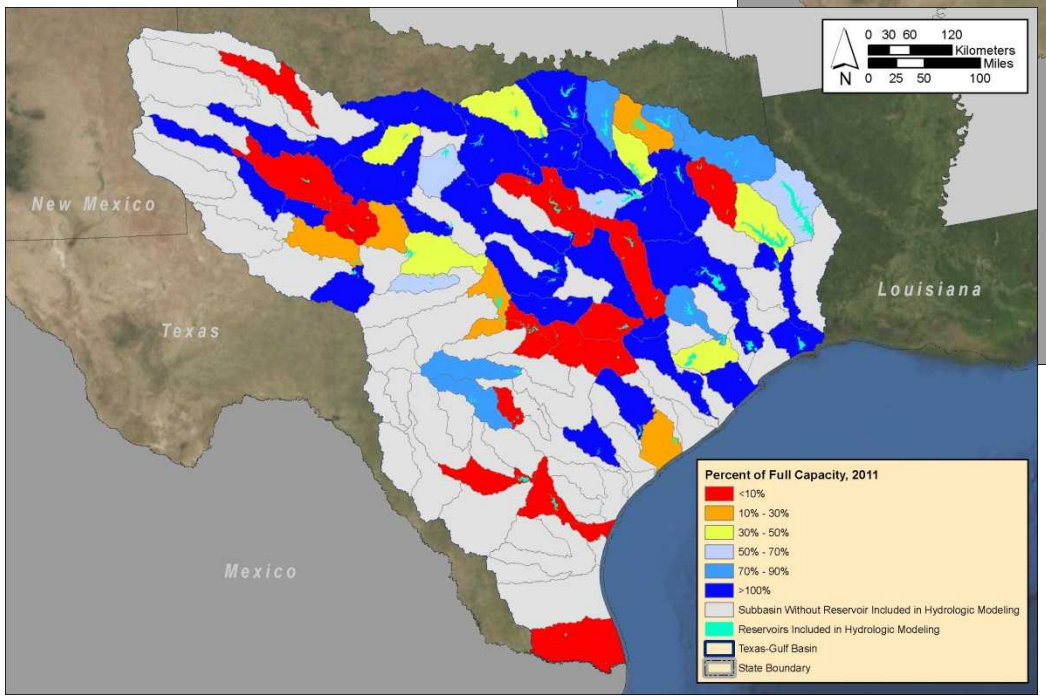
(i) water effluent temperature permit limits can reduce power generation,

(ii) intake levels constrain water intake, and therefore power generation

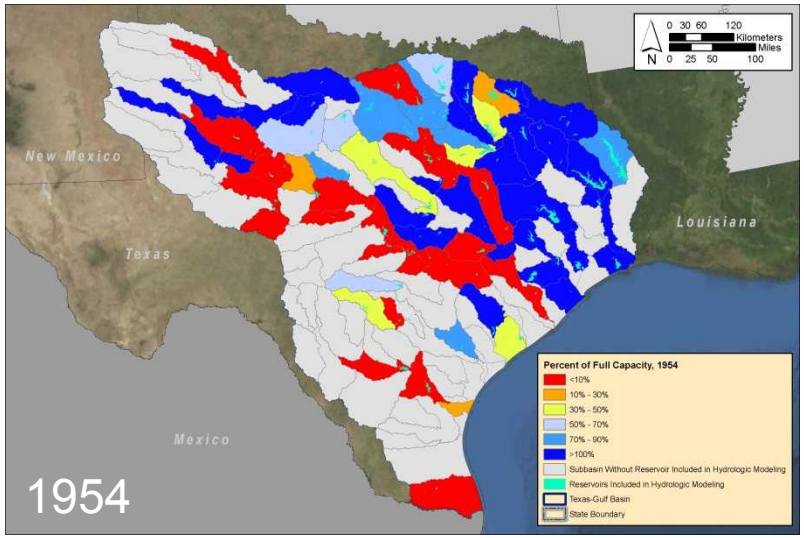
Hydrologic Modeling Results – *Single-Year Drought*

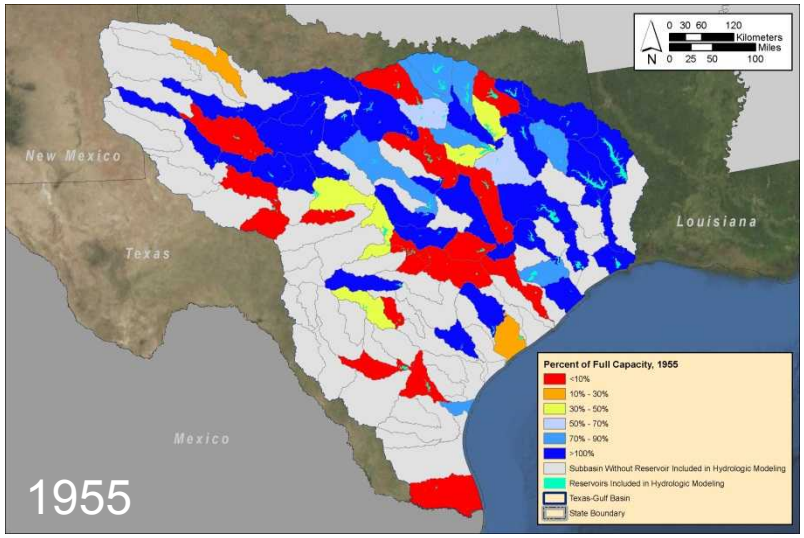
- Projected Reservoir Capacity in HUC-8 Basins



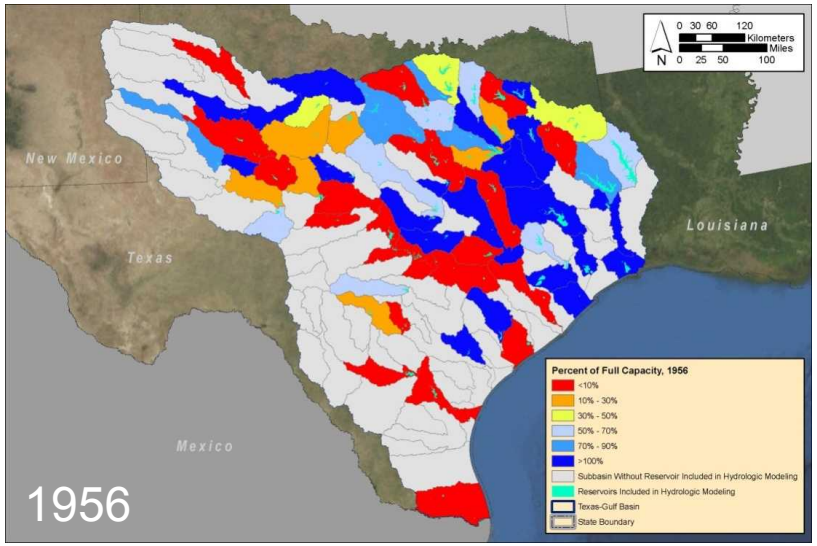


Hydrologic Modeling Results – *Multiple-Year Drought*

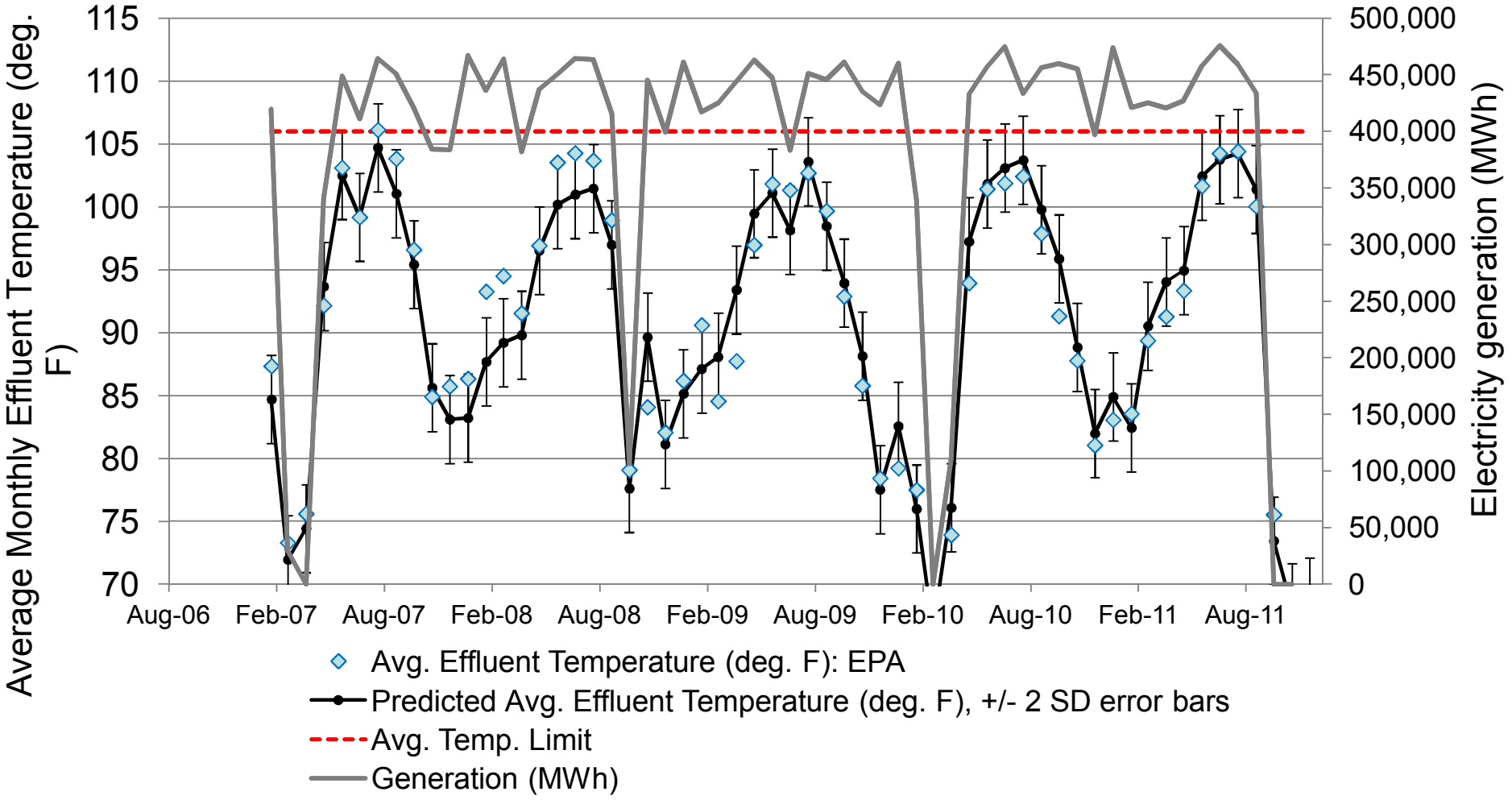




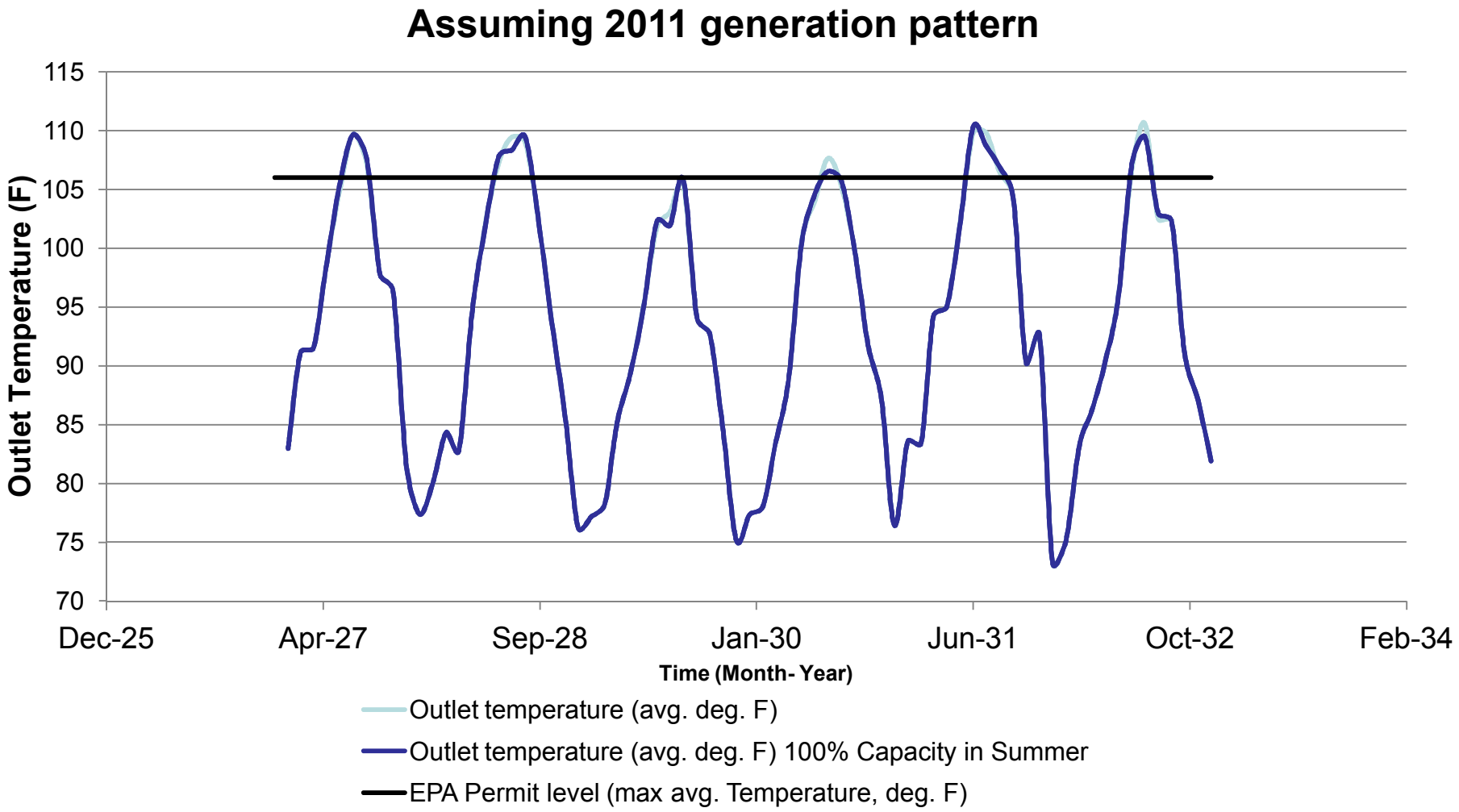
- Projected reservoir storage in HUC-8 basins under 1950-1957 drought scenario



Operations near thermal limit



Operations near thermal limit in future summers



Power Plant Siting Decisions

- West-wide objectives
  - Minimize cost
  - Maximize reliability
  - Maximize transmission capacity utilization
  - Limit exposure to policy change
  - ***Minimize stress over water***
- Power plant siting criteria
  - Fuel type
  - Cooling type
  - Capacity
  - Location
  - Water source

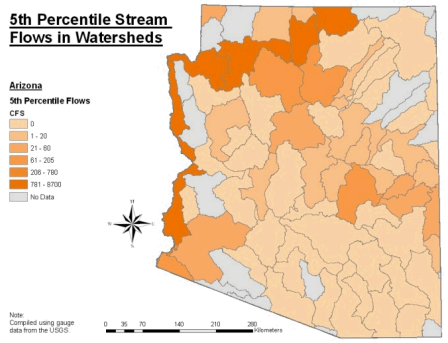
Key Water Sources

- **Potable Water**
  - **Unappropriated surface water**
  - **Unappropriated groundwater**
  - **Appropriated water (rights transfers)**
- **Non-Potable Water**
  - **Municipal/Industrial wastewater**
  - **Shallow brackish water**

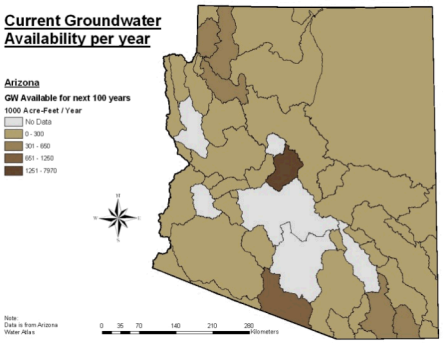
Relative Availability and Cost

Utilized State Water Data

Water Supply

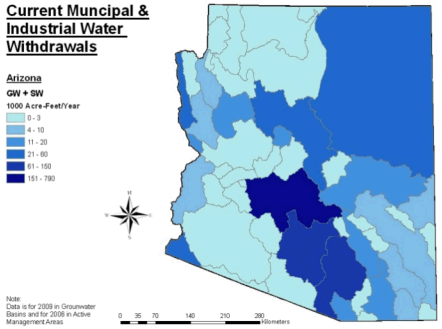


Mean Gauged Streamflow

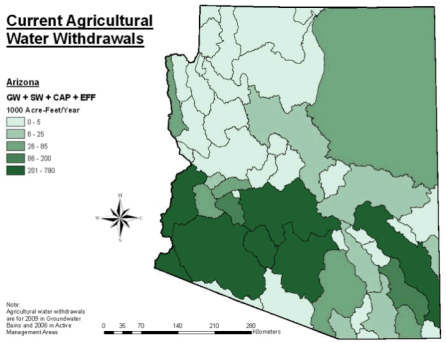


Groundwater Depletion

Water Demand

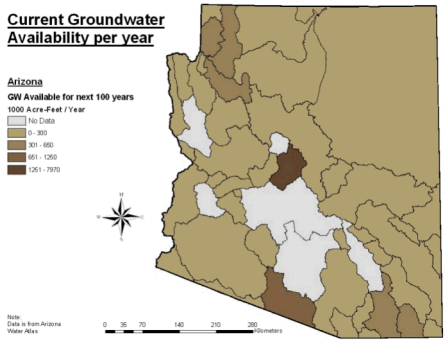


Municipal Demand

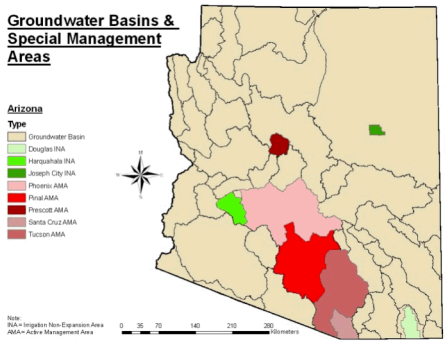


Irrigation Demand

Water Institutions



Unappropriated Water



Administrative Control Areas

Overcoming Multiple Reference Systems

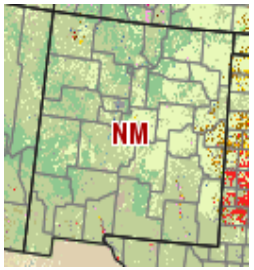
Data available from variety of sources

-State water plans
-State and basin-level data -
USGS
-USDA
-EPA

Multiple data formats and levels of detail

Points: wells, population centroids, wastewater plants, stream gages

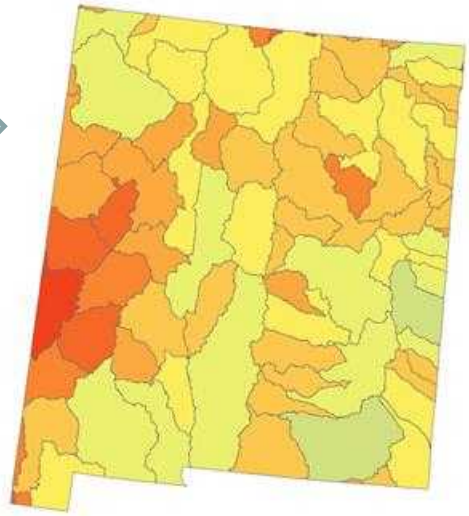
Polygons: Counties, water management areas, groundwater basins



Raster: irrigated agriculture, groundwater recharge

Documents: water plans,
population projections,
time-dependent data

Scaled to HUC-8 boundary

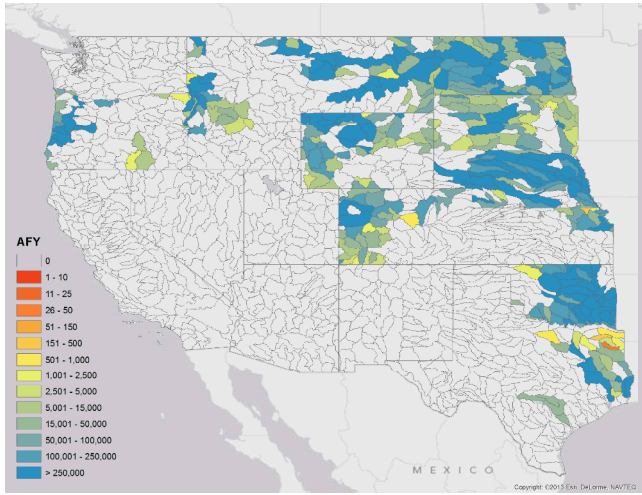


Metric Development

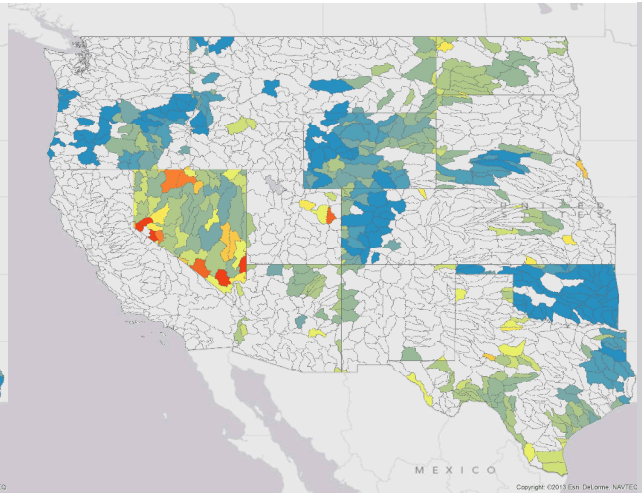
- **Data on “available water” are rare**
- **As such, metrics were estimated from available information**
- **Assisted by volunteer team from WSWC**
  - **Bret Bruce (USGS)**
  - **Dan Hardin (TX)**
  - **Sara Larsen (WSWC)**
  - **Dave Mitamura (TX)**
  - **Andy Moore (CO)**
  - **Ken Stahr (OR)**
  - **Todd Stonely (UT)**
  - **Steve Wolff (WY)**
  - **Dwane Young (WSWC)**

Water Availability

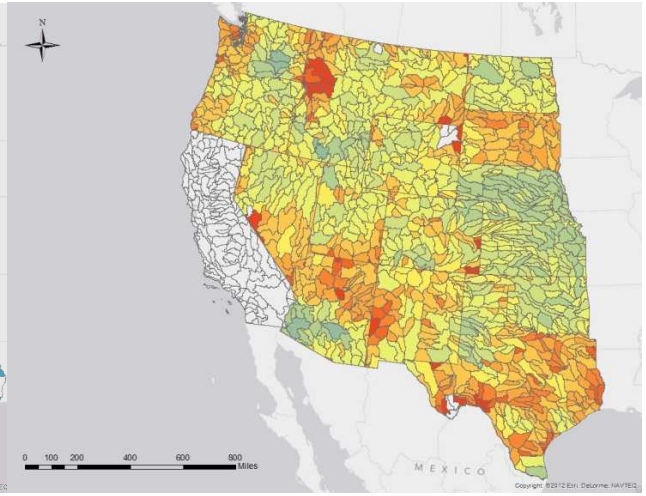
Unappropriated Surface Water



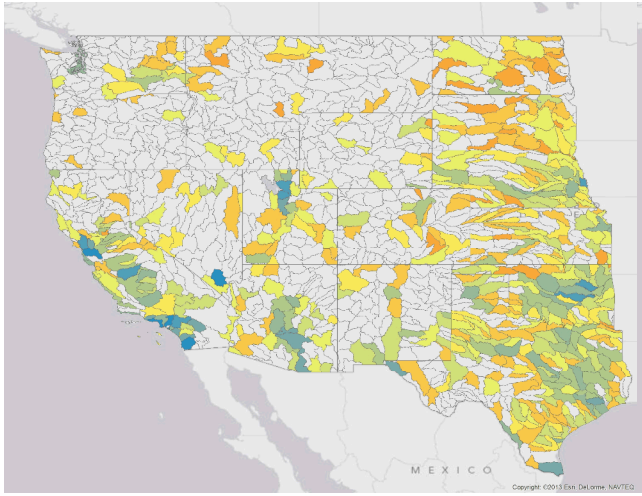
Unappropriated Groundwater



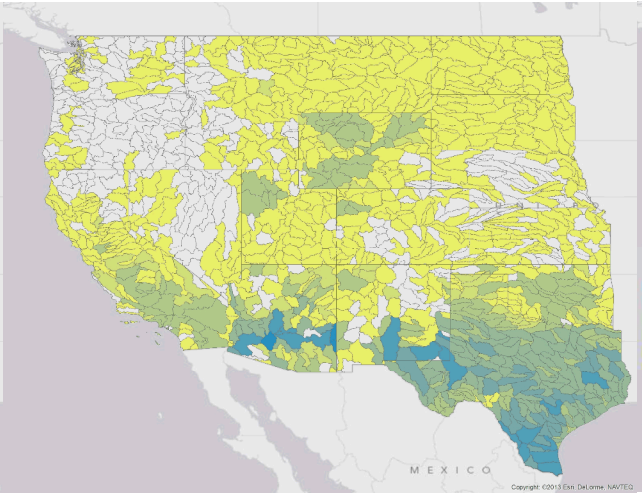
Appropriated Water



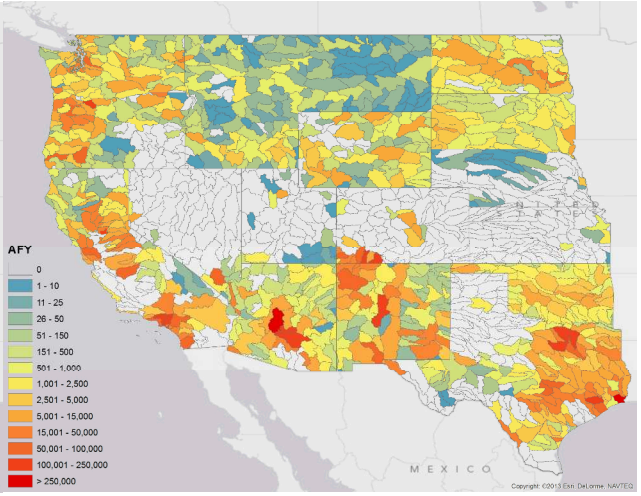
Municipal Wastewater



Brackish Groundwater

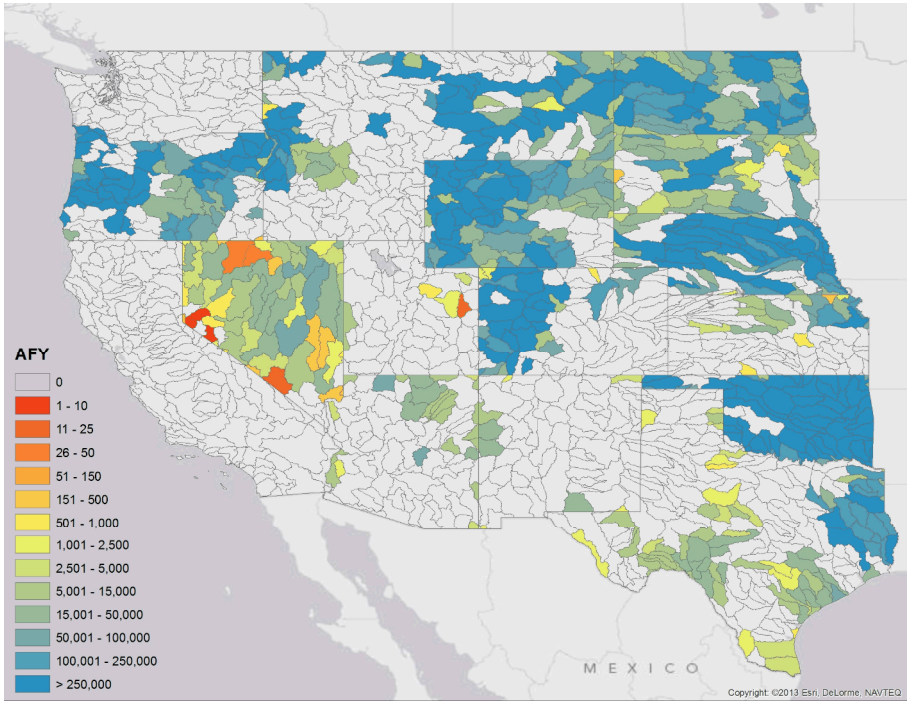


Consumptive Demand 2010-2030

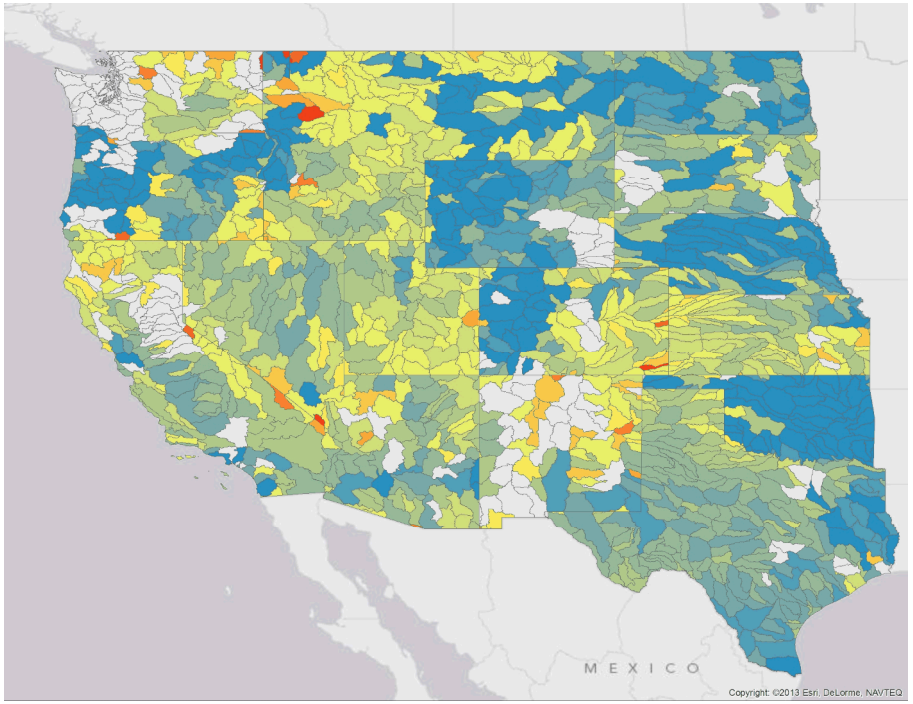


Water for Development

Unappropriated Water Sources – Change in Demand 2030

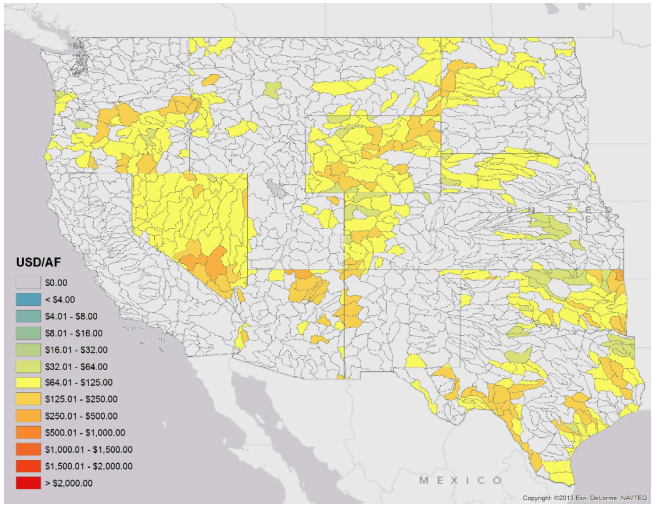


All Water Sources – Change in Demand 2030

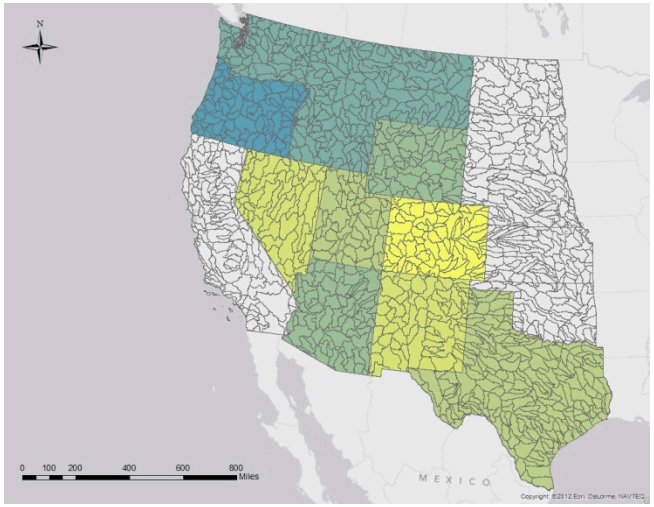


Relative Cost of Water

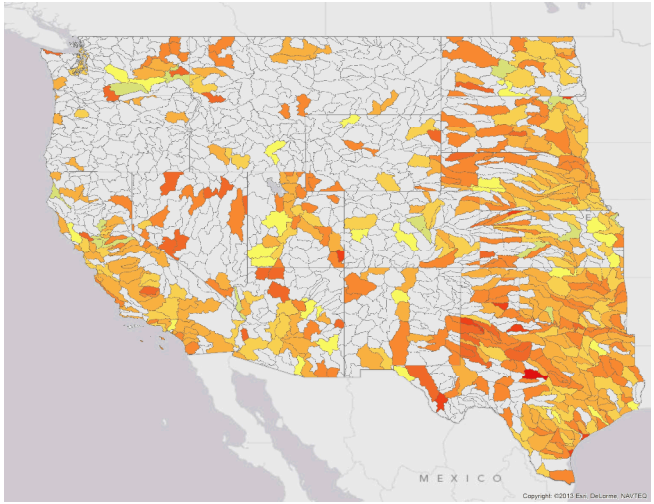
Unappropriated Groundwater



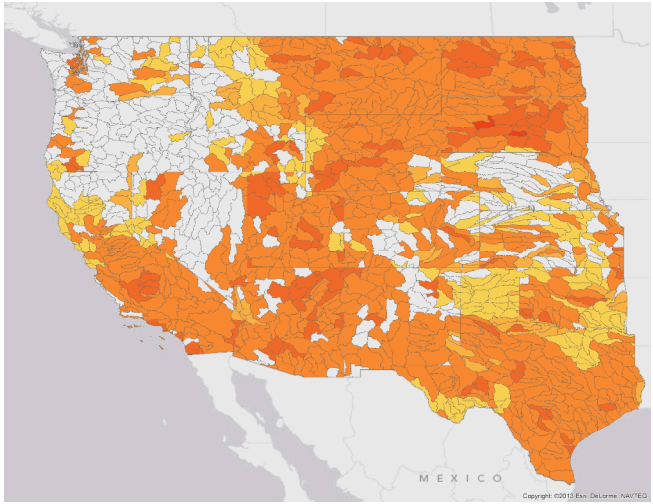
Appropriated Water



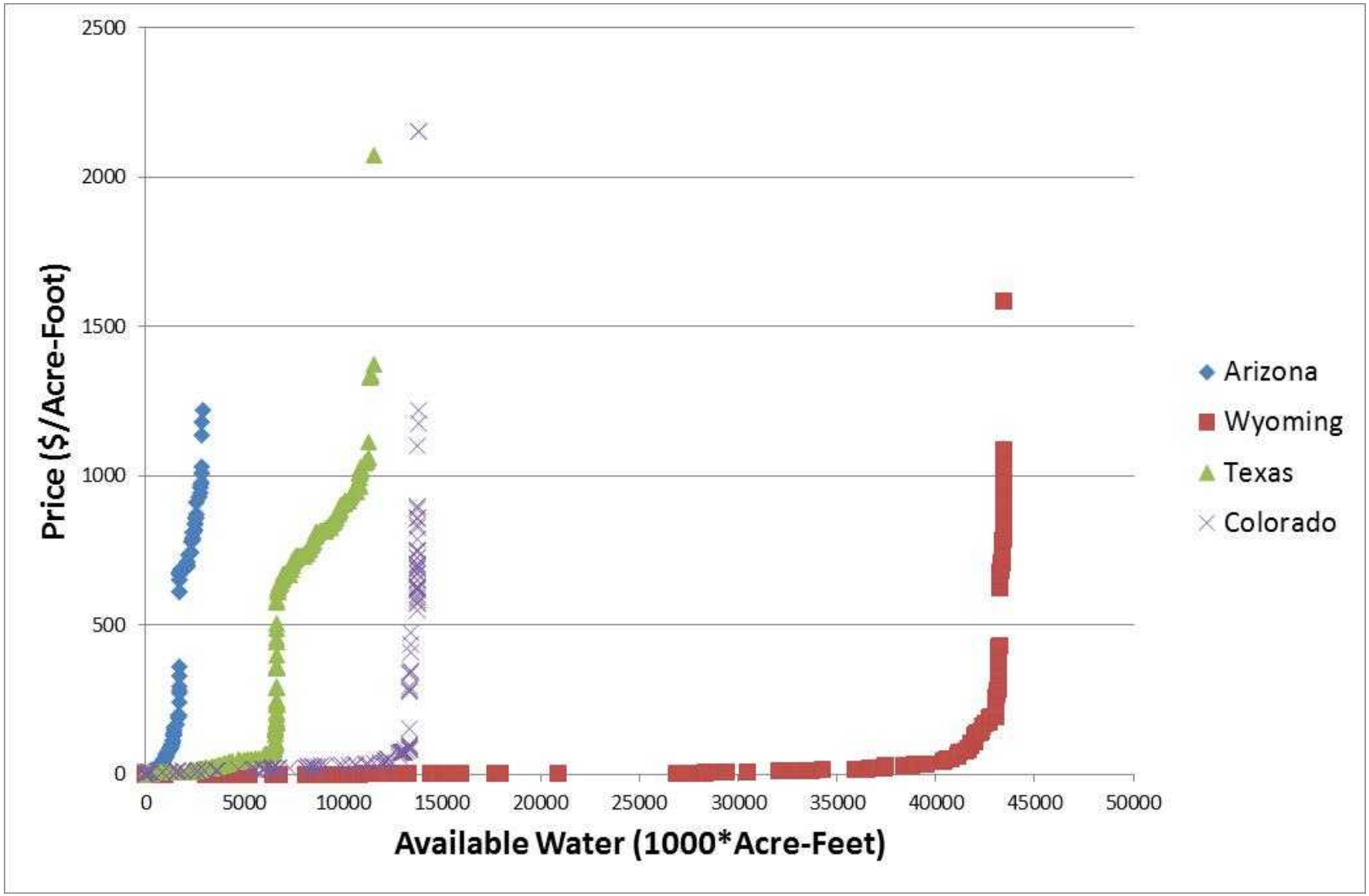
Municipal Wastewater



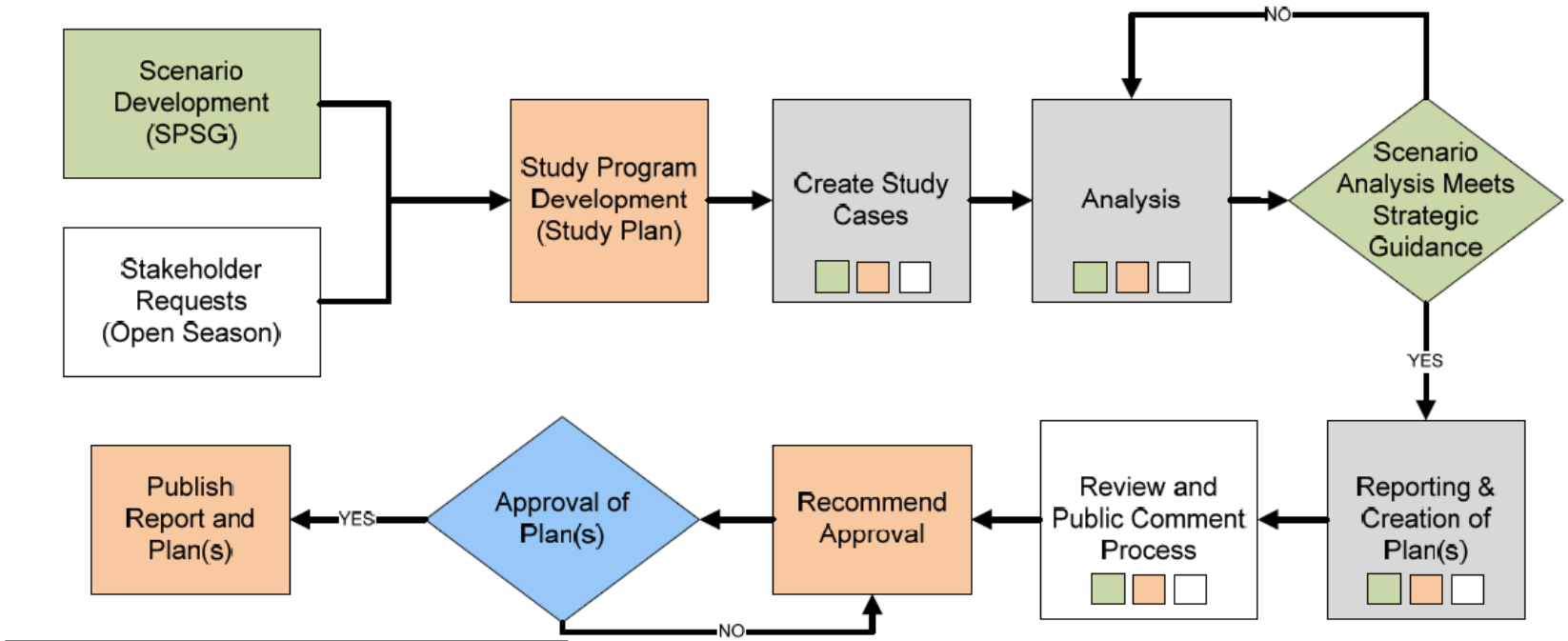
Brackish Groundwater

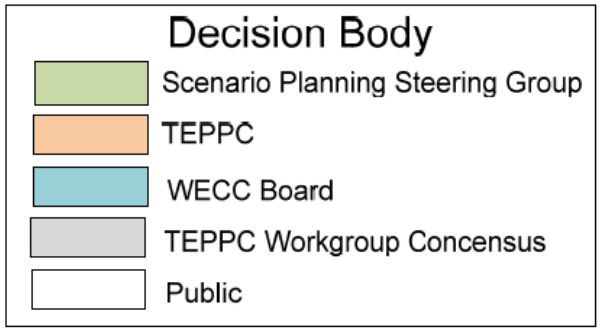


State-Level Supply Curves



Transmission Planning





Note – The small boxes represent opportunities for stakeholders to be directly involved in planning processes.

TEPPC Workgroup activities are open to all and decisions are made by consensus. It is at these meetings where many of the details of the planning process are decided.

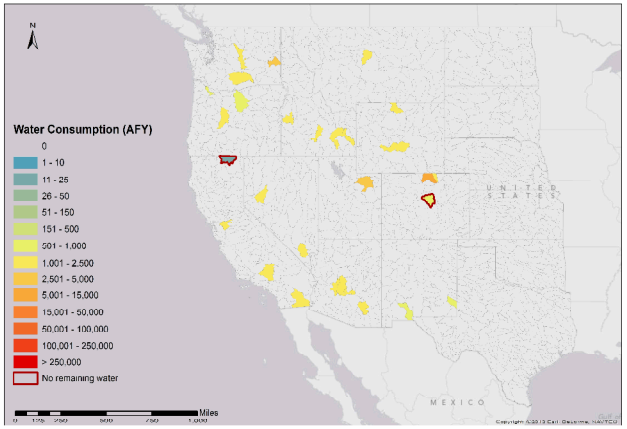
Long Range Planning Results

Case Description		Water Limited Watersheds	Number of New Units	Total Water Consumption (AFY)
Reference Case		2	59	53,128
Scenario 1 - Focus on Economic Recovery		3	106	106,808
Scenario 2 - Focus on Clean Energy		6	46	51,527
Scenario 3 - Focus on Short-Term Consumer Costs		2	108	108,203
Scenario 4 - Focus on Long-Term Societal Costs		1	43	38,637
Sensitivity - $0/ton CO2 Tax		6	124	124,907
Sensitivity - $2/MMbtu Natural Gas price		3	164	170,269
Sensitivity - $12/MMbtu Natural Gas price		1	11	34,462
Sensitivity - $75/ton CO2 Tax		5	131	133,674
Study Request - Enhanced Geothermal Breakthrough		4	20	19,230

Long Range Planning Results

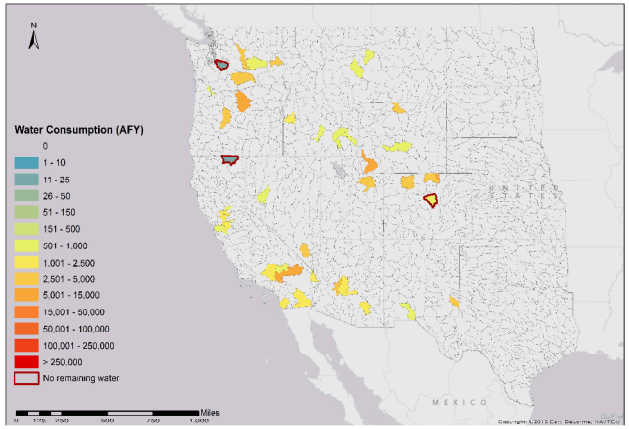
Reference Case

Total water demand (AFY) and areas where demand exceeds availability (red)



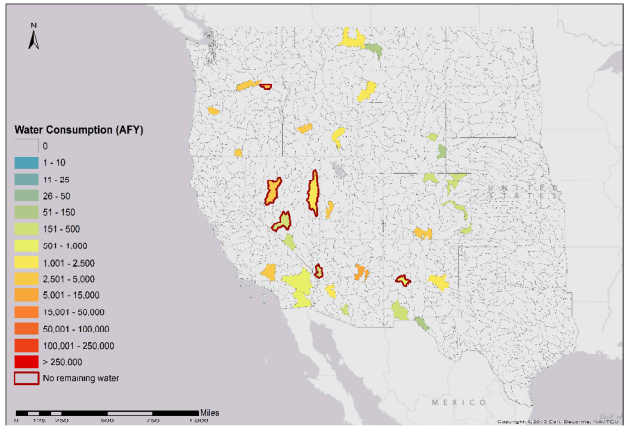
Scenario 1: Focus on Economic Recovery

Total water demand (AFY) and areas where demand exceeds availability (red)



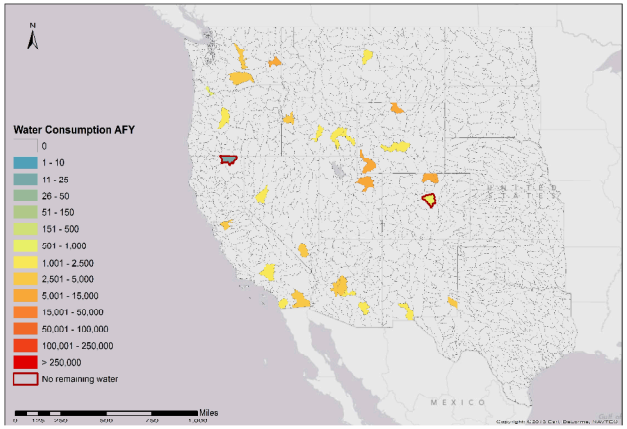
Scenario 2: Focus on Clean Energy

Total water demand (AFY) and areas where demand exceeds availability (red)



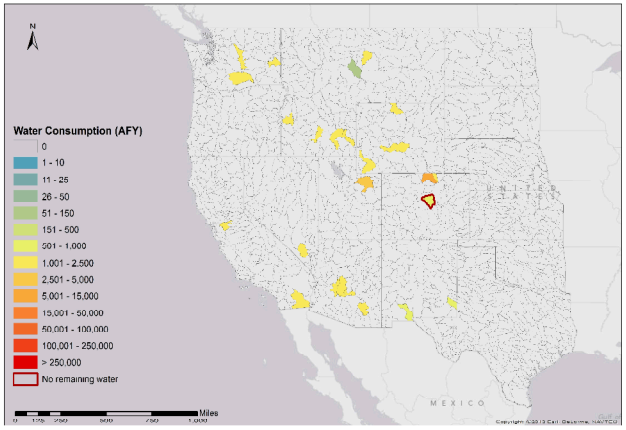
Scenario 3: Focus on Short-Term Consumer Costs

Total water demand (AFY) and areas where demand exceeds availability (red)



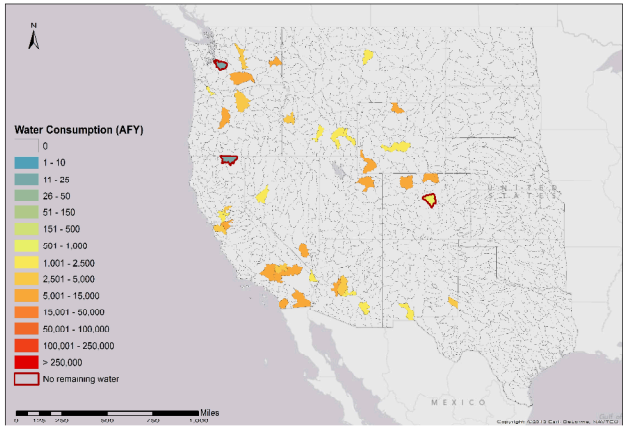
Scenario 4: Focus on Long-Term Societal Costs

Total water demand (AFY) and areas where demand exceeds availability (red)

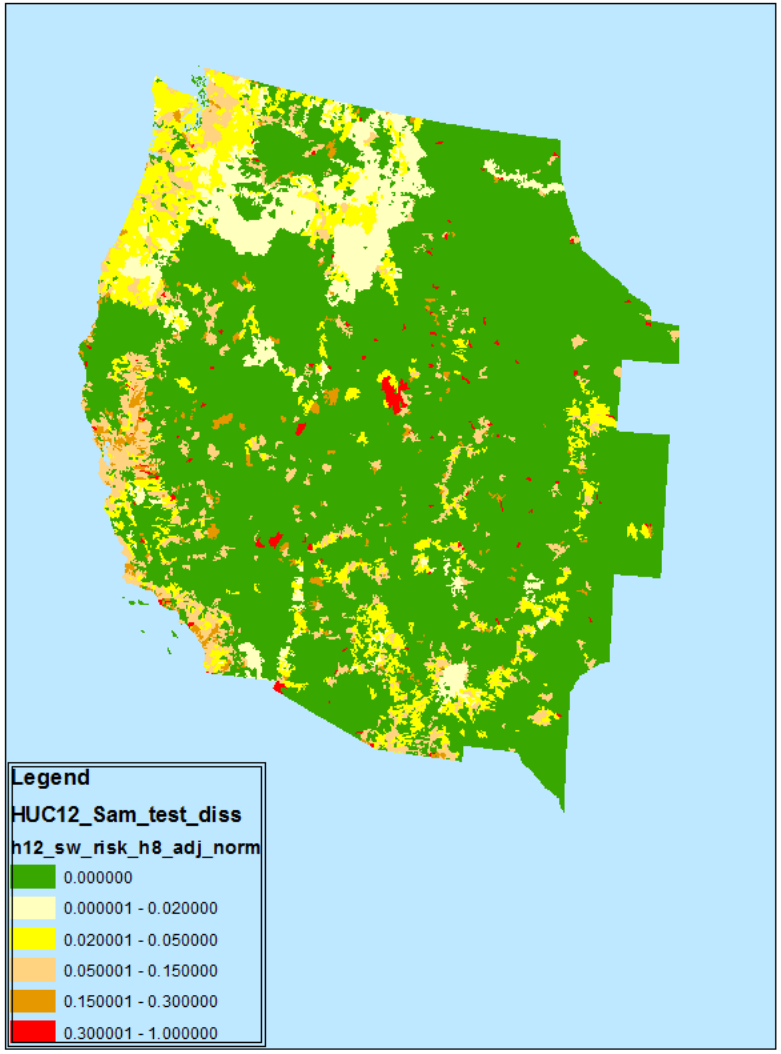


Sensitivity Analysis: $2/MMbtu Natural Gas Price

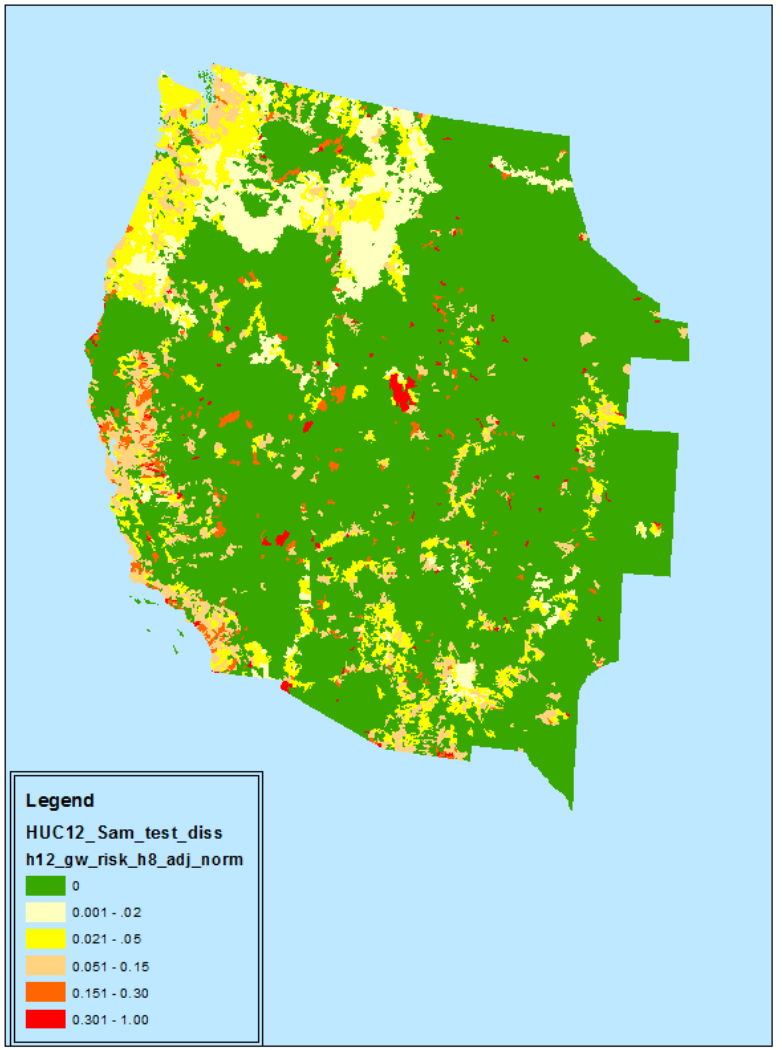
Total water demand (AFY) and areas where demand exceeds availability (red)



HUC-12 Risk Map (From Surface Withdrawals)

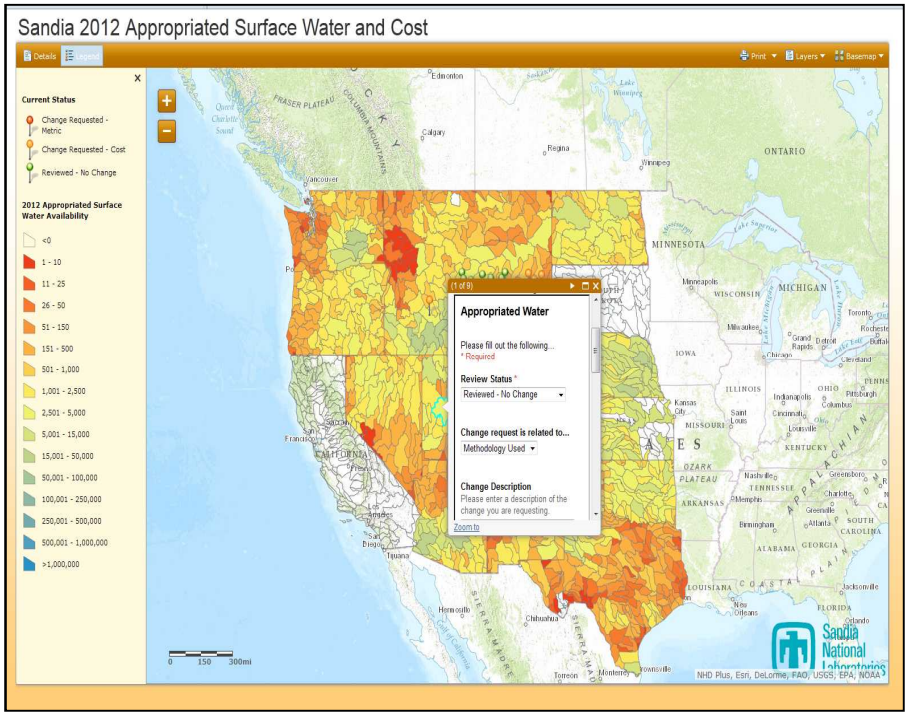


HUC-12 Risk Map (From Underground Withdrawals)

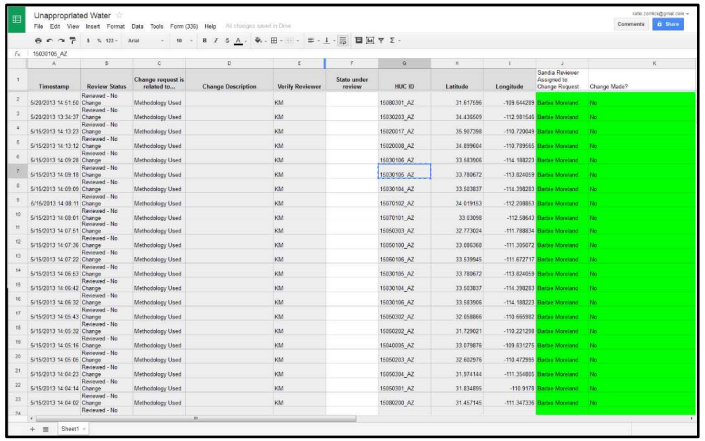


Data review

ArcGIS Online site
Reviewers select metric map by water source and make comments/revisions by watershed. Changes are tracked with pins on map and in a spreadsheet.

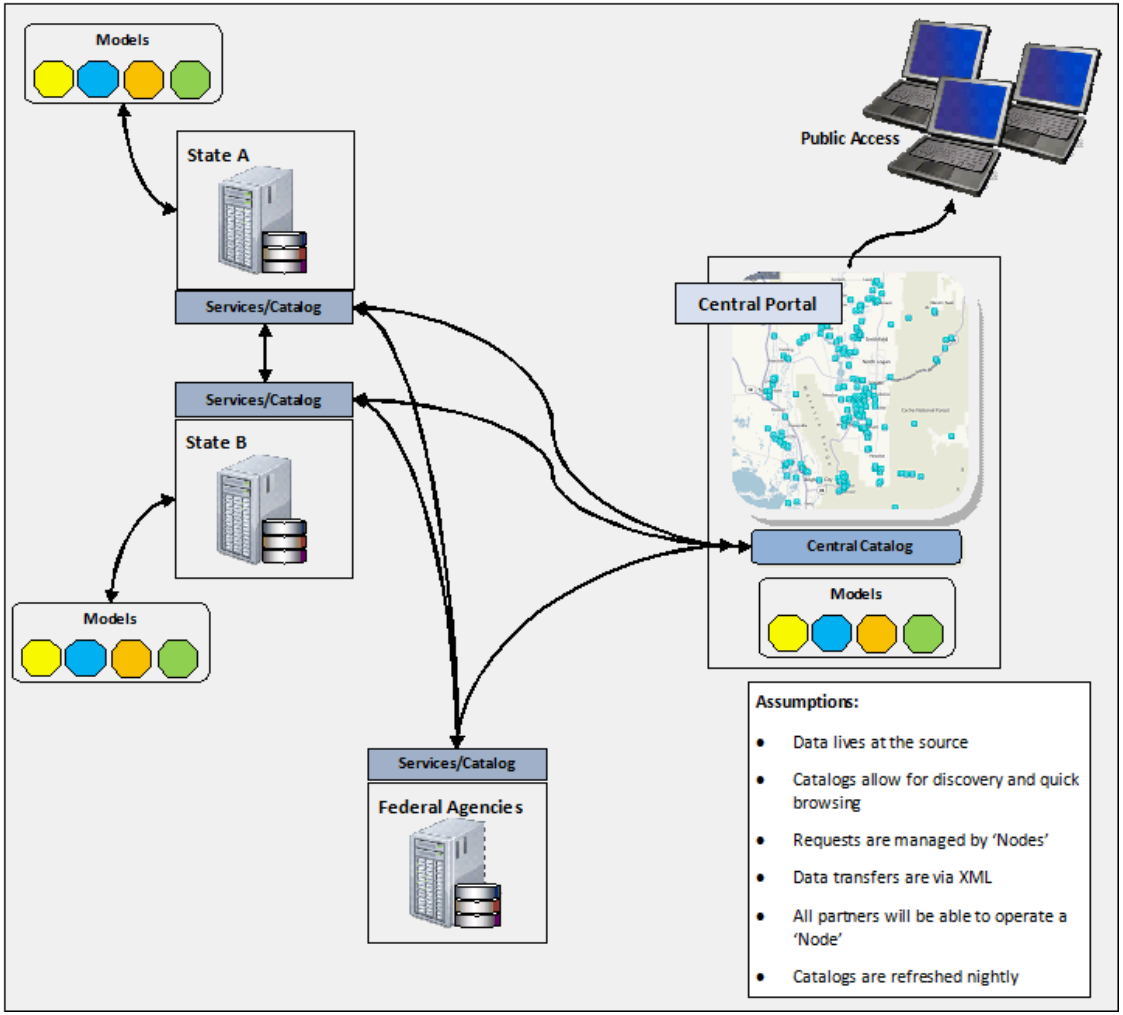


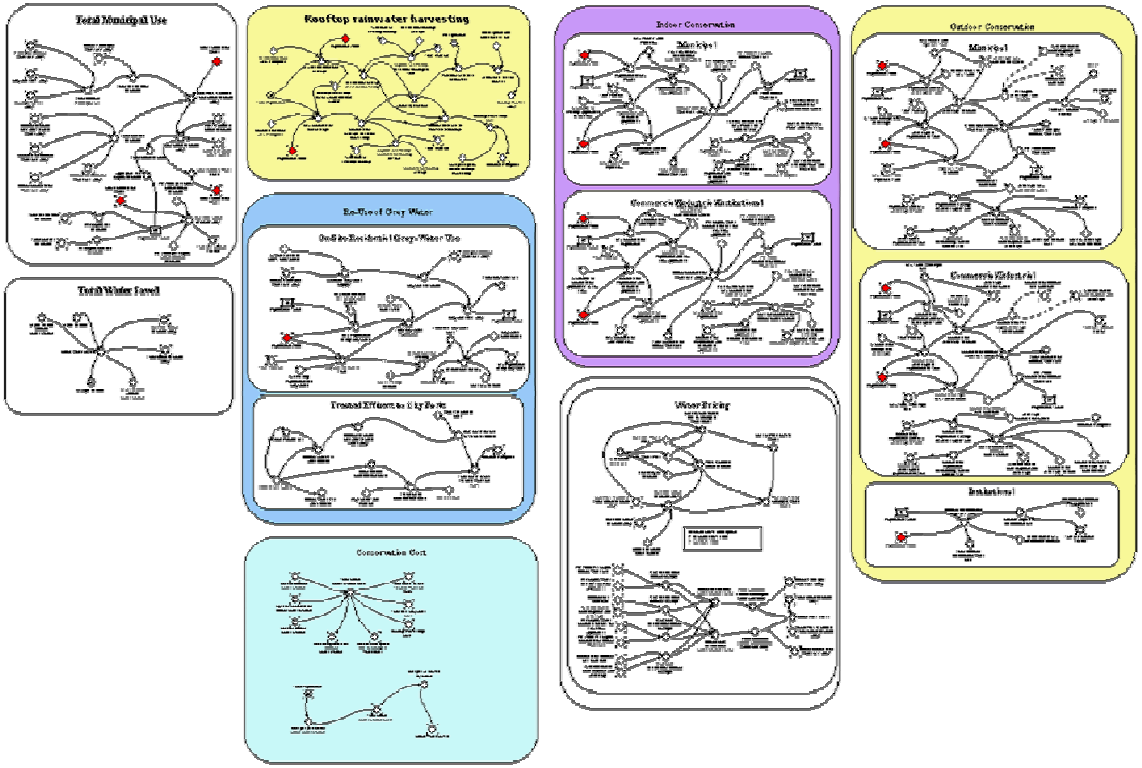
Google Docs
User comments are reported; changes to the metrics are recorded

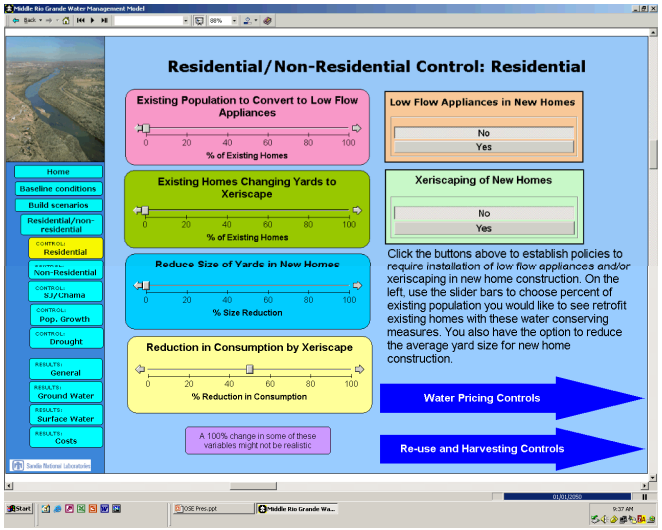


Water Use Data Exchange (WaDE)

- Use Web Services to transfer data
- Data Stay at the Source (i.e. the states)
- Provide transparent link between state data and integrated water metrics
  - Link to metadata
  - Changes in state data are automatically reflected in metrics







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