Climate Change Impacts on Water Demand & Supply in the Central Puget Sound, WA

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Central Puget Sound Region

- Major metropolitan area of Washington, includes cities of Seattle, Tacoma, Bellevue and Everett
- 118 water utilities with 500 or more connections
- Current population over 3.3 million, water demand of 395 MGD
- GDP over $183 billion
- Annual precipitation over 38 inches

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Project Overview

- **Develop a comprehensive regional water supply outlook for the Central Puget Sound**
- **Forecast water demands using a consistent method, with ability to capture uncertainty**
- **Assess existing supplies and evaluate future supply and conservation options**
- **Determine potential impacts of climate change on water demands and supply**

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Acknowledgements

- **Central Puget Sound Water Suppliers' Forum -** *Project sponsor and lead organization*
- **University of Washington -** *Technical lead on climate change modeling and impacts on stream flow*
- **Seattle Public Utilities, City of Everett, and Tacoma Public Utility -** *Climate change impacts on utility operations*
- **CDM -** *Overall project consultant and developer of water demand model and climate change impacts on demands*

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Central Puget Sound Water Supply

- Surface Water (66% of total):
  - Sultan River (Everett Supply)
  - Tolt and Cedar Rivers (Seattle Supply)
  - Green River (Tacoma Supply)
- Groundwater (34% of total):
  - Wells mostly in King and Pierce Counties

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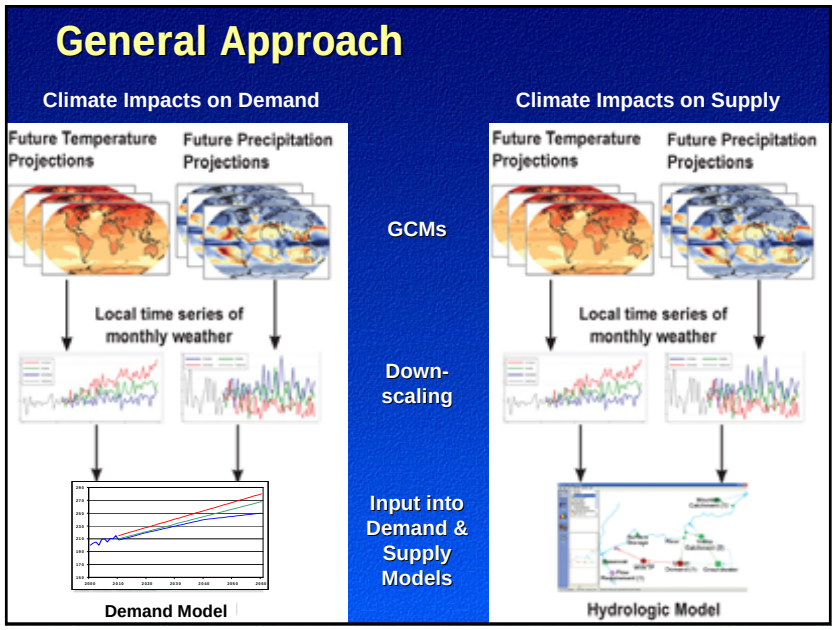
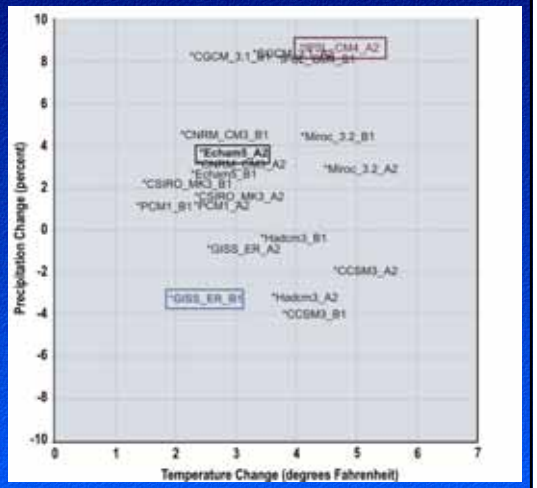
General Approach



Global Climate Models

- Started with 21 GCMs
- Plotted impacts on temperature and precipitation
- Stakeholder consensus reached on three representative GCMs
- GISS (warm); Echam (warmer); and IPSL (warmest)



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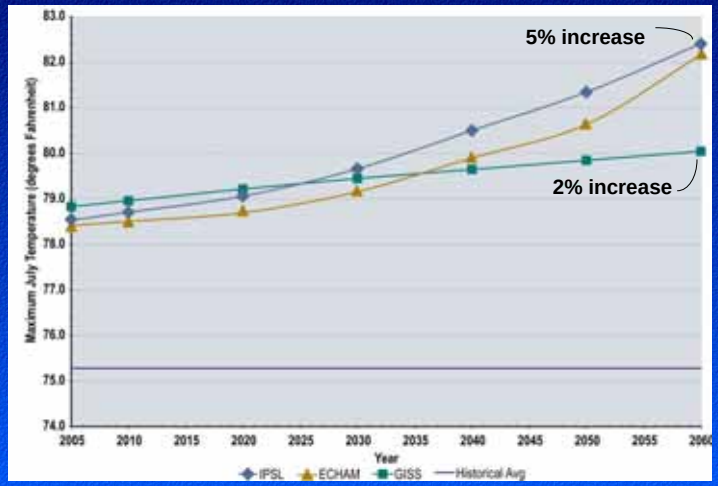
Maximum Average July Temperature (°F)



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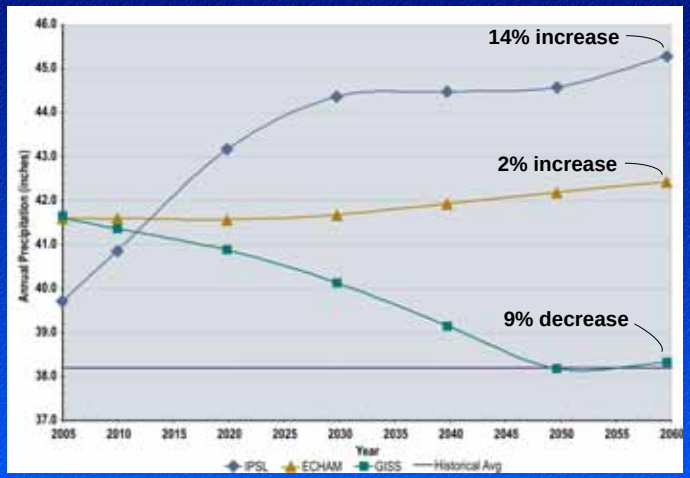
Annual Total Precipitation (Inches)



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Water Demand Forecast Model

- Statistical model based on unit use coefficients for single-family, multifamily, and non-residential
- Model drivers:
  - households
  - employment
  - real price of water
  - real personal income
- Model weather variables:
  - max. temperature during summer season
  - total precipitation during summer season

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Statistical Regression Results

$$GPD = e^{a} \cdot (Precip)^{b} \cdot (MaxTemp)^{b} \cdot (Empl)^{b}$$

GPD = gallons per day
Precip = total precipitation in summer season
MaxTemp = average maximum monthly temperature in summer
Empl = annual employment

R2 = 0.85
Pr>F = <0.0001

Coefficients:

Intercept	-14.62
Precip	-0.03
MaxTemp	5.85
Empl	0.82

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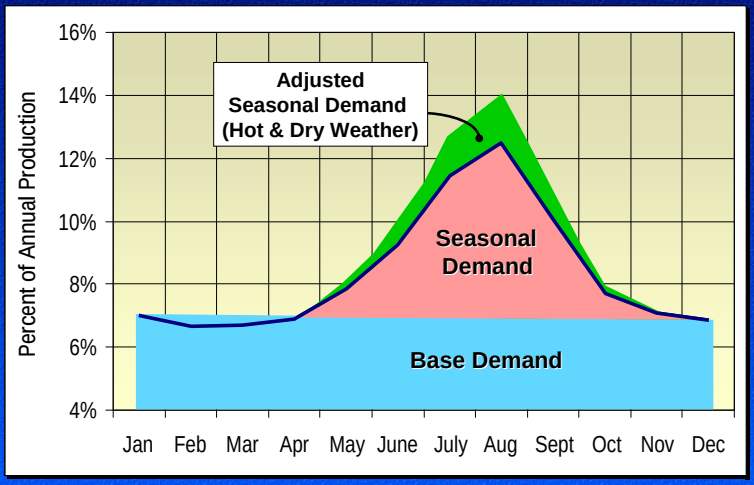
Applying Results of Regression



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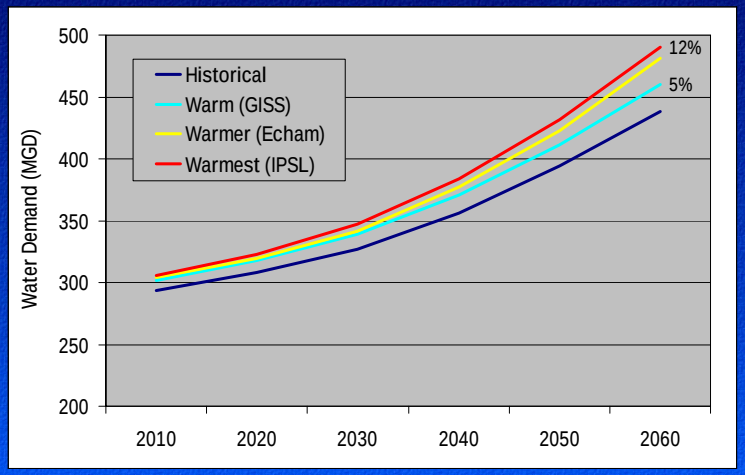
Demand Forecasts with Climate Change*



* For Seattle PU, Tacoma, and Everett

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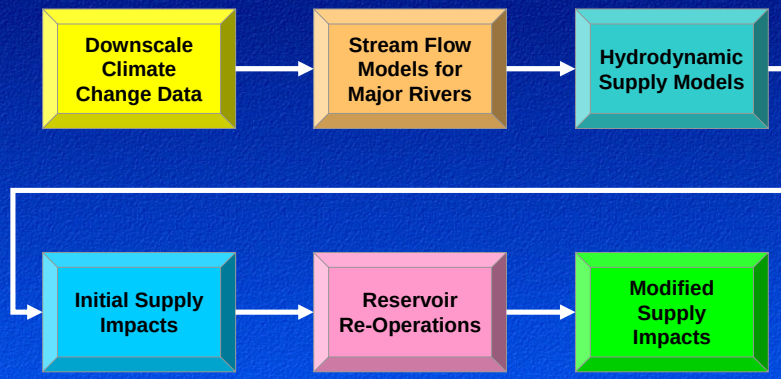
Water Supply Impacts Method*



** Only impacts to surface supplies were modeled; impacts to groundwater require further investigation.*

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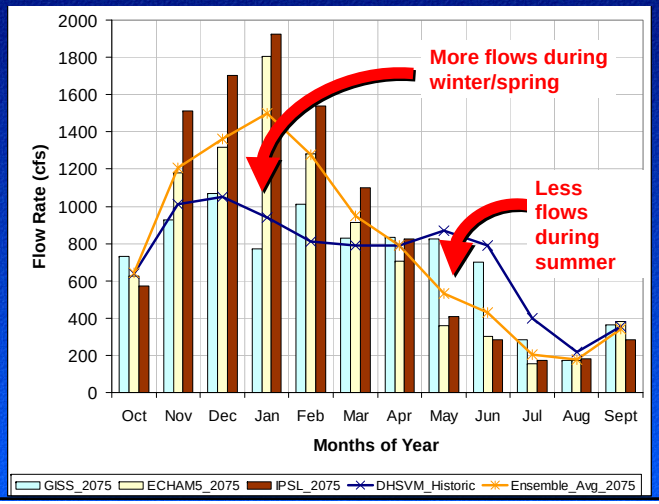
Climate Change Impacts on Stream Flow (Example: Sultan River, Year 2060)



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Stream Flow Impact Ramifications

- Reservoirs usually already at maximum capacity during winter months -- meaning more stream flow does not equal more yield
- Water demands peak in summer months, sometimes as much as 2 to 3 times -- so less stream flow in summer will lead to shortages
- Reservoir re-operations can help mitigate impacts in the short-term, but longer term climate change will impact existing supplies

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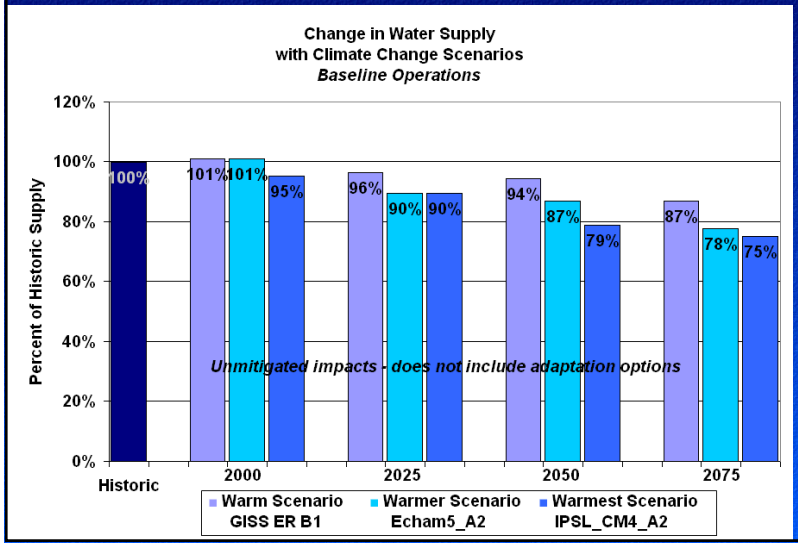
Supply Impacts for Seattle



Seattle's Adaptation Measures

- SPU identified a series of intra-system modifications and new supply options – and grouped them into Tiers.
- Applied the effects on supply using Tier 1 intra-system modifications.
- Where Tier 1 modifications did not restore supply fully, new supply options have been identified.

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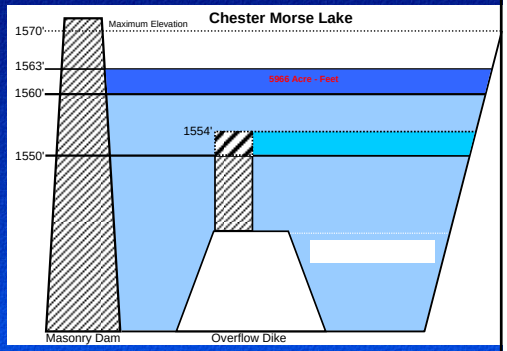
Seattle Reservoir Re-Operations

- Refill to 1563’
  - Current practice but 1560’ used for firm yield
  - Adds 5966 AF or 12% more useable storage
- Modify Overflow Dike to 1554’
  - Current crest is at 1550’
  - Reduces seepage losses
  - New project under development



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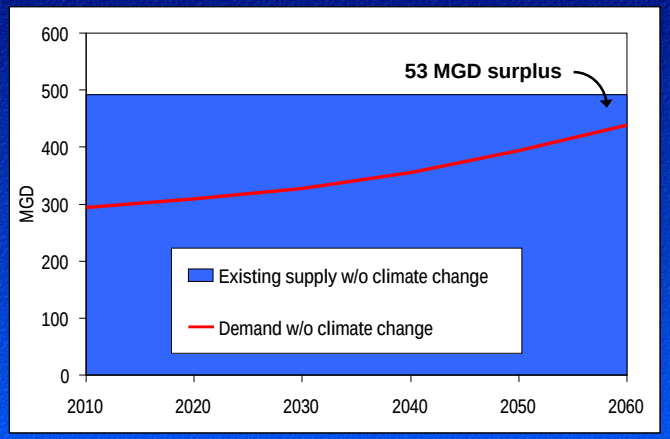
Demand & Supply Comparison: *without climate change*



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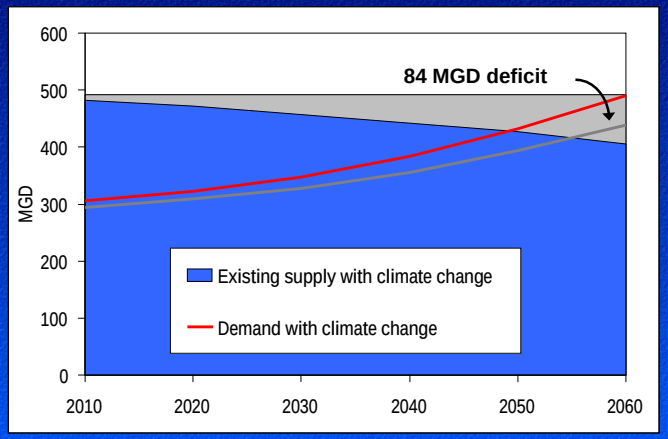
Demand & Supply Comparison:
with climate change (warmest scenario)



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Conclusions

- Important to evaluate climate change impacts to **both** water demands & supplies
- Supply impacts must be done on a monthly basis to capture seasonal stream flow changes
- More research is needed on impacts of climate change on groundwater
- Several climate change scenarios should be used to test sensitivity of impacts

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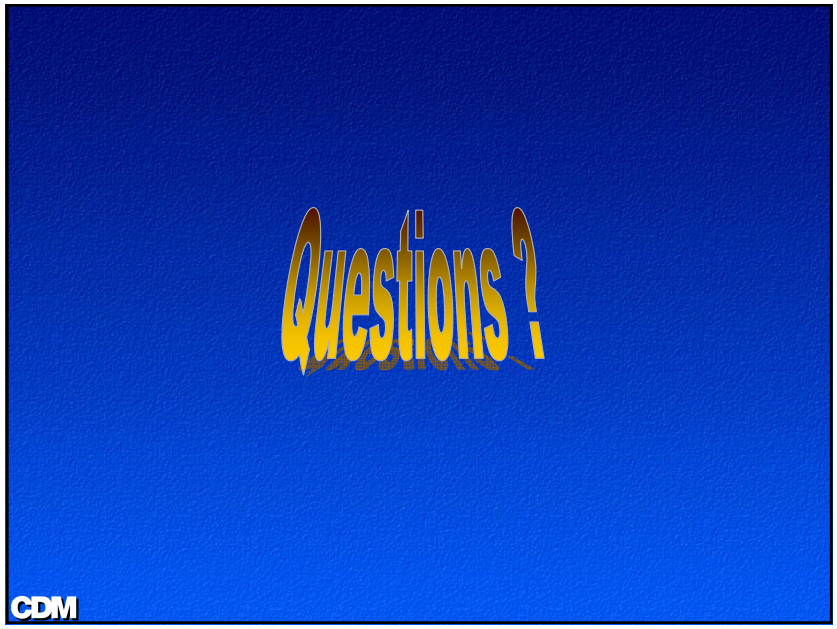
Questions ?
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