Water and Climate: Observations from Seattle

Joan Kersnar, Manager, Drinking Water Planning, Seattle Public Utilities
Paul Fleming, Manager, Climate & Sustainability Group, Seattle Public Utilities

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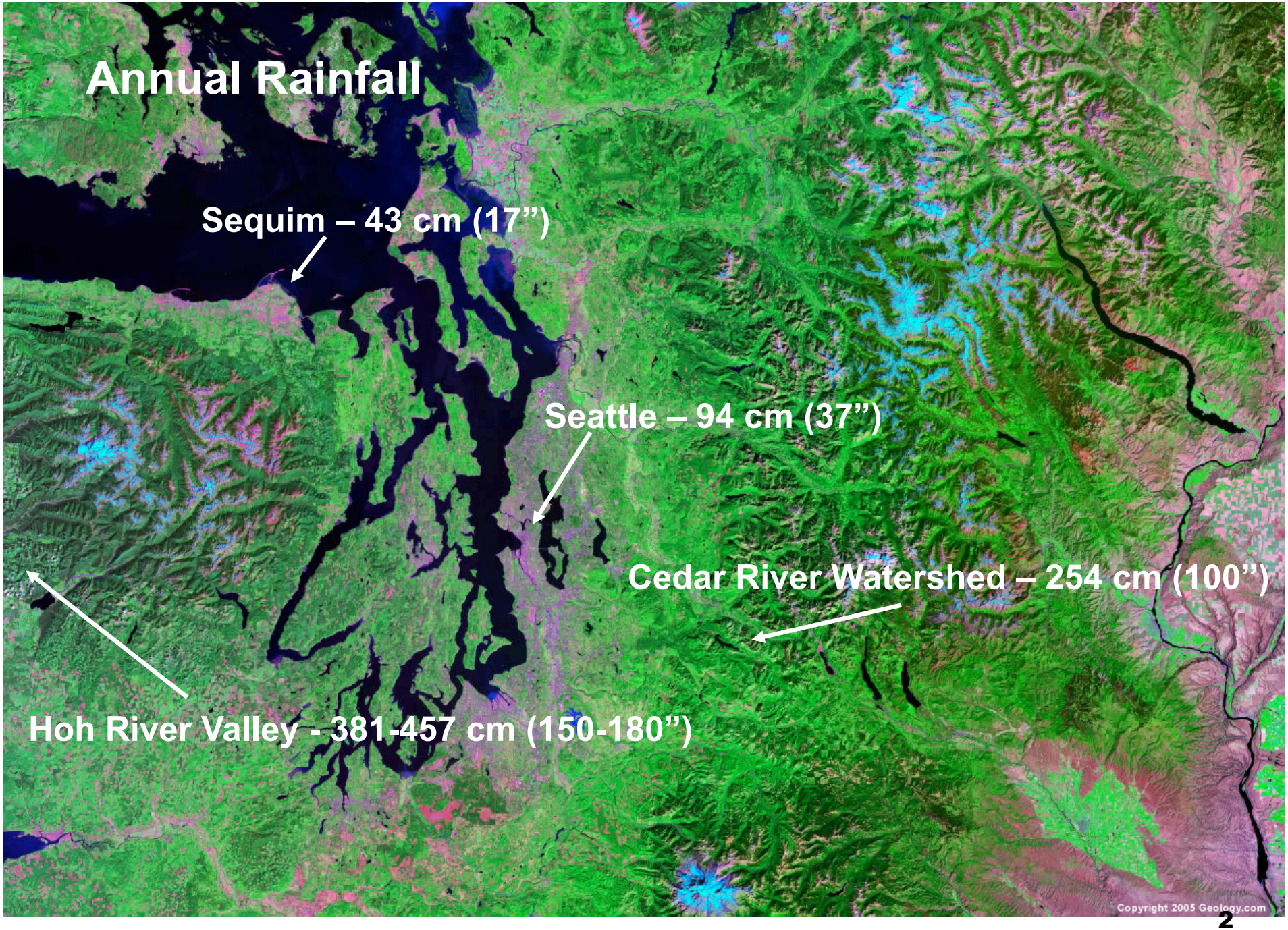
Annual Rainfall
Sequim – 43 cm (17”)
Seattle – 94 cm (37”)
Cedar River Watershed – 254 cm (100”)
Hoh River Valley - 381-457 cm (150-180”)
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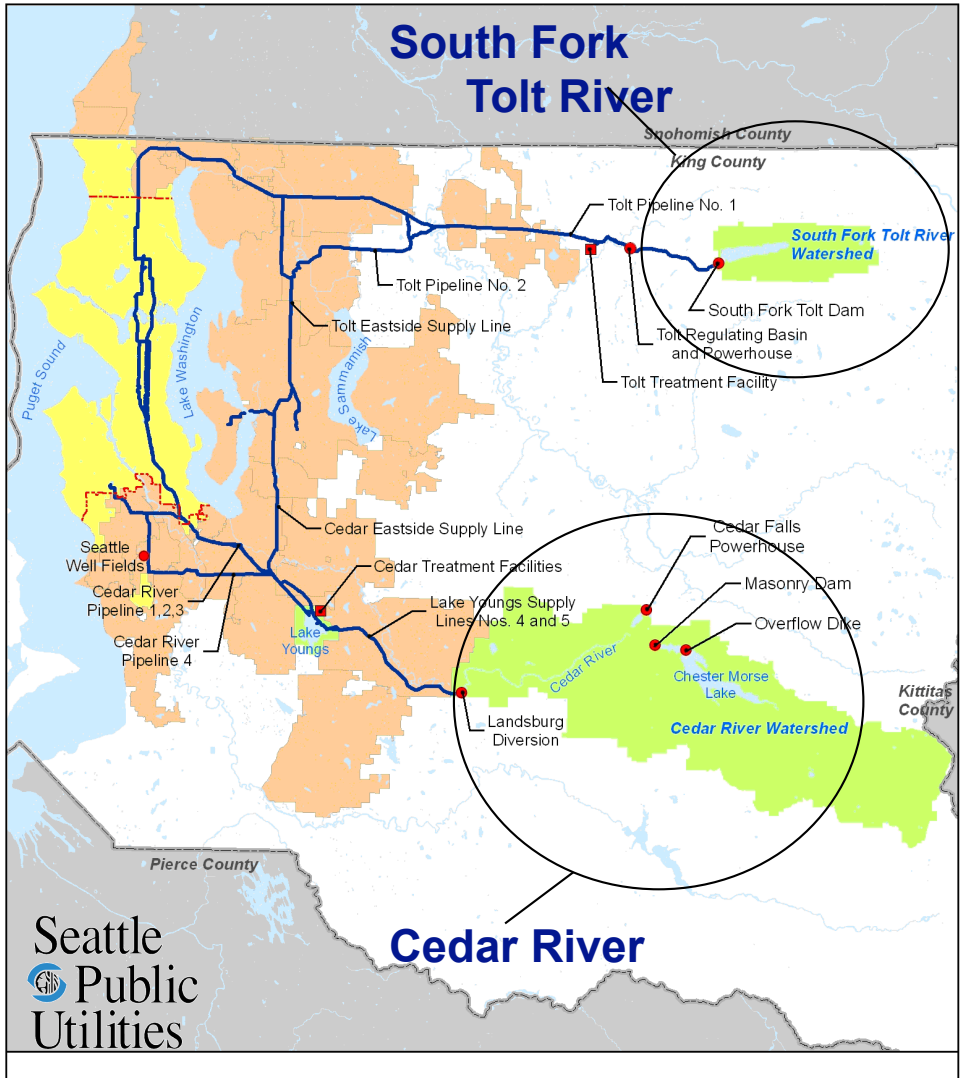
Seattle's Water System



- Responsibilities:
  - Drinking water to 1.3 million people for municipal and industrial use – no agriculture
  - Instream flows for salmon
  - Flood management
  - Hydropower generation
- Surface water reservoirs in the central Cascade Mountains, small amount of groundwater
- Rely on snowpack and rain, may be more dependent on rain than snow
- Ratio of storage to inflows is low, but critical to supplying water
  - 19% on Cedar
  - 48% on Tolt

Seattle's Water Supply Outlook

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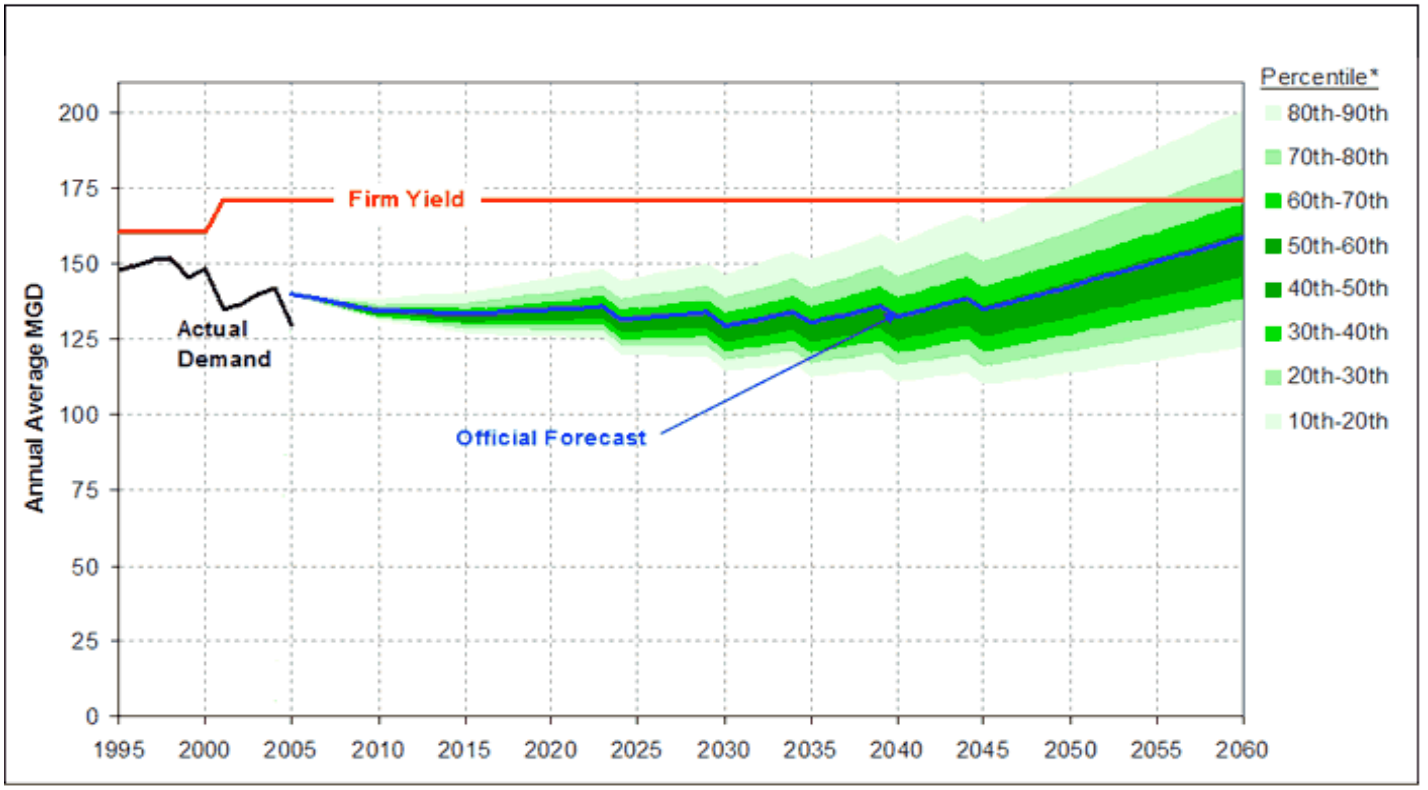
Average Daily Demand:

- 2007: 477,000 m^3 (126 MGD, 390 AF)
- 2060: 602,000 m^3 (159 MGD, 490 AF) with conservation

Available Supply:

- 647,000 m^3 per day (171 MGD, 525 AF/d) can be diverted, after meeting instream flows
- 98% reliability - not available in 1 year in past 76 years



Note: Percentiles represent the probability that actual demand will be less than the value shown. Ranges reflect uncertainty in projected household, employment, price and income growth, price elasticity, income elasticity, and conservation. Note that the Official Forecast is at about the 57th percentile.

Without considering climate change, new supply needed after 2060

SPU's Involvement with Downscaling Studies

Statistical Downscaling – Water Supply

- **2002-2006:** SPU-funded project with University of Washington – Climate Impacts Group (UW CIG)
  - Methods and Uncertainties
  - Supply Impacts
- **2006-2008:** Regional study with UW CIG - *Will focus on this study*
  - Regional Datasets
  - Supply and Demand Impacts
  - Adaptation Strategies
- **2008:** UW CIG study for State of Washington
  - Supply Impacts

Dynamical Downscaling – Urban Drainage

- **2008:** UW CIG study for State of Washington
  - For infrastructure chapter, SPU funded study to run downscaled precipitation data through urban hydrology watershed model
  - Peak Annual Flow, Erosive Flow Energy, Seasonality of High Flows, Low Flow Extremes, Flow Flashiness

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SPU's Involvement with Downscaling Studies

2002-2006: SPU-funded project with UW CIG

- SPU interest: establish internal capacity (knowledge and models) to use climate data for planning purposes.
- Objectives: exploration and development of analytical methods, evaluation and documentation of the uncertainty and limitations, and exploratory-level assessment of possible impacts on supply.
- "Chain of models" Method used by UW CIG:
  - ECHAM4, HadCM3, GFDL_R30, and PCM with SRES A2 for 2000, 2020, and 2040 (air temperature and precipitation)
  - Statistical downscaling to the local watershed, extending time series
  - Watershed hydrology models used to produce inflows
  - Systems simulation model to evaluate supply
- Reported results in 2007 Water System Plan
  - A climate change scenario shows that a 50 percent loss in average snowpack could result in a 10 percent loss in firm yield by 2040. If so, a new source of supply would be needed in 2055.
    - http://www.seattle.gov/util/stellent/groups/public/@spu/@usm/documents/webcontent/spu01_002165.pdf
- No specific analysis on adaptation

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SPU's Involvement with Downscaling Studies

2006-2008: Regional study with UW CIG

- Funded by four agencies (local and state) as part of regional water supply planning process
- Used Echam5-A2, IPSL_CM4-A2, and GISS_ER-B1 for decades surrounding the years 2000, 2025, 2050, and 2075
- Work products included an on-line database of downscaled meteorology and hydrology for 3-county region
  - http://www.climate.tag.washington.edu/index.html
- CIG generated datasets; utilities used it to gain understanding of their own systems
- SPU's use of the data:
  - assess impacts on supply and demand
  - assess effectiveness of operational adaptation options
- To be reported in Water Supply Forum's *2009 Water Supply Outlook*
  - Utility-reported impacts on supply for Everett, Seattle and Tacoma
  - Consultant-generated impacts on demand for Everett, Seattle and Tacoma

2006-2008 Regional Study:
GCM Selection

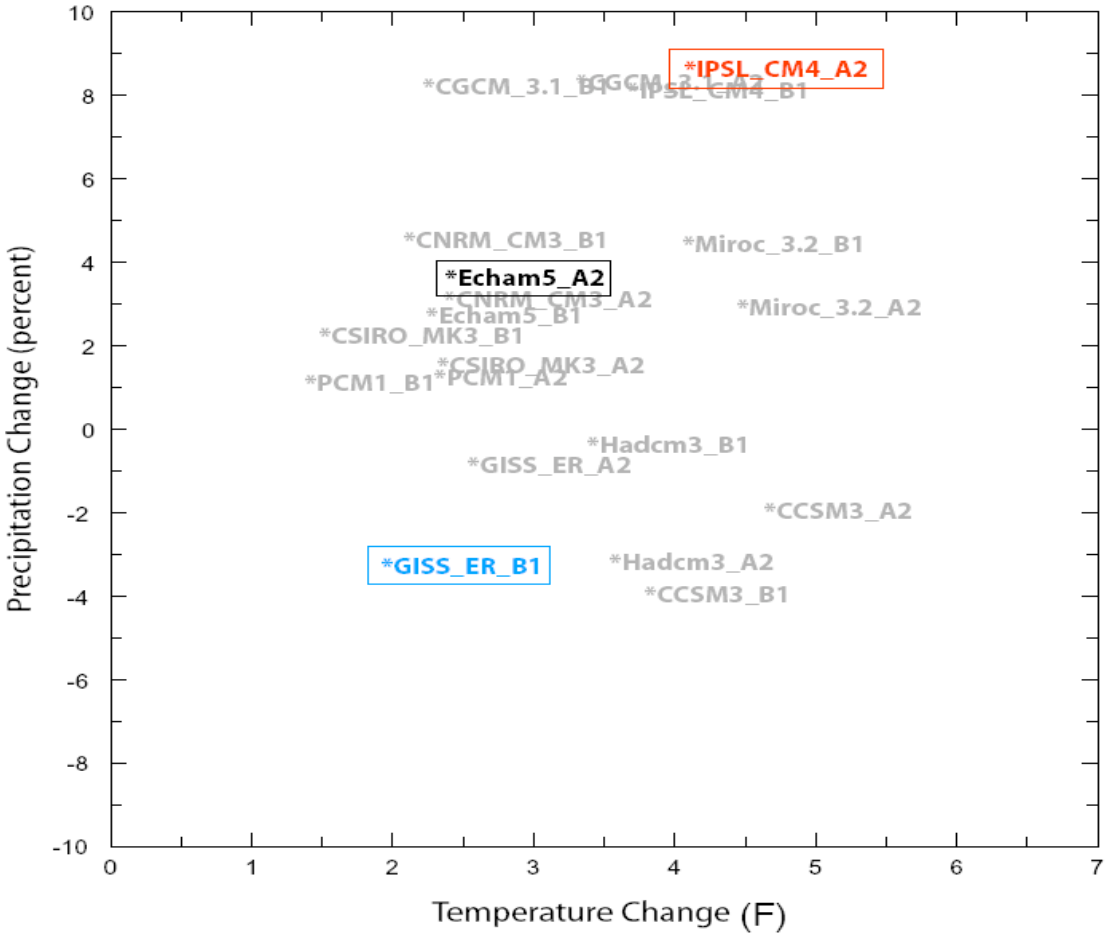
Selected 3 GCM model/ scenario couples that provide a broad range of future scenarios for Pacific Northwest:

-Warm

-Warmer/Mid-range

-Warmest

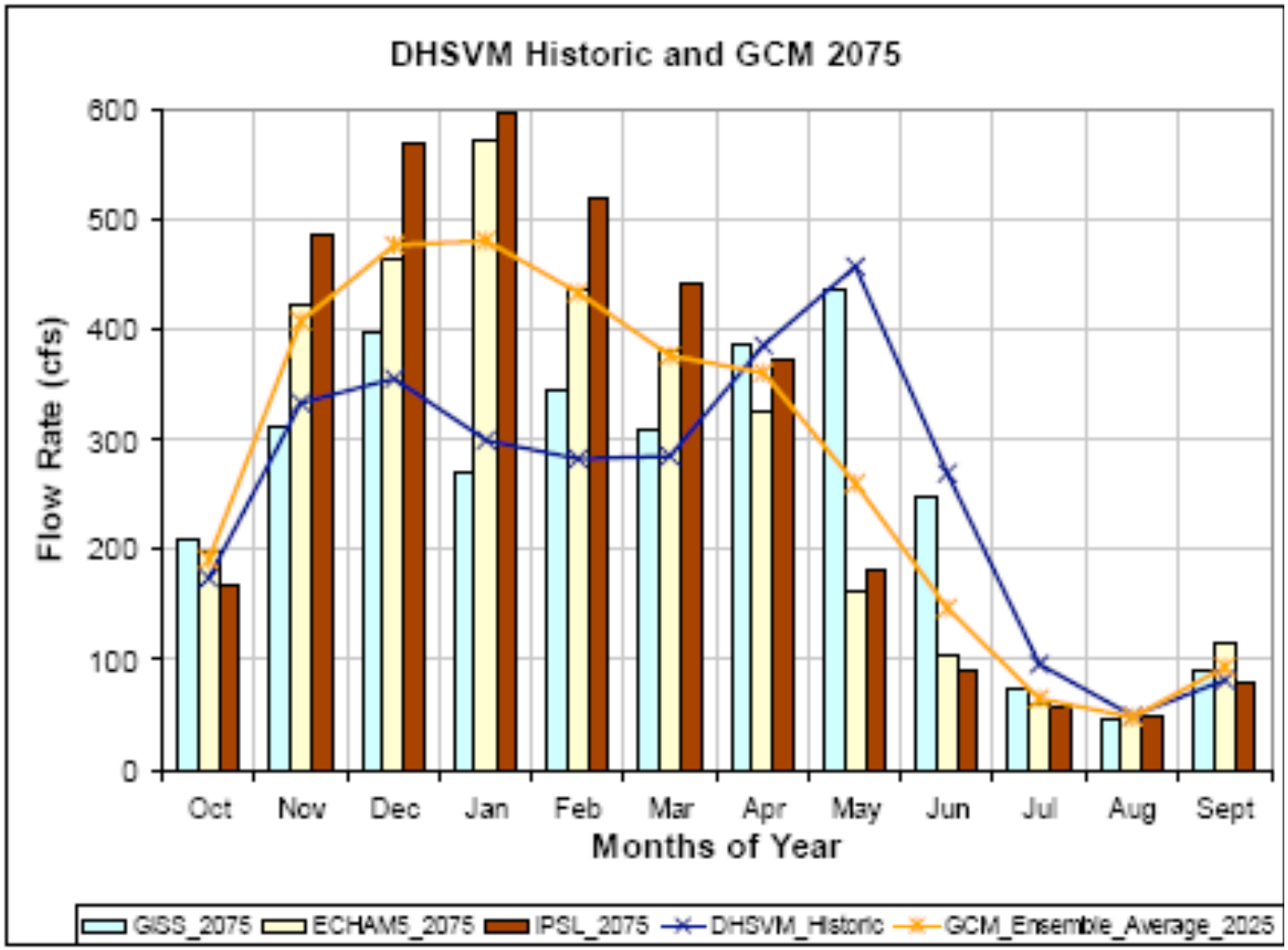
Based on simple average of the temperature and precipitation values at all the Pacific Northwest grid points to define a regionally averaged time series. Here, the Pacific Northwest is defined as the region between 124° and 111° west longitude, 42° to 49° north latitude: Washington, Oregon, Idaho, and western Montana. GCMs have different resolutions; the number of model grid points enclosed in this latitude-longitude box is typically 12-20.



Scatterplot of Change in Annually Averaged Temperature and Precipitation for Various GCM-scenario Combinations as of 2040's (2030 - 2059 minus 1970 - 1999)

Source: Mote, P. W., E. Salathe, and C. Peacock. 2005. Scenarios of Future Climate for the Pacific Northwest. University of Washington: Climate Impacts Group.

2006-2008 Regional Study:
Climate-Altered Hydrology



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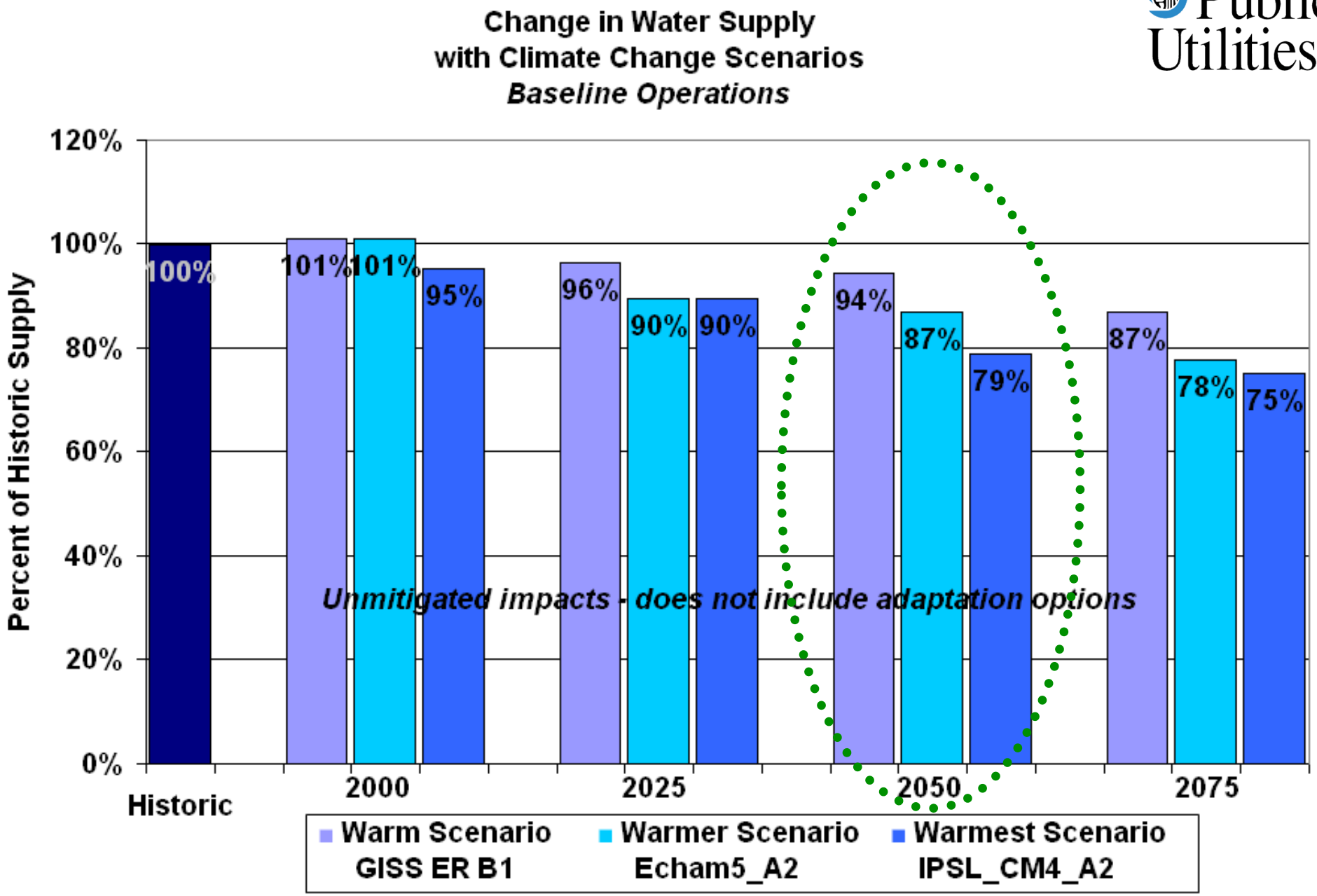

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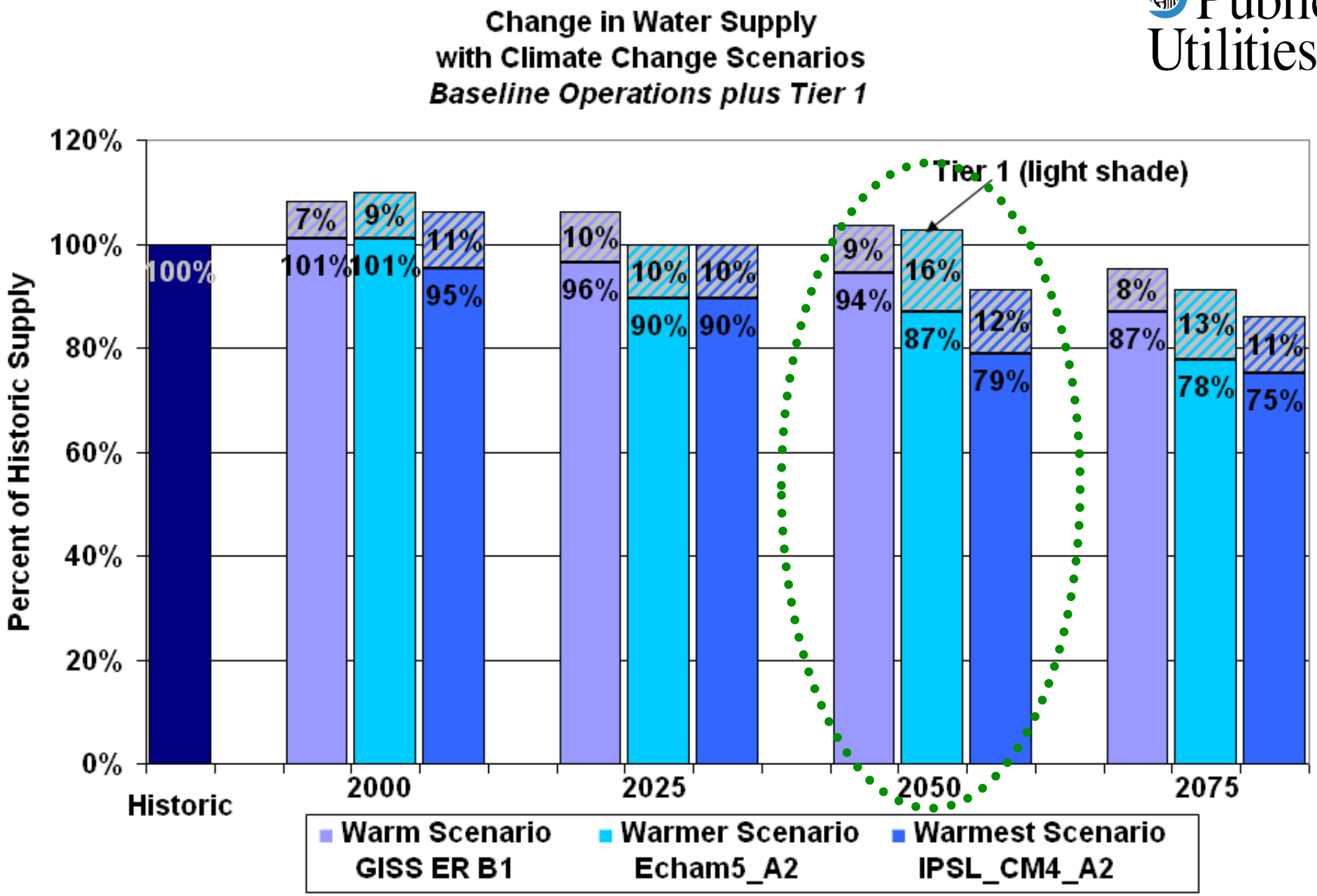

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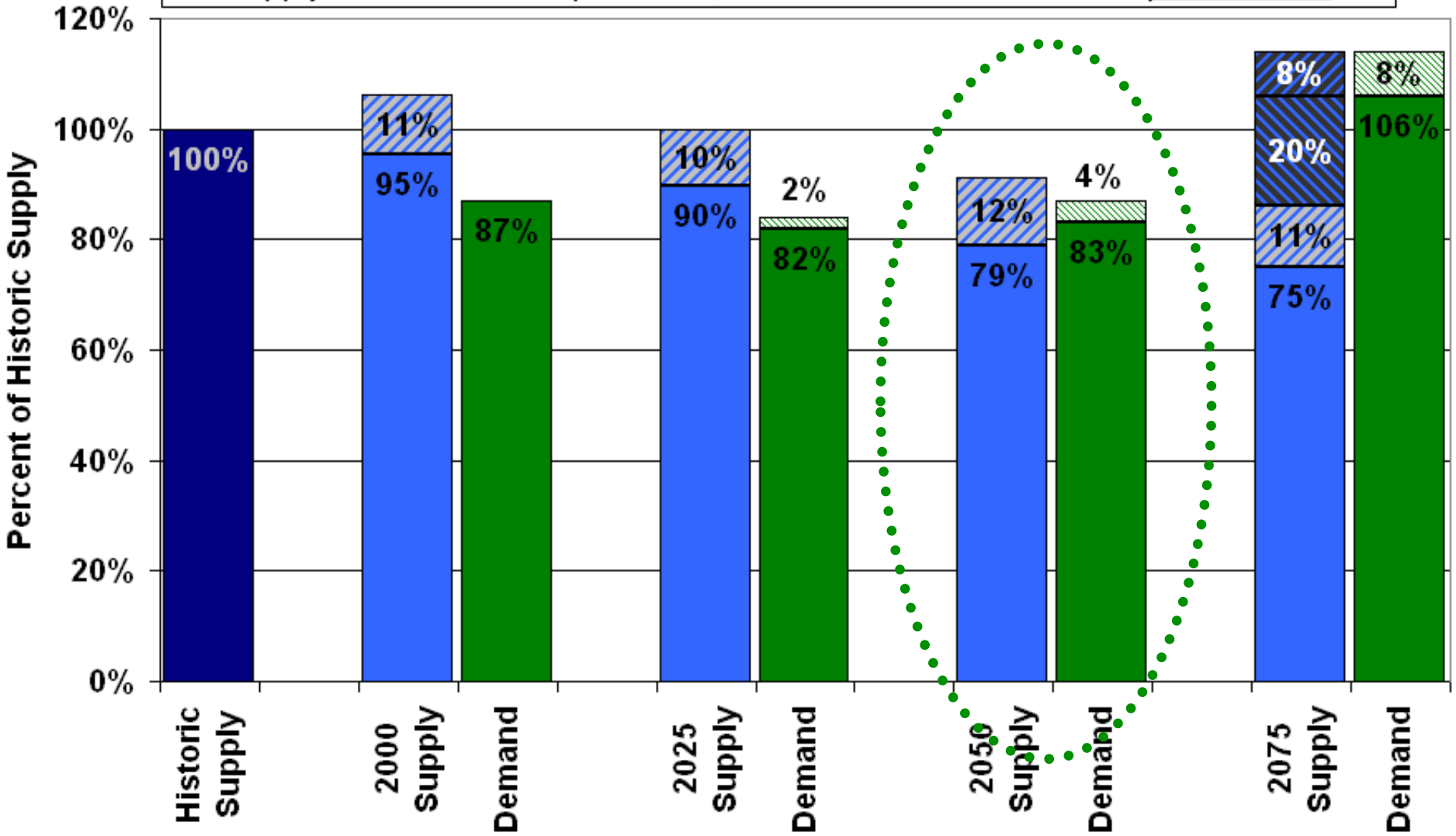
Warmest Scenario

Results from Monthly CUE and Demand Forecast Model - IPSL_CM4_A2

Supply bars show Base plus Tiers; Demand bars show forecast plus climate



SPU's Involvement with Downscaling Studies

2008: UW CIG study for State

- Funded by Washington State Legislature through House Bill 1303; research partners included Washington State University and Pacific Northwest National Laboratory.
- Examined several sectors, including water and infrastructure (stormwater)
- Used 20 GCMs and two emission scenarios (A1B and B1), statistically downscaled, used in hydrology models, and run through models of Everett's, Seattle's, Tacoma's water systems.
- SPU asked to be included in water sector analysis, but was turned down due to concerns over time constraints; we provided comments on draft on water sector chapter
- Study did not quantify the effectiveness of adaptation options
- Presented at Washington Climate Change Assessment Workshop in February 2009
  - http://cses.washington.edu/cig/res/ia/waccia.shtml

Benefits of Using GCMs and downscaling

- Provides a glimpse at how system would be impacted/ perform under plausible future climatic/hydrologic conditions
- Provide opportunity to work with best available scientific info.
- Establishes and builds institutional capacity on a critical emerging issue
- Provides a forum for two-way engagement between the research community and water utility

Challenges of Using GCMs and Downscaling

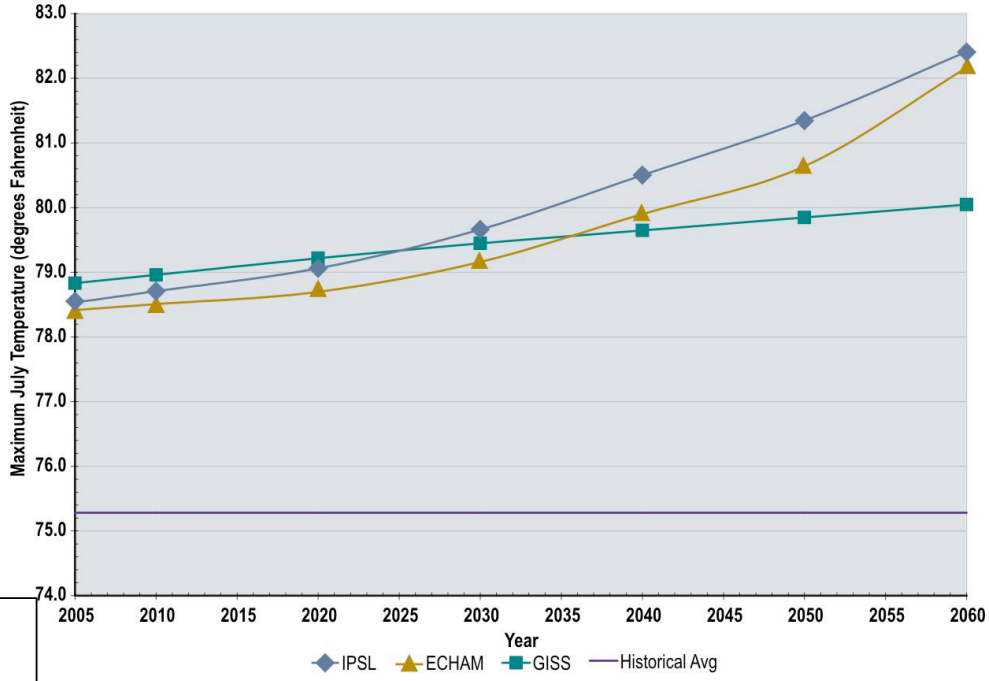
- Difficulty understanding the nature of the uncertainties associated with downscaling
- Addressing perception that probing about this uncertainty is an attempt to discredit the information
- Portraying the downscaling and impacts assessment accurately: not definitive but not useless either
- Defining role for researchers and water utilities

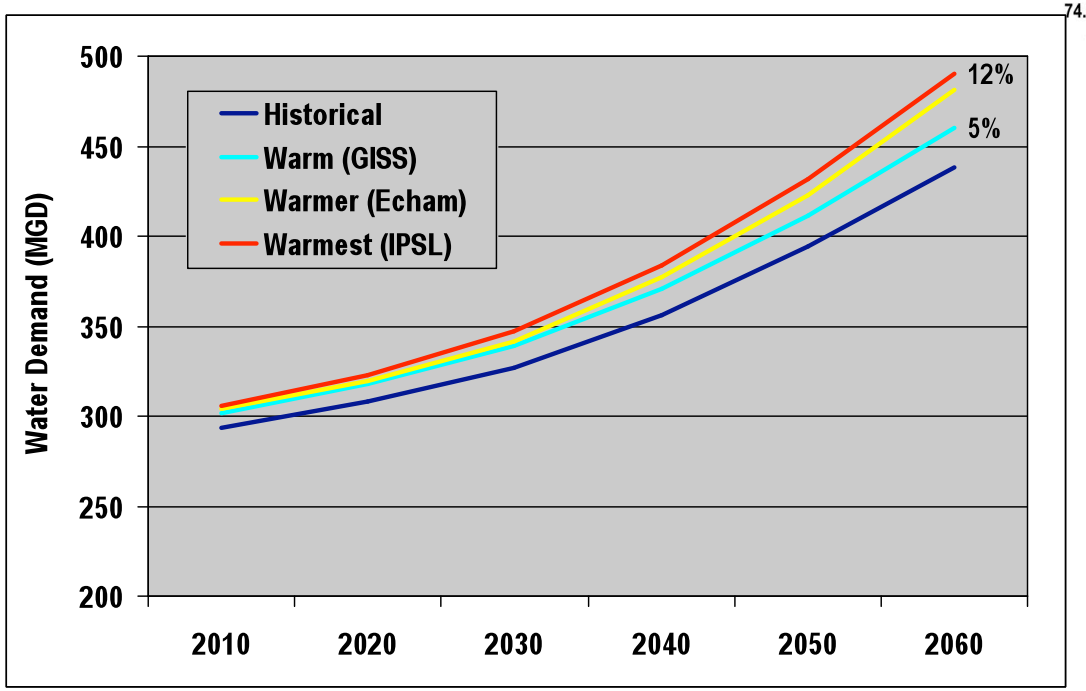
Challenges in Using GCMs and Downscaling

- Timestep Issues
  - Archived monthly temp/precip data statistically downscaled to hourly timestep needed for hydrology model:
    - Does this misrepresent climate impacted hydrology for these finer timescales, in both frequency and magnitude?
    - What should be used in systems model?

Challenges in Using GCMs and Downscaling

- Working with the Numbers
  - Handling mismatches between GCMs and observed data (starting point issue)





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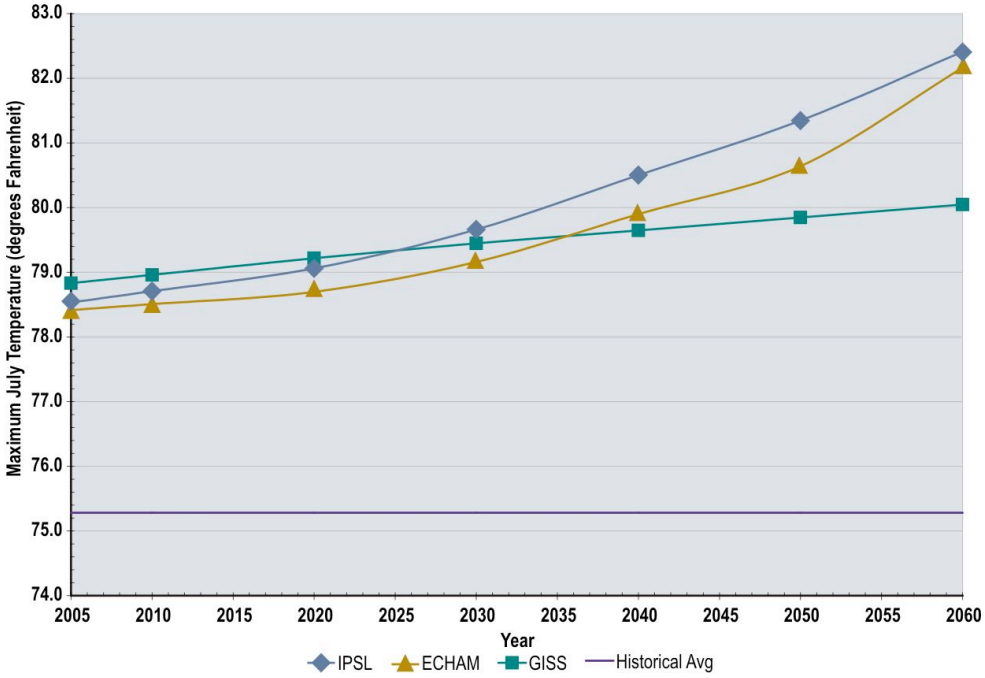
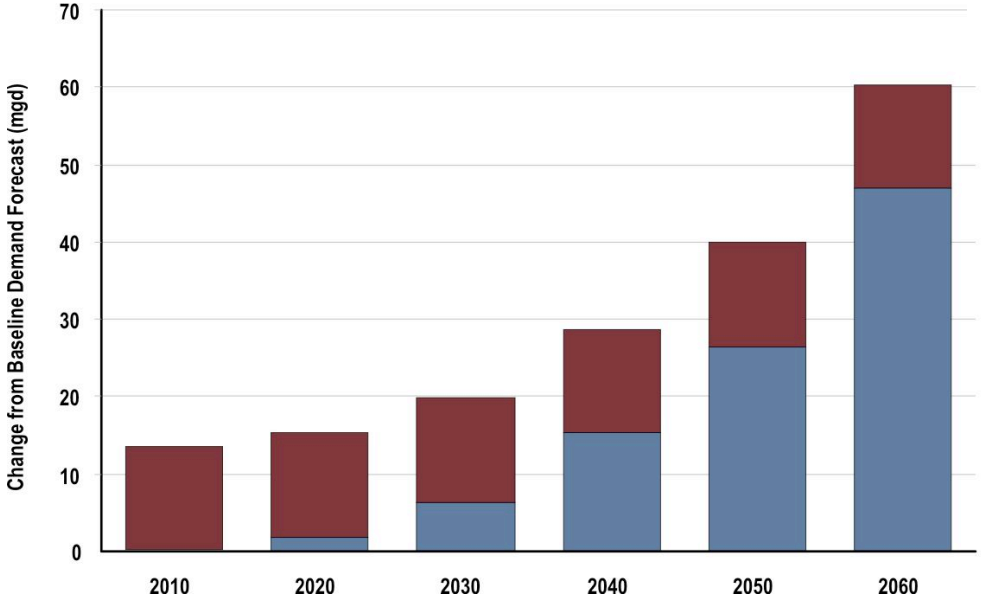
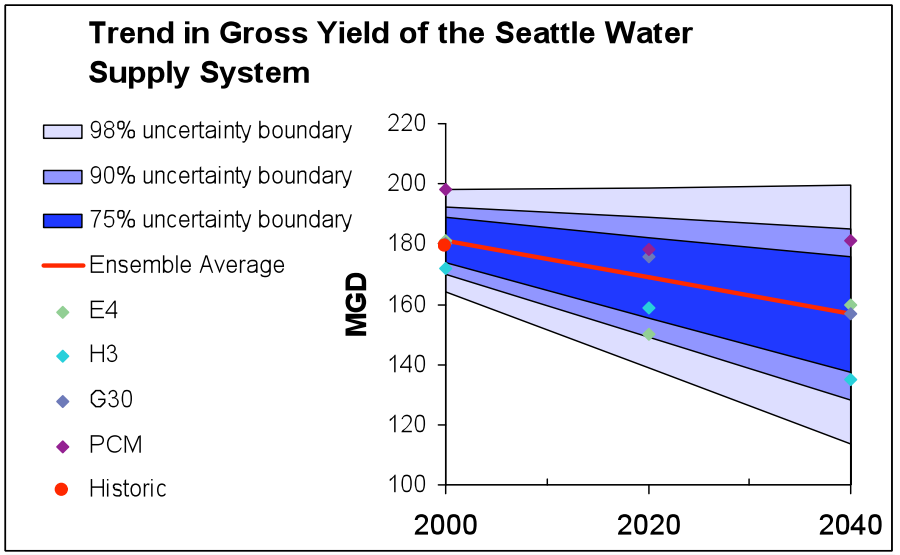
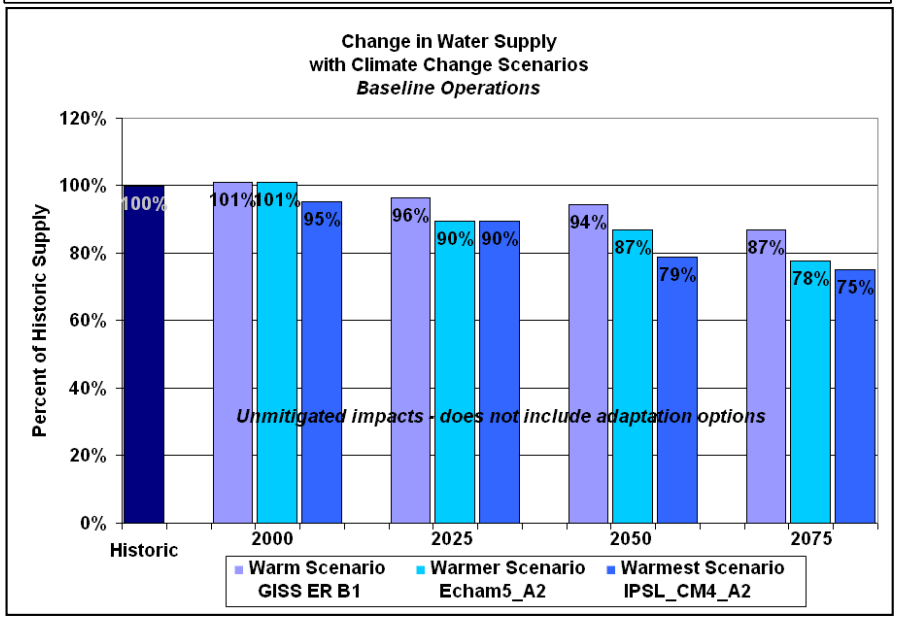




Challenges in Using GCMs and Downscaling

- Working with the Numbers
  - Ensemble averages vs individual results
  - Again, not matching results for recent observations
- Communicating the Results
  - False sense of certainty
  - Balancing simplicity of message with appropriate portrayal of uncertainties





Challenges in Using GCMs and Downscaling

- Application of GCM data
  - Uncovering outliers as datasets are applied for different purposes?
  - Inadvertent misuse of archived data, or just luck of the draw?
  - Supports advice to use more than one GCM run