Climate Change& Decision Support Methods to Assist Water Utility Planning

AWWA Pacific NW Annual Conference
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Boise, Idaho

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Formed in 2008

Deliver water to 43 Million people

Currently has 10 large metropolitan water provider members

Central Arizona Project
Denver Water
Metropolitan of Southern California
New York City Department of Environmental Protection
Portland Water Bureau
San Diego County Water Authority
San Francisco PUC
Seattle Public Utilities
Southern Nevada Water Authority
Tampa Bay Water

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Water Utility Climate Alliance

Mission Statement

Dedicated to providing leadership and collaboration on climate change issues affecting drinking water utilities by improving research and developing adaptation strategies.

Goals:

- Improve and expand climate change research so water managers can consider the potential implications climatic changes may have on water resource planning;
- Promote and collaborate in the development of adaptation strategies and tools to reduce the impacts of rising temperature and changes in precipitation patterns on our infrastructure and water supplies; and
- Identify and minimize greenhouse gas emissions resulting from the operations of WUCA member agencies.

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Observed Climate Trends in North America

- Hotter days/nights increased heat waves
- Extreme rainfall events have increased in frequency and intensity
- Flooding – increasing frequency and intensity
- Droughts – longer, more frequent & intense
- Tropical cyclones increasing in Pacific
- Coastal inundation and erosion

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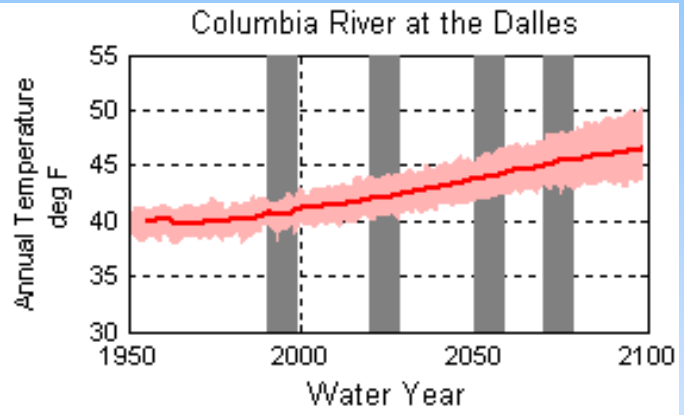
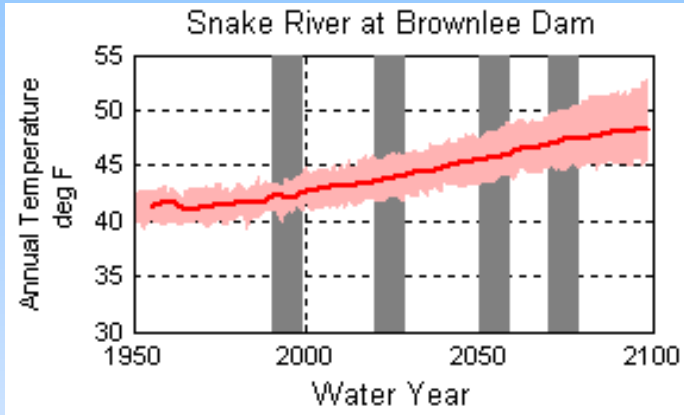
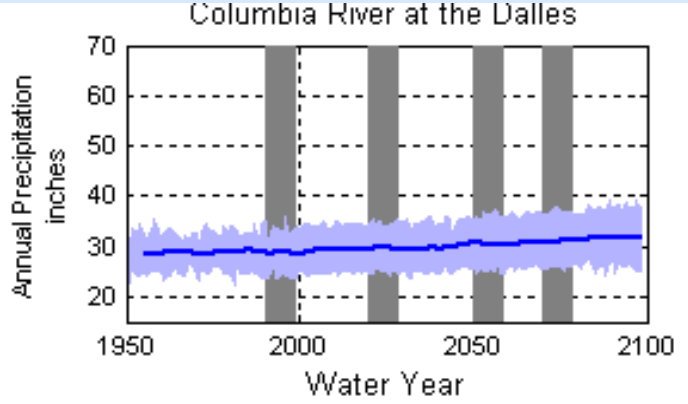
Climate Change Modeling Columbia River Basin Averages

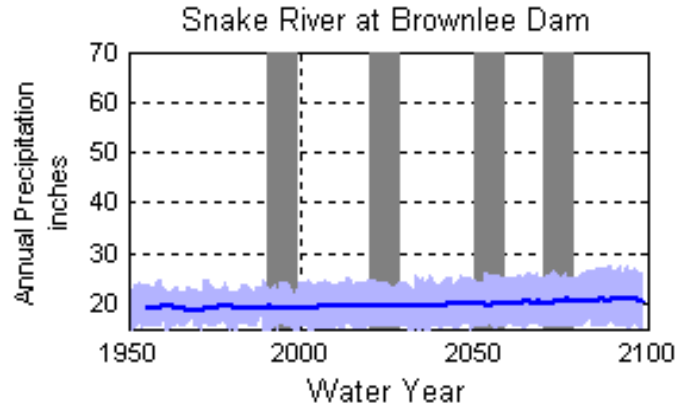
Temperature





Precipitation





Source: BuRec Managing Water in the West 2011

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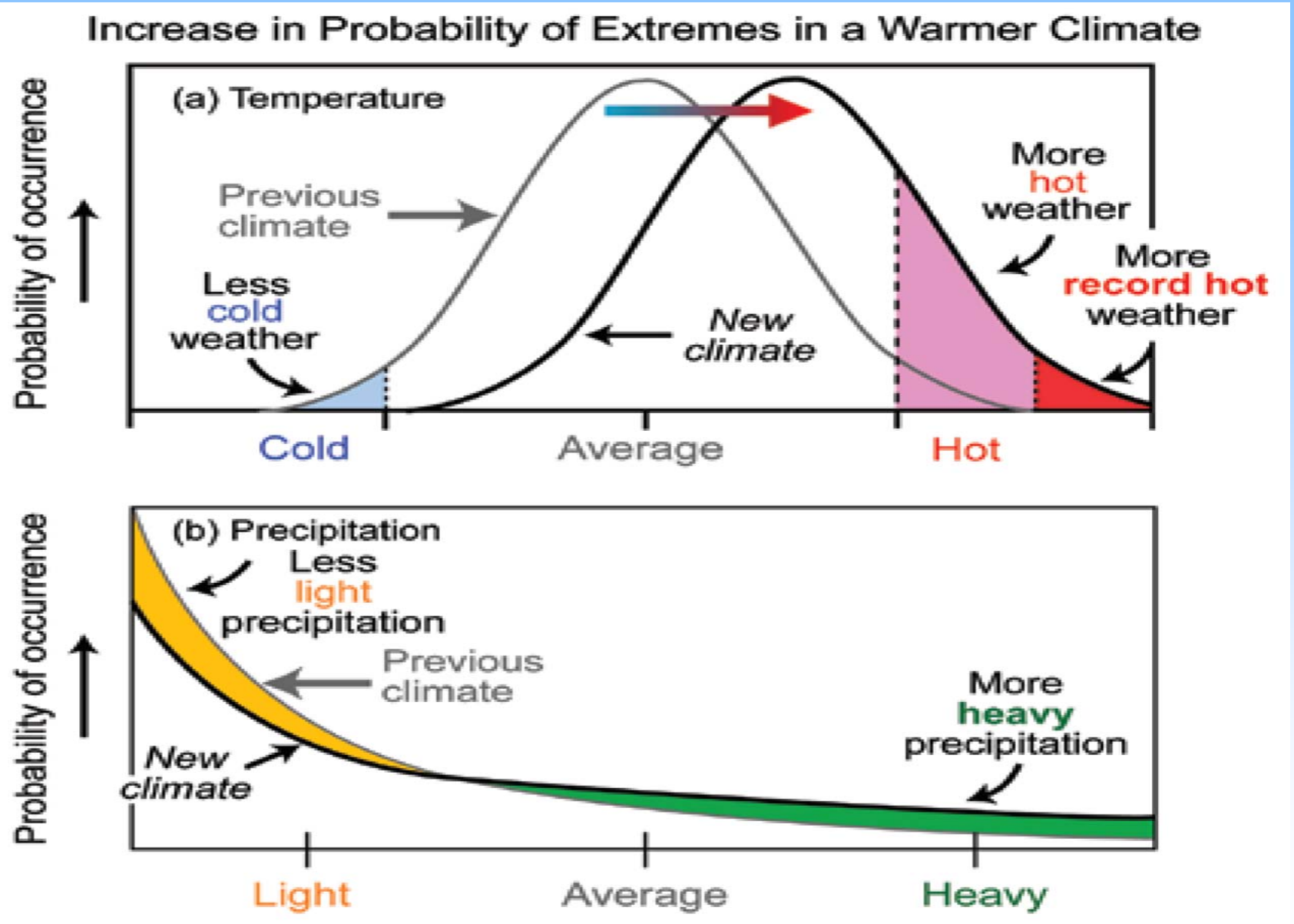

Source: NOAA CCSP SAP Report 3.3

Impacts of Climate Change on Municipal Water Supplies

- Changing hydrographs outside the historic ranges?
- Increased precipitation intensity?
- Hotter, longer summers – impacts on demand patterns?
- Changes in vegetative patterns (fire, invasive species, hydrologic impacts)
- Sea Level rise impacts?
- Regulatory impacts?

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WHAT'S IN THE TOOL BOX?

Climate change is a nail, so I need a hammer, right?

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Including Climate Change in Decision Making Processes

1. Integrated Planning Tools (Top-down)
   - Using GCM downscaled data in the “chain of models”
   - Create climate & hydrologic “futures”
   - Test outcomes on water resources and demand patterns
   - Use mass balance models to create scenarios
2. Asset Management Vulnerability Risk Analysis – (Bottom up)
   - Identify critical infrastructure
   - Using climate change trends (or key parameters) conduct sensitivity analysis

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Including Climate Change in Decision Making Processes

- Select "best fit" decision support methods based on which process works best in the individual utility circumstances:
  - How utility fits within the larger picture – including size, number of other water utilities, different sources of supply, geographic location such as higher or lower order watersheds involved
  - Availability of:
    - Historic hydrologic data and watershed conditions data
    - Demand data & forecasting methods
  - Cost & resources needed for selected method
  - Internal and external leadership/commitment
  - Willingness to utilize what ever method is selected to assess adaptation strategies
  - One-off or longer term phased process

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Top Down Methods

Using downscaled climate data in decision making

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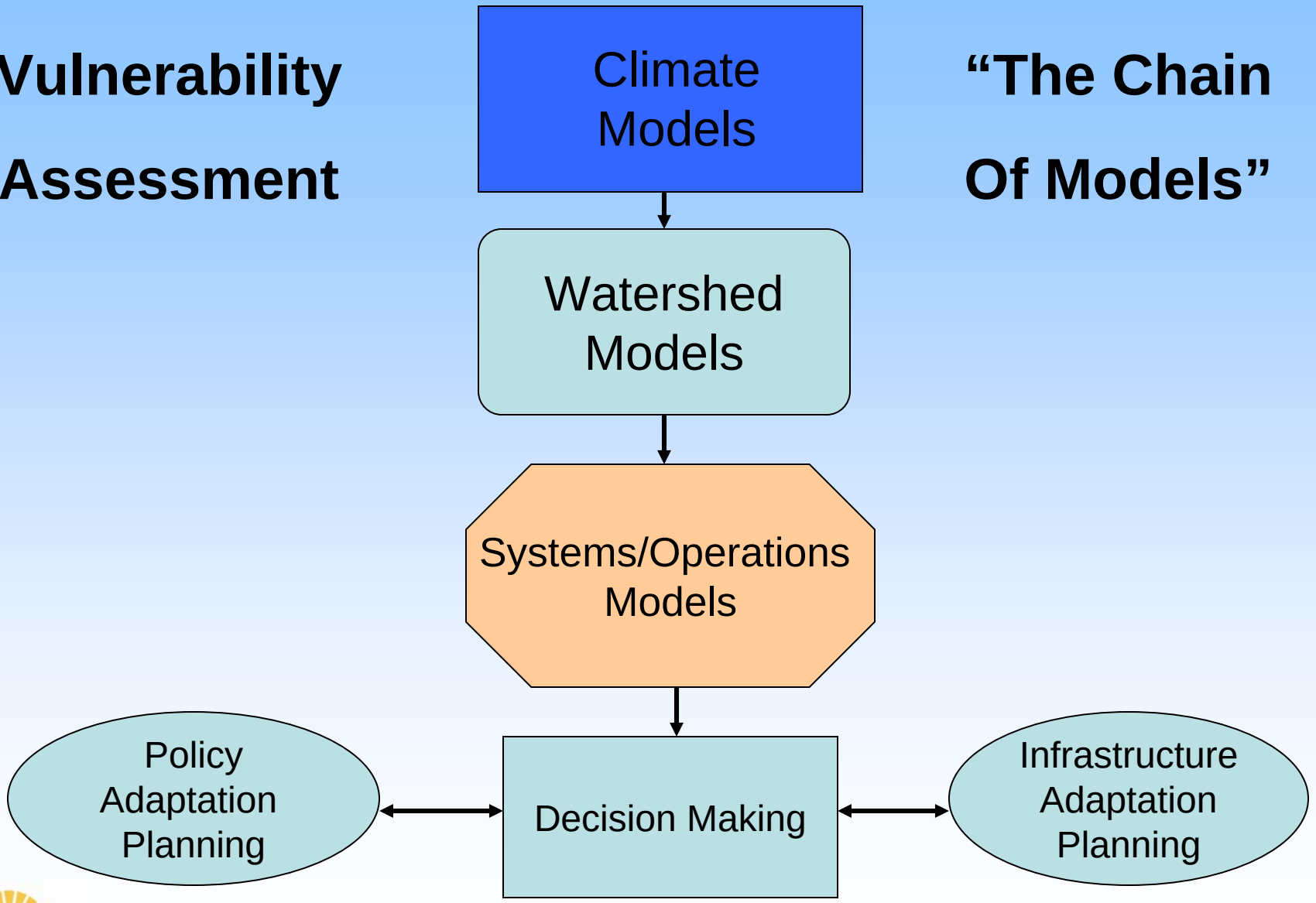
Vulnerability Assessment

"The Chain Of Models"



Slide courtesy of Seattle Public Utilities

Climate Impacts Science Primer: How do scientists project future climates and their impact on resources in Washington State (WA) and the Pacific Northwest (PNW)?

1. Estimate future atmospheric greenhouse gas concentrations and other climate drivers.

Q1 - What do scientists have to know before they can project future climate?

See Climate Impacts Science Questions for answers to Q1-Q9

2. Use global climate models (CMs) to project future climate at a global scale

→

3. Downscale CM results to project the future climate of WA and the PNW

→

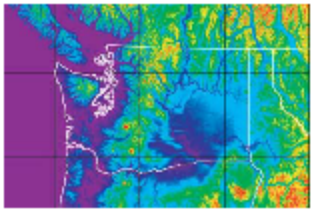
4. Use regional hydrology models to project future snow-pack, streamflow, and soil moisture

→

5. Use resource management models or empirical relationships to understand implications for WA and PNW resources

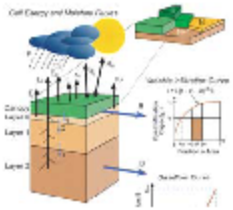
Q2 - How does a CM work?
Q3 - Why is there so much uncertainty in projected climate changes?
Q4 - Why can I believe climate change projections if it's impossible to forecast weather beyond two weeks?
Q5 - Which CM climate projections are most trusted? Which are less certain?

Q6 - What factors control WA and PNW climate?
Q7 - How do scientists "down-scale" CM results to a region like WA?



WA topography with typical GCM grid resolution (~150 miles)

Q8 - How do scientists project climate change impacts on the water cycle?



VIC hydrology model

Q9 - How do scientists project impacts on natural resources?

Credit: Mercer Island Parks

Salmon in Lake Washington

Prepared by Jennifer Kay, Joe Casola, Amy Snover, and the Climate Impacts Group (CIG) at the University of Washington for King County's October 27, 2005 Climate Change Conference. This and other conference materials are available at: http://www.cses.washington.edu/cig/outreach/workshops/kc2005.shtml

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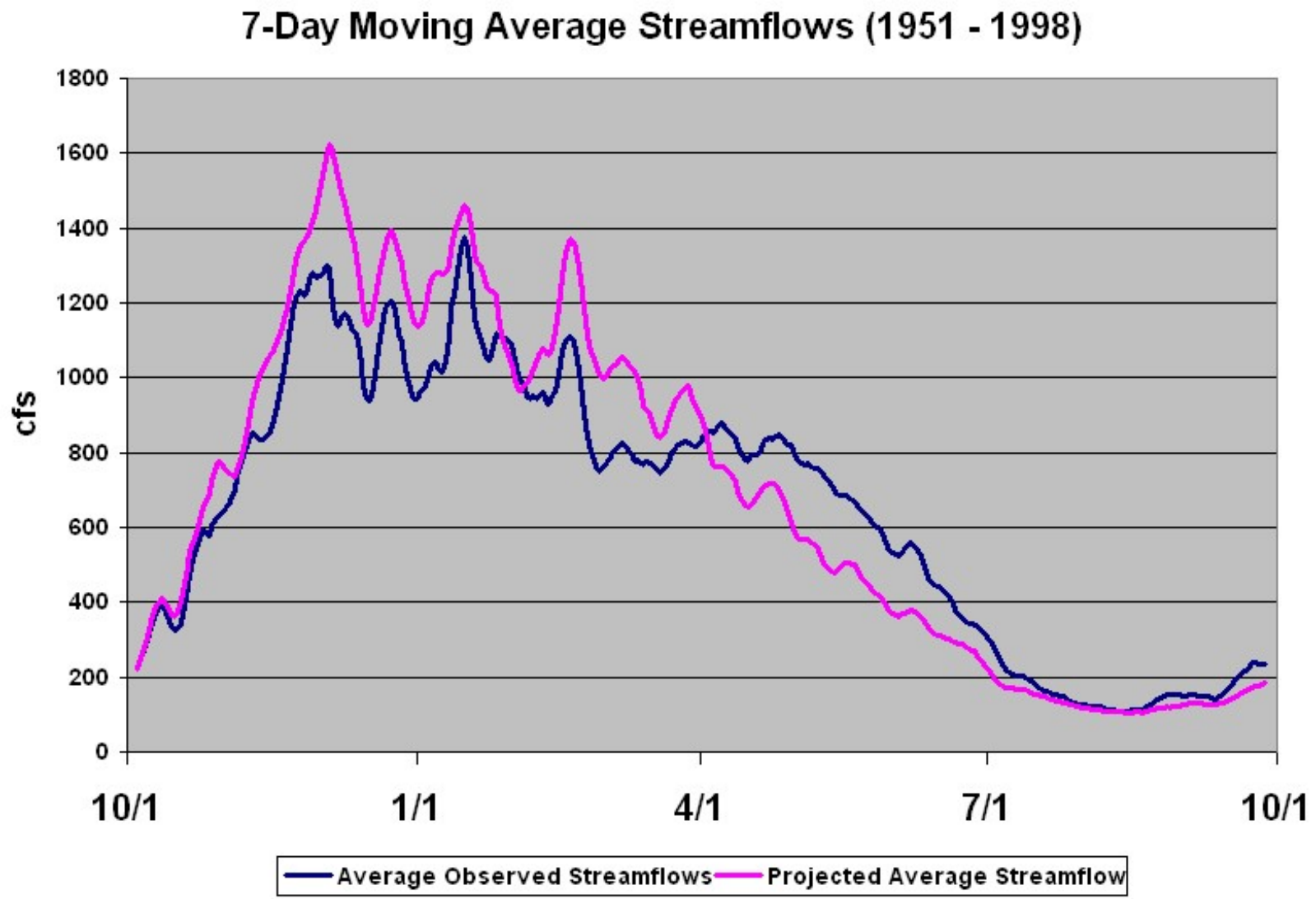
Bull Run Study: Impacts to Streamflow



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Results of the Portland Climate Change Study 2002

- The Bull Run is in a transient watershed where climate change scenarios show more water coming as rain in winter and less snow pack to boost inflows in the Spring and longer fall dry periods.
- The Bull Run reservoirs will still fill in every year, however, the number of years with longer drawdown periods increases.
- Water supplies will be stressed more by future growth, but climate change will compound that impact requiring more groundwater pumping to make up the amount needed.

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Other Top Down Examples

- Seattle Public Utilities
- New York City
- MWRA
- Denver Water
- Boulder Utilities

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To downscale or not?

- Some data is already available from known sources, but the skill to apply may not be available, affordable or necessary.
- Level of detail for small scale utility water sources, or conversely large upstream watersheds, present challenges.
- The science may not be up to the desired level of detail to resolve specific impact analysis.
- There are other ways to incorporate climate change into decision making, phased approaches can be used.
- Readiness to incorporate prospective climate change data into decision making at both the internal and political level needs to assessed.

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Bottom Up Methods

Using past climate and future trend data in vulnerability/risk assessments

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Vulnerability/Risk Analysis

- Identify climate change trends that are of importance, evaluate quality of information for usage in analysis
- Categorize infrastructure groupings that could be impacted by identified climate change trends.
- Evaluate existing data record, are the impacts already captured adequately?
- Identify the risks of outside the record impacts on facilities and ability to meet forecasted demands.
- Group climate change vulnerabilities and risks with other factors where possible.
- Select, categorize, prioritize the factors of most concern in preparation for assessing adaptation strategies.

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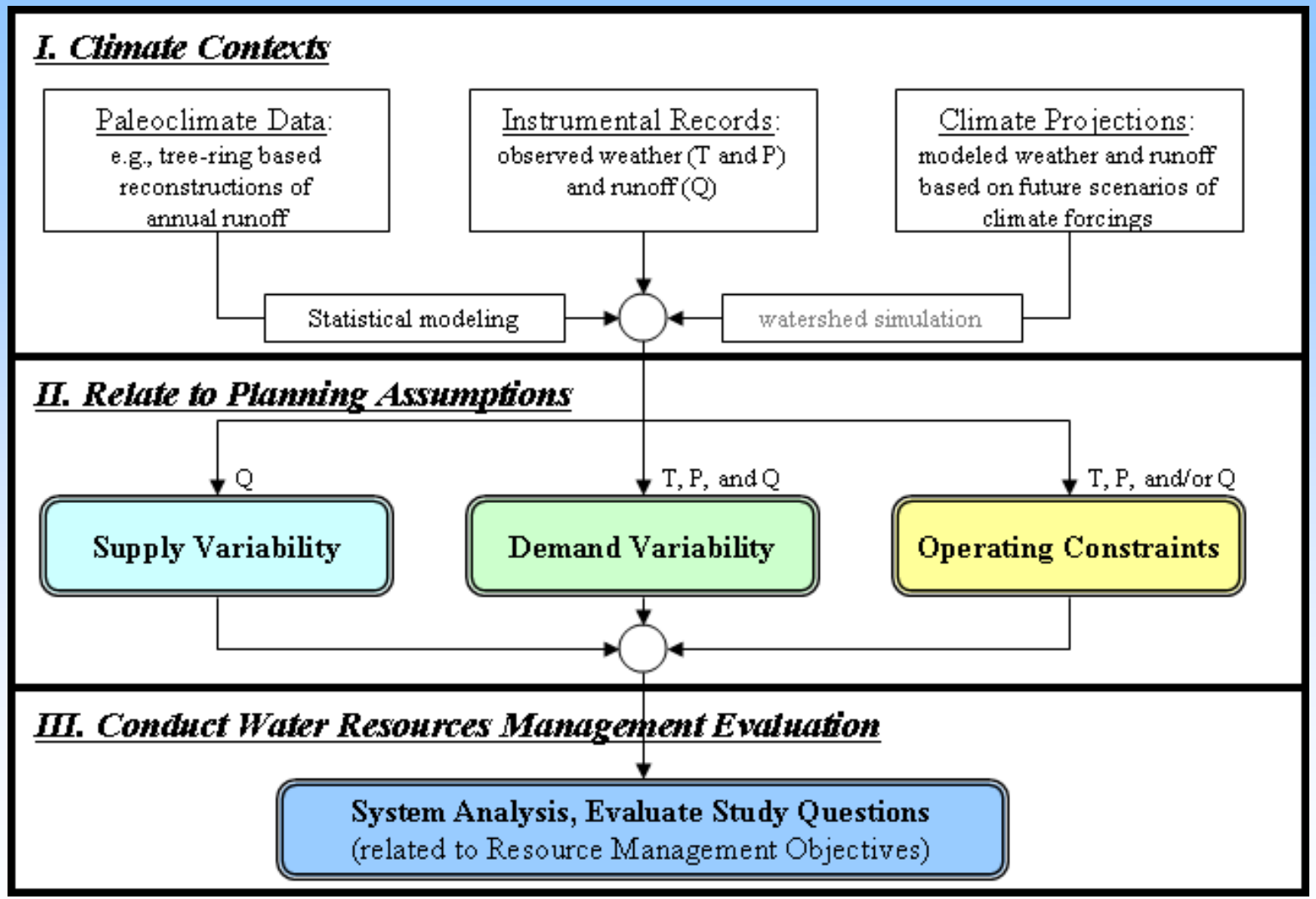

Chart from BuRec/ACOE Report

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Climate parameters

- ✓ Use your own existing tools to assess impacts of climate on facilities in concert with other key vulnerabilities
- ✓ Pick water years that are similar to identified trends
- ✓ Use temperature proxies to increase demands based on historic use patterns in peak season
- ✓ Alter historic record by factors that match trends identified on larger regional scales – or that are of key concern (extreme events such as rainfall intensity, flooding, wind, fire, peak season lengths, snowpack SWE)

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Existing Tools - Examples

- Climate Wizard – Nature Conservancy
  - http://www.climatewizard.org/AboutUs.html
- "Preparing for Climate Change: A Guidebook for Local, Regional, and State Governments" Climate Impacts Group, University of Washington/King County
  - http://cses.washington.edu/cig/fpt/guidebook.shtml

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Water System Asset Categories

- Water sources (quality & quantity)
- Transmission pipelines
- Treatment Plants
- Distribution System
  - Pump stations
  - In-town Storage
- Operational system
  - Reporting & management systems
  - Monitoring and warning systems
- Emergency backup systems

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Assess Climate Variables

- General Changes by variable
- Specific change & reference period
- Size of projected change against recent history
- Seasonal patterns of change
- Confidence (H-L, qualified)
- Sources of information & context

- Based on materials from “Preparing for Climate Change” 2007 CIG/King County, WA

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Sensitivity/Vulnerability Assessments

- How exposed are the system parts to climate change impacts?
- Are these same system parts already stressed?
- Can the system parts be adapted to impacts or are there limiting factors?
- Are there " impact thresholds" to parts of the system:
  - Changes in demand
  - Design standards
  - Operational condition limits
  - Natural system triggers
  - Recovery time intervals
- Rate the degree of sensitivity, adaptive capacity, and vulnerability of each system part to climate change (e.g. Low, Medium, High)

Partially based on materials from "Preparing for Climate Change" 2007 CIG/King County, WA

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Risk Analysis

- Consequence of climate variable impacts on system parts
- Probability of impact
- Estimated Risk to system parts
- Identify areas of greatest concern and/or opportunity
  - Near term
  - Long term
  - Convergence of risks types

Partially based on materials from “Preparing for Climate Change” 2007 CIG/King County, WA

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Vulnerability-Risk Matrix to Identify Priority Planning Areas

	Low Vulnerability	High Vulnerability
High Risk	**May be** priority planning areas	**Should be** priority planning areas
Low Risk	**Are unlikely to be** priority planning areas	**May be** priority planning areas

Credit: Preparing for Climate Change, CIG Univ. of Washington, King County 2007 p. 91

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CREAT EPA Tool

Climate Resilience Evaluation and Awareness Tool

Off the Shelf - Free

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CREAT Process

Inventory utility and climate change concerns → Evaluate risks and inform adaptation planning

- Setup
- Assets
- Threats (w/ climate information)
- Adaptive Measures

- Baseline Analysis
- Resilience Analysis
- Implementation Planning
- Results and Reports

CREAT – Inventory Climate

National and regional climate change descriptions → **Climate-related threat descriptions** → **Preliminary adaptation libraries**

CREAT – Evaluate Risk

Adaptive Measures

- Inventory built using provided library, with each measure defined with respect to status
  - Existing – used in Baseline as measures already available for protecting assets from threat
  - Potential – used in Resilience Analysis as measures being planned or considered for future use

Baseline Analysis

- Assessment of consequences to assets from threats on selected time periods using existing adaptive measures

Resilience Analysis

- Re-assessment of consequences after the addition of potential adaptive measures

CREAT – Evaluate Adaptation

Implementation Planning

- Develop adaptation packages of potential adaptive measures used in assessments
- Each package has a computed benefit based on consequence reduction from Baseline to Resilience
- Benefits, compared to costs, can be reviewed across time periods and between packages

Results and Reports

- Risk profiles for Baseline and Resilience reviewed with respect to time periods and selected adaptation package
- Narrative and data reports available
- Planning report also available that details the costs and benefits of adaptation packages across time periods

Bottom Up Case Studies

- East Bay MUD
  - Modeled their system with a 3 degree C rise and 1997 precipitation
  - Portfolio analysis used selected programs that reduce the impacts of uncertainty:
    - Robust against future variables
    - Parallel projects selected
    - Flexible and diverse
- "A bottom up approach consists of identifying the factors that most affect the system's reliability and testing the system's sensitivity to and performance under expected changes in those factors."
- Spartanburg, S.C. & Lower Colorado Water Authority (LCRA)

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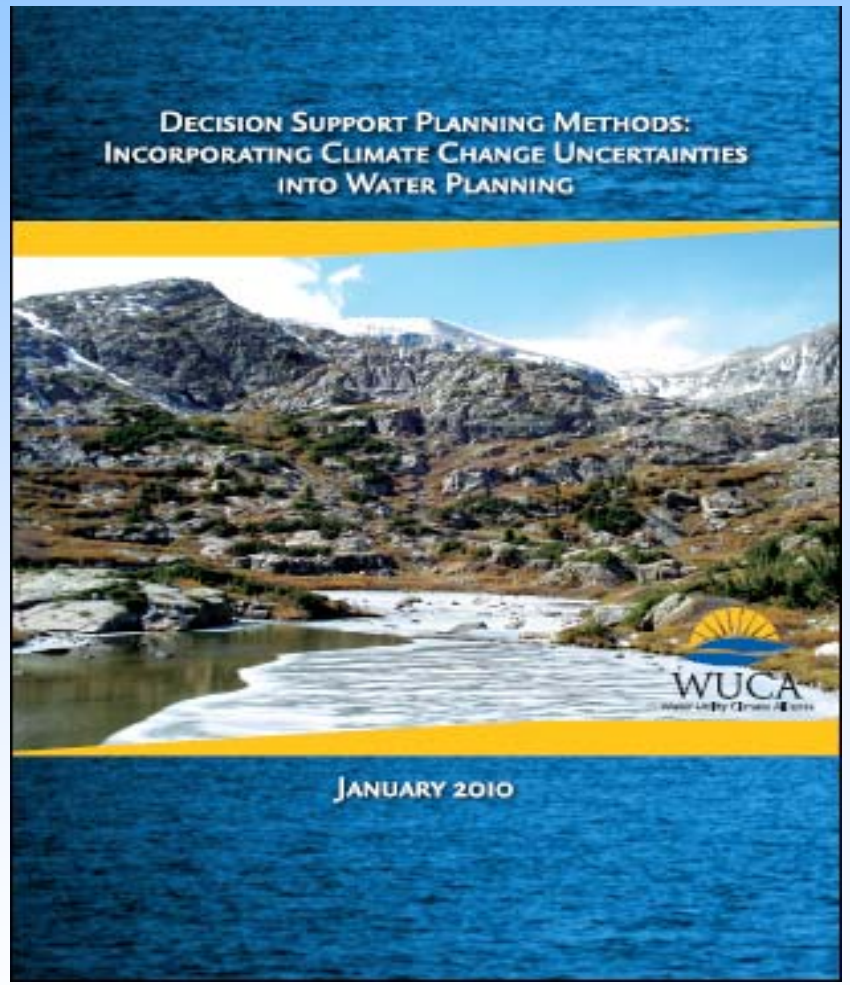
Decision Support White Paper

- Decision Support Planning Methods: Incorporating Climate Change Uncertainties into Water Planning
- Prepared by Malcolm Pirnie and Denver Water
- Released January 2010
- Available on WUCA website as a pdf file



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Four Adaptation Steps

- **Understand** – climate science and model projections both what they might be telling us and what they don't
- **Assess** – water system vulnerabilities to potential climate change
- **Plan** – Incorporate climate change uncertainty into water utility planning
- **Implement** – adaptation and mitigation strategies in the face of climate uncertainties

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Five Planning Methods Evaluated in the DSM White Paper

- Classic decision analysis
- Traditional scenario planning
- Robust decision making
- Real options
- Portfolio planning

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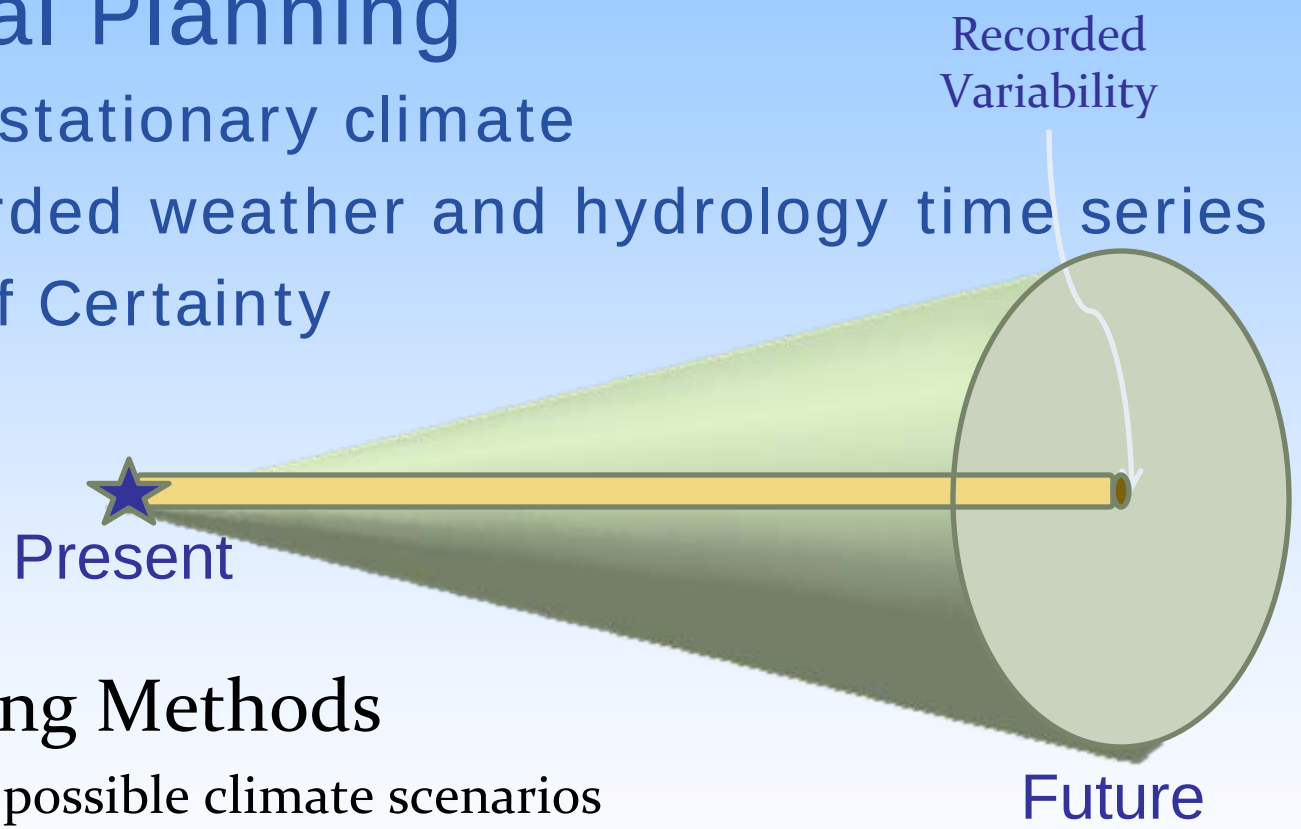
Slide courtesy of Denver Water

Cone of Uncertainty

- Traditional Planning
  - Assumes stationary climate
  - Uses recorded weather and hydrology time series
  - Cylinder of Certainty



- New Planning Methods
  - Hundreds of possible climate scenarios
  - Multi-outcome planning
  - Robust over optimal

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Decision Analysis

- Decision trees, probabilities and costs
- Minimize expected costs

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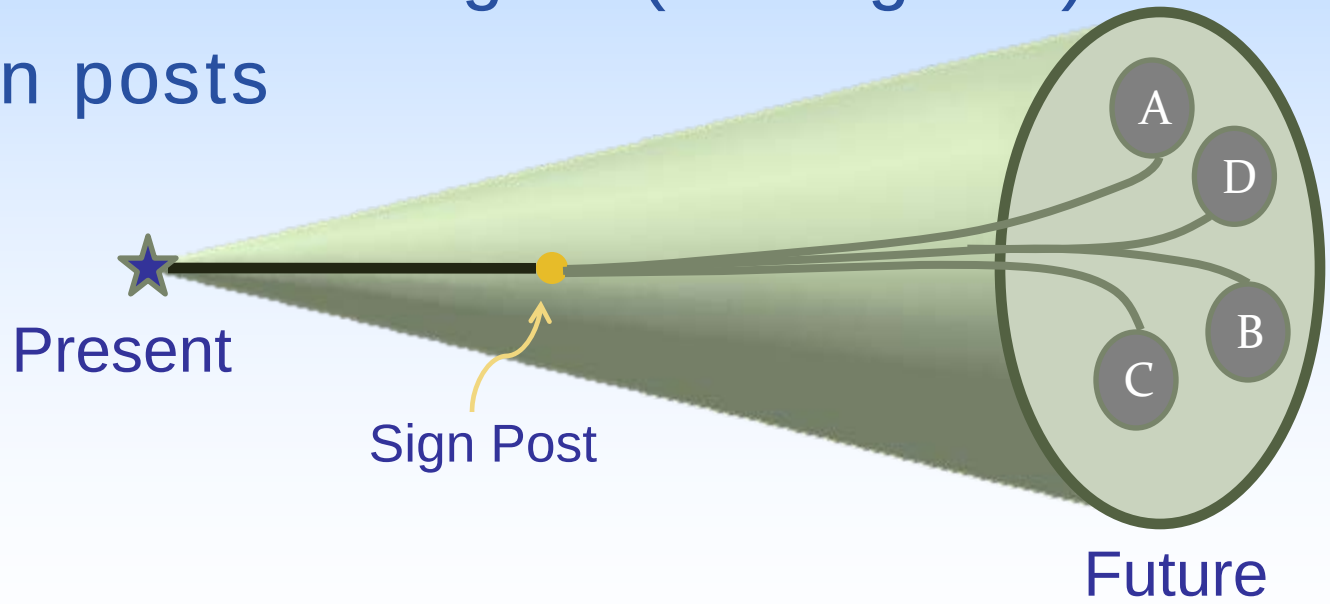
Scenario Planning

- Small number of equally likely scenarios [A, B, C, D]
- Common strategies (no regrets)
- Sign posts



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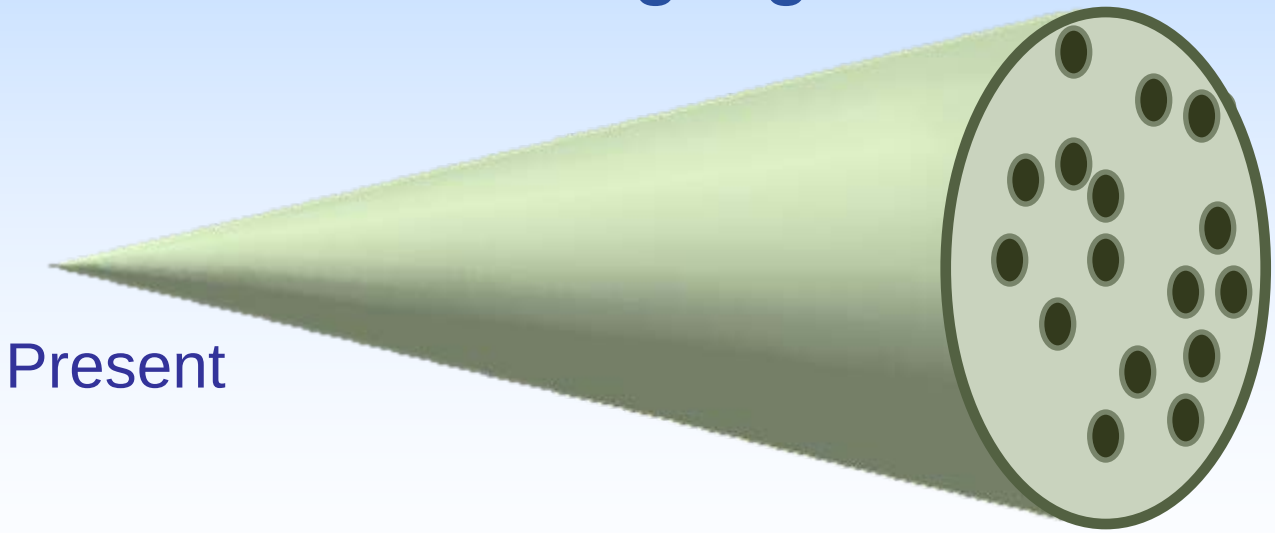
Robust Decision Making

- Computer analysis of many plausible likely scenarios
- Iteration and hedging



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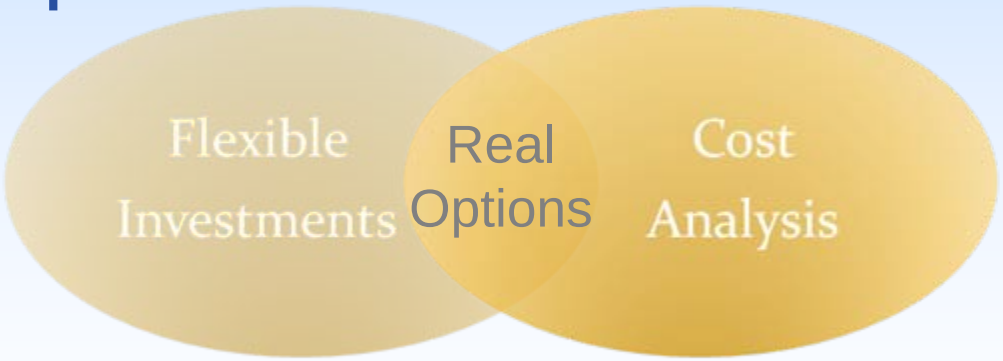
Real Options

- Combines decision analysis and financial theory
- Decision tree and financial hedging concepts



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Decision Methods Considerations

No one size fits all circumstances

- Decision analytics - familiar but requires estimates of probabilities
- Scenario planning - relatively simply but only a few scenarios can be considered
- Robust Decision Making - considers many uncertainties but is highly computational and requires outside expertise
- Real Options – Perth, Australia is using this, but not yet written up.

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Decision making in the face of climate uncertainty

- Types of Strategic Adaption Actions -
  - Planning Methods
  - Infrastructure Development and Use
  - Programmatic and Institutional Actions
- Uncertainty is an issue in many aspects of providing water service,
  - Match up vulnerabilities – portfolio of actions, some are likely to be already in place
  - Bundle up “no/ low regrets” actions
  - Use phased approaches
  - Preparedness goes a long way

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Links to Websites

- **EPA – Climate Ready Water Utilities**
  - Vulnerability Studies (EPA/600/R-10/077F/March 2011/www.epa.gov)
  - CREAT Tool
  - Climate Change Tool Box
  - Other Links

  http://water.epa.gov/infrastructure/watersecurity/climate/
- **WUCA Website: www.wucaonline.org**
  - **Modeling White paper**
  - **Decision Support Methods White paper**

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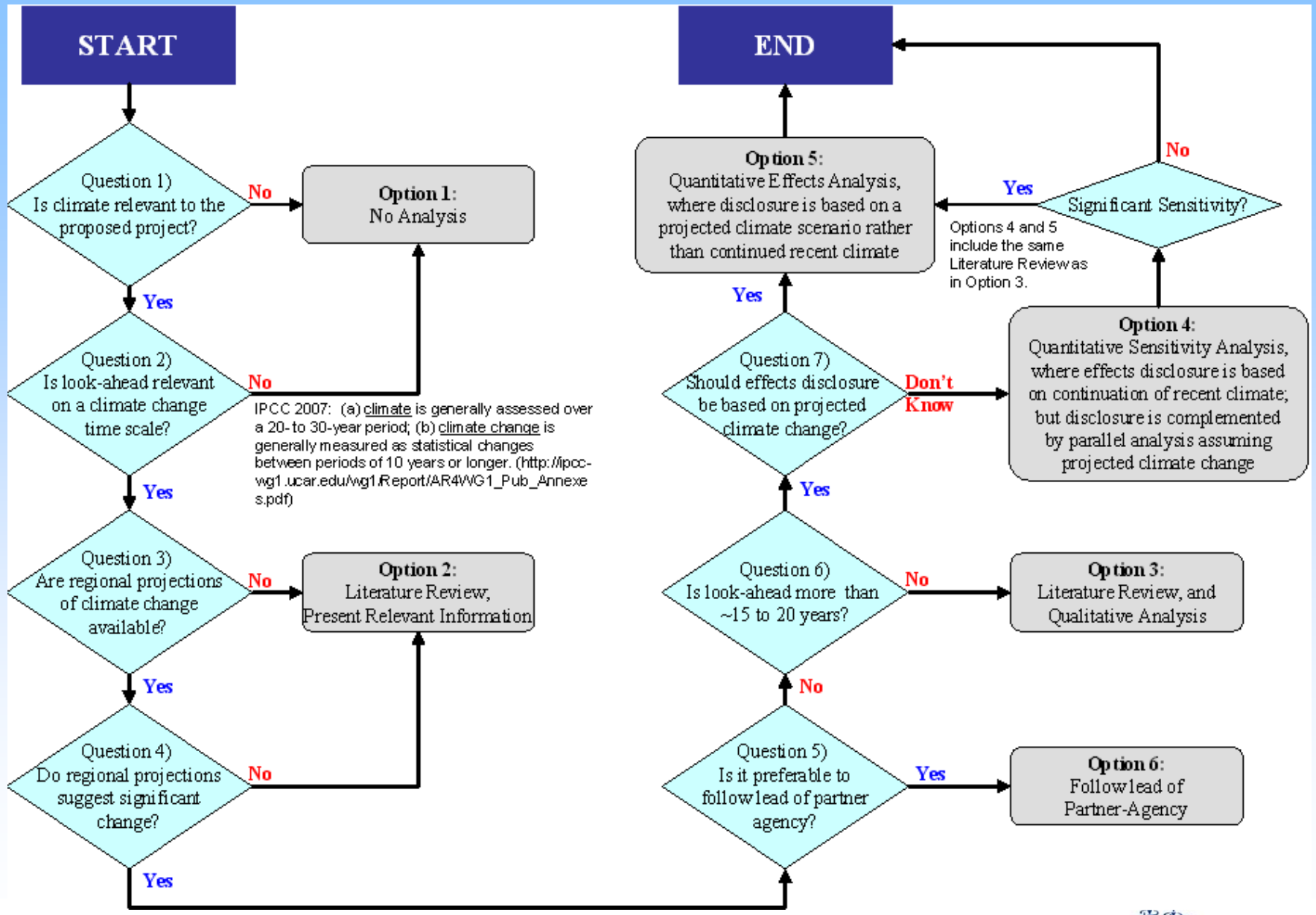

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