SLIDES: Impacts of Climate Change on Municipal Water Supplies: A Time for Action

Richard Palmer

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Impacts of Climate Change on Municipal Water Supplies: A Time for Action

Climate Change and the Future of the American West: Exploring the Legal and Policy Dimensions
June 7-9, 2006
University of Colorado Law School
Boulder, Colorado

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www.tag.washington.edu
Presentation Outline

• Overview of the Challenge
• Indications of Climate Change
• Two Case Studies
• Policy Responses
• Conclusions
Should Utilities be Concerned?

- Water supplies in the west will be impacted by climate change
  - Changes in both supply and demand
- This is currently not widely accepted (natural variability in supply)
- Water supply engineering is a conservative discipline (Safe Yield)
- Institutional mechanisms (policy and law) do not adapt quickly
- Economic incentives are unclear
Is the message spreading?

- Water supplies in the west will be impacted by climate change
"I say the debate is over.  
We know the science.  
We see the threat.  
And we know the time for action is now."
Governor Arnold Schwarzenegger, June 1, 2005
“We must break our addiction to oil."

President George Bush  
State of the Union Address
SPECIAL REPORT GLOBAL WARMING

BE WORRIED.
BE VERY WORRIED.

Climate change isn’t some vague future problem—it’s already damaging the planet at an alarming pace. Here’s how it affects you, your kids and their kids as well.

EARTH AT THE TIPPING POINT
HOW IT THREATENS YOUR HEALTH
HOW CHINA & INDIA CAN HELP
SAVE THE WORLD—OR DESTROY IT
THE CLIMATE CRUSADERS
### June 2nd, 2006

**Get More Weekend Numbers**

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Indications of Climate Change

• Temperature
• Snowpack
• Streamflow
Temperature trends (°F per century) since 1920

PNW warmed +1.5 F during the 20th century
Trends in April 1 SWE 1950-1997

April 1 SWE Trends

April 1st snow trends from simulated snotel sites

- Meadows Pass trend: -3.9 in/decade
- Mt Gardner trend: -3.9 in/decade
- Rex River trend: -3.9 in/decade
- Tinkham Creek trend: -4.0 in/decade
- Skookum Creek trend: -3.6 in/decade

Declining trends also seen in other PNW water supply basins
Other Evidence

- The total quantity of run-off into municipal water supplies (Seattle)
  - Significant decreases in annual inflows during the past 50 years (-18%, -24%)
- Significant shift in the timing of run-off
  - Average flow in March has doubled
  - Average flow in June has been halved
Concerns

• During recent decades, we have experienced warmer temperatures
• This has resulted in lower snowpack and shifted and decreased streamflows
• These changes alter systems that are already undergoing other stresses
  – Increased populations
  – Increased demands for instream flows
Case Studies

Seattle, Washington

Portland, Oregon
Impact Assessment Method

Rate of Change in Gross Yield as percent of GCM's year 2000 values

Non-Exceedence Probability

January TEMP

Non-Exceedance Probability

Rate of Change in Gross Yield as percent of GCM's year 2000 values

Percent change since year 2000

2000 2020 2040

8 6 4 2 0 -2 -4 -6 -8 -10

0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0

Cedar
GFDL_R30

Cedar_1_S
G30A2Ddm_2000
G30A2Dqc_2040

Portland, Oregon

- Increasing water demands due to growth
- Seeks to serve as regional water provider
- Considers building a new dam on Bull Run and removing other small dams blocking salmon habitat
Portland Water Supply Climate Change Study

2040s WATER NEEDS IN PORTLAND (OR):
Regional growth: +40 mgd
Climate change: +20 mgd

Climate change impacts = 50% of growth impacts

Average Monthly Bull Run Inflows 1950-1999

- Current Climate
- PCM3 2040
- ECHAM4 2040
- HadCM2 2040
- HadCM3 2040

Impact of population growth on demand (no climate change) 66%

Climate change impacts on water supply 16%
Climate change impacts on water demand 18%
Predictions suggest changes in runoff

Climate Impacts on Bull Run Inflows, 2040

Average Monthly Bull Run Inflows
1950-1999

Inflows, cfs

Current Climate
PCM3 2040
ECHAM4 2040
HadCM2 2040
HadCM3 2040

Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep

Climes lows, cfs
Portland Climate Change Study

2040s WATER NEEDS IN PORTLAND (OR):
Regional growth: +40 mgd
Climate change: +20 mgd

Climate change impacts = 50% of growth impacts

![Average Monthly Bull Run Inflows 1950-1999](chart.png)

- Climate change impacts on water supply: 16%
- Climate change impacts on water demand: 18%
- Impact of population growth on demand (no climate change): 66%
Seattle, Washington

- Increasing regional population, but decreasing per capita consumption
- New water providers emerging
- Commitments to environmental stewardship
Seattle Climate Change Study

2040s Climate Impacts
SEATTLE (WA):
Decreasing Snowpack: -50%
Loss of Gross Yield: ≈ 20 mgd

System water demand has decreased!

Average Annual System Wide Snow Storage

<table>
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<tr>
<th>KAF</th>
<th>Historic Ensemble</th>
<th>GCM Ensemble 2000</th>
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Trend in Gross Yield of the Seattle Water Supply System

- 98% uncertainty boundary
- 90% uncertainty boundary
- 75% uncertainty boundary
- Ensemble Average
- E4
- H3
- G30
- PCM
- Historic
Average Annual System Wide Snow Storage

Historic Ensemble
GCM Ensemble 2000
GCM Ensemble 2020
GCM Ensemble 2040

Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep
Seattle Climate Change Study

2040s Climate Impacts
SEATTLE (WA):
Decreasing Snowpack: -50%
Loss of Gross Yield: ≈ 20 mgd

System water demand has decreased!

Average Annual System Wide Snow Storage

Trend in Gross Yield of the Seattle Water Supply System

- Historic Ensemble
- GCM Ensemble 2000
- GCM Ensemble 2020
- GCM Ensemble 2040

KAF

Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep

MGD

2000 2020 2040
Concerns

• Median summer inflows decrease
• Run-off is earlier, summer flows lower
• 1-in-50 year event becomes a 1-in 8
• Higher peak flows – significant impacts on salmon production
• Groundwater impacts – less recharge
Policy Responses

• State of Washington Department of Ecology partnering with UW CIG to do state-wide climate risk assessment

• Tri-county study of climate impacts on water supply, demand, and environmental flows

• All task groups have wide representation

• Task groups to inform professional groups and public about climate impacts
Study results were not being used

Implementation approach sought

Recognized need for involvement

Implementation required

- Identifying regional needs
- Engaging stakeholders
- Cooperative operation
- Structure for future evaluations
- New technology
Points of Agreement

Impacts of Climate Change on Temperature

Building Block 1 – The global average temperature will increase during the 21st century.

Building Block 2 – Warming in the Puget Sound has been more significant during the 20th century than the global average.

Building Block 3 – Warming temperatures in the Pacific Northwest will result in higher rates of evapotranspiration.

Impacts of Climate Change on Precipitation

Building Block 4 – Precipitation is expected to increase in the future, although variation in precipitation is expected to increase with increases in temperatures.

Building Block 5 – The frequency of precipitation events is expected to increase.

Impacts of Climate Change on Snowpack and Glaciers

Building Block 6 – Climate Change will reduce snowpack in the Western US and continue to reduce in other parts of the world.

Building Block 7 – Climate Change will intensify snowmelt and reduce snowpack in the high latitudes of the world.

Building Block 8 – The loss of snowpack can be directly attributable to warming temperatures.

Building Block 9 – Climate Change will increase the frequency of flood events.

Building Block 10 – Climate Change will increase the frequency of drought events.

Impacts on Sea Level Rise

Building Block 11 – Climate Change will create rises in sea level.

Impacts on Salomonids

Building Block 12 – Climate Change will negatively impact Salmonid populations.
Water Supply Actions

- Educate profession to climate impacts
- Identify appropriate frameworks
- Include climate evaluations in local, state and federal water plans
- Develop a common vocabulary
- Recognize that uncertainties do not prevent action
Then it's agreed. We'll hold hearings on global warming.
Policy Responses
Here’s what I think the truth is: We are all addicts of fossil fuels in a state of denial, about to face cold turkey…… I really wonder what gives us the right to wreck this poor planet of ours.
• What the country needs is dirtier fingernails and cleaner minds.
Climate Impacts: Peak Flow

Incubation peak flow—maximum instantaneous flow between Sept. 15th and Feb. 15th

Increases in average peak incubation flows 7-27%
Minimum spawning flow—lowest instantaneous flow between Sept. 15th and Nov. 15th

Average reductions in minimum spawning flows 15-22%
Evidence of Warming

In the past 16 years we have experienced the 13 warmest global temperatures on record.

Forecasts for increases by 2.7 to 10.4°F by 2100
April 1 SWE at Mt. Gardner

April 1st Snow Water Equivalent at Mt Gardner

- Simulated DHSVM SNOTEL site
- Observed, Mt Gardner Snowcourse
- 1959-2001 (simulated) trend decreases -1.9 in/decade
- 1959-2001 (observed) trend decreases -1.7 in/decade

Consistent declining trend between observed and simulated April 1 SWE for Mt. Gardner
Total annual volume at major reservoir inflows points (1949-2003)

- Cedar River above Chester Morse Reservoir
  - Cedar trend, -18%

- South Fork Tolt above Tolt Reservoir
  - Tolt trend, -24%
Changes in Annual Spring Flow on the Cedar River above Chester Morse Reservoir, 1949-2003

Fractions of annual flow occurring in March and June on the Cedar River above Chester Morse reservoir. Station Elevation 1560 ft.
Federal Study Finds Accord on Warming
By ANDREW C. REVKIN
Published: May 3, 2006

A scientific study commissioned by the Bush administration concluded yesterday that the lower atmosphere was indeed growing warmer and that there was "clear evidence of human influences on the climate system."
Trends in average daily temperature (1949-2002)

Rate of change in degrees (C) per decade

Winter
Spring
Summer
Autumn

Station elevation (m)

Kent
Everett
Monroe
Startup
SeaTac
Snoqualmie
Landsburg
Darrington
McMillin
Buckley
Palmer
MudMt
Cedar
Longmire
Stampede
Paradise
These changes contribute to...

1. Higher winter flows (incr. winter flood risk)
2. Earlier and lower peak flows (longer dry season, less water for salmon)
3. Lower summer flows

Projected Climate Change Impacts on Combined Seattle Water Supply
Impacts of Climate Change
Gross Yield

- Measure of demand level at which the system fails in no more than 2% of years.

- Trend fit to all GCM points shows a decrease of ~6 MGD per decade.

- Substantial spread in the results from each GCM.

<table>
<thead>
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<tr>
<td>90% boundary</td>
<td>-2.0% to -4.8%</td>
</tr>
<tr>
<td>98% boundary</td>
<td>-1.2% to -5.6%</td>
</tr>
</tbody>
</table>
Impacts of Climate Change: Cedar and the Tolt: Storage

- Median value decreases by 7.4 KAF between 2000 and 2040
- Equivalent to 2 weeks of supply at peak summer demand.
- 50 year drought event shifts to 8 year return interval
Impacts of Climate Change: Cedar and the Tolt: Snowpack

- Average annual max seen to decrease by as much as 50% by 2040
- Timing of peak shifts earlier in year
- Extreme event more common -- a 50 year event by 2000 standards is a 5 year event by 2040
Will Rogers

Even if you're on the right track, you'll get run over if you just sit there.