2015 PNWS AWWA Annual Conference

May 1, 2015

Bellevue, WA

From Assessment to Decision-Making: Mainstreaming Climate Change at Seattle Public Utilities

Paul Fleming

Manager, Climate Resiliency Group

Seattle Public Utilities

paul.fleming@seattle.gov

Seattle Public Utilities

outline

- water cycle changes affect physical assets and delivery of services
- cascade into other core utility functions
- strategic reframing required to manage risks, leverage opportunities and mainstream

"According to many experts, water and its availability and quality will be the main pressure on, and issues for, societies and the environment under climate change."

- Intergovernmental Panel on Climate Change Technical Paper VI

Seattle Public Utilities

U.S. Global Change Research Program

National Climate Assessment

Climate Change Impacts in the United States

CHAPTER 3
WATER RESOURCES

Convening Lead Authors

Aris Georgakakos, Georgia Institute of Technology
Paul Fleming, Seattle Public Utilities

Lead Authors

Michael Dettinger, U.S. Geological Survey
Christa Peters-Lidard, National Aeronautics and Space Administration
Terese (T.C.) Richmond, Van Ness Feldman, LLP
Ken Reckhow, Duke University
Kathleen White, U.S. Army Corps of Engineers
David Yates, University Corporation for Atmospheric Research

Recommended Citation for Chapter

Georgakakos, A., P. Fleming, M. Dettinger, C. Peters-Lidard, Terese (T.C.) Richmond, K. Reckhow, K. White, and D. Yates, 2014: Ch. 3: Water Resources. *Climate Change Impacts in the United States: The Third National Climate Assessment*, J. M. Melillo, Terese (T.C.) Richmond, and G. W. Yohe, Eds., U.S. Global Change Research Program, 69-112. doi:10.7930/J0G44N6T.

On the Web: http://nca2014.globalchange.gov/report/sectors/water

INFORMATION DRAWN FROM THIS CHAPTER IS INCLUDED IN THE HIGHLIGHTS REPORT AND IS IDENTIFIED BY THIS ICON

Climate Change Impacts in the United States

CHAPTER 28
ADAPTATION

Convening Lead Authors

Rosina Bierbaum, University of Michigan
Arthur Lee, Chevron Corporation
Joel Smith, Stratus Consulting

Lead Authors

Maria Blair, Independent
Lynne M. Carter, Louisiana State University
F. Stuart Chapin III, University of Alaska Fairbanks
Paul Fleming, Seattle Public Utilities
Susan Ruffo, The Nature Conservancy

Contributing Authors

Shannon McNeeley, Colorado State University
Missy Stults, University of Michigan
Laura Verduzco, Chevron Corporation
Emily Seyller, University Corporation for Atmospheric Research

Recommended Citation for Chapter

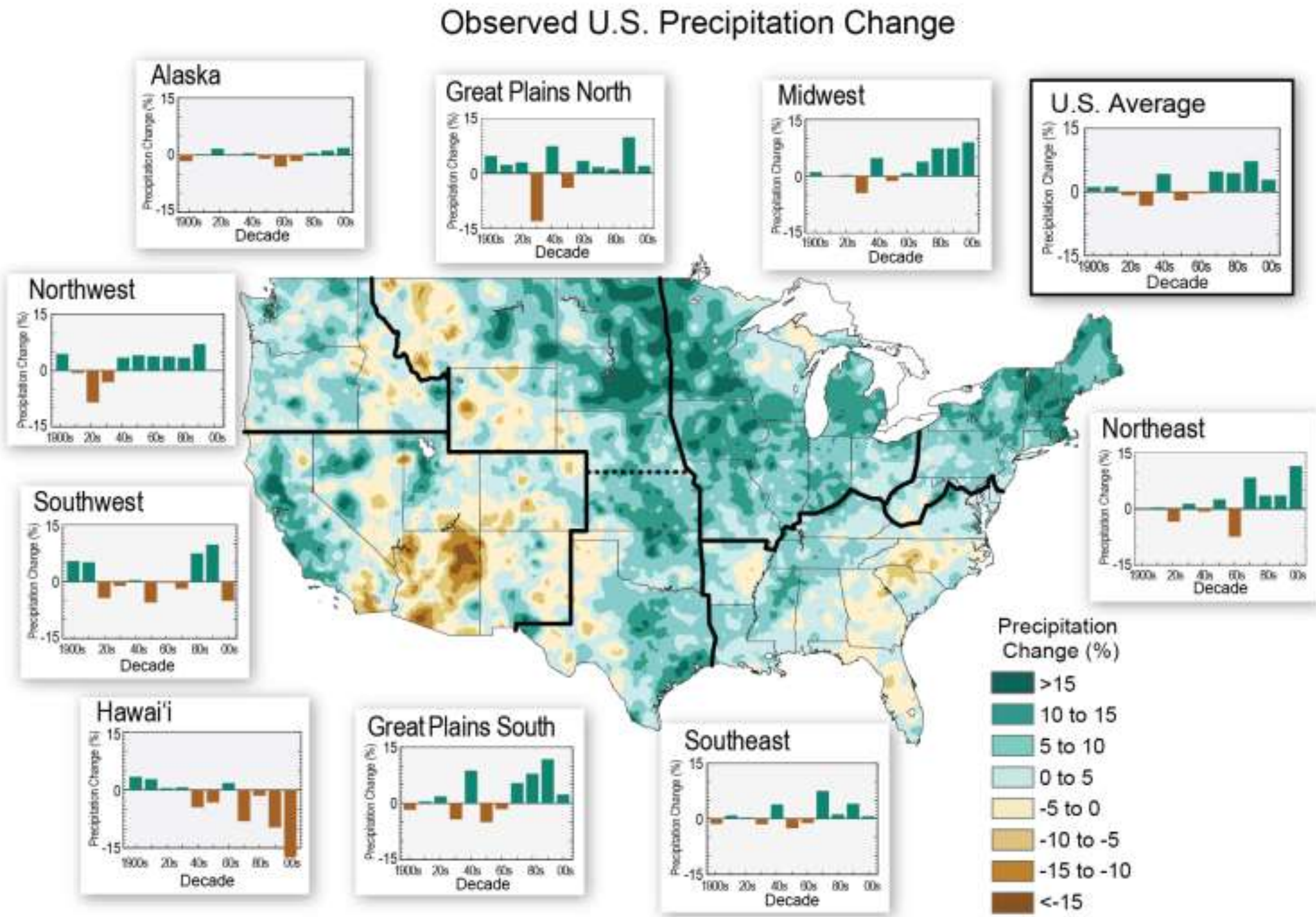
Bierbaum, R., A. Lee, J. Smith, M. Blair, L. M. Carter, F. S. Chapin, III, P. Fleming, S. Ruffo, S. McNeeley, M. Stults, L. Verduzco, and E. Seyller, 2014: Ch. 28: Adaptation. *Climate Change Impacts in the United States: The Third National Climate Assessment*, J. M. Melillo, Terese (T.C.) Richmond, and G. W. Yohe, Eds., U.S. Global Change Research Program, 670-706. doi:10.7930/J07H1GGT.

On the Web http://nca2014.globalchange.gov/report/response-strategies/adaptation

INFORMATION DRAWN FROM THIS CHAPTER IS INCLUDED IN THE HIGHLIGHTS REPORT AND IS IDENTIFIED BY THIS ICON

Seattle Public Utilities

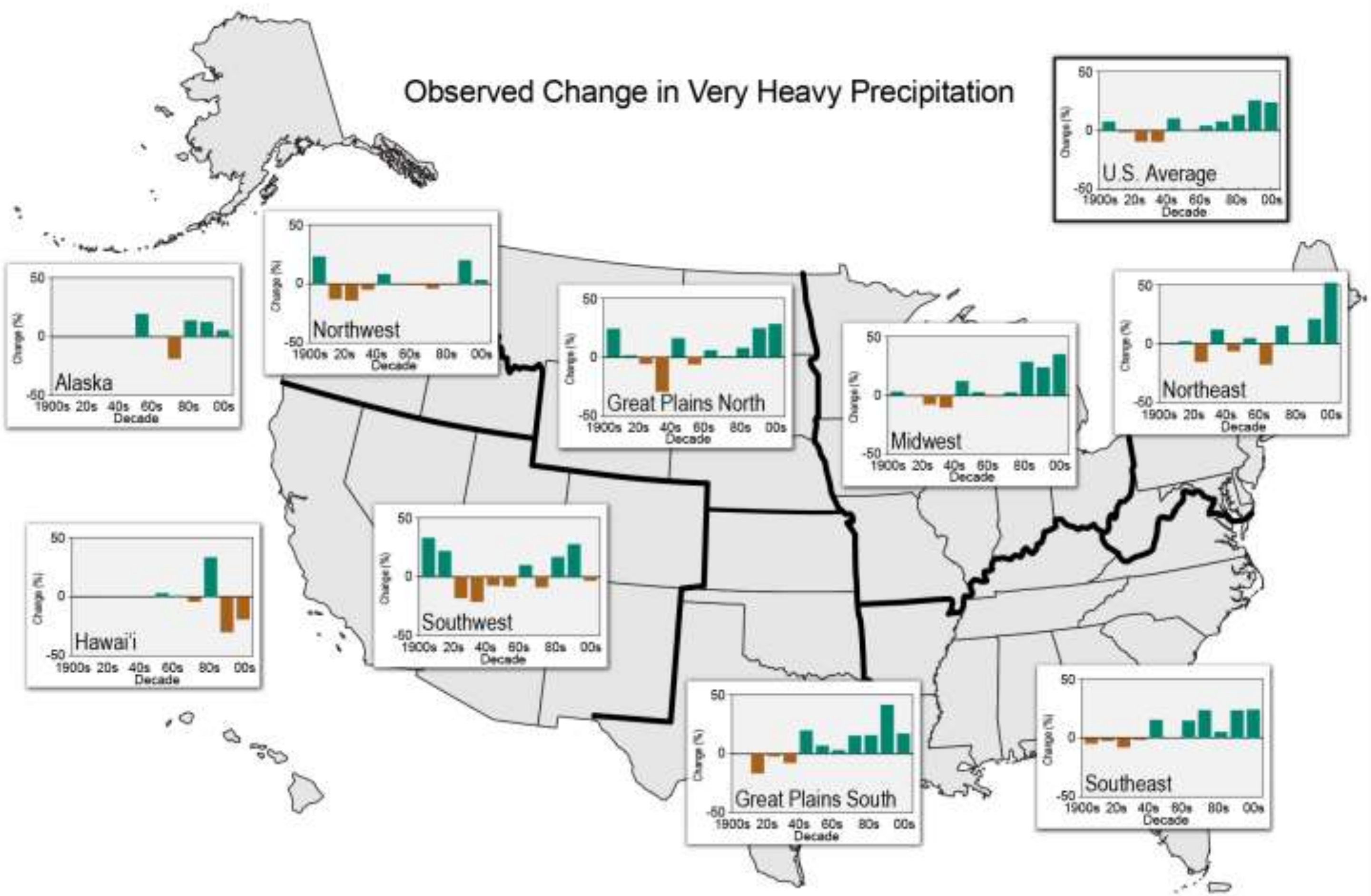
U.S. Global Change Research Program
National Climate Assessment



NCA Ch. 2, “Our Changing Climate”

Seattle Public Utilities

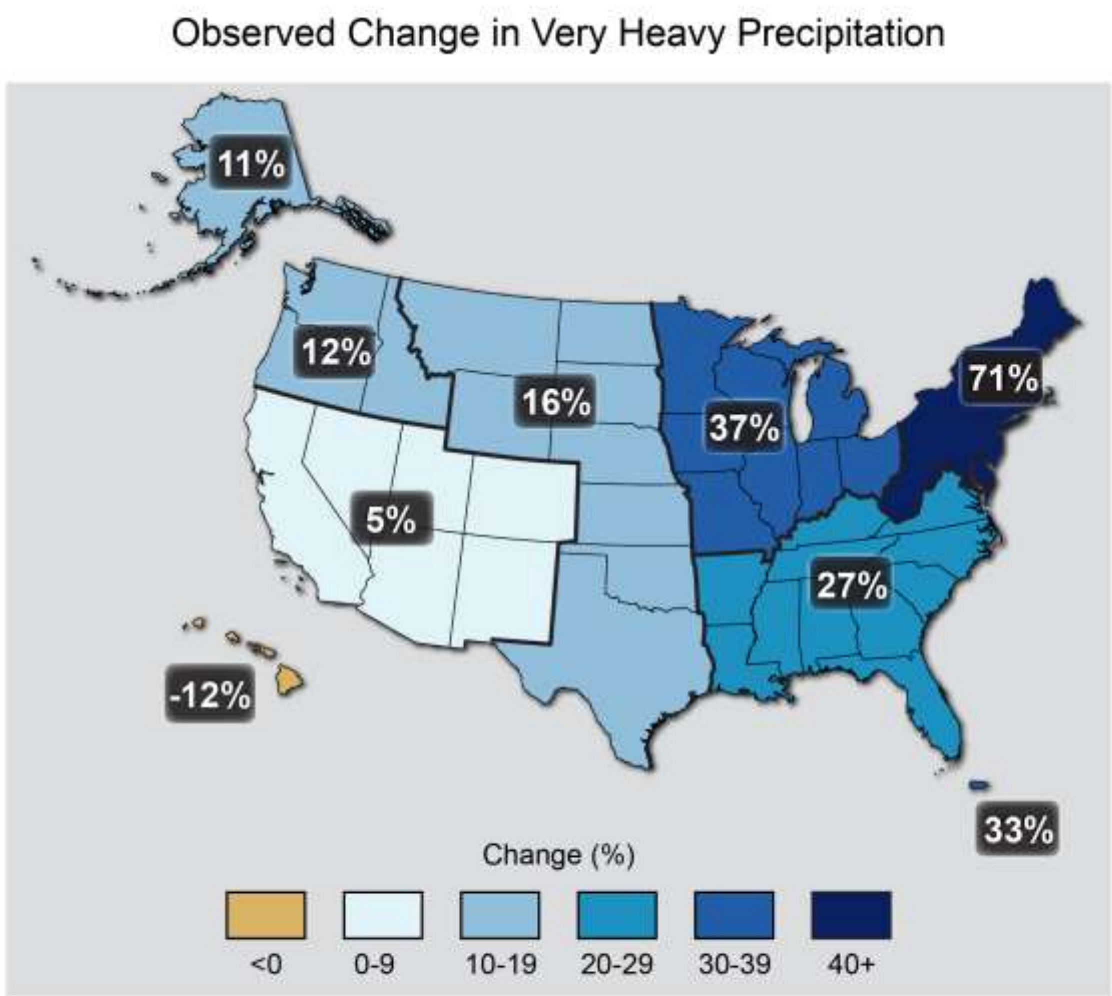
U.S. Global Change Research Program
National Climate Assessment



Seattle Public Utilities

NCA Ch. 2, "Our Changing Climate"

U.S. Global Change Research Program
National Climate Assessment



NCA Ch. 2, “Our Changing Climate”

Seattle Public Utilities

Trends in Flood Magnitude

NCA Ch. 3, “Water Resources”

CLIMATE CHANGE

Stationarity Is Dead: Whither Water Management?

Climate change undermines a basic assumption that historically has facilitated management of water supplies, demands, and risks.

P. C. D. Milly,[1*] Julio Betancourt,[2] Malin Falkenmark,[3] Robert M. Hirsch,[4] Zbigniew W. Kundzewicz,[5] Dennis P. Lettenmaier,[6] Ronald J. Stouffer[7]

Systems for management of water throughout the developed world have been designed and operated under the assumption of stationarity. Stationarity—the idea that natural systems fluctuate within an unchanging envelope of variability—is a foundational concept that permeates training and practice in water-resource engineering. It implies that any variable (e.g., annual streamflow or annual flood peak) has a time-invariant (or 1-year-periodic) probability density function (pdf), whose properties can be estimated from the instrument record. Under stationarity, pdf estimation errors are acknowledged, but have been assumed to be reducible by additional observations, more efficient estimators, or regional or paleohydrologic data. The pdfs, in turn, are used to evaluate and manage risks to water supplies, waterworks, and floodplains; annual global investment in water infrastructure exceeds U.S.$500 billion (1).

The stationarity assumption has long been compromised by human disturbances in river basins. Flood risk, water supply, and water quality are affected by water infrastructure, channel modifications, drainage works, and land-cover and land-use change. Two other (sometimes indistinguishable) challenges to stationarity have been externally forced, natural climate changes and low-frequency, internal variability (e.g., the Atlantic multidecadal oscillation) enhanced by the slow dynamics of the oceans and ice sheets (2, 3). Planners have tools to adjust their analyses for known human disturbances within river basins, and justifiably or not, they generally have considered natural change and variability to be sufficiently small to allow stationarity-based design.

[1]U.S. Geological Survey (USGS), c/o National Oceanic and Atmospheric Administration (NOAA) Geophysical Fluid Dynamics Laboratory, Princeton, NJ 08540, USA. [2]USGS, Tucson, AZ 85745, USA. [3]Stockholm International Water Institute, SE 11151 Stockholm, Sweden. [4]USGS, Reston, VA 20192, USA. [5]Research Centre for Agricultural and Forest Environment, Polish Academy of Sciences, Poznań, Poland, and Potsdam Institute for Climate Impact Research, Potsdam, Germany. [6]University of Washington, Seattle, WA 98195, USA. [7]NOAA Geophysical Fluid Dynamics Laboratory, Princeton, NJ 08540, USA.

*Author for correspondence. E-mail: cmilly@usgs.gov

An uncertain future challenges water planners.

In view of the magnitude and ubiquity of the hydroclimatic change apparently now under way, however, we assert that stationarity is dead and should no longer serve as a central, default assumption in water-resource risk assessment and planning. Finding a suitable successor is crucial for human adaptation to changing climate.

How did stationarity die? Stationarity is dead because substantial anthropogenic change of Earth's climate is altering the means and extremes of precipitation, evapotranspiration, and rates of discharge of rivers (4, 5) (see figure, above). Warming augments atmospheric humidity and water transport. This increases precipitation, and possibly flood risk, where prevailing atmospheric water-vapor fluxes converge (6). Rising sea level induces gradually heightened risk of contamination of coastal freshwater supplies. Glacial meltwater temporarily enhances water availability, but glacier and snow-pack losses diminish natural seasonal and interannual storage (7).

Anthropogenic climate warming appears to be driving a poleward expansion of the subtropical dry zone (8), thereby reducing runoff in some regions. Together, circulatory and thermodynamic responses largely explain the picture of regional gainers and losers of sustainable freshwater availability that has emerged from climate models (see figure, p. 574).

Why now? That anthropogenic climate change affects the water cycle (9) and water supply (10) is not a new finding. Nevertheless, sensible objections to discarding stationarity have been raised. For a time, hydroclimate had not demonstrably exited the envelope of natural variability and/or the effective range of optimally operated infrastructure (11, 12). Accounting for the substantial uncertainties of climatic parameters estimated from short records (13) effectively hedged against small climate changes. Additionally, climate projections were not considered credible (12, 14).

Recent developments have led us to the opinion that the time has come to move beyond the wait-and-see approach. Projections of runoff changes are bolstered by the recently demonstrated retrodictive skill of climate models. The global pattern of observed annual streamflow trends is unlikely to have arisen from unforced variability and is consistent with modeled response to climate forcing (15). Paleohydrologic studies suggest that small changes in mean climate might produce large changes in extremes (16), although attempts to detect a recent change in global flood frequency have been equivocal (17, 18). Projected changes in runoff during the multidecade lifetime of major water infrastructure projects begun now are large enough to push hydroclimate beyond the range of historical behaviors (19). Some regions have little infrastructure to buffer the impacts of change.

Stationarity cannot be revived. Even with aggressive mitigation, continued warming is very likely, given the residence time of atmospheric CO_2 and the thermal inertia of the Earth system (4, 20).

A successor. We need to find ways to identify nonstationary probabilistic models of relevant environmental variables and to use those models to optimize water systems. The challenge is daunting. Patterns of change are complex; uncertainties are large; and the knowledge base changes rapidly.

Under the rational planning framework advanced by the Harvard Water Program (21, 22), the assumption of stationarity was

EDITORIAL

The End of Reliability

Casey Brown, A.M.ASCE

Asst. Prof., Dept. of Civil and Environmental Engineering, 12B Marston Hall, Univ. of Massachusetts, 130 Natural Resources Rd., Amherst, MA 01003-9293. E-mail: CBrown@ecs.umass.edu

Recent attention has focused on the declaration of the death of stationarity and the associated implications for water management (Milly et al. 2008; Lettenmaier 2008). A recent panel convened by the EPA on the subject of water infrastructure planning in the context of climate change was notable for a lack of consensus and need for guidance expressed by water managers. Here I argue that the major implication of the end of stationarity is the end of the static design paradigm, exemplified by the concept of reliability, as the underlying design principle for water resource systems.

Here reliability is defined in a general way, as "the probability

The death of stationarity means that those statistics are changing and therefore our estimated reliability is not what we expect it to be. More generally, the traditional approach to water supply design depends on precise estimates of the probabilities of events that are difficult to estimate, involve linked physical and societal processes that are difficult or impossible to model and have only recently been considered worthy of research, and due to secular changes in climate, land use, etc., are becoming even more uncertain. This presents the water manager and the larger water resources research community with a dilemma.

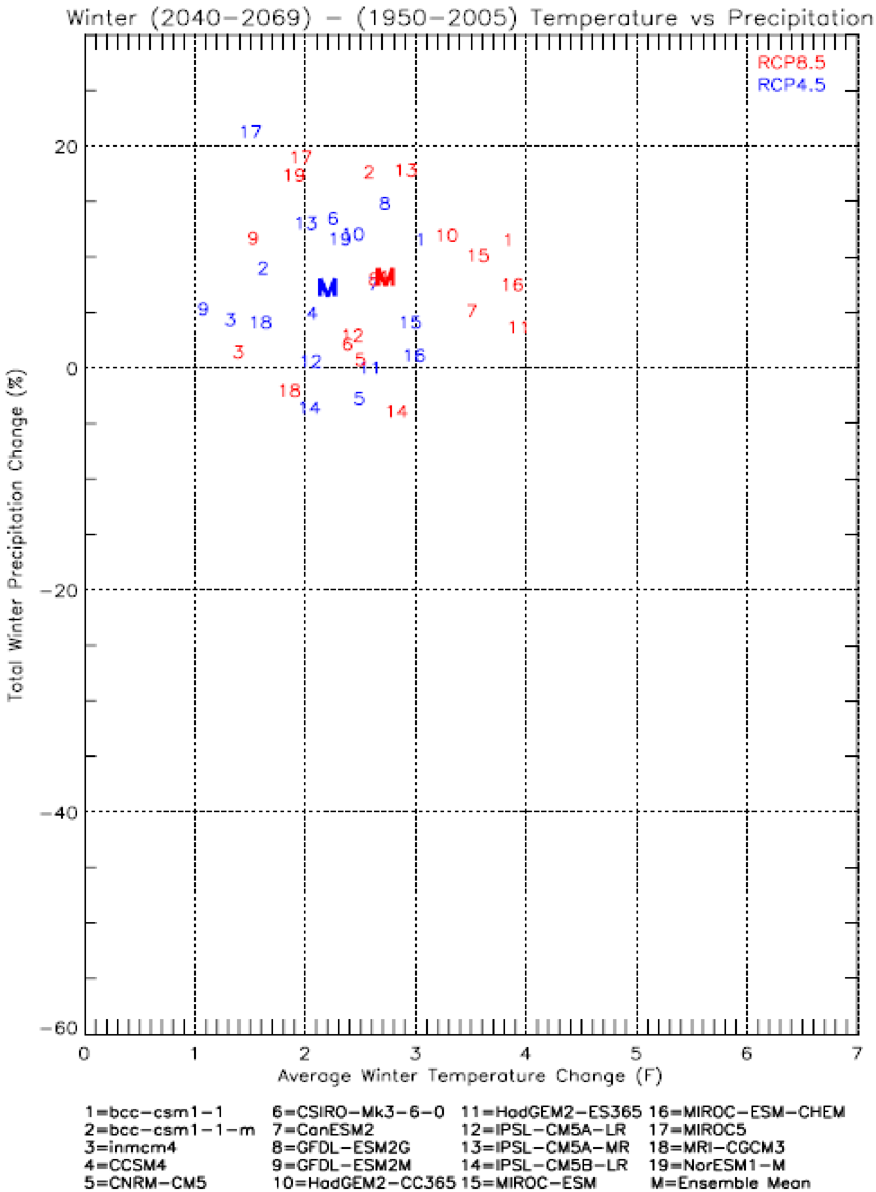
The Traditional Design Approach in the Face of Nonstationarity

Seattle Public Utilities

climate resiliency group objectives:

- build sustained capacity to manage the risks of climate change by:
  - enhancing knowledge
  - assessing impacts and vulnerabilities
  - building collaborative partnerships
  - strengthening institutions and people
  - pursuing portfolios of approaches
- leverage sustained capacity to embed what we're learning in what we do
  - strategic planning
  - system planning
  - capital planning
  - system operations

Seattle Public Utilities



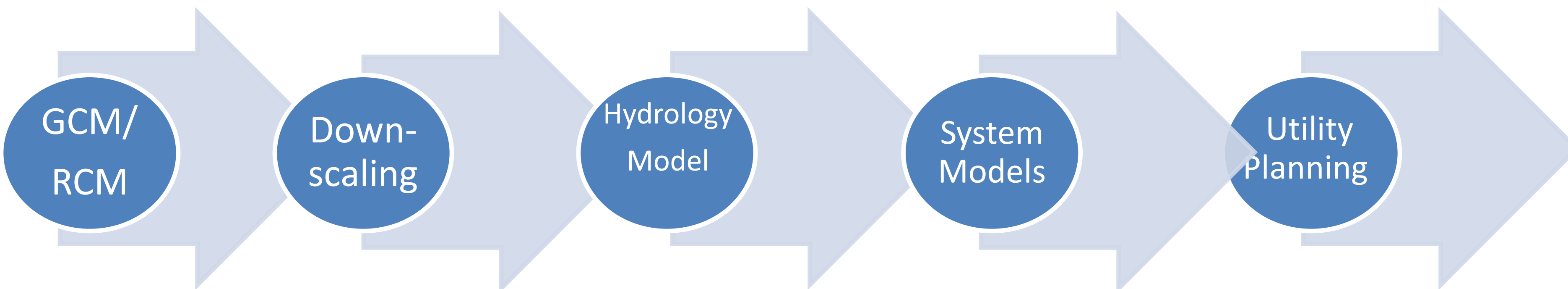
graph created by Darrin Sharp, OCCRI

Seattle Public Utilities

Oregon State/Univ of ID

CMIP5 data
20 GCMs, 2 RCPs

40 data sets
150 yrs daily data



generate climate-altered hydrologies

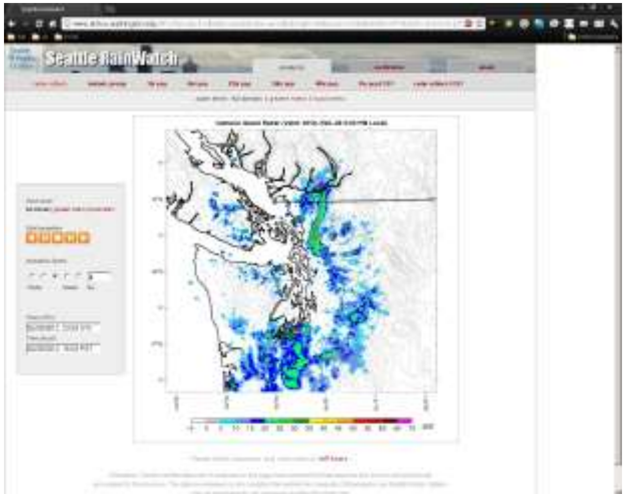
assess impacts on yield

integrate into system planning

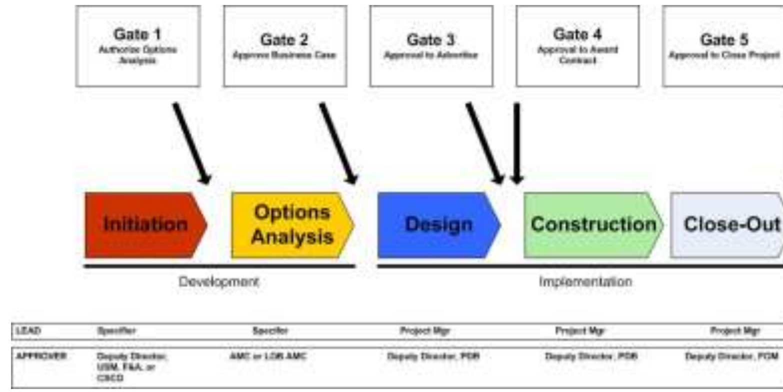
Seattle

Seattle Public Utilities

Seattle RainWatch



SPU's Stage Gates Asset Management Process



Seattle Water System Plan

2013 Water System Plan
Our Water. Our Future.

Volume I
July 2012

SPU 2015-2020 Strategic Business Plan

Seattle Public Utilities

WUCA
Water Utility Climate Alliance

Mission: The Water Utility Climate Alliances provides leadership in assessing and adapting to the potential effects of climate change through collaborative action. We seek to enhance the ***usefulness of climate science*** *for the adaptation community and improve water management* ***decision-making in the face of climate uncertainty.***

Seattle Public Utilities

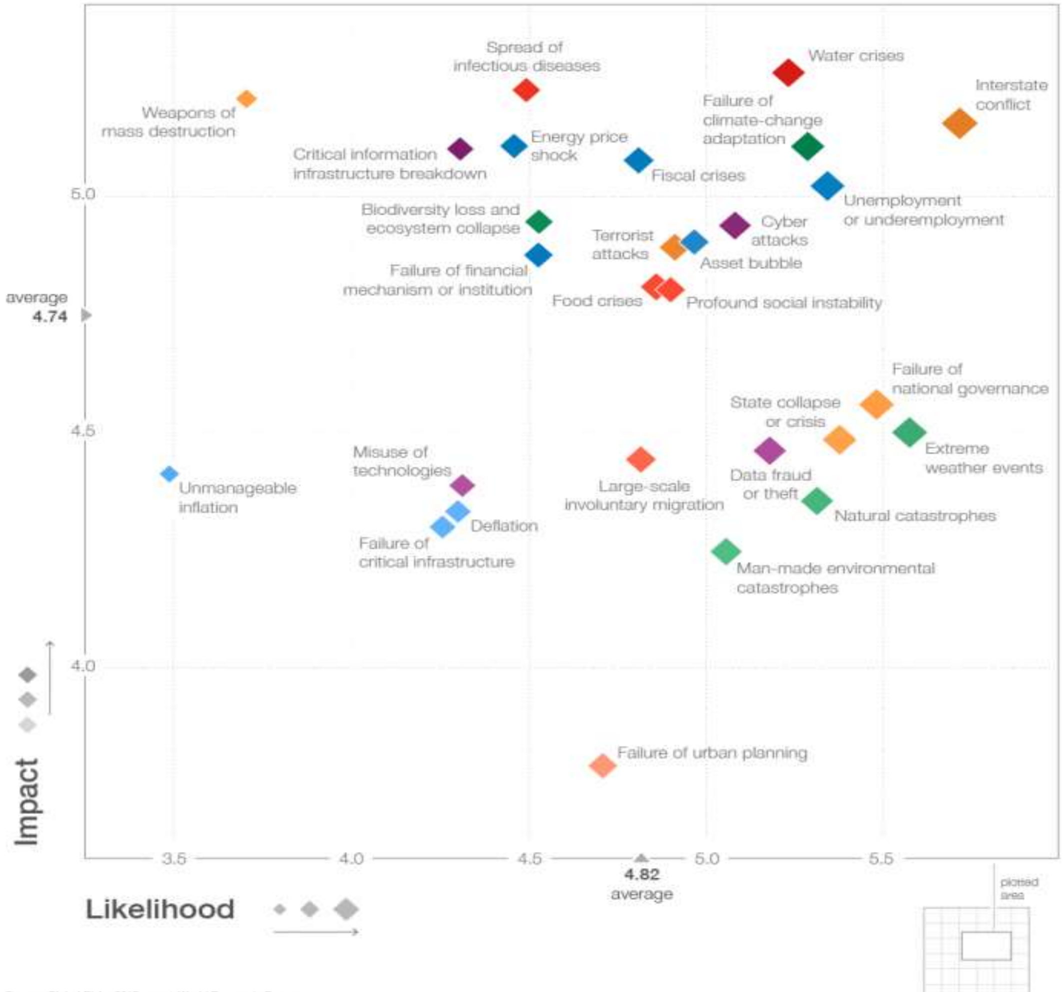
Slide created by David Behar, SFPUC

The Global Risks 2015 Report

WORLD ECONOMIC FORUM
COMMITTED TO IMPROVING THE STATE OF THE WORLD

The Global Risks Landscape 2015

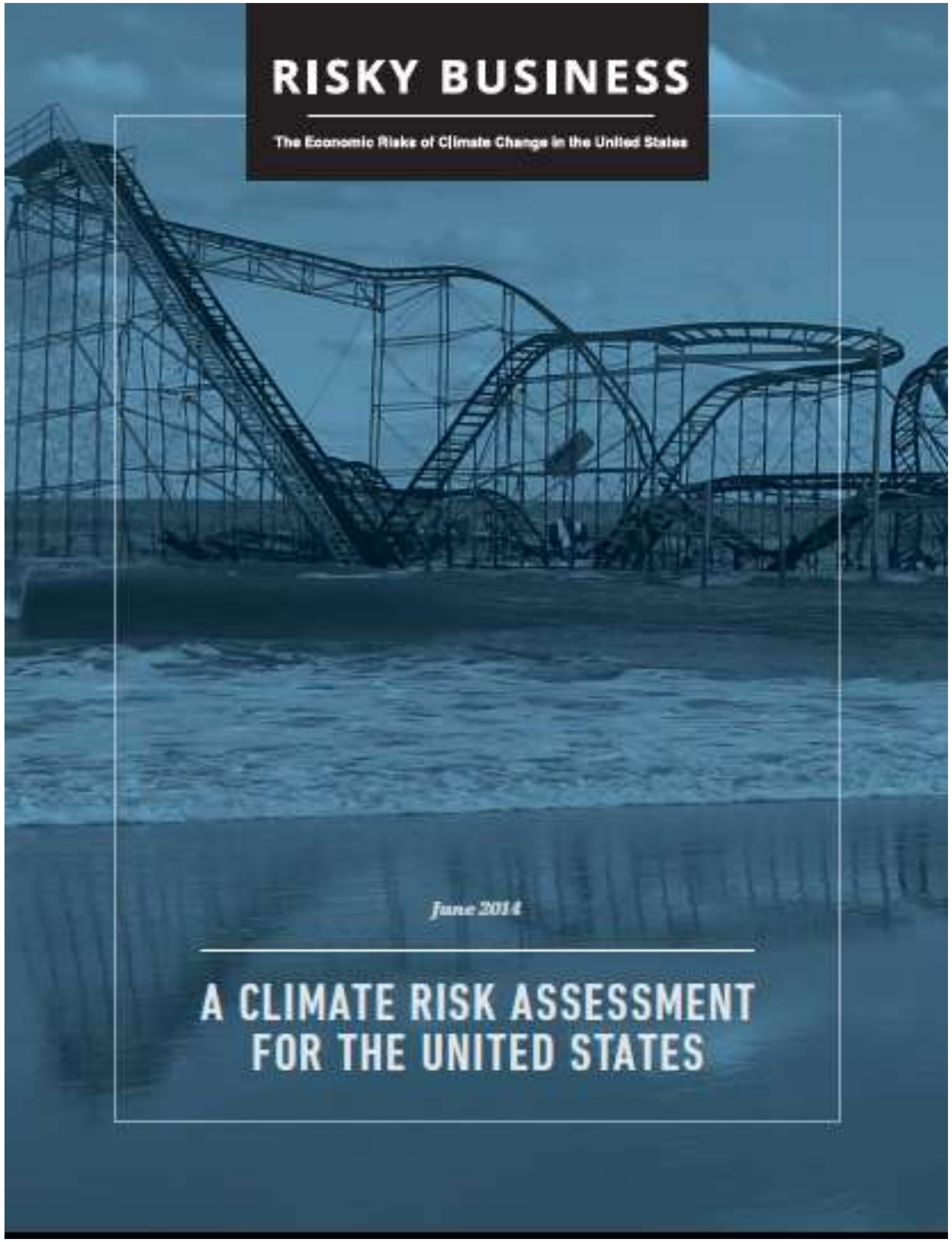
Respondents were asked to assess the impact and likelihood of each global risk on a scale of 1 to 7 and in the context of a 10-year time frame.



Source: Global Risks 2015 report, World Economic Forum

Learn more at http://wef.ch/grr2015 Get in touch: GlobalRisksReport@weforum.org or call +41 (0)22 869 1212

Seattle Public Utilities



Seattle Public Utilities

Harvard Business Review

APRIL 2014

"Auditions" Are the Best Way to Hire

111 Operations
A Manufacturing Renaissance in Europe

117 Managing Yourself
15 Rules for Negotiating a Job Offer

THE RESILIENT COMPANY

HOW TO THRIVE IN A WARMER WORLD

PAGE 55

Seattle Public Utilities

WORLD ECONOMIC FORUM

COMMITTED TO IMPROVING THE STATE OF THE WORLD

Insight Report

Global Risks 2013
Eighth Edition

An Initiative of the Risk Response Network

"Climate smart mindset incorporates climate change analysis into strategic and operational decision-making"

…as well capital, financial and communication planning and anywhere else it makes sense…

Seattle Public Utilities

The Economist

Green bonds

Spring in the air

Bonds tied to green investments are booming

Mar 22nd 2014 | From the print edition

The Economist | World politics | Business & finance | Economics | Science & technology

Green bonds

Green grow the markets, O

The market for green bonds is booming. But what makes a bond green?

Jul 5th 2014 | From the print edition

The New York Times | http://nyti.ms/1zp9CCq

POLITICS

Climate Is Big Issue for Hispanics, and Personal

By CORAL DAVENPORT FEB. 9, 2015

WASHINGTON — Alfredo Padilla grew up in Texas as a migrant farmworker who followed the harvest with his parents to pick sugar beets in Minnesota each summer. He has not forgotten the aches of labor or how much the weather — too little rain, or too much — affected the family livelihood.

Now an insurance lawyer in Carrizo Springs, Tex., he said he was concerned about global warming.

The New York Times | http://nyti.ms/1veH8QV

POLITICS

Most Republicans Say They Back Climate Action, Poll Finds

By CORAL DAVENPORT and MARJORIE CONNELLY JAN. 30, 2015

WASHINGTON — An overwhelming majority of the American public, including half of Republicans, support government action to curb global warming, according to a poll conducted by The New York Times, Stanford University and the nonpartisan environmental research group Resources for the Future.

Millennials: We care more about the environment

03/22/14 01:42 PM – UPDATED 03/22/14 02:00 PM

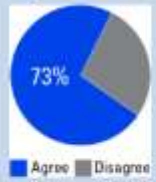
By Jane C. Timm

Millennials say they are more focused on the environment than their parents' generation, 76% to 24%, according to a new poll.

The poll – commissioned by the Clinton Global Initiative and Microsoft, and provided exclusively to msnbc – found that 66% of millennials say there is "solid evidence" the earth is getting warmer, and 75% of those respondents say human activity is responsible for it.

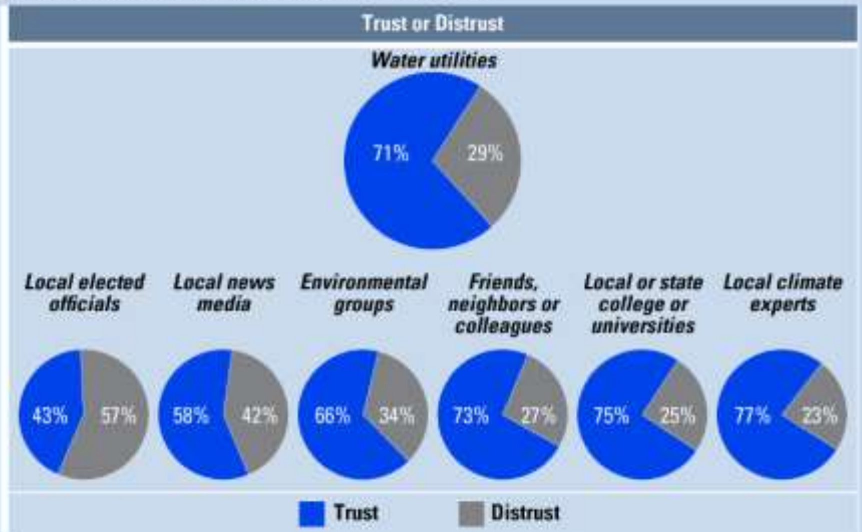
Seattle Public Utilities

Climate change will have a significant impact on the water cycle.



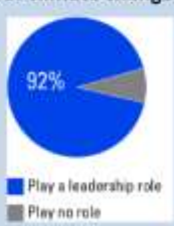
Source: Stratus Consulting, 2013.

How much do you trust or distrust the following as a source of information about climate change impacts for your local water system?



Source: Stratus Consulting, 2013.

How large of a leadership role should your community water utility play in helping your community prepare for the impacts of climate change?



Source: Stratus Consulting, 2013.

Water Research Foundation

Survey conducted April 10–April 28, 2013
Funding provided by the Water Research Foundation

STRATUS CONSULTING
ENVIRONMENTAL RESEARCH AND CONSULTING

CLIMATE CHANGE COMMUNICATION

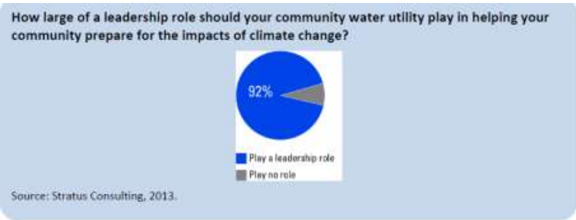
Data instincts

Seattle Public Utilities

2014 State of the Water Industry

- state of water and sewer infrastructure
- long term water supply availability
- financing for capital improvements
- public understanding of the value of water resources, systems and services

where are we:



American Water Works Association
The Authoritative Resource on Safe Water

The Economist

Green bonds

Spring in the air

Bonds tied to green investments are booming

Mar 22nd 2014 | From the print edition

The New York Times

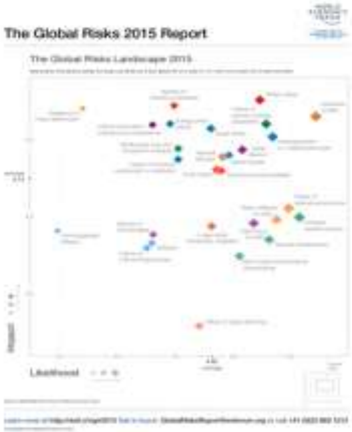
POLITICS

Climate Is Big Issue for Hispanics, and Personal

By CORAL DAVENPORT FEB. 9, 2015

WASHINGTON — Alfredo Padilla grew up in Texas as a migrant farmworker who followed the harvest with his parents to pick sugar beets in Minnesota each summer. He has not forgotten the aches of labor or how much the weather — too little rain, or too much — affected the family livelihood.

Now an insurance lawyer in Carrizo Springs, Tex., he said he was concerned about global warming.



Seattle Public Utilities

going forward

- water cycle changes affect physical assets and delivery of services
- cascade into other core utility functions
- strategic reframing required to manage risks and leverage opportunities

Seattle Public Utilities

Thank You

Paul Fleming
Climate Resiliency Group
Seattle Public Utilities
Paul.fleming@seattle.gov