USACE Climate Change Activities

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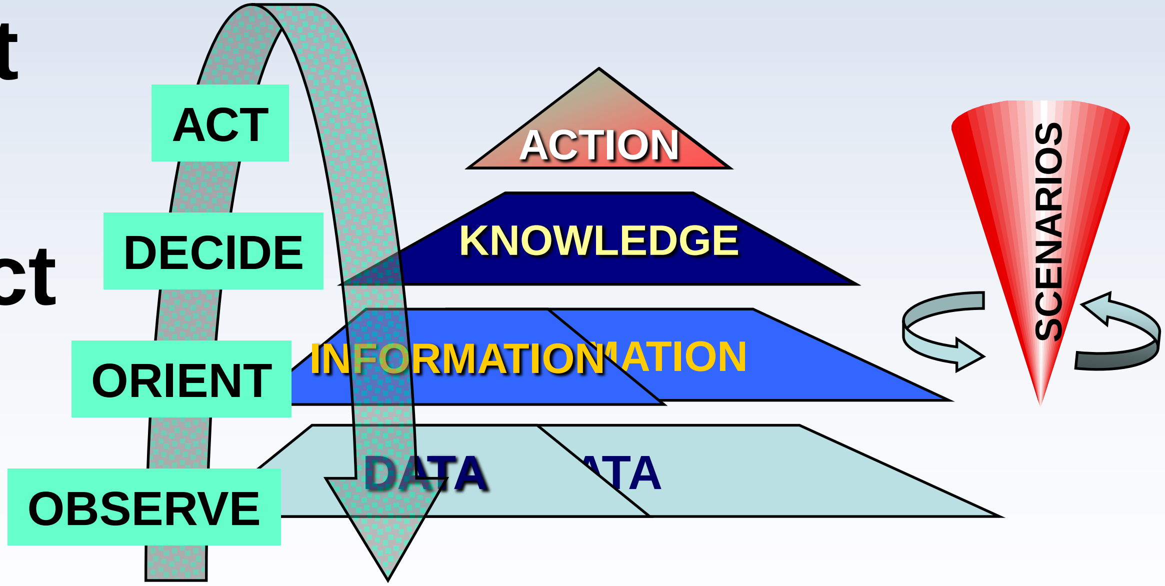
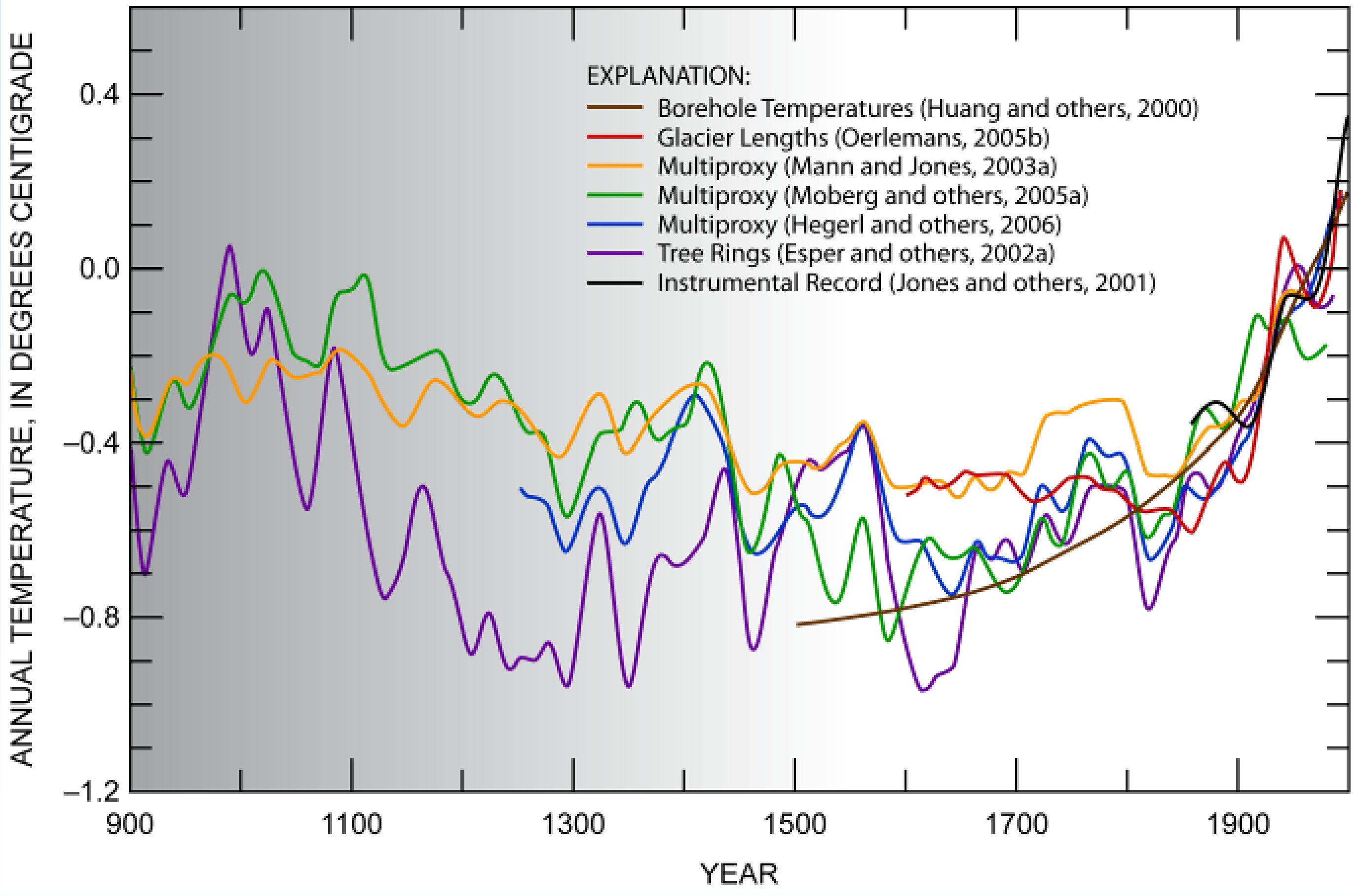
Prologue

- Water resources managers must turn data into information for decision makers
- Boyd's OODA loop: Observe, Orient, Decide, Act
- We do not have perfect knowledge



NRC: 2000-Year Temperature Reconstruction

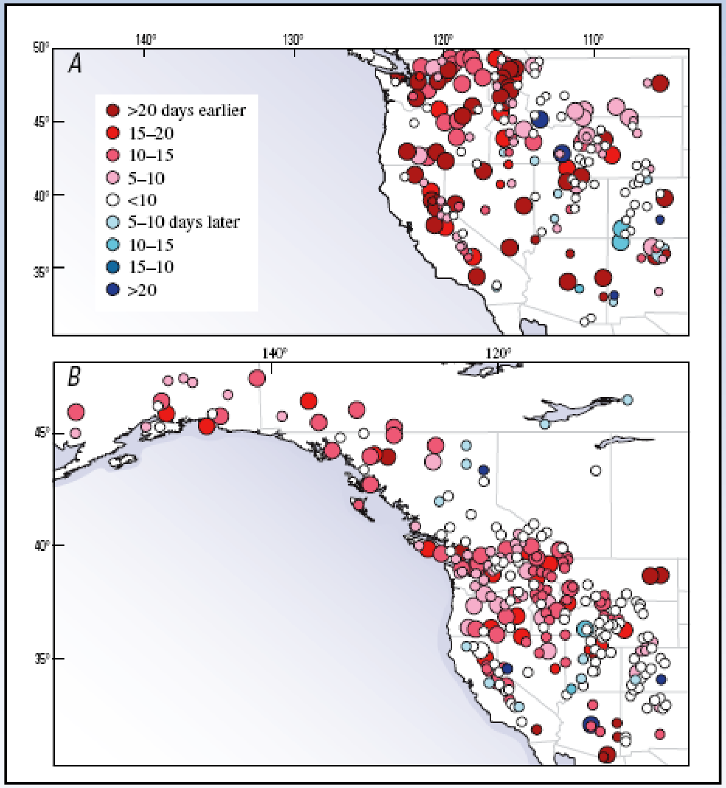
- **Climate is changing; changes can be abrupt**



NRC 2006, Surface temperature reconstruction for the last 2000 years: Washington, DC: National Academy Press

USACE Actions for Change

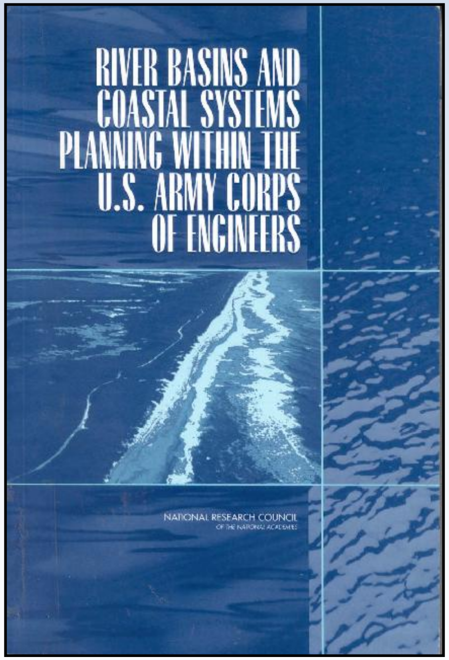
- **Temporal and Spatial System Changes**
  - **ASCE post-Katrina review panel stressed need to incorporate new and changing information**
  - **Develop guidelines and recommend policy and program changes along with supporting technologies, to address dynamic processes, temporal and spatial changes and their impacts to USACE projects on watershed, regional or system scale (e.g., subsidence, climate change and variability, altered seismicity, sea level change)**
  - **POC Rolf Olsen (IWR)**



A, yearly dates of spring snowmelt onset
B, centers of volume of yearly streamflow
Large circles indicate sites with trends that differ significantly from zero at a 90-percent confidence level; small circles are not confidently identified. (From Dettinger, 2005a.)

AFC Comprehensive Systems Approach

- **What is a system?**
  - **A dynamic and complex whole interacting as a structured functional unit**
- **What is a comprehensive systems approach?**
  - **A multidisciplinary, multi-objective, and multi-stakeholder framework supporting "a balanced evaluation of all relevant issues (e.g., hydrologic, geomorphic, ecologic, social, economic)" (NRC 2004, p. 19)**



- **Corps-specific context?**
  - **Shifting the focus on making decisions from individual, isolated projects to an interdependent system, and from local or immediate solutions to regional or long-term solutions, at appropriate scales of space and time**

USACE AFC: Near Term Activities

- **Interagency paper on climate impacts to water resources**
- **Interim and detailed guidance to address sea level change**
- **Water management: operations incorporating climate change and systems approach to water control**
- **Geospatial tool for vulnerability analysis**
  - **Initial product: USACE coastal projects and local relative sea level rise**
  - **USACE, USGS, NOAA**
- **Review of USACE vulnerability to seismic events and changing knowledge of seismicity**
  - **USACE, USGS, other experts**
- **Workshop on alternatives to stationarity**

POLICYFORUM

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.

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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.

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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

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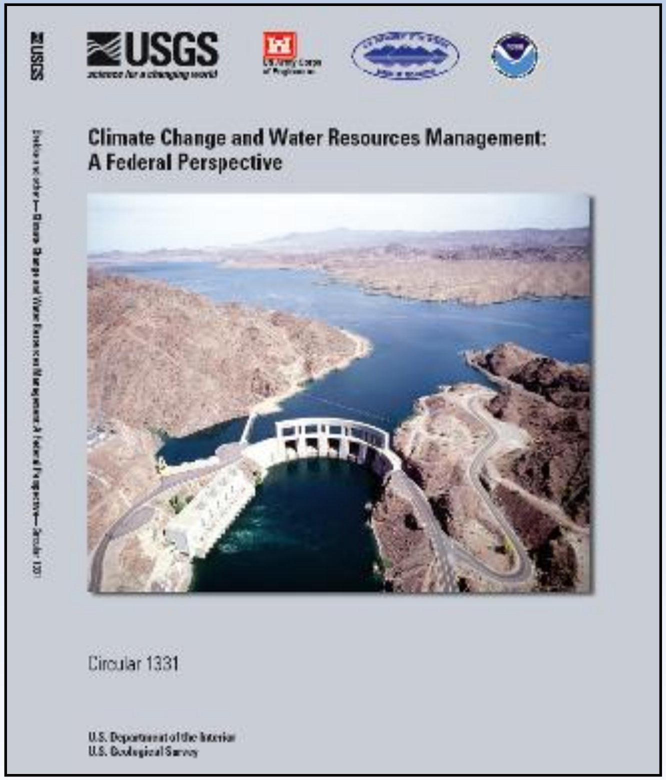
Interagency Workgroup on Climate Change

- **The four major US water resources agencies:**
  - **USACE, U.S. Geological Survey, Bureau of Reclamation, National Oceanic and Atmospheric Administration**
- **Mission:**
  - **To evaluate practices of federal agencies to incorporate climate change considerations into activities related to Nation's water resources**
  - **Provide foundation for future policies**
- **Report to be released as USGS Circular 1331 February 2009**

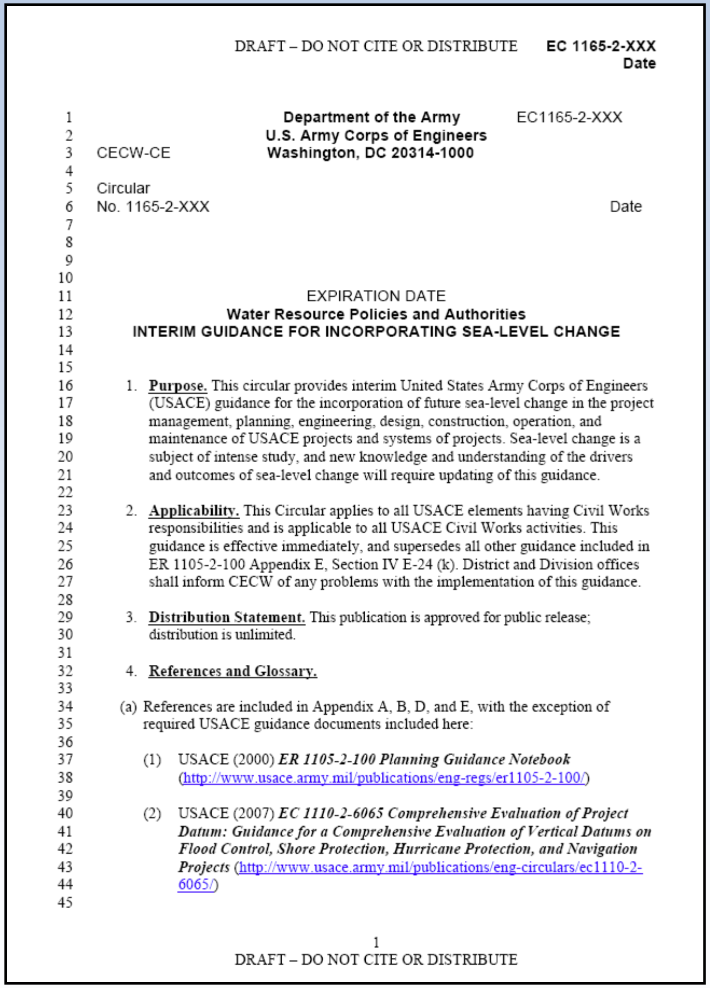


South Pacific Division Preliminary Study on Water Control

- **SPD, Sacramento District, AFC, IWR, CW R&D, Reclamation**
- **Analyze 22 General Circulation Models (GCM) for year 2030 temp and precip under 2 climate scenarios, generate reservoir inflows for perturbed T&P using National Weather Service River Forecast System, and test flood control curves using HEC RES-SIM**
  - **Increased precipitation intensities lead to an increase in the volume of rainfall runoff**
  - **Decreased precipitation intensities do not always decrease volumes of rainfall runoff**
  - **Static rule curves appear to perform poorly for a range of climate scenarios.**
  - **Dynamic rule curves provide more flexible drawdown and refill requirements, resulting in better flood protection and refill performance**

Interim Guidance on Sea Level Change: Status

- **Proposed through chain of command 7 April 2008**
  - **Engineer Circular 1165-2-XXX, applies to Planning, Engineering and Construction**
- **Interagency PDT members:**
  - **IWR, ERDC, NOAA National Ocean Service, USGS, Sacramento and Philadelphia Districts**
- **Internal peer review Aug 2008 by USACE, USGS, NOAA**
- **External peer review Oct - Dec 2008**
- **Implementation team finalizes Jan - Apr 2009**
- **Release guidance Apr 2009**



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Date

Department of the Army EC1165-2-XXX
U.S. Army Corps of Engineers
CECW-CE **Washington, DC 20314-1000**

Circular
No. 1165-2-XXX Date

EXPIRATION DATE
Water Resource Policies and Authorities
INTERIM GUIDANCE FOR INCORPORATING SEA-LEVEL CHANGE

1. **Purpose.** This circular provides interim United States Army Corps of Engineers (USACE) guidance for the incorporation of future sea-level change in the project management, planning, engineering, design, construction, operation, and maintenance of USACE projects and systems of projects. Sea-level change is a subject of intense study, and new knowledge and understanding of the drivers and outcomes of sea-level change will require updating of this guidance.

2. **Applicability.** This Circular applies to all USACE elements having Civil Works responsibilities and is applicable to all USACE Civil Works activities. This guidance is effective immediately, and supersedes all other guidance included in ER 1105-2-100 Appendix E, Section IV E-24 (k). District and Division offices shall inform CECW of any problems with the implementation of this guidance.

3. **Distribution Statement.** This publication is approved for public release; distribution is unlimited.

4. **References and Glossary.**

(a) References are included in Appendix A, B, D, and E, with the exception of required USACE guidance documents included here:

(1) USACE (2000) *ER 1105-2-100 Planning Guidance Notebook* (http://www.usace.army.mil/publications/eng-regs/er1105-2-100/)

(2) USACE (2007) *EC 1110-2-6065 Comprehensive Evaluation of Project Datum: Guidance for a Comprehensive Evaluation of Vertical Datums on Flood Control, Shore Protection, Hurricane Protection, and Navigation Projects* (http://www.usace.army.mil/publications/eng-circulars/ec1110-2-6065/)

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USACE Climate Activities: Next Steps

- Continue practice of using best expertise available
- Complete and implement interim sea level change guidance
- Develop and implement detailed sea level change guidance
- Develop methods, technologies, and policies for non-stationary cases
- Identify vulnerabilities to dynamic and changing processes
- Build on USGS Circular 1331 and District projects by developing processes, methods, technologies, policy to support climate change adaptation and mitigation
- Coordinate with AFC activities in adaptive management, sustainable systems, multi-objective planning and policy, asset management

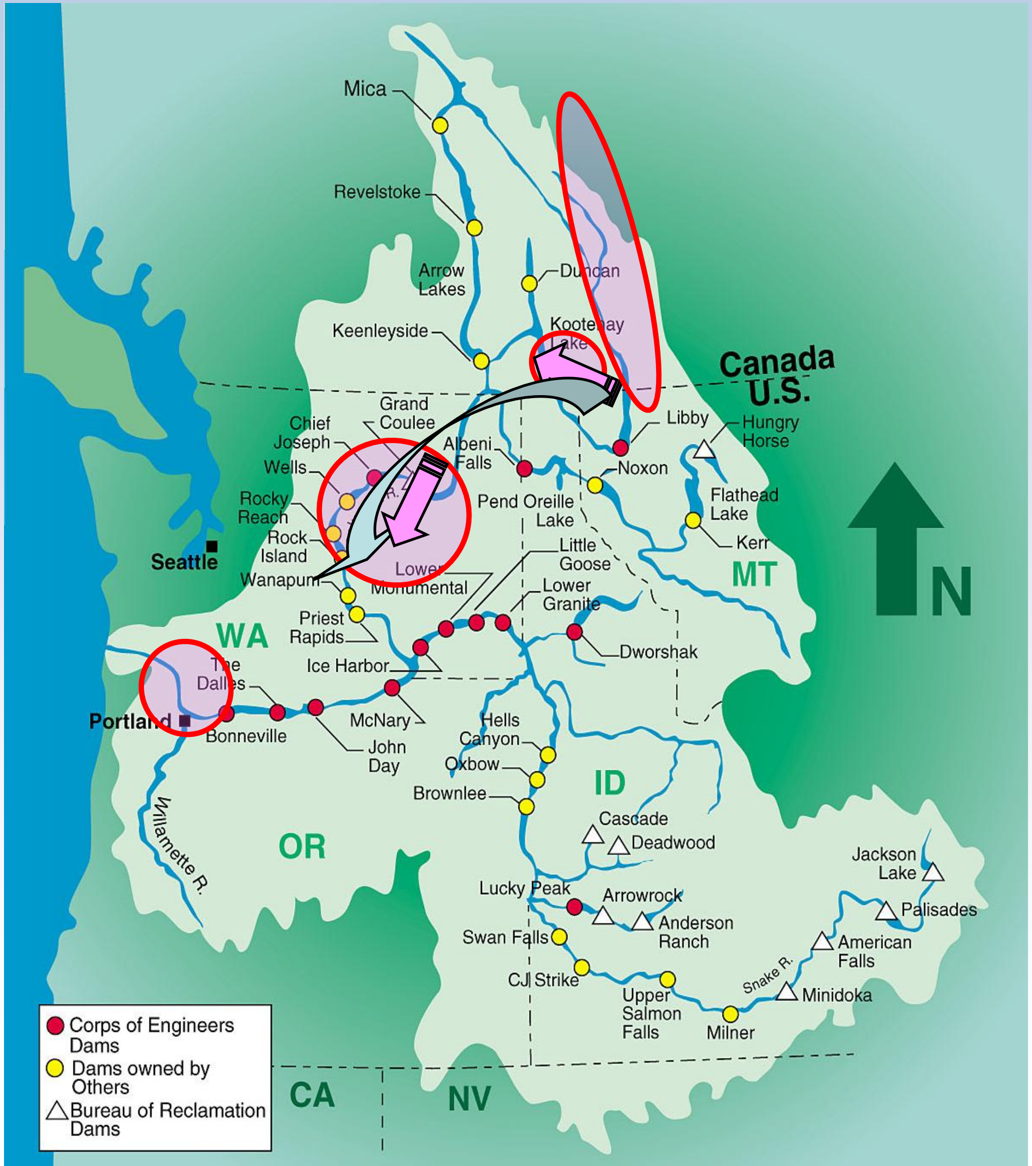
Columbia River Treaty

- **Construct large storage projects in Canada & Montana**
- **Provide for flood control benefits for the U.S. and hydropower benefits for both Canada & the U.S.**
- **Signed in 1964**
- **Augmented w/ other trans-boundary agreements**

Challenge of Operating FCRPS

- 13 Salmonid species listed as endangered
  - BiOp & the Courts now dictates operations on the FCRPS
  - Anadromous & Resident Fish
- With others close to being listed
- Minimum Operating Pool requirements
  - Lower Columbia and Snake Dams must operate reservoirs at specified pool elevations
- Requires upwards of 30-60% spill from Apr 3 – Aug 10
- Plus countless other challenges

Challenge of Operating FCRPS



- **Differential & conflicting needs**
  - **between Upstream & Downstream stakeholders**
- **Libby –flood storage to protect Portland & also locally at Bonners Ferry**
- **But Libby flows are also needed to support local fish and agricultural needs**
- **Libby provides fisheries flows for lower Columbia**
- **Agricultural flows support a large industry in the region**

Challenge of Operating FCRPS

- **Water Temperature challenges in the Snake River**
  - **From Dworshak to Lower Granite**
- **Hells Canyon Dam is a fish barrier**
  - **Releases much warmer water than fish are able to handle**
- **Emergence of Wind Power as an alternative Energy Source**
  - **Significantly complicates hydropower operations**
- **Increasing Scrutiny on every operation**
  - **With Court involvement from BiOp many public entities have access to review operations**

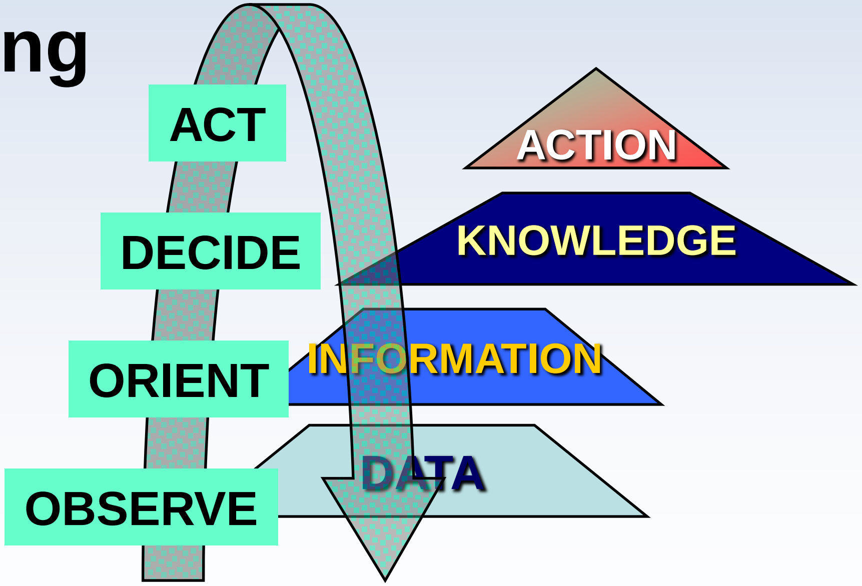
Multiple Challenges w/o Climate Change

- Operating FCRPS
  - Across Reclamation, BPA & USACE
  - Along w/ Local and Regional Stakeholders
  - Biological Opinions
  - Water Quality Issues
  - Increasing Demands, decreasing Supply
  - Competing Demands
- Many Public Utilities also operate on the Columbia

- Treaty
  - Originally included only Hydropower and Flood Control
  - New needs for Agriculture, Fisheries, Water Quality, Navigation
  - Energy markets are changing due to Wind and Oil prices and Carbon, etc

Epilogue

- **To speed up the tempo of the OODA loop as it relates to climate change, we need:**
  - **Diverse and creative ideas and opinions**
  - **Scenario planning**
  - **Prioritization**
  - **Leadership**



Questions?