Under What Scenario Do We Need A Guy from the US Army Corps of Engineers at this Thing?

Or, How's USACE Using Scenarios in Its Impacts, Adaptations, & Vulnerabilities Work?

Jeff Arnold

US Army Engineer Institute for Water Resources

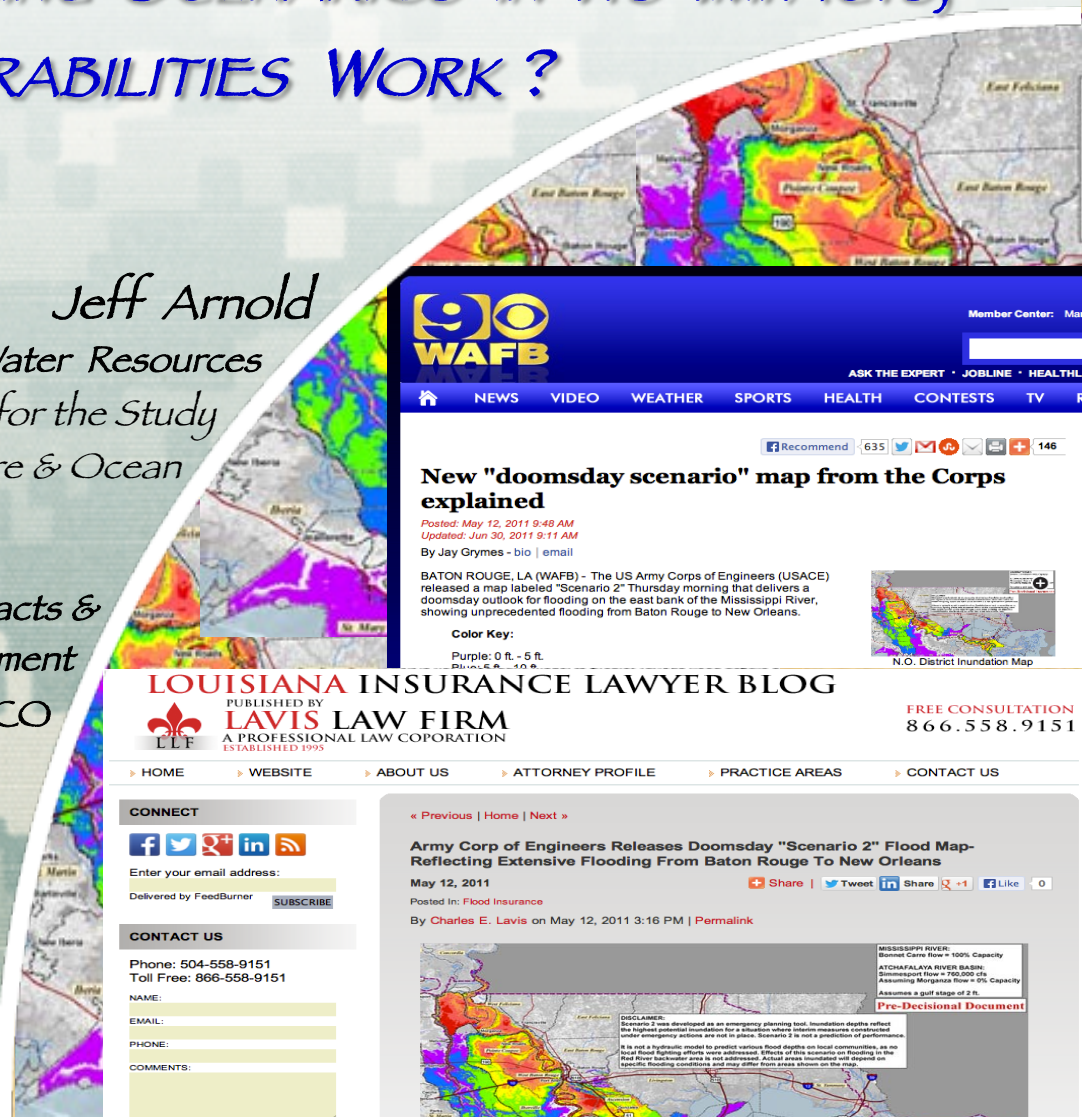
University of Washington | NOAA Joint Institute for the Study of the Atmosphere & Ocean

EMF | Workshop on Climate Change Impacts & Integrated Assessment

1 August 2013 | Snowmass, CO

US Army Corps of Engineers

BUILDING STRONG®



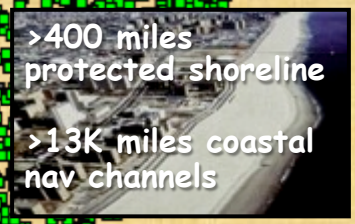
Why Does USACE Need Climate Scenarios?

>3% of the nation's electricity; 25% of its total hydropower

~$800M; ~80B kwh in 2011

>4K recreation sites; >370M annual visits

~$18B yr^{-1} & 500K jobs



USGS science for a changing world

US Army Corps of Engineers®

jeffrey.r.arnold@usace.army.mil

We Start with our Applications Decisions

Decision scaling » derive the *climate response function* of the system being managed, & use that to help direct us to appropriate climate science & climate change information to the decision problem at that scale

» moves the emphasis for the water resource managers from *'reduce scientific uncertainty'* to *'understand your decision terms & the information needed to support action'*

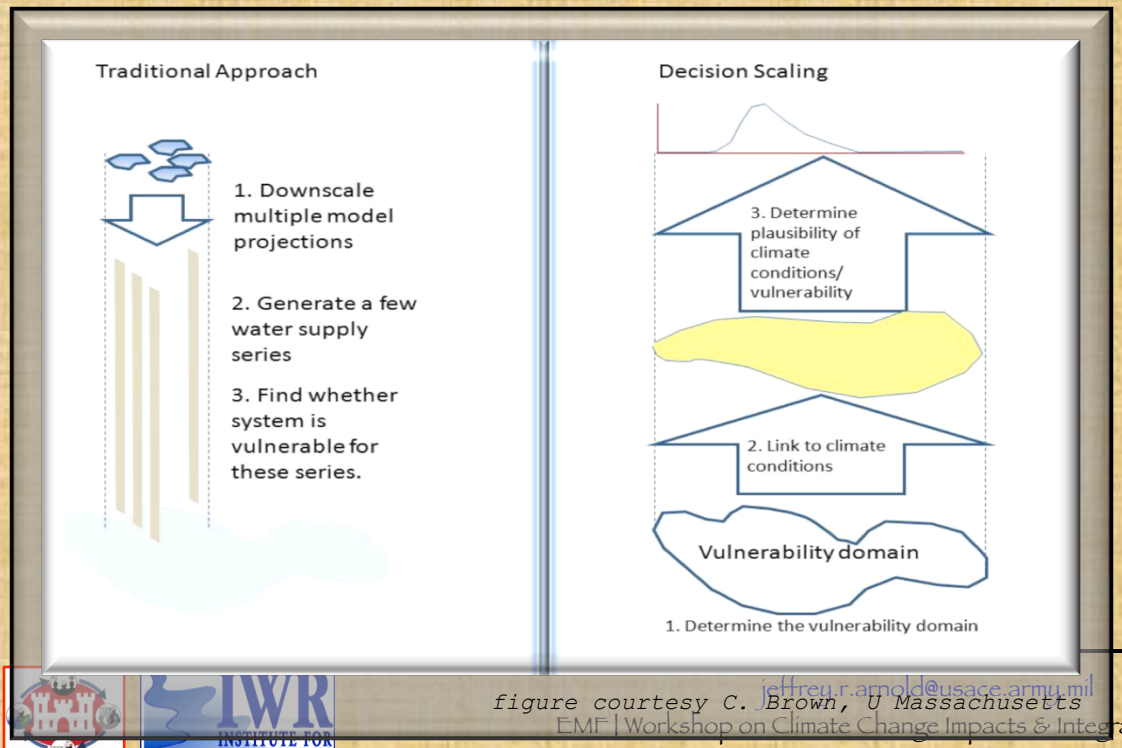


figure courtesy C. Brown, U Massachusetts

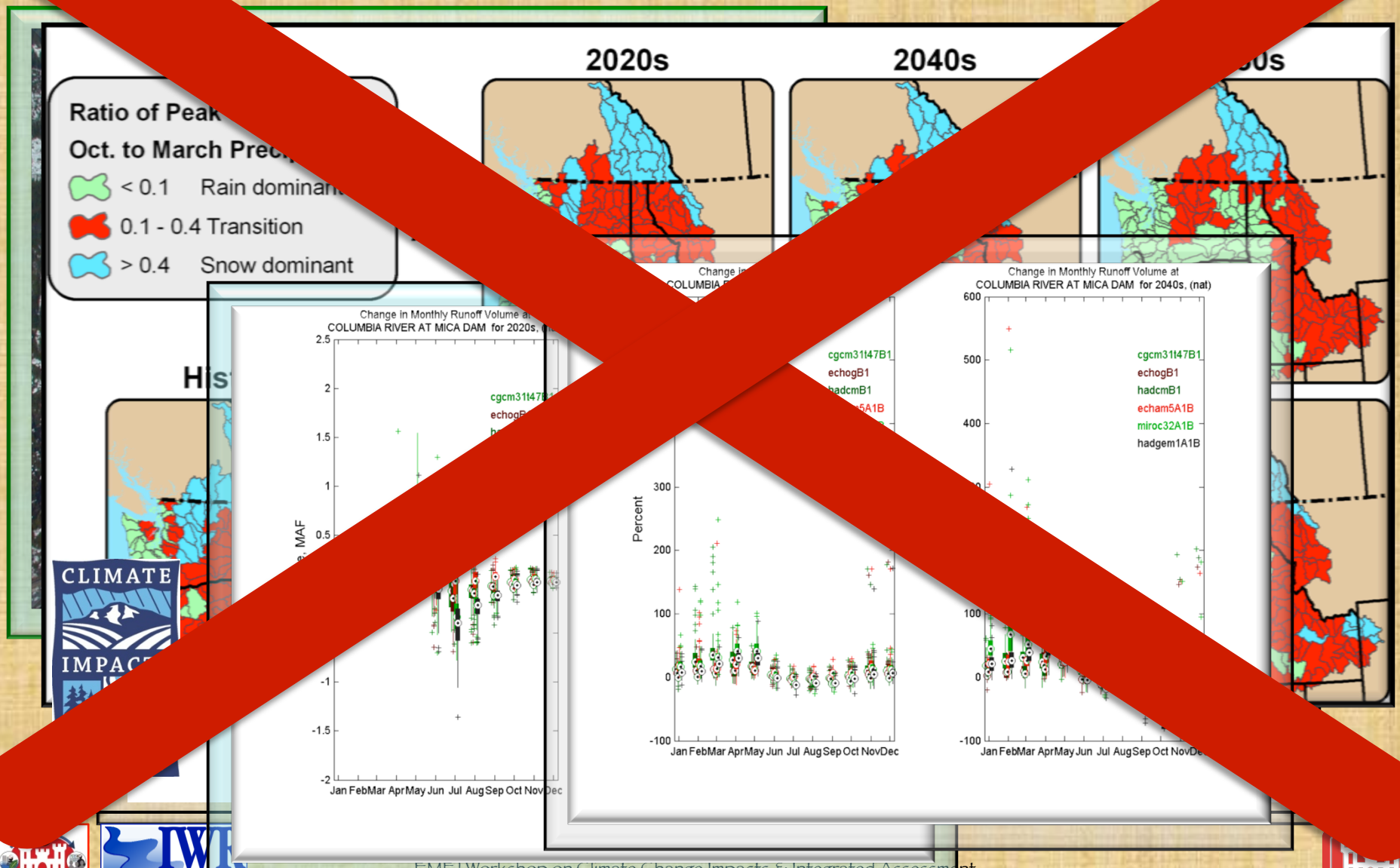
Uncertainty will persist . . .

Manage vulnerabilities & residual risks adaptively

Learn to watch for surprise

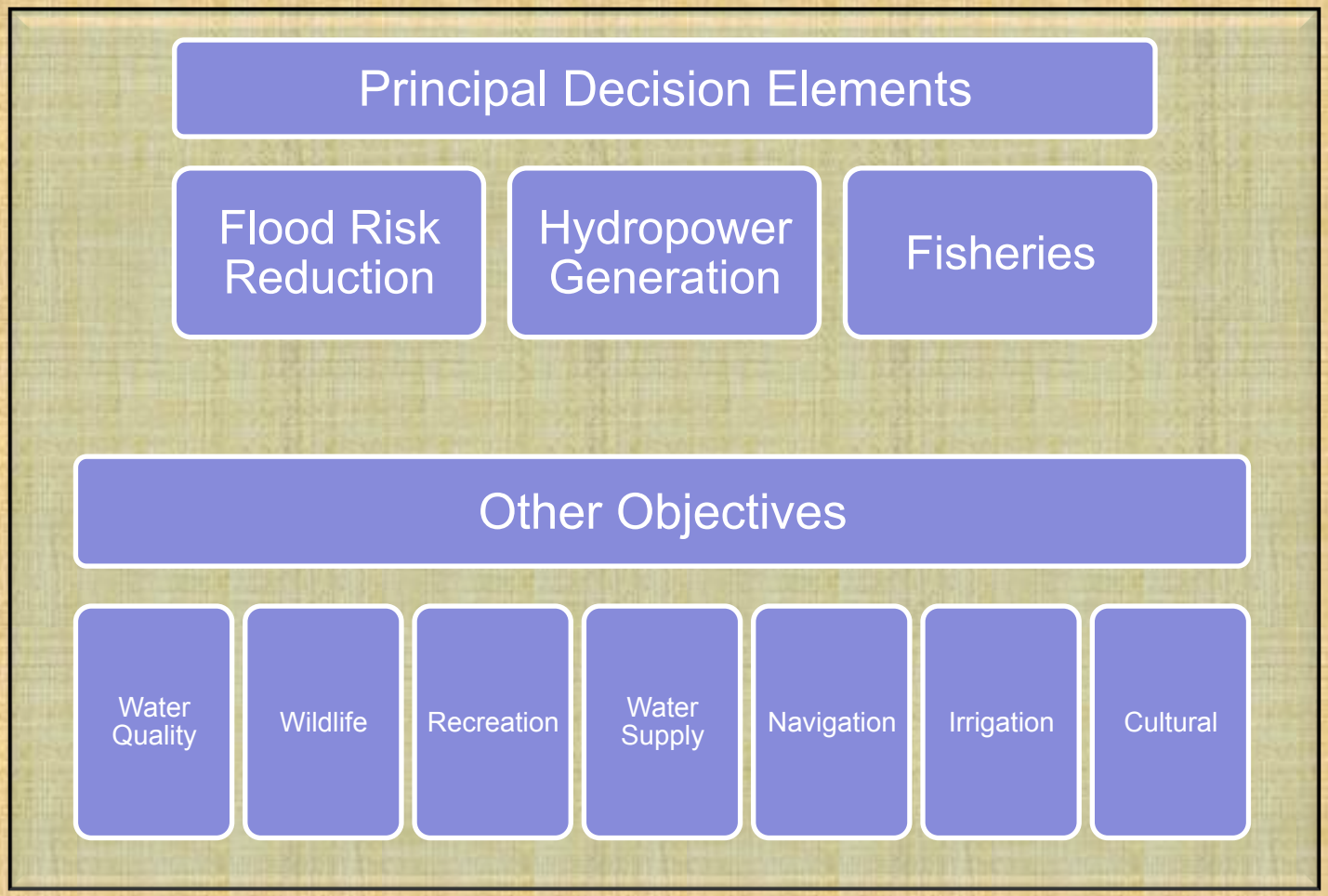
Decision Support (?)

Example : Snow to Rain Dominated HUCs



What Types of Decisions are Required?

Typical Decision Elements at Some USACE Reservoirs



Some Science & Engineering Components of Those Decision Elements

Climatology

- Analysis of T, P, & SWE

Hydrology

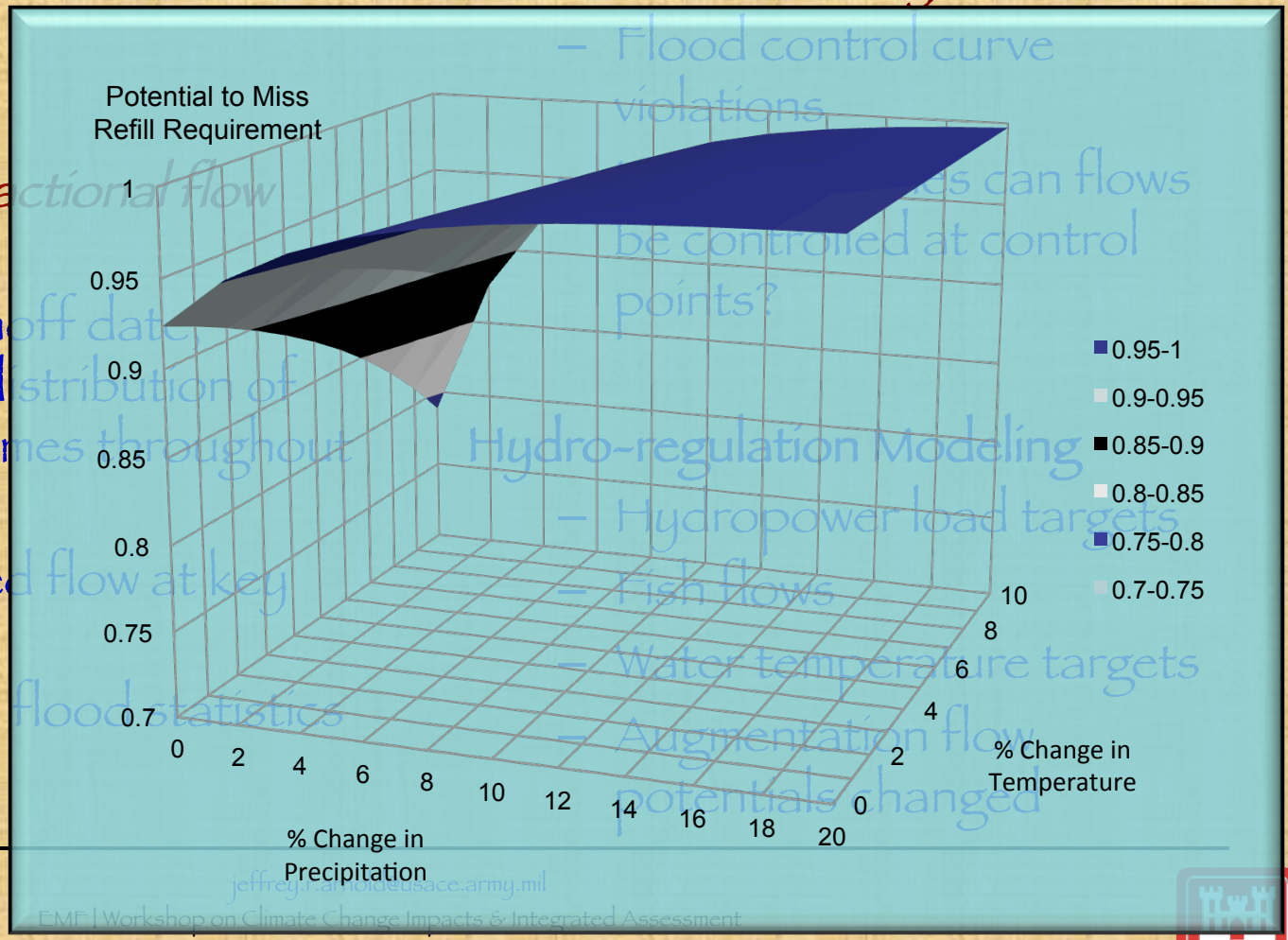
- *Monthly fractional flow volumes*
- Median runoff date, statistical distribution of runoff volumes throughout the year
- Unregulated flow at key locations
- Changes in flood statistics

Flood Control Modeling

- *Refill reliability*
- Flood control curve violations
- How can flows be controlled at control points?

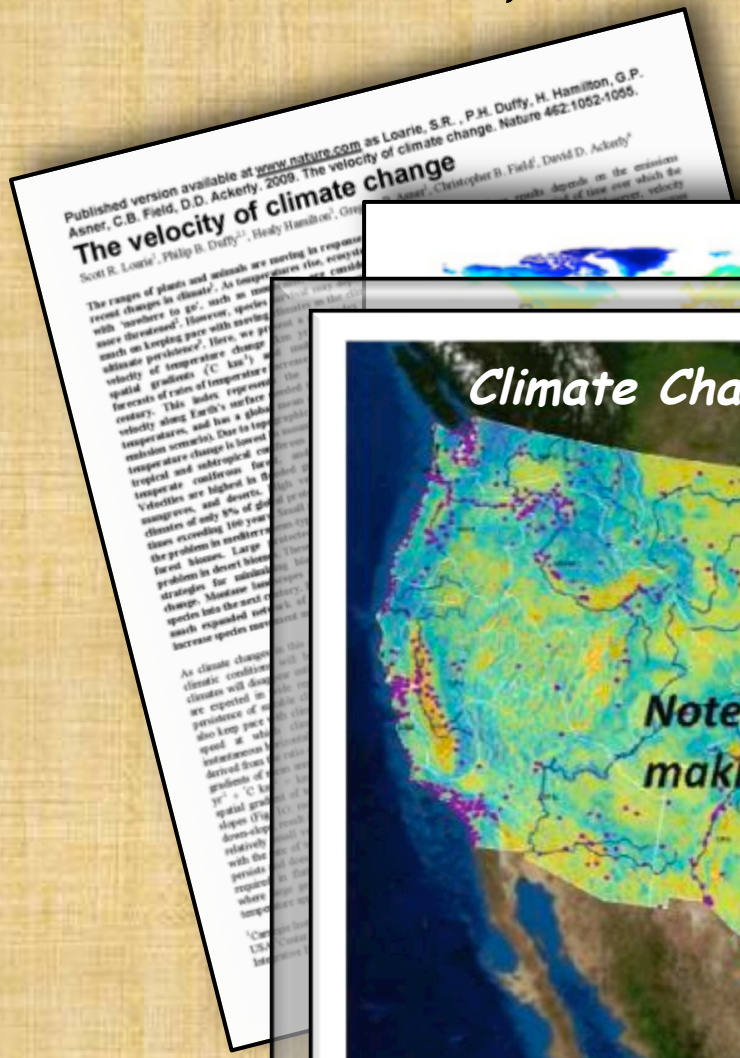
Hydro-regulation Modeling

- Hydropower load targets
- Fish flows
- Water temperature targets
- Augmentation flow potentials changed



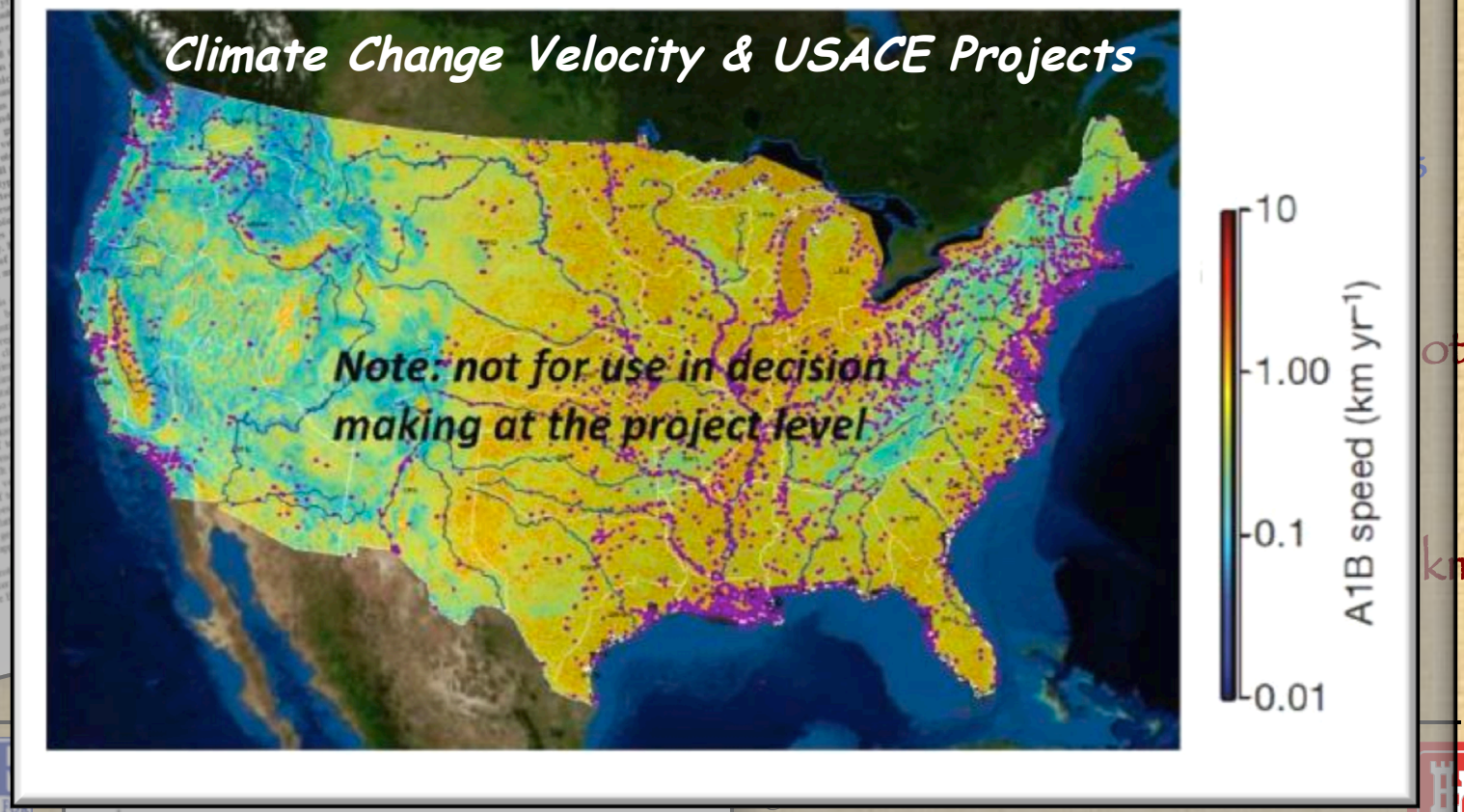
Vulnerability Assessments for USACE Missions

How Fast is Temperature Projected to Change Where We Operate?


Published version available at www.nature.com as Loarie, S.R., P.H. Duffy, H. Hamilton, G.P. Asner, C.B. Field, D.D. Ackerly. 2009. The velocity of climate change. Nature 462:1052-1055.

The velocity of climate change

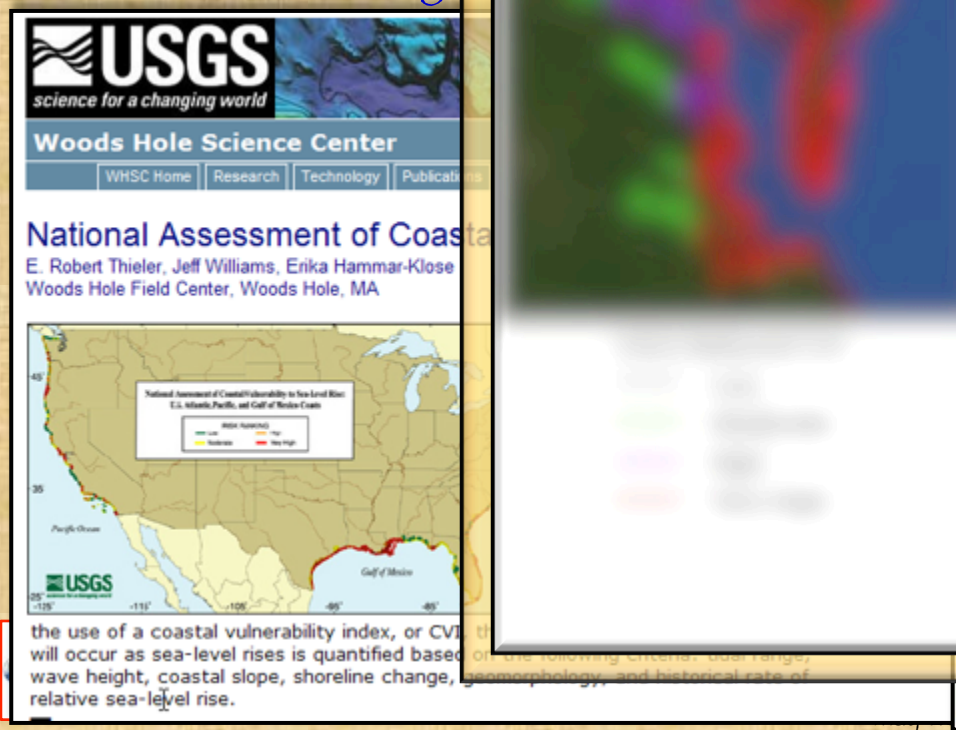
This index is built from spatial & temporal gradients of projected climate change.

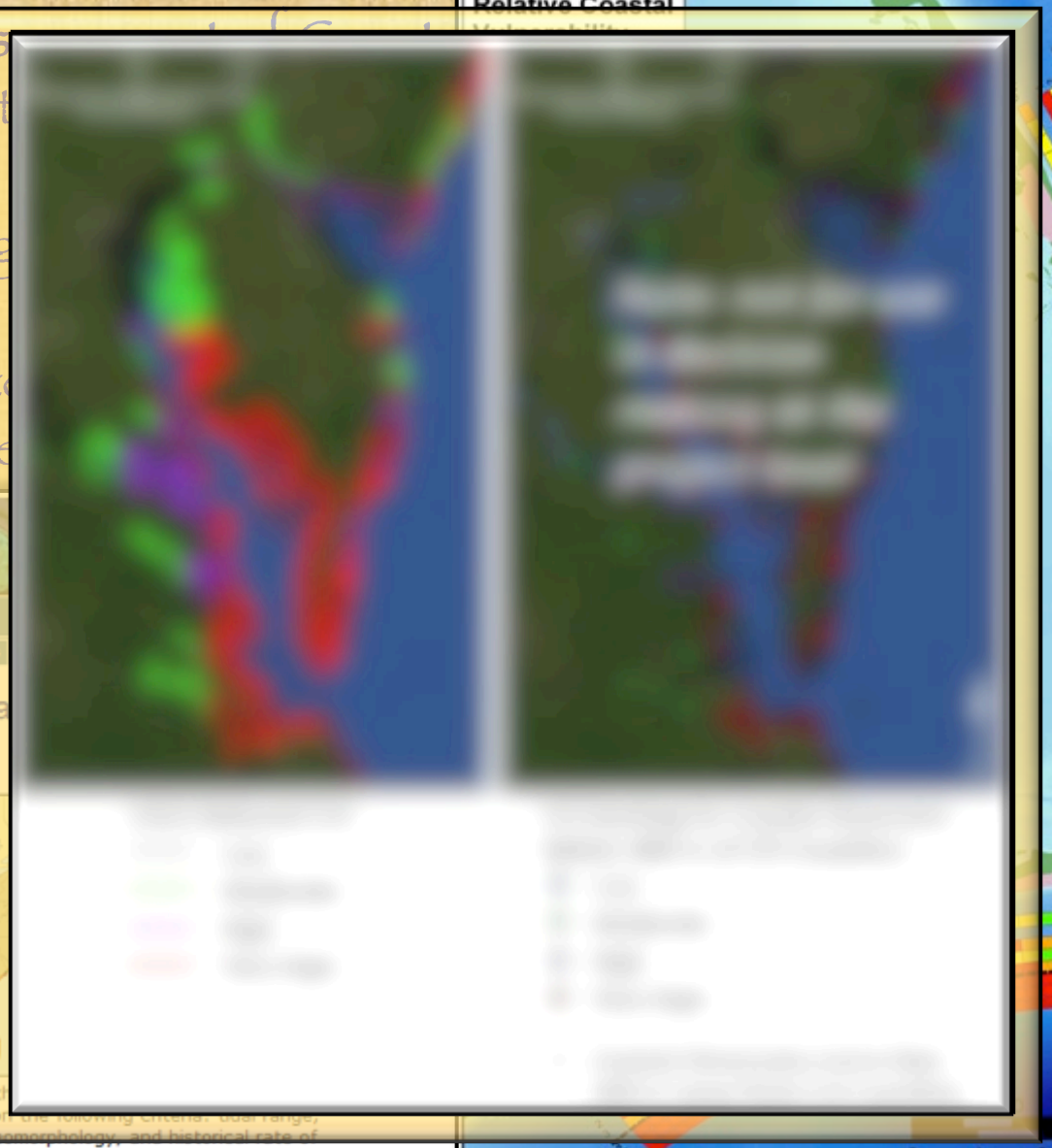


Vulnerability Assessments & Coastal Change

USGS National A
potential for coast

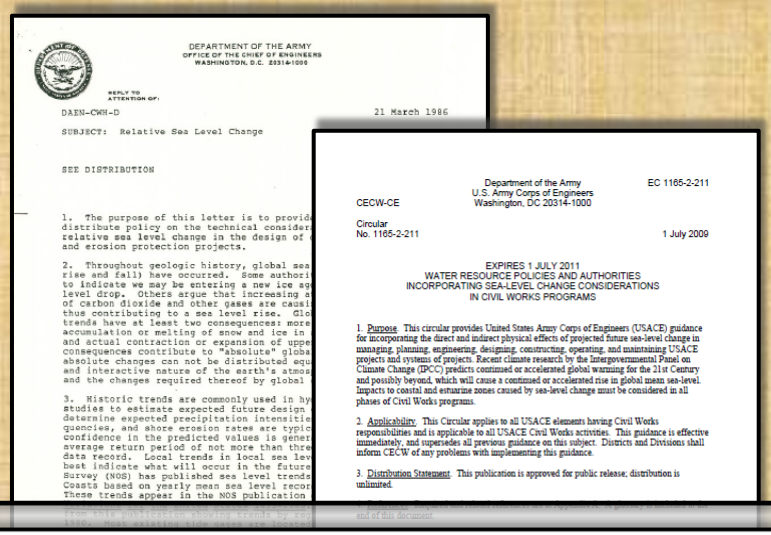
- ✓ Already up
- ✓ Joint upda
tool to analyz





Actionable Science for Sea-level Vulnerabilities

- ✓ 1986: characterize observed trends
- ✓ 2000: USACE planners consider potential for increased global sea-levels
- ✓ 2009: use 3 scenarios developed for USACE *Engineering Circular 1165-2-211*
- ✓ 2011: *EC 1165-2-212* surveys recent science: 0.2m to 1.5m by 2100
- ✓ 2012: adaptation engineering studies continue with applications of the EC guidance for USACE projects potentially vulnerable to sea-level change



DEPARTMENT OF THE ARMY
OFFICE OF THE CHIEF OF ENGINEERS
WASHINGTON, D.C. 20314-1000

DAEN-CWH-D 21 March 1986

SUBJECT: Relative Sea Level Change

SEE DISTRIBUTION

1. The purpose of this letter is to provid
distribute policy on the technical consider
relative sea level change in the design of
and erosion protection projects.

2. Throughout geologic history, global sea
rise and fall) have occurred. Some authori
to indicate we may be entering a new ice ag
level drop. Others argue that increasing a
of carbon dioxide and other gases are caus
thus contributing to a sea level rise. Glo
trends have at least two consequences: more
accumulation or melting of snow and ice in
and actual contraction or expansion of uppe
consequences contribute to "absolute" globa
absolute changes can not be distributed equ
and interactive nature of the earth's atmos
and the changes required thereof by global

3. Historic trends are commonly used in hy
studies to estimate expected future design
determine expected precipitation intensiti
gencies, and shore erosion rates are typic
confidence in the predicted values is gener
average return period of not more than thre
data record. Local trends in local sea lev
best indicate what will occur in the future
Survey (NOS) has published sea level trends
Coasts based on yearly mean sea level recor
These trends appear in the NOS publication

Department of the Army
U.S. Army Corps of Engineers
Washington, DC 20314-1000

CECW-CE

Circular
No. 1165-2-211

EC 1165-2-211

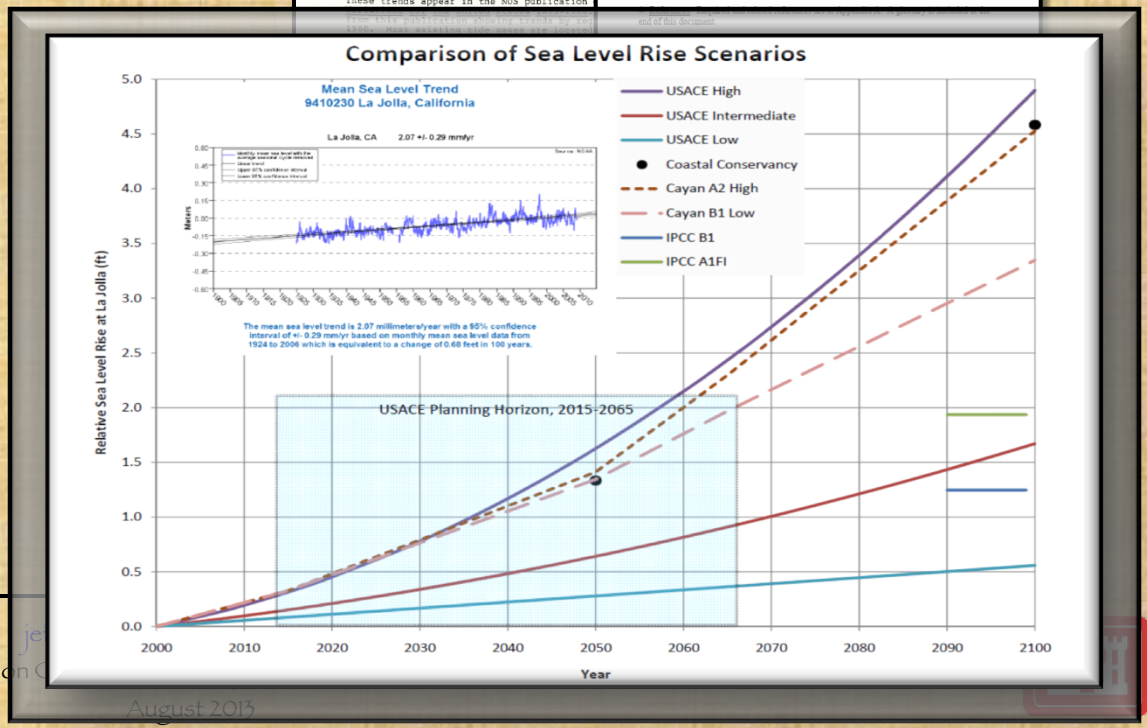
1 July 2009

EXPIRES 1 JULY 2011
WATER RESOURCE POLICIES AND AUTHORITIES
INCORPORATING SEA-LEVEL CHANGE CONSIDERATIONS
IN CIVIL WORKS PROGRAMS

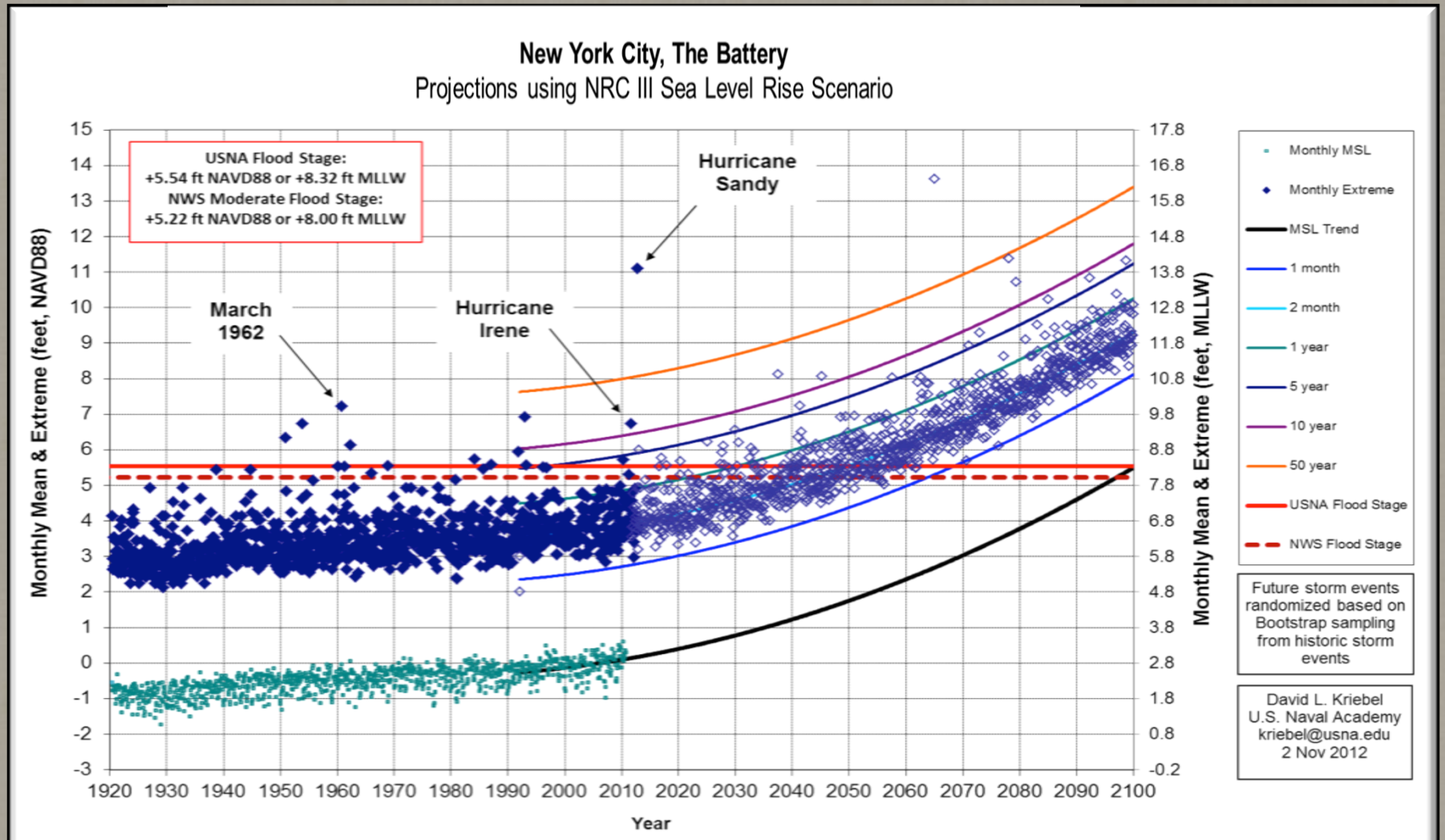
1. Purpose. This circular provides United States Army Corps of Engineers (USACE) guidance for incorporating the direct and indirect physical effects of projected future sea-level change in managing, planning, engineering, designing, constructing, operating, and maintaining USACE projects and systems of projects. Recent climate research by the Intergovernmental Panel on Climate Change (IPCC) predicts continued or accelerated global warming for the 21st Century and possibly beyond, which will cause a continued or accelerated rise in global mean sea-level. Impacts to coastal and estuarine zones caused by sea-level change must be considered in all phases of Civil Works programs.

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 previous guidance on this subject. Districts and Divisions shall inform CECW of any problems with implementing this guidance.

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

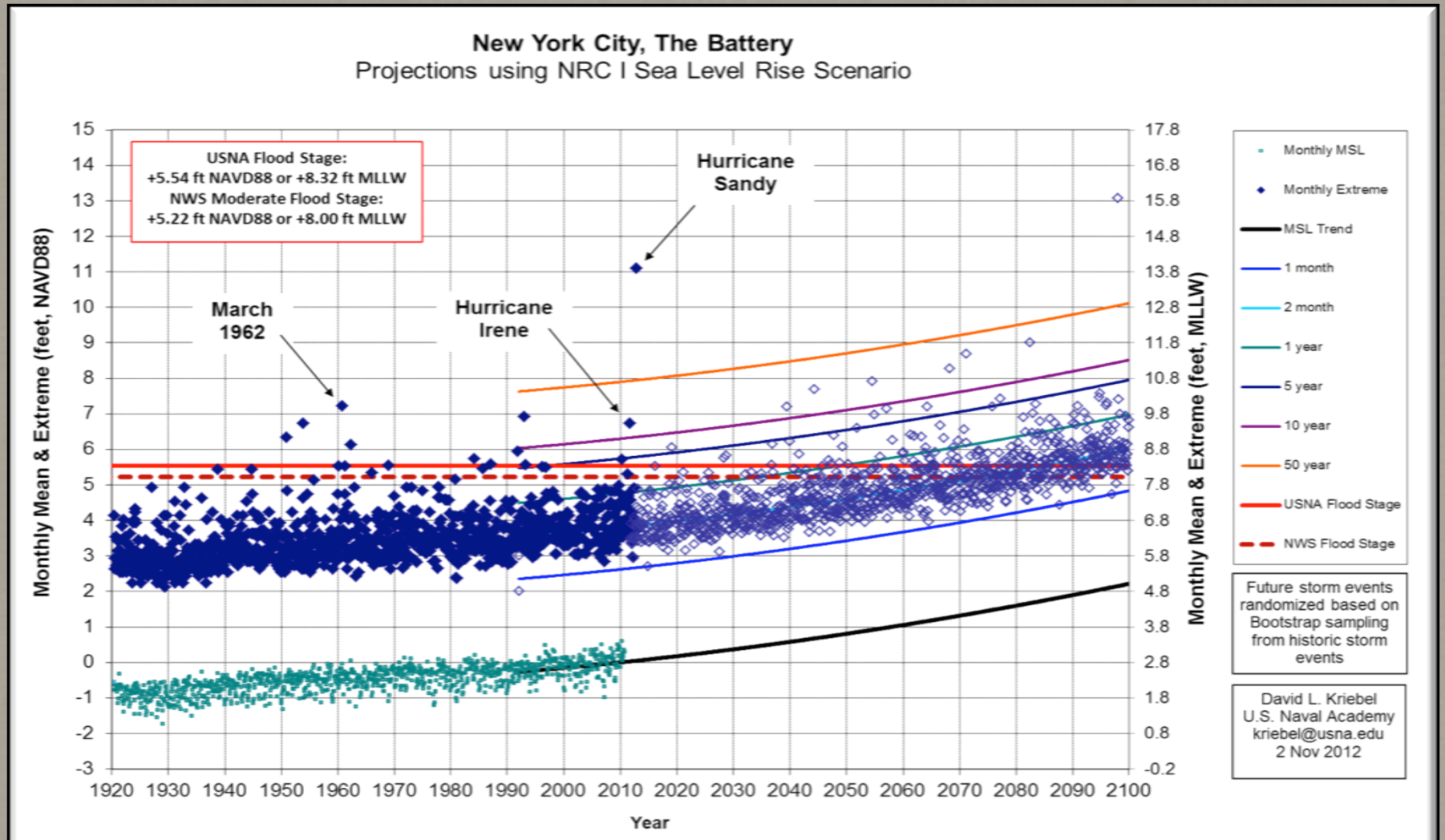


Actionable Science for Coastal Applications: Storms Adding to Sea-level Change



slide courtesy Dave Kriebel, USNA

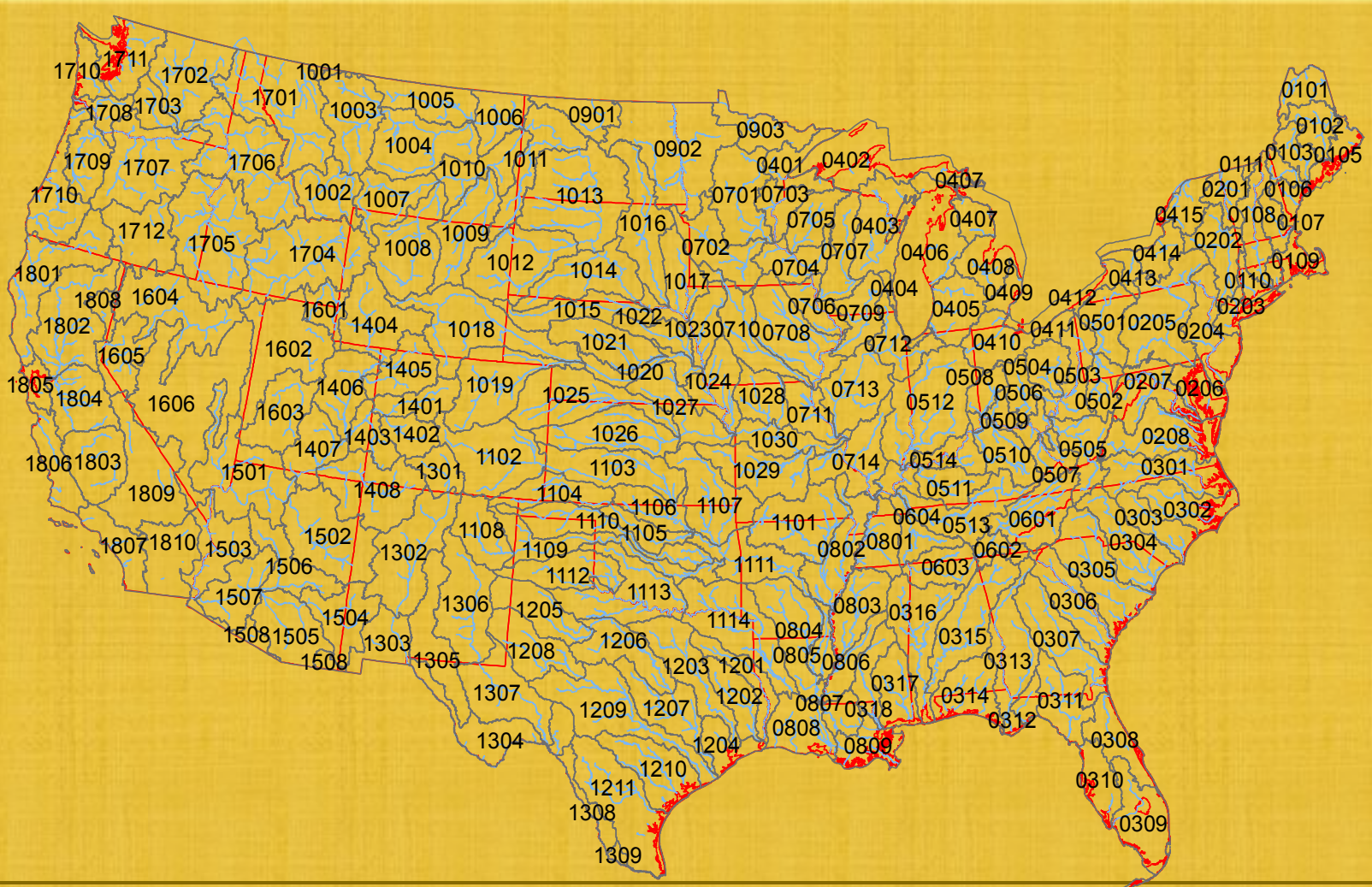
Actionable Science for Coastal Applications: Storms Adding to Sea-level Change *(cont'd)*



slide courtesy Dave Kriebel, USNA

What about Inland Hydrology?

USGS HUC-4s *in the CONUS*



USACE Vulnerability Assessment Indicators

What's at Risk? What're the Threats? How're those Indicated?

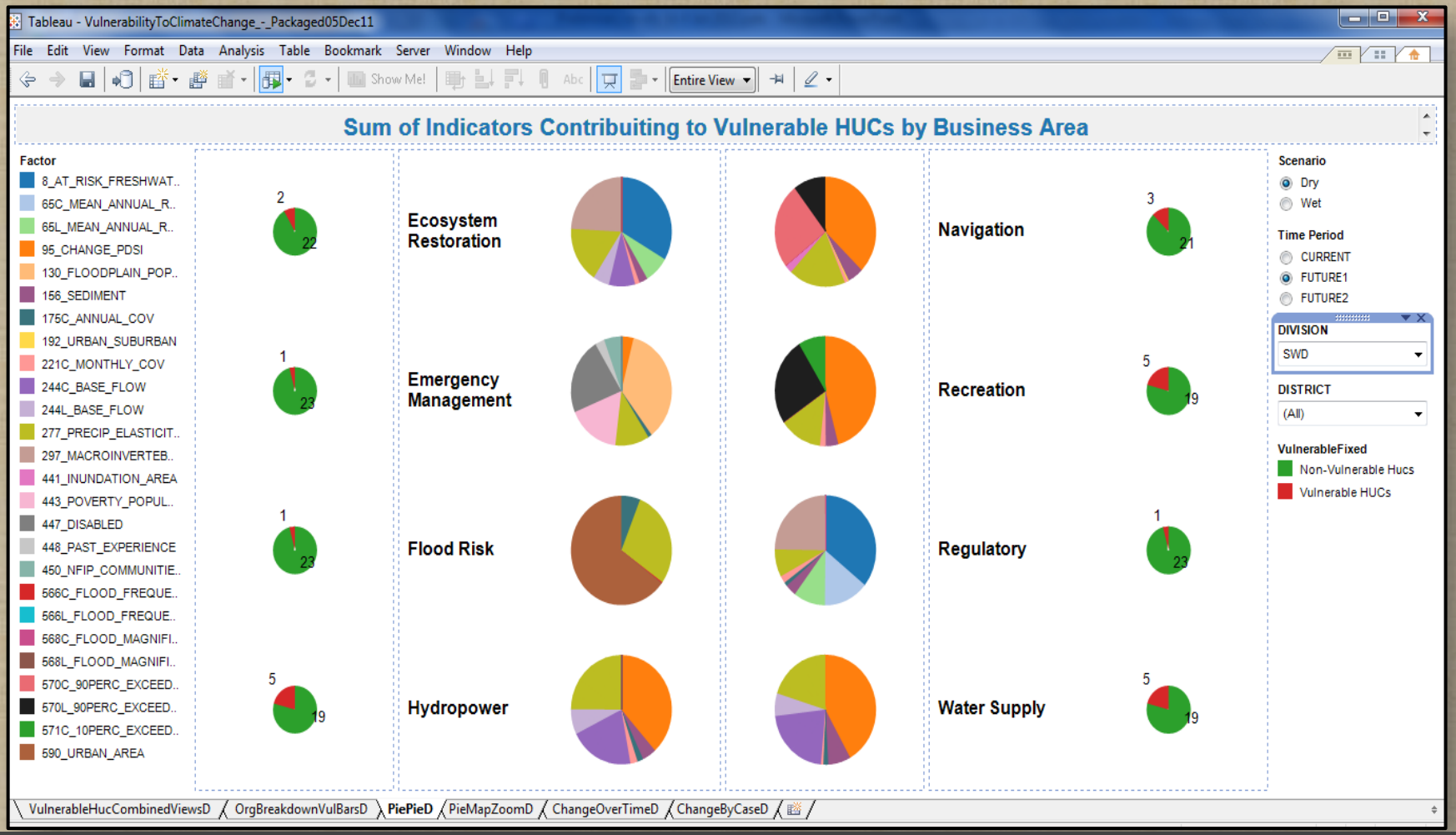
Threat to the Quantity or Reliability of Power Production	Some Example Indicators, Both Magnitude & Change
Peak Q & Sediment Load	CV of Annual Unregulated Streamflow (cumulative & local) Annual Streamflow Variability Streamflow & Sediment Load Elasticities Peak Flow *… others …*
Min Q & Sediment Load	*… as above and …* Baseflow (cumulative & local) Drought Events & Severity Matrix of Drought Indices
Q & Sediment Load Timing	*… as above and …* Storage Reservoir to Mean Annual Flow Ratio Date of Highest Springtime Streamflow
Change	Flood Magnification or Reduction Factor (cumulative & local) Wetlands Migration Potential Ecosystem Thermal Regime *… others …*

Other Common Indicators
Ecosystem Services Ratings
Biodiversity Indices
Freshwater Plant & Macroinvertebrate Communities at Risk
Urban & Suburban Area
Population Distributions
NFIP Communities
Low Flow (exceeded >90%)
Flood Flow (exceeded <10%)

593 indicators at the start; reduced to 68 for all USACE missions – hydropower has 19; reduced again & combined to 29 for inland hydrology + 3 coastal for the final scores

Vulnerability Indicators for All USACE Missions

100 CMIP5 Model Runs, All Scenarios, 50 "Driest" 2050 Vulnerabilities

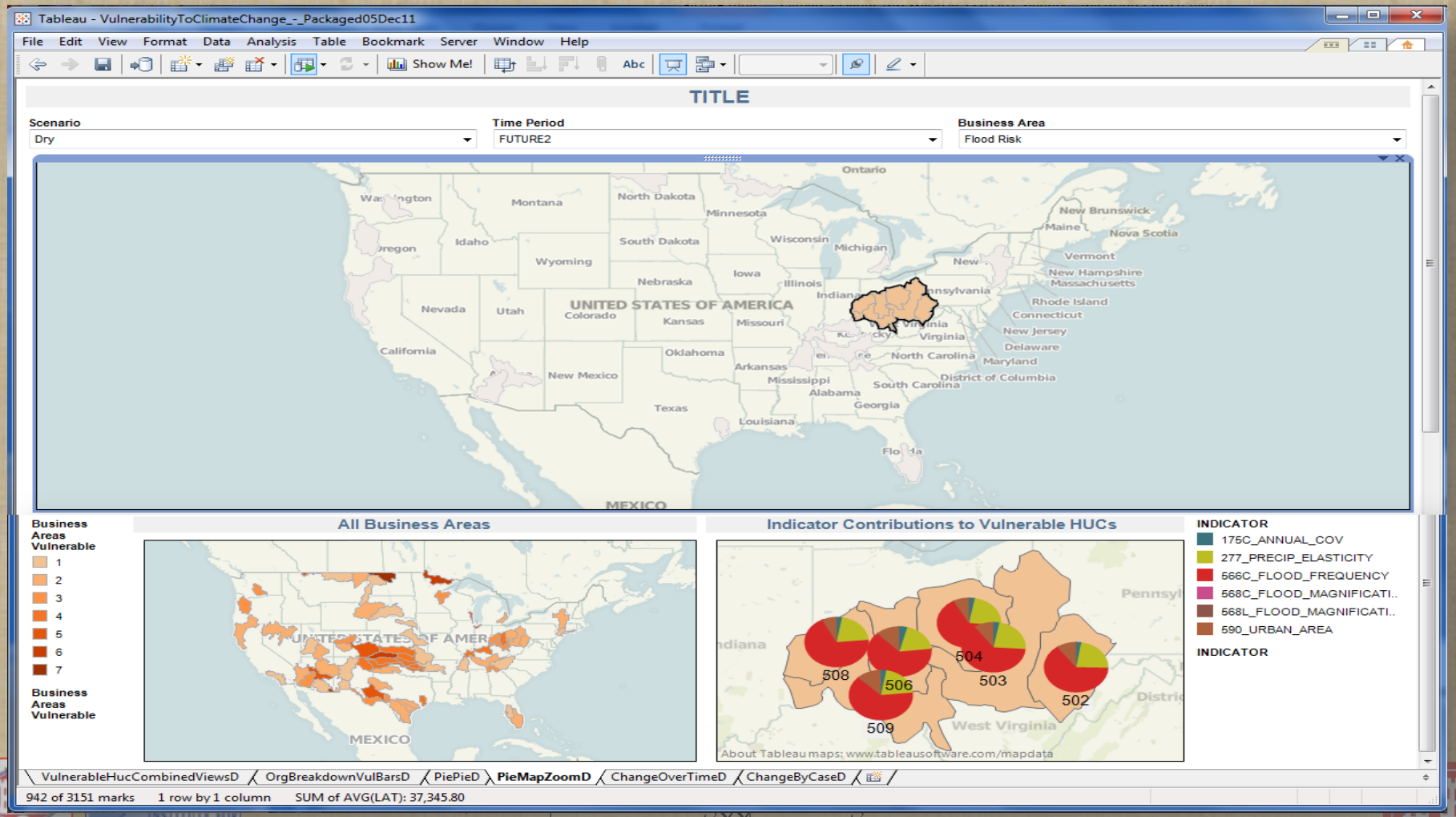


jeffrey.r.arnold@usace.army.mil

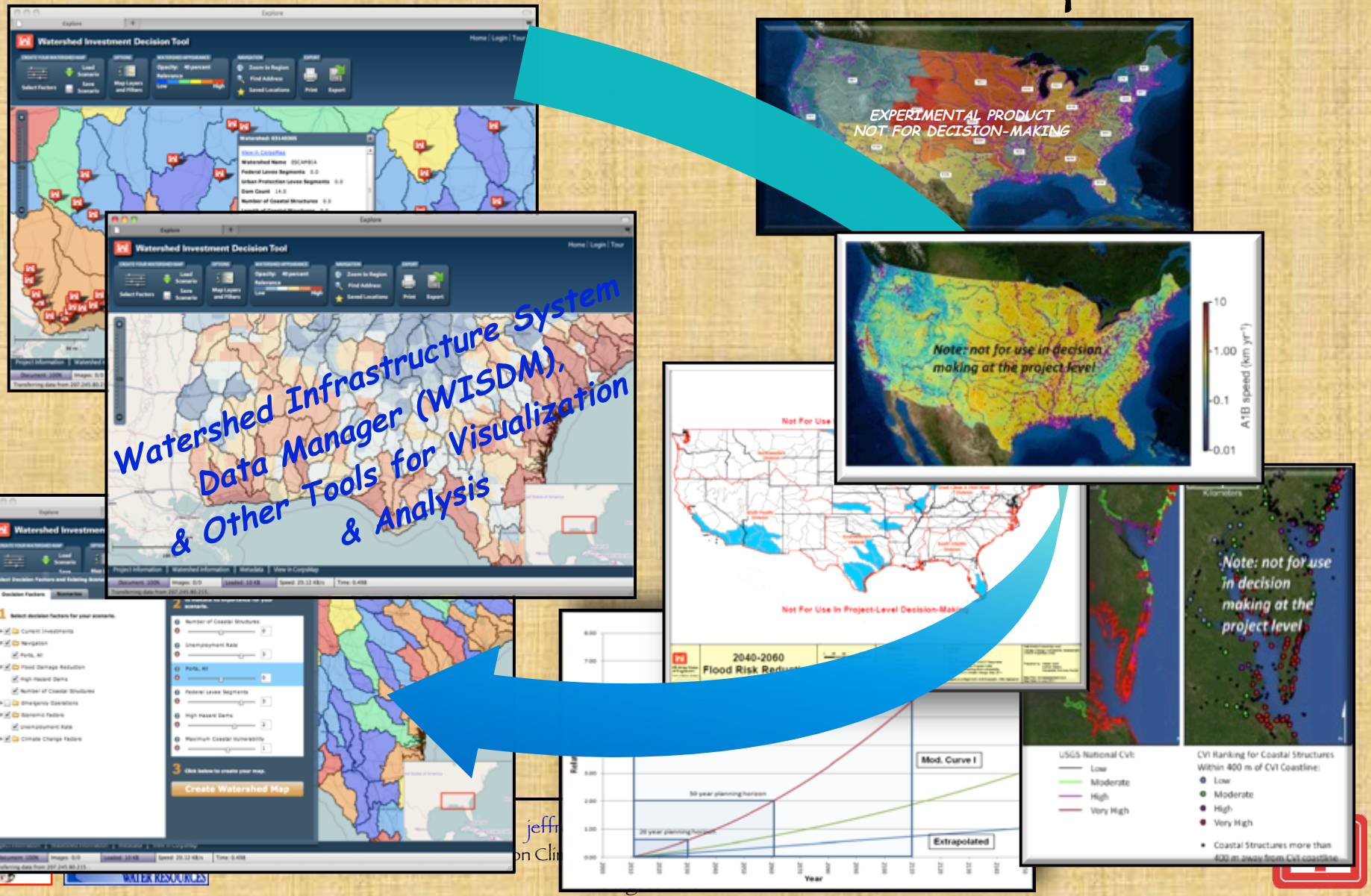
Vulnerability Assessment for USACE Flood Risk

HUC-4 Basins with 10% Lowest Q Values

100 CMIP5 Model Runs, All Scenarios, 50 "Driest" 2085 Vulnerabilities



Integrated Analysis of Climate & Global Change Vulnerabilities & Possible USACE Responses



Let's Not Wait!

photo courtesy K. Dixon, NOAA GFDL

Thanks for your invitation & interest

[jeffrey.r.arnold@usace.army.mil]