WICCI Infrastructure Working Group Issues related to Planning

APA – WI 2022 Annual Meeting

Rob Montgomery

Maria Hart, Bu Wang, Daniel Wright

WISCONSIN INITIATIVE ON CLIMATE CHANGE IMPACTS
INFRASTRUCTURE WORKING GROUP

Infrastructure Working Group

- Assembled in 2019, new working group to contribute to the 2021 Assessment Report update
- Rob Montgomery, Dan Wright, Maria Hart, Bu Wang cochairs
- Several work products, subcommittees, work ongoing
- WG Report, publications at https://wicci.wisc.edu/infrastructure-working-group/

Some observations on Infrastructure:

- **It lasts a long time**
- **Service life typically 75 to 100 years or more**
- **Civil Engineering Infrastructure built now will serve most of its service life under substantially different climate conditions than exist at present**
- **Professional standards will evolve to require clear evaluation of climate risks in engineering planning and design**

A few definitions (Sorry)

- **Sustainability:** a set of economic, environmental, and social conditions (aka "The Triple Bottom Line") in which all of society has the capacity and opportunity to maintain and improve its quality of life indefinitely without degrading the quantity, quality, or the availability of economic, environmental, and social resources. ASCE Policy Statement 418

- **Resilience:** the ability of a system to maintain required function and safety under extreme conditions based on evaluation of exposure, sensitivity, interdependence and adaptive capacity

Sorry Again!

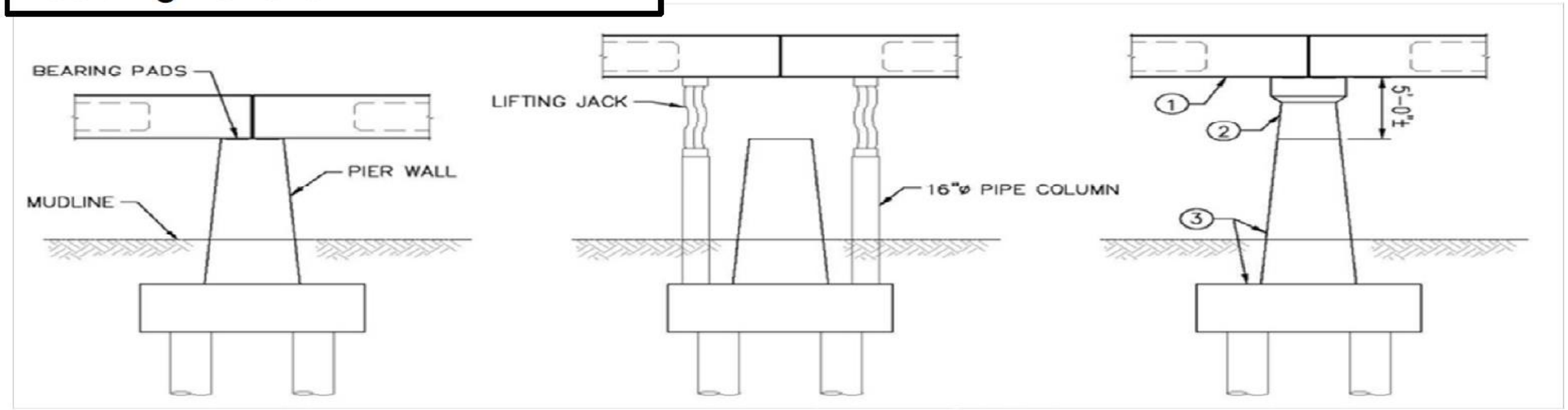
- **Climate Change Adaptation:** adapting to life in a changing climate – involves adjusting designs to meet requirements of current actual or expected future climate.

- **Mitigation:** reducing climate change – involves changing project materials or use to reduce Greenhouse Gas Emissions

Example: LOSSAN Adaptive Design

Los Angeles to San Diego (LOSSAN) Rail Corridor follows the sea coast and crosses low-lying areas on trestles

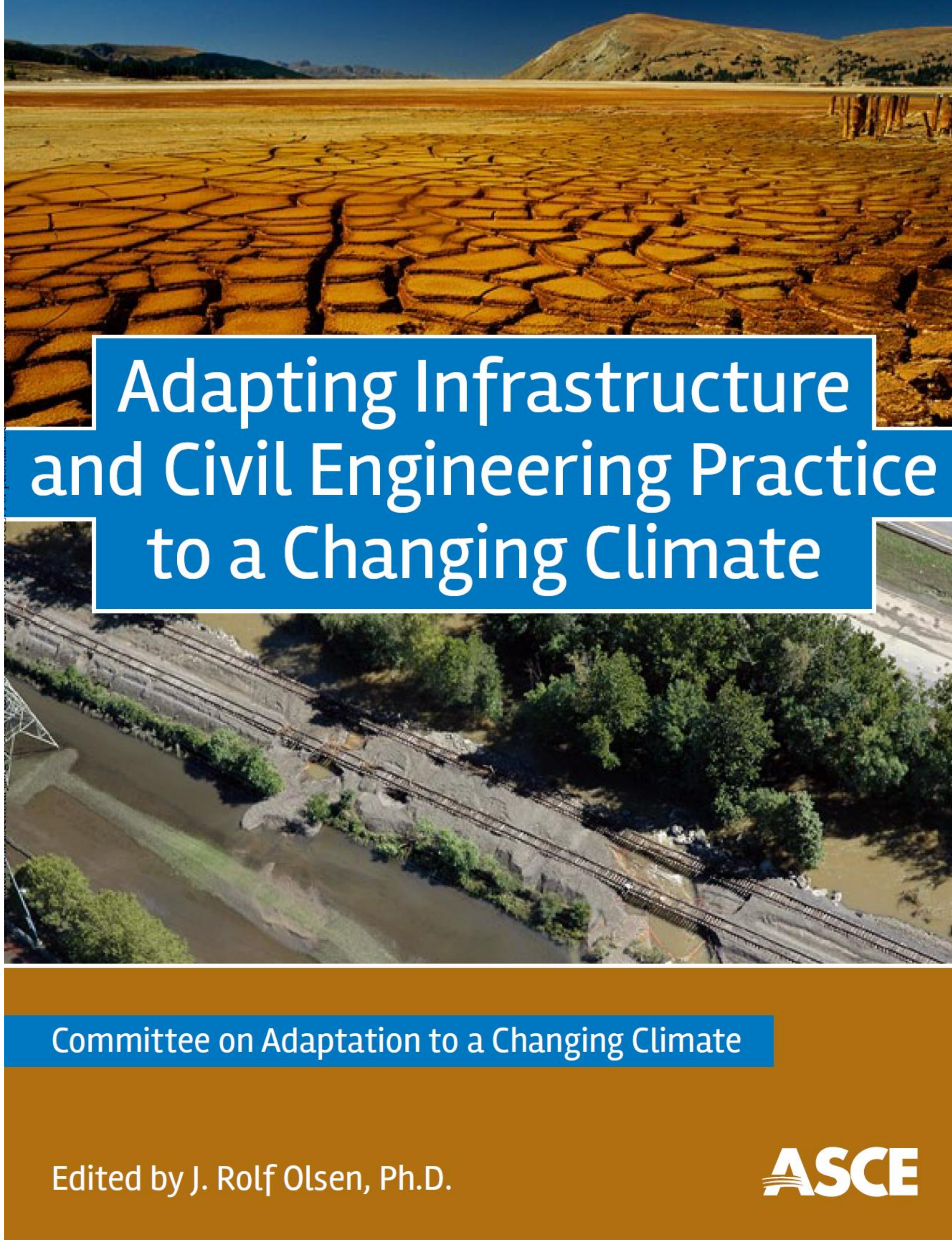
Uses precast piers and caps to allow insertion of additional pier segments if needed to adapt to flooding hazard

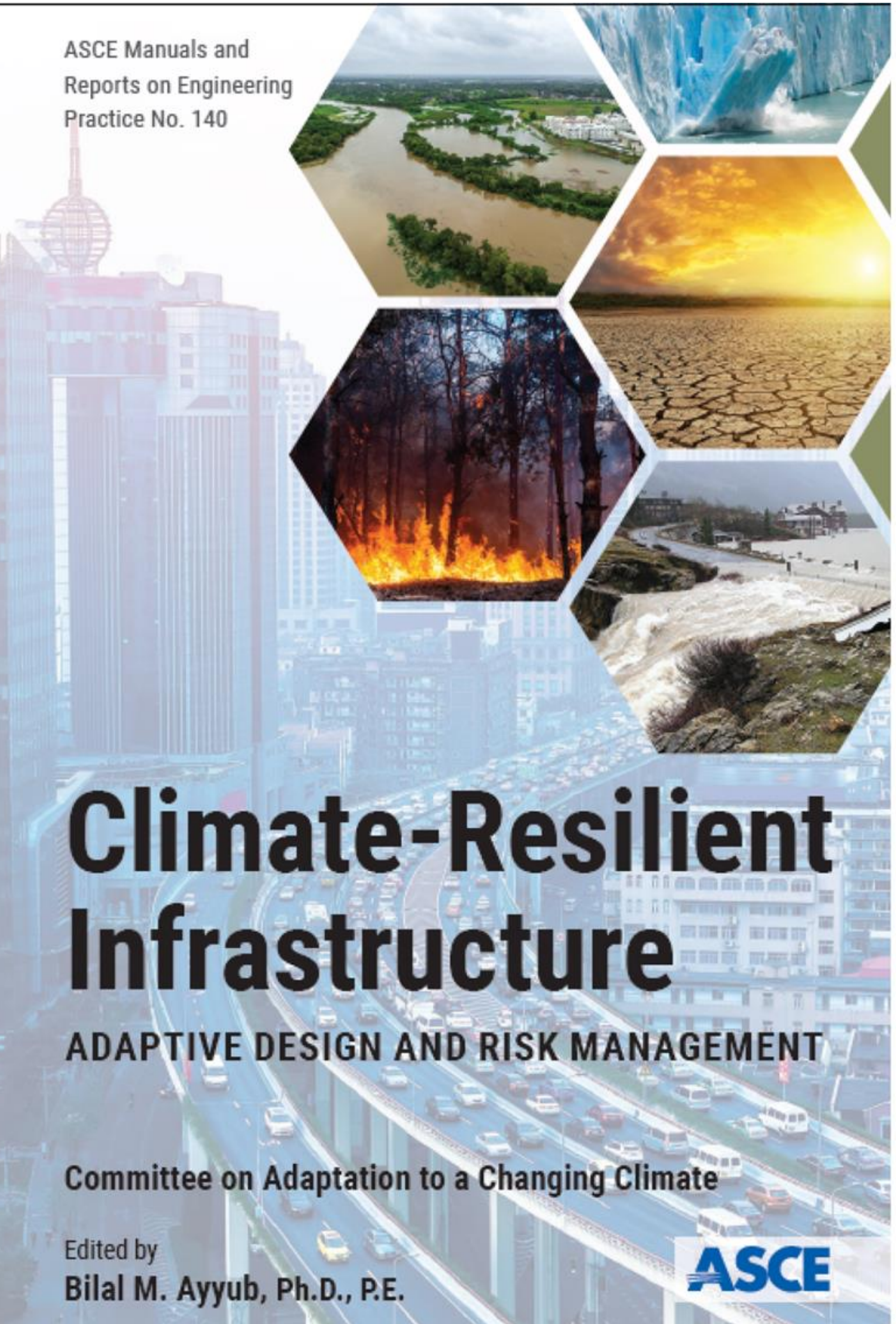


Dial, R., Smith, B., and Rosca, Jr., G., "Evaluating Sustainability and Resilience in Infrastructure: Envision™, SANDAG and the LOSSAN Rail Corridor," Proceedings of the 2014 International Conference on Sustainable Infrastructure, American Society of Civil Engineers, pp 164-174. ISBN 978-0-7844-4

Techniques for Engineering Design under Climate Change are evolving rapidly

2015

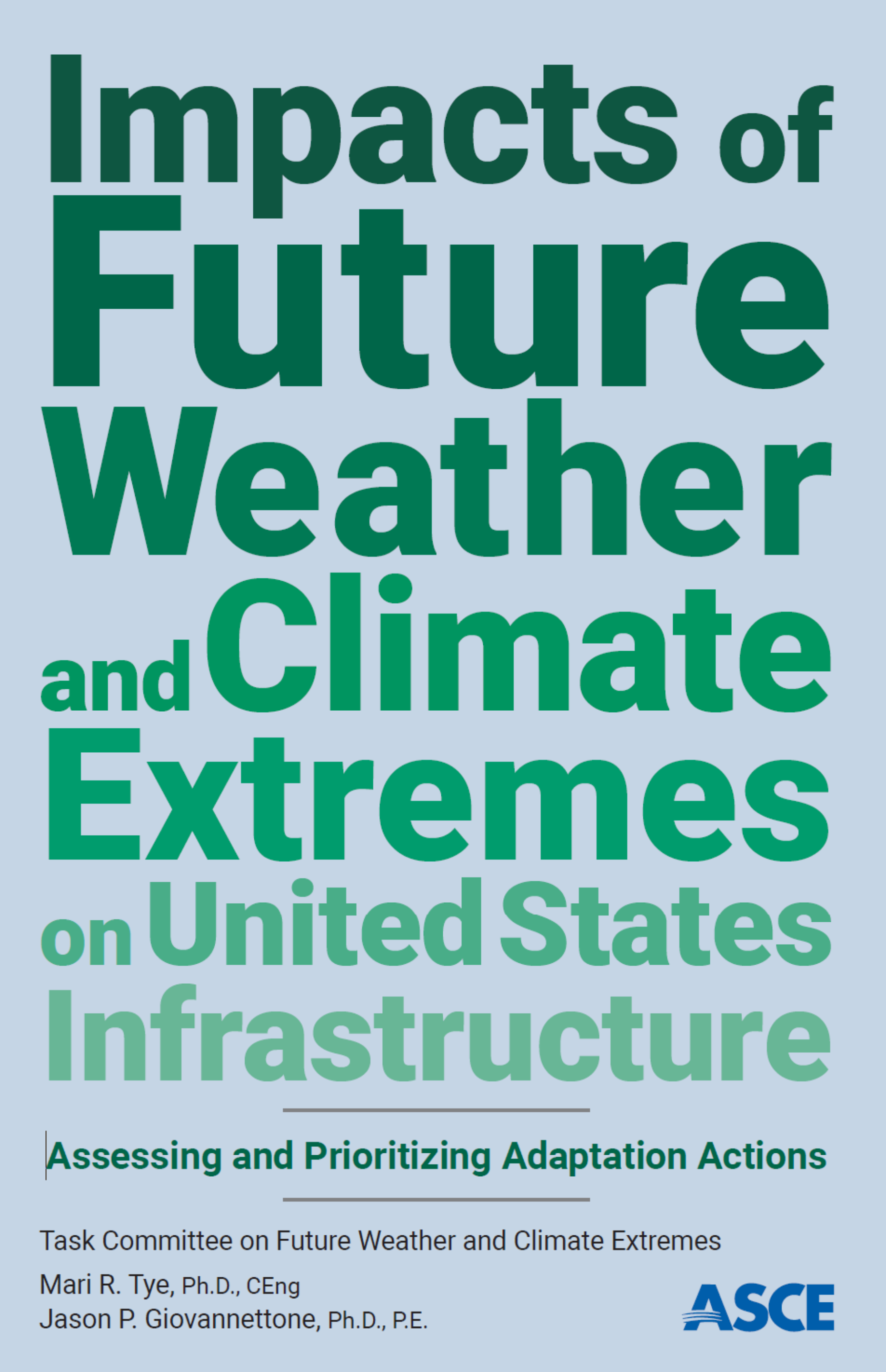




ASCE Manuals and Reports on Engineering Practice No. 140
Climate-Resilient Infrastructure
ADAPTIVE DESIGN AND RISK MANAGEMENT
Committee on Adaptation to a Changing Climate
Edited by
Bilal M. Ayyub, Ph.D., P.E.
ASCE

2018

2021



Impacts of Future Weather and Climate Extremes on United States Infrastructure
Assessing and Prioritizing Adaptation Actions
Task Committee on Future Weather and Climate Extremes
Mari R. Tye, Ph.D., CEng
Jason P. Giovannettone, Ph.D., P.E.
ASCE

What has the WICCI IWG been doing?

Wisconsin Infrastructure & Climate Change Survey 2020

A Report on the State of Practice

December 2020

Maria Viteri Hart
Emma Cutler

- Discover the state of practice
- Identify topics that would be valuable for the infrastructure working group to work on
- Document findings

Infrastructure Working Group
Wisconsin Initiative on Climate Change Impacts
Nelson Institute for Environmental Studies | Wisconsin Department of Natural Resources

Survey Response

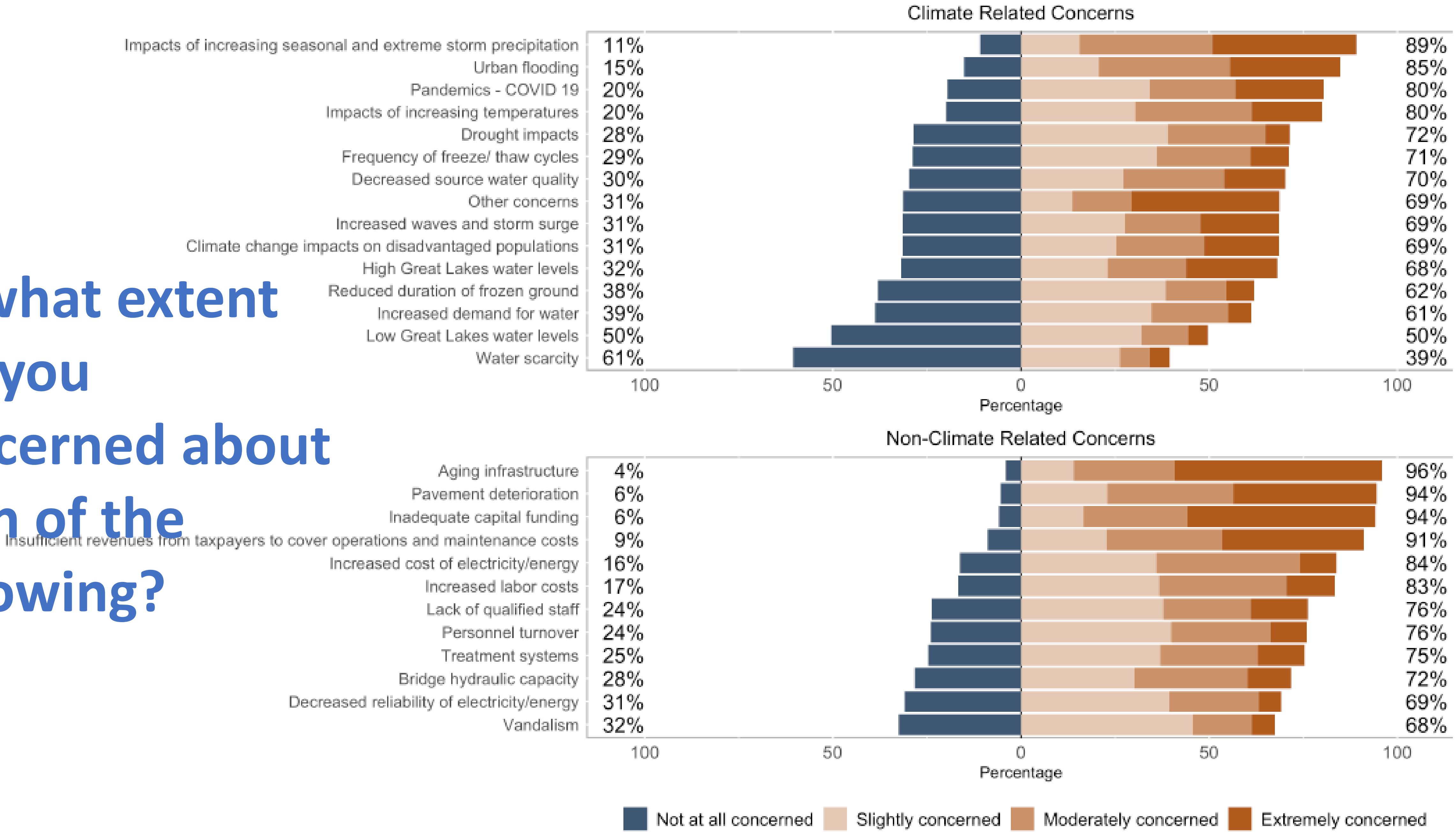
FIGURE 1. Wisconsin Climatic Divisions

Source: http://glisa.umich.edu/resources/great-lakes-climate-divisions

TABLE 3. Respondents by Climatic Division and Years of Experience

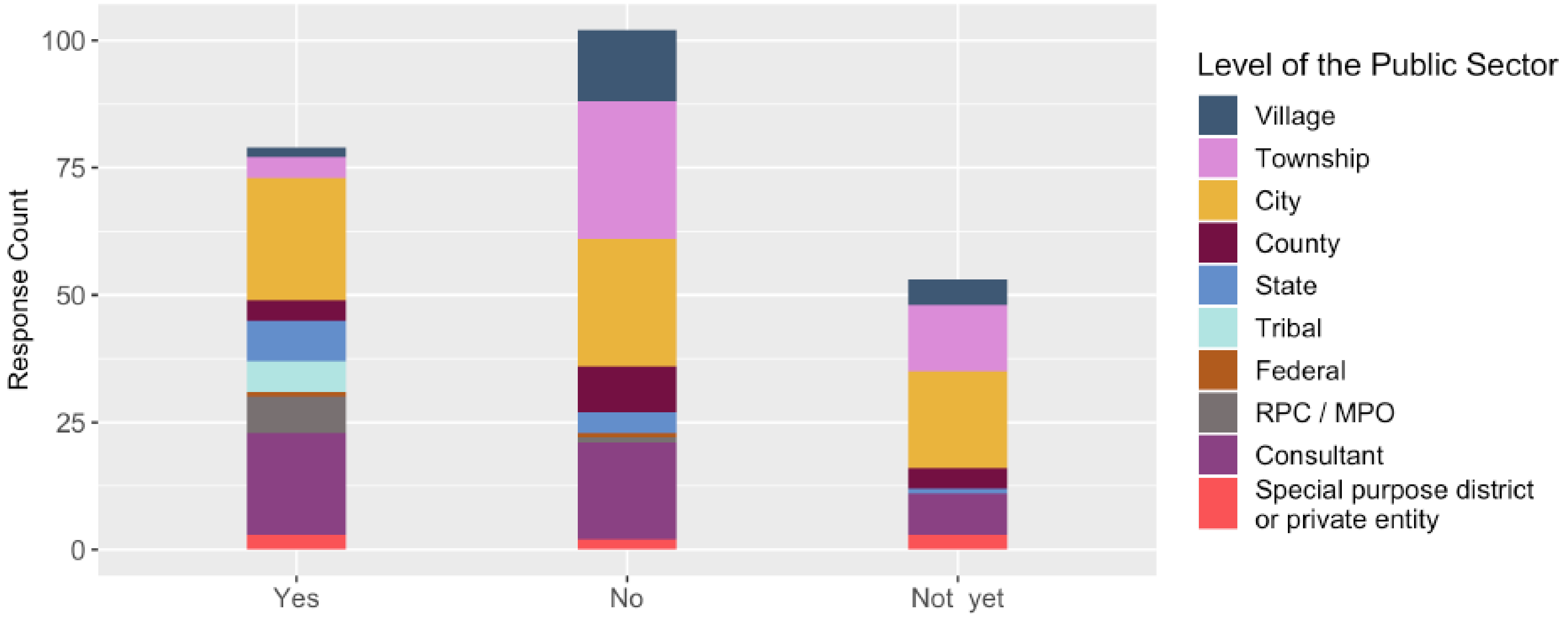
	Less than 5 Years	5-10 Years	11-20 Years	Over 20 Years	Not Specified	Total
Northwest	1	2	2	2	–	7
North Central	5	3	5	7	–	20
Northeastern	2	1	0	1	–	4
East Central	3	7	16	7	–	33
Central	0	2	2	1	–	5
West Central	5	0	4	8	–	17
Southwest	2	6	2	4	–	14
South Central	9	6	12	19	–	46
Southeastern	8	8	9	17	–	42
Not Specified	1	0	0	1	44	46
Total	36	35	52	67	44	234

To what extent are you concerned about each of the following?



What’s in a word? Depends on the word.

FIGURE 7. Does your organization, agency, or municipality use the words “climate change” in your plans, strategies, or actions?



Survey Respondents priorities for the IWG

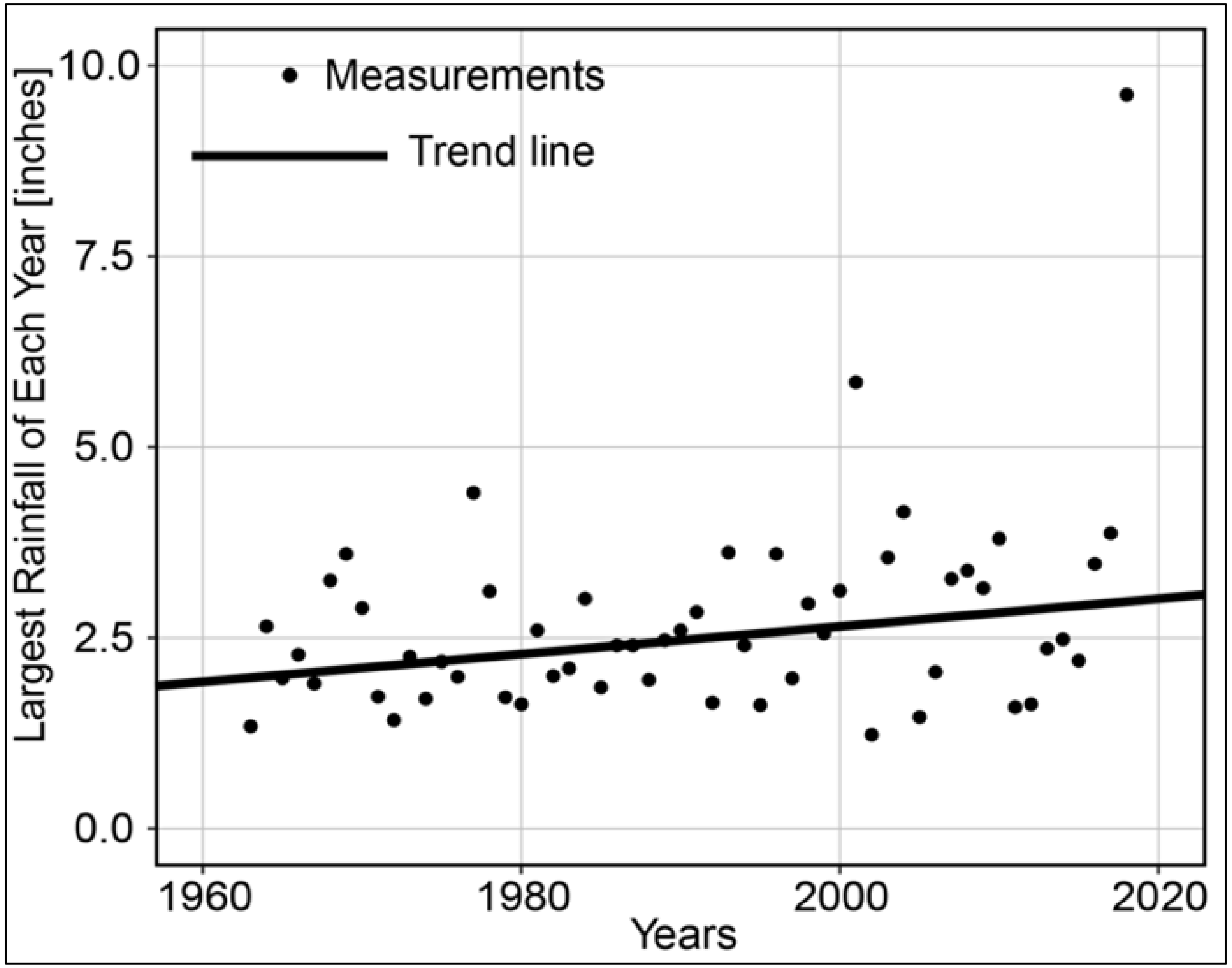
- Develop technical data
- Describe the benefit of nature-based solutions and Green Infrastructure
- Providing guidance on design approaches
- Work to create a policy framework and standards

Top IWG Priority: Updated Current Conditions and Future Rainfall Statistics

Observation: Rainfall intensity has been increasing for decades

Project Objectives:

1. Develop rainfall statistics (IDF data) for current conditions using up-to-date station data and new techniques
2. Estimate rainfall statistics for future conditions based on climate model results
3. Provide Results in Web Portal

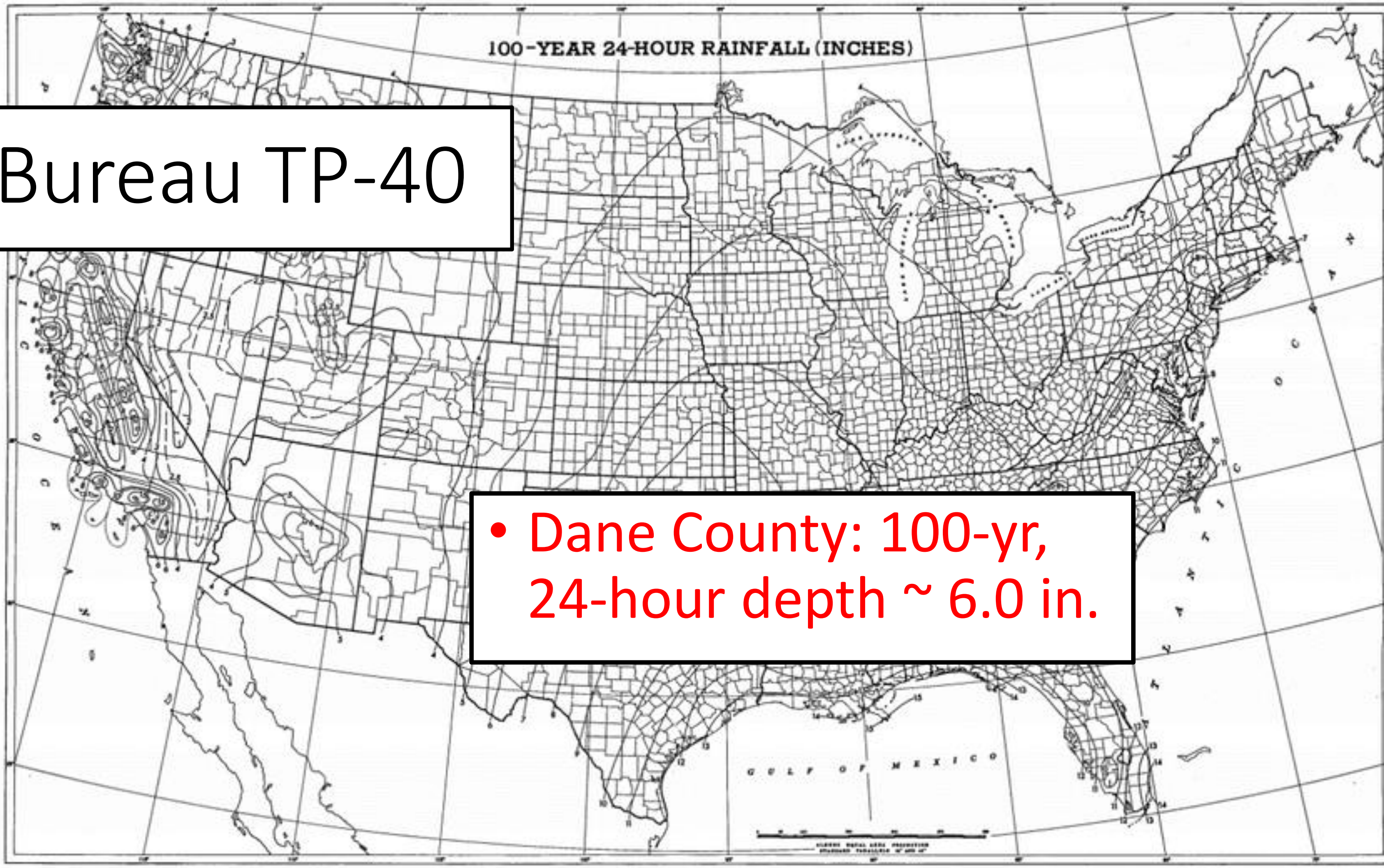


RAINFALL FREQUENCY ATLAS OF THE UNITED STATES
for Durations from 30 Minutes to 24 Hours and Return Periods from 1 to 100 Years

DAVID M. HERSHFIELD

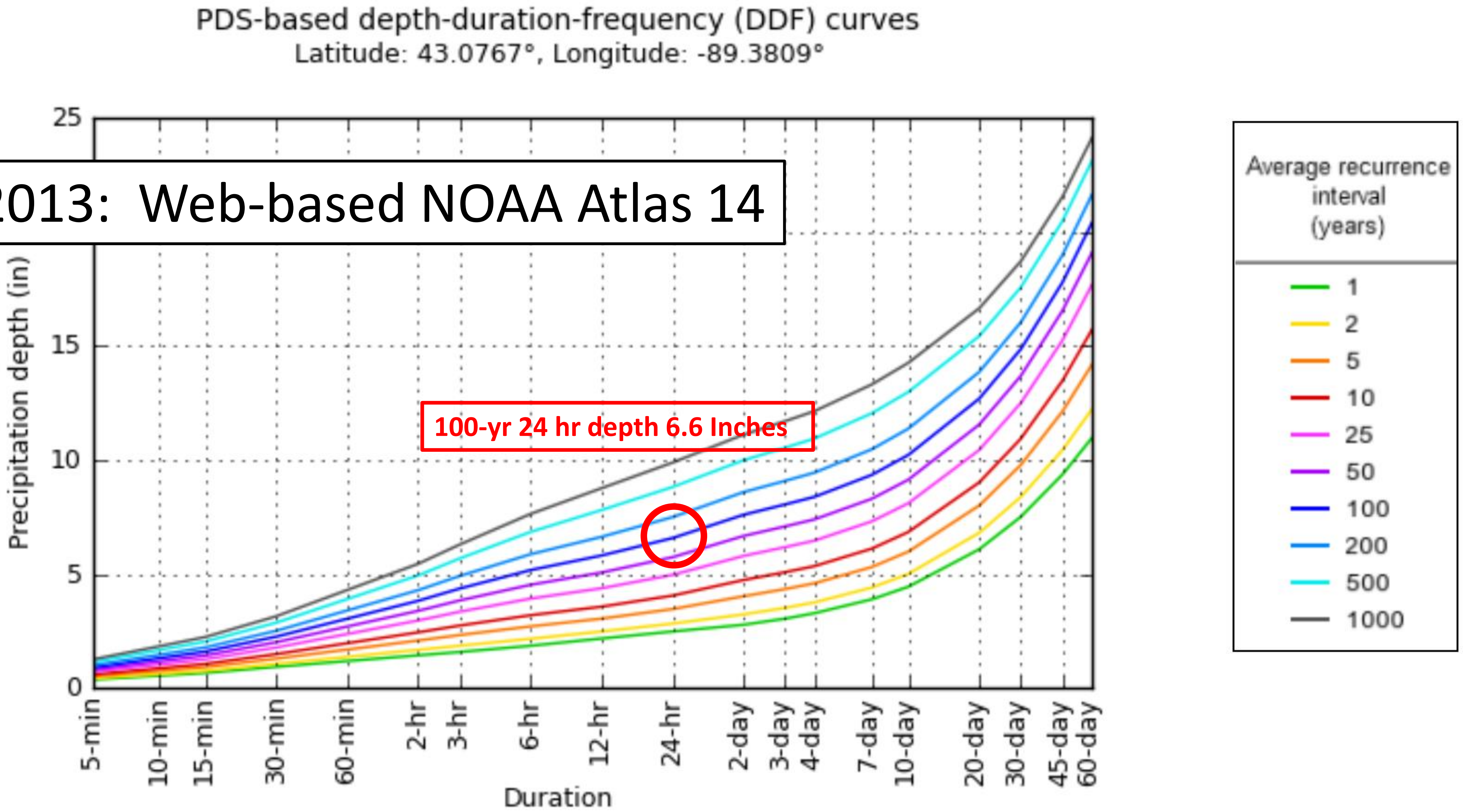
Cooperative Studies Section, U.S. Weather Bureau, Washington, D.C.

1961: US Weather Bureau TP-40



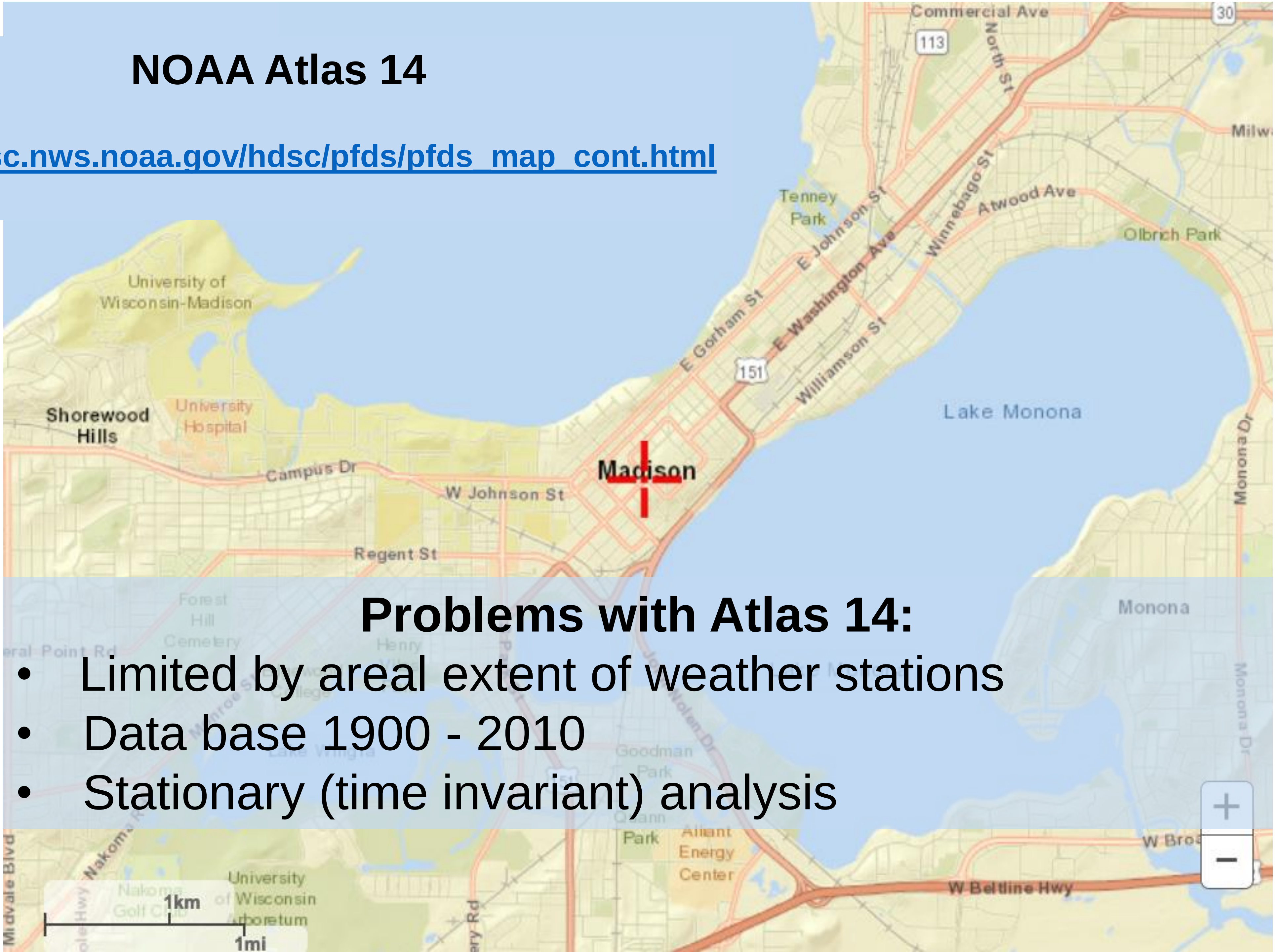
- Dane County: 100-yr, 24-hour depth ~ 6.0 in.

2013: Web-based NOAA Atlas 14



NOAA Atlas 14

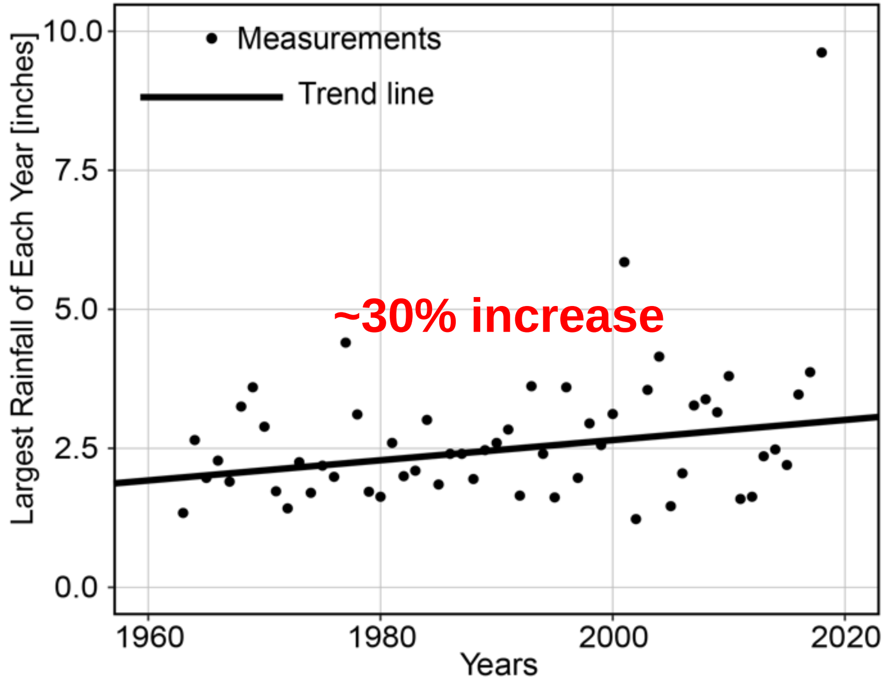
https://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html

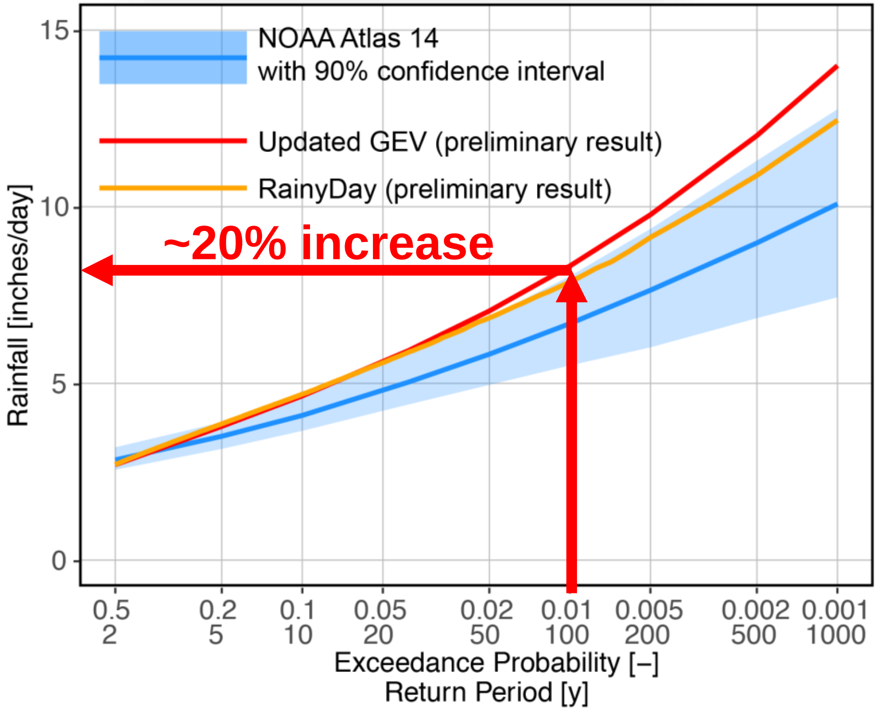


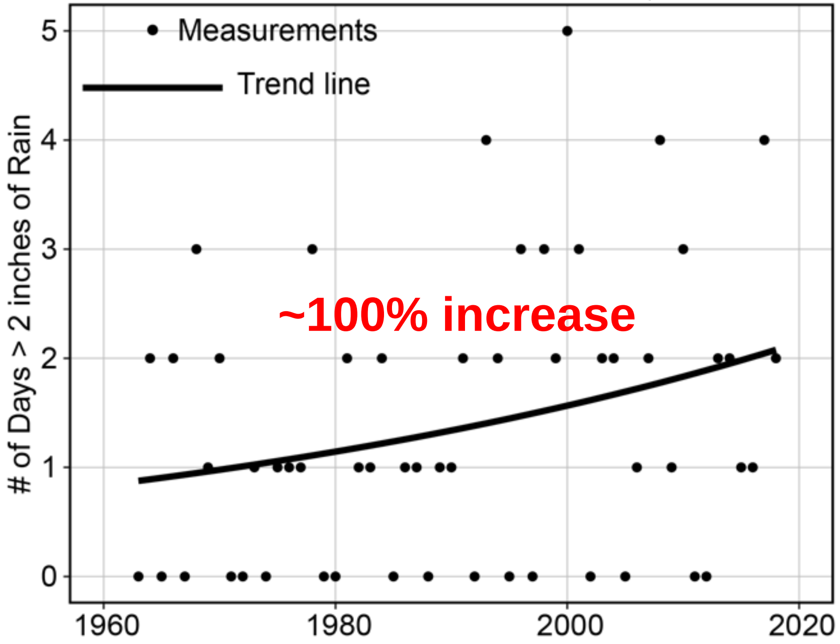
Problems with Atlas 14:

- Limited by areal extent of weather stations
- Data base 1900 - 2010
- Stationary (time invariant) analysis

Rainfall is changing fast!

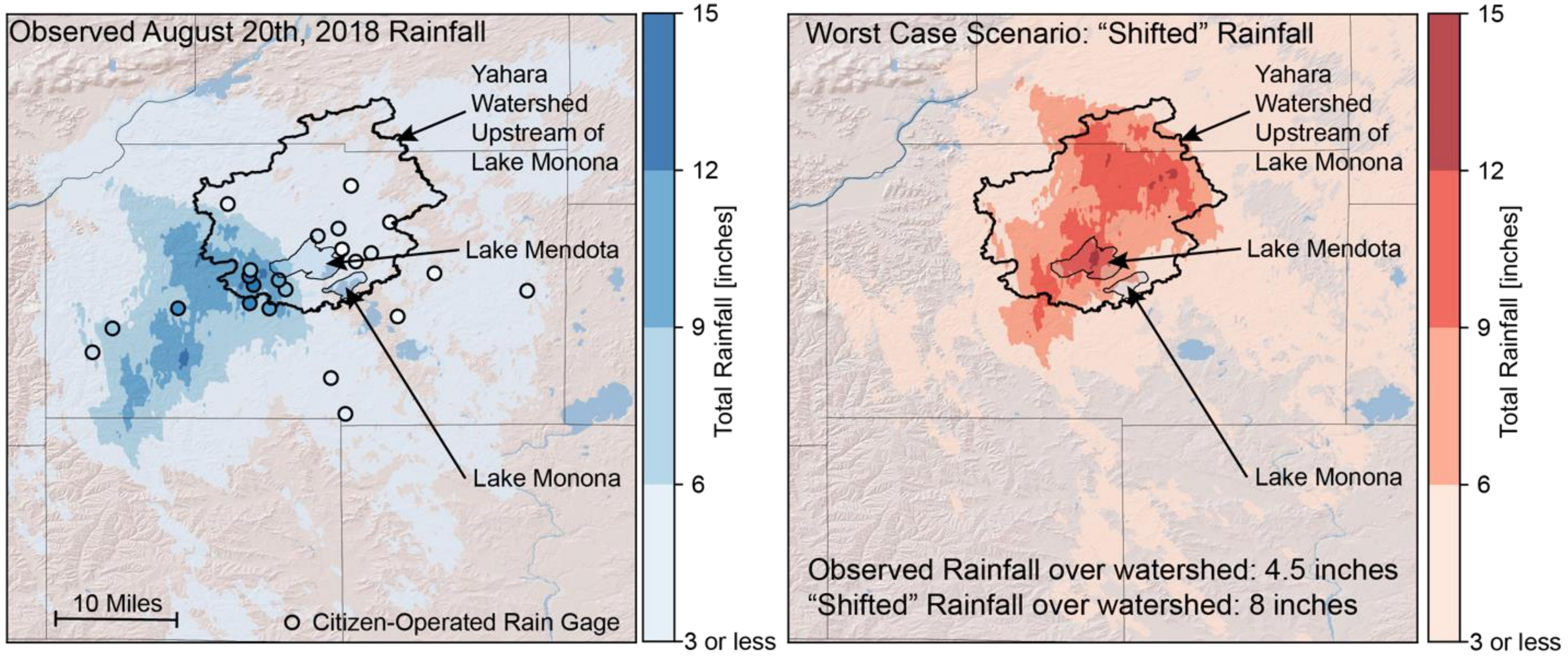






RainyDay (by Dan Wright) uses radar precip data to better estimate current rainfall statistics

Uses the concept of Storm Transposition



Summary of IDF Data for current conditions from RainyDay

- County-level rainfall Intensity–Duration–Frequency (IDF) statistics and uncertainties for 3, 6, 12, 24, and 48-hour as well as 4-day and 10-day durations based on gage-corrected National Weather Service radar rainfall observations from 2002-2019 (19 years)
- Recurrence Intervals: 2, 5, 10, 25, 50, 100, 200 500, and 1,000 years
- Direct comparisons with NOAA Atlas 14 results (available here)
- Uncertainty estimates—in the form of 90% confidence intervals—for all estimates

Task 2: Future Rainfall Statistics

Recent NOAA-funded project:

water

MDPI

Article

A Comparative Analysis of the Historical Accuracy of the Point Precipitation Frequency Estimates of Four Data Sets and Their Projections for the Northeastern United States

Shu Wu [1,*], Momcilo Markus [2], David Lorenz [1], James R. Angel [2] and Kevin Grady [2]

[1] Nelson Institute Center for Climatic Research, University of Wisconsin–Madison, Madison, WI 53706, USA; david.lorenz@wisc.edu

[2] Prairie Research Institute, Univ. of Illinois at Urbana-Champaign, Champaign, IL 61801, USA; mmarkus@illinois.edu (M.M.); jimangel@illinois.edu (J.R.A.); kagrady2@illinois.edu (K.G.)

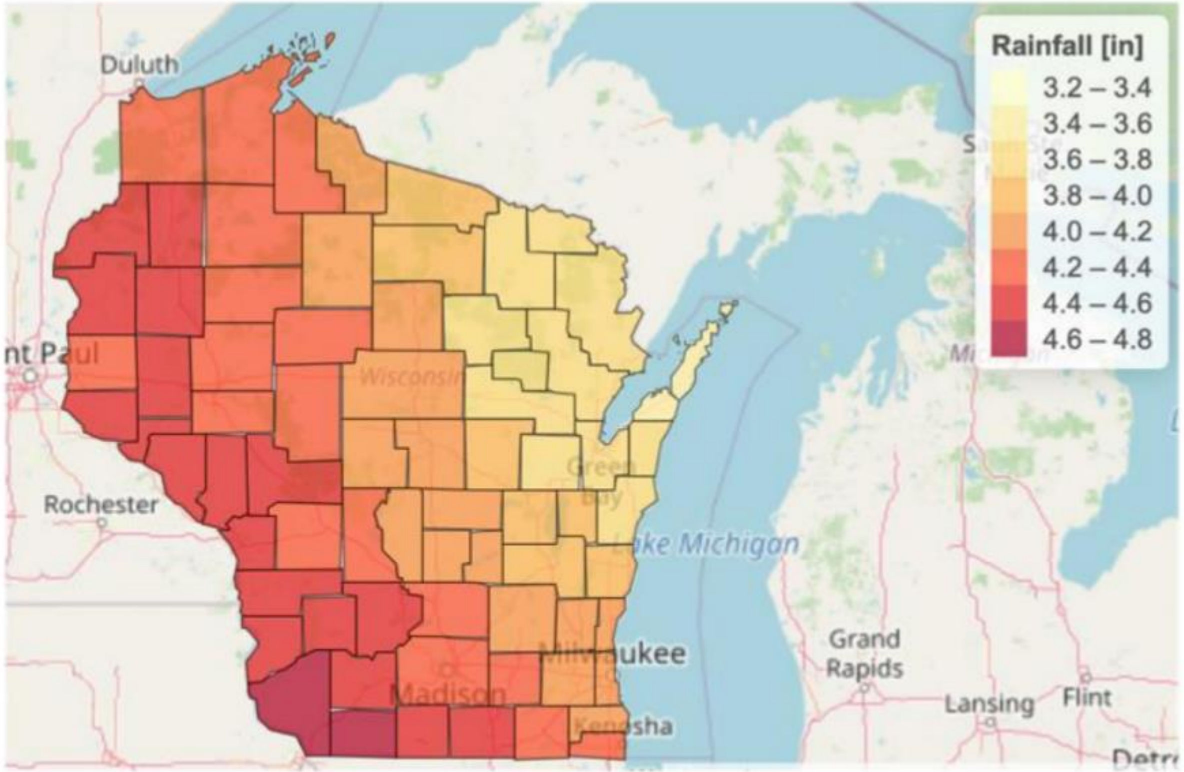
Key Findings:

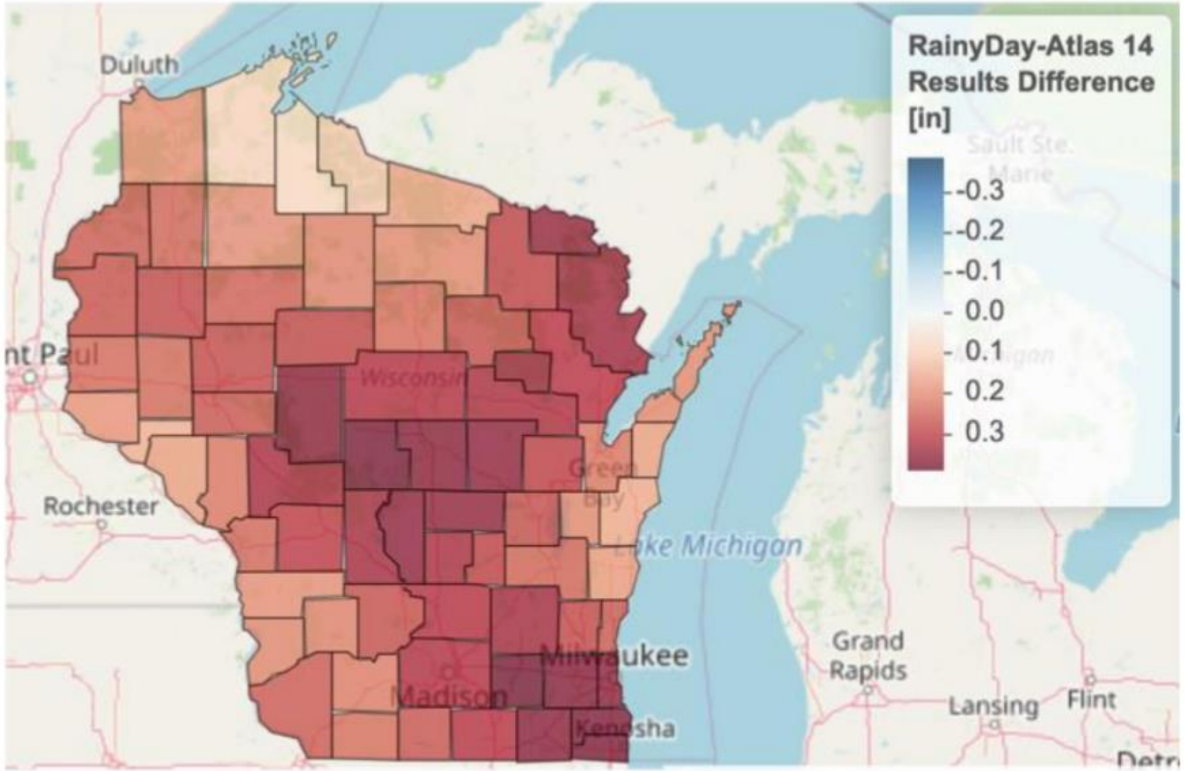
1. UW Probabilistic Downscaling appears to be the most reliable technique currently available
2. Today's 100-year storm in northeastern US is likely to be a 20-year storm by late 21st century

Summary of future conditions data

- County-level rainfall Intensity–Duration–Frequency (IDF) statistics and uncertainties for 24-hour duration, every ten years from 2001-2100 for Wisconsin
- For 2010 onwards: Two greenhouse gas emission scenarios (RCP4.5—low/intermediate emissions scenario; RCP8.5—high emissions “business as usual” scenario)
- Recurrence Intervals: 2, 5, 10, 25, 50, 100, 200 and 500 years
- 22 Climate models from the Coupled Model Intercomparison Project Phase 5 (CMIP5) are each downscaled individually to provide both the average across all models and uncertainty estimates, in the form of 90% confidence intervals.

Below Left: 10-year 24-hour rainfall from the UW-Madison RainyDay-based analysis. Below Right: Difference between the 10-year 24-hour rainfall from RainyDay and the National Weather Service Atlas 14 Volume 8. These maps show more heavier rainfalls from the RainyDay approach than from Atlas 14, though this result varies with location, rainfall duration and return period.

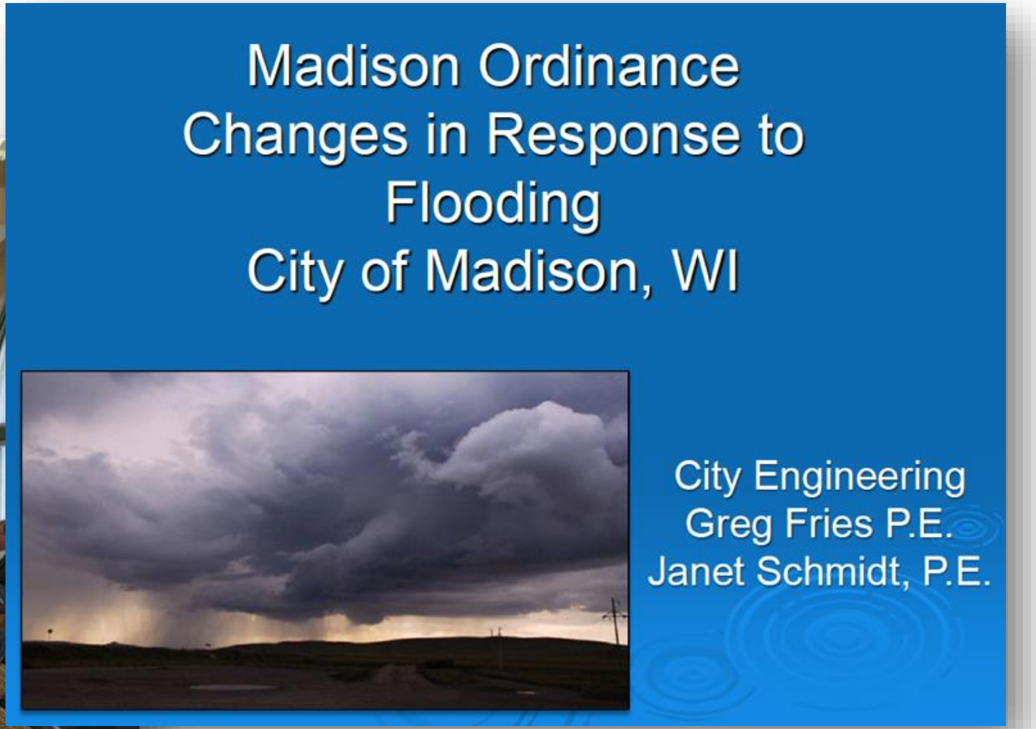




Perspective #1: Numbers create conversations

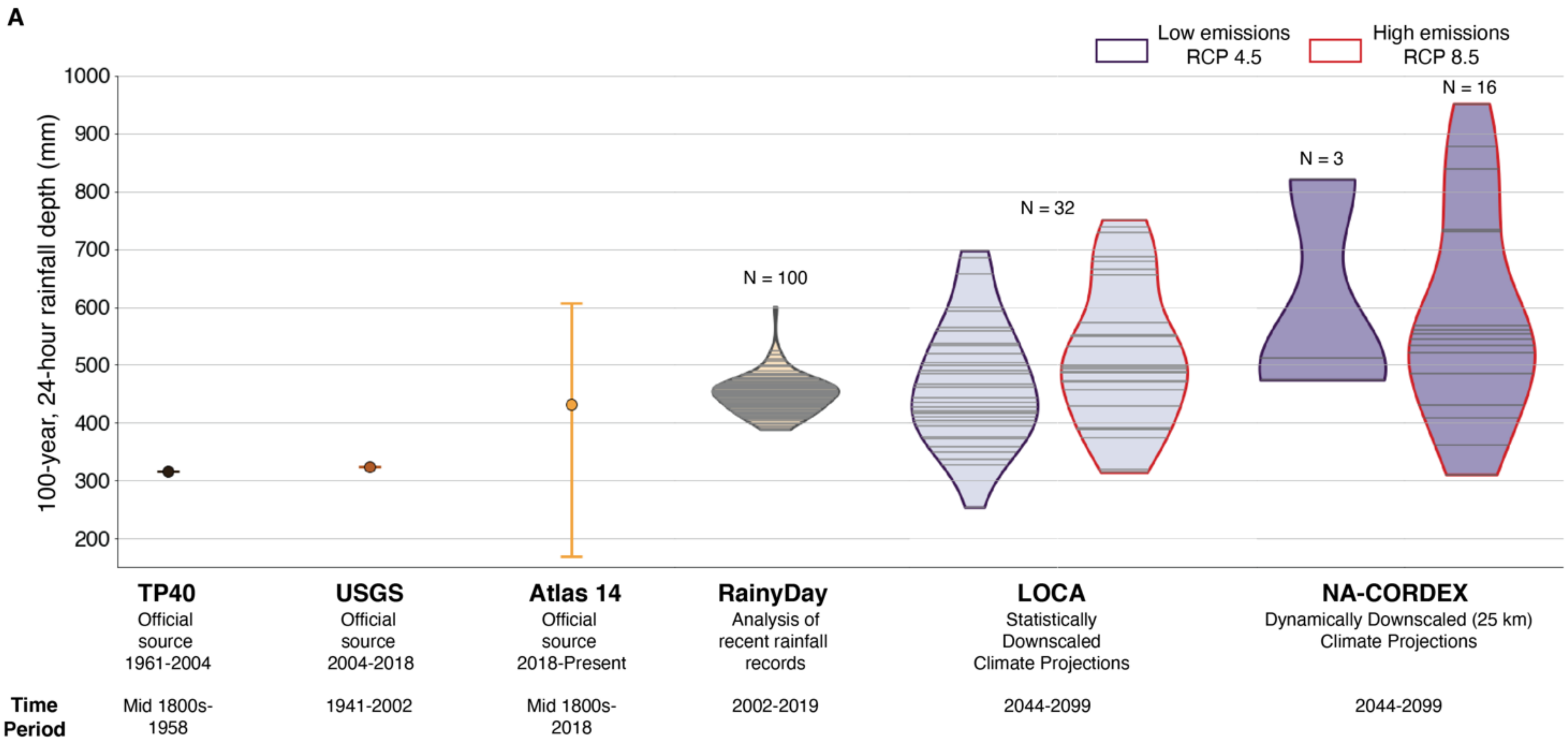
City of Madison + Dane County:

- Stick with Atlas 14
- Move from 100-year to 200-year storm



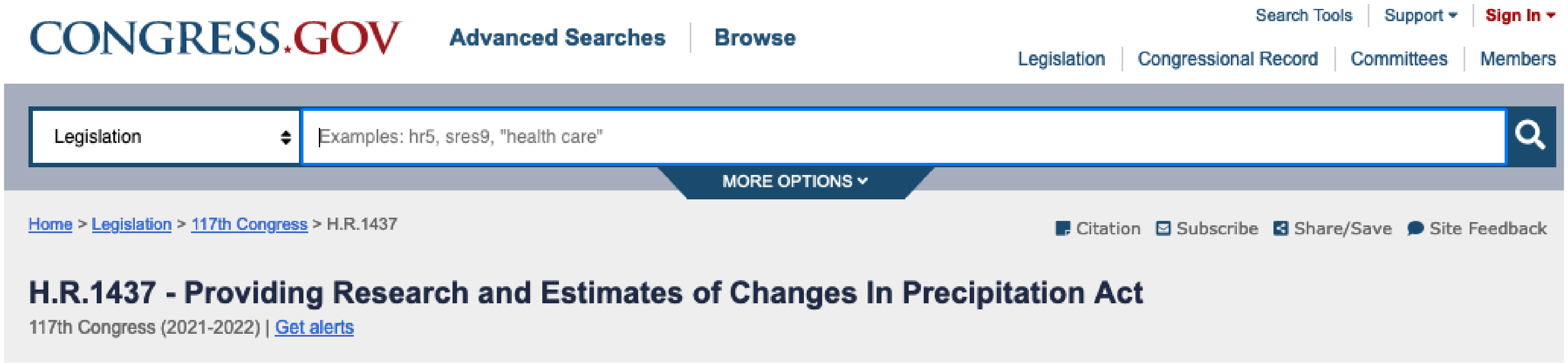
Perspective #2: A diversity of methods and data are a pro, not a con

Different 100-year 24-hour storm estimates for Houston, TX



Wright et al., Resilience to Extreme Rainfall Starts with Science, *Bulletin of the American Meteorological Society*, 2021

Perspective #3: Change is coming—We need to get ready



Precipitation Act: "NOAA shall, no less than every five years, update precipitation frequency estimates for the United States."

What does a "moving target" like this mean for regulation and design?

Perspective #4: Flooding is complicated

Point vs. watershed rainfall:

- “Point scale” IDF statistics don’t represent rainfall in larger systems/watersheds

Flood ingredients/spices:

- Rainfall
- Land properties
- Soil moisture
- Snow/frozen soil
- Agricultural practices
- Dams, reservoirs, lakes
- Flood control

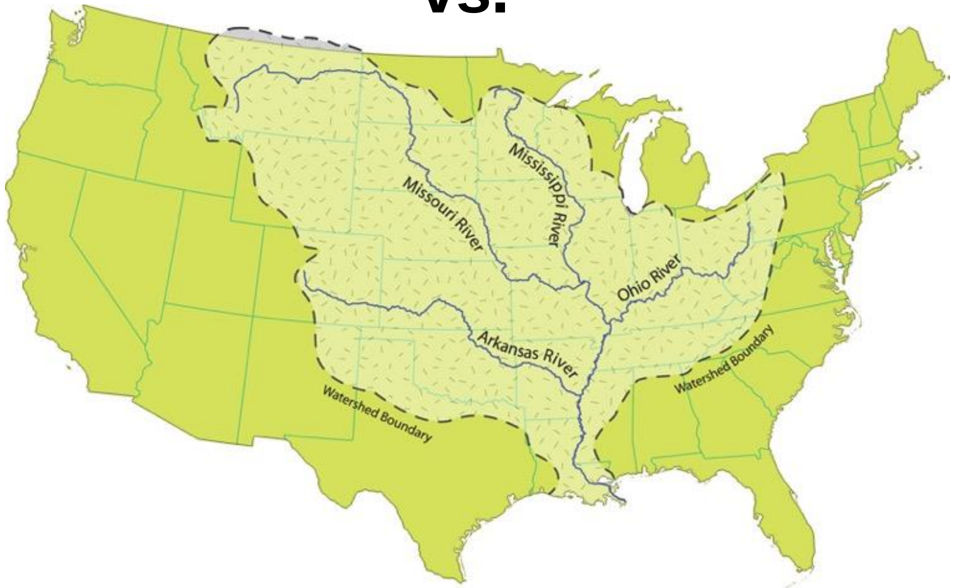
Lots of kinds of floods:

- Riverine, pluvial, groundwater, coastal, etc.

We’re on the case!

- Some tools that I’ve mentioned can help

vs.



Accounting for Embodied Emissions in Wisconsin Construction Materials

Summary Report

Prepared By:
Clare Bassi
Sam Hartke
Sunjoo Hwang

For the Wisconsin Initiative on Climate Change Impacts

June 2021

Concrete and steel alone account for 15% to 20% of global greenhouse gas emissions.

These embodied emissions are produced during mining, manufacturing, and transportation of materials, and the construction process itself.

The first step in reducing this impact is to quantify the emissions embodied by materials like Portland Cement concrete, steel, and asphalt.

In the news…

- WASHINGTON, Nov 2 (Reuters) - U.S. steel industry executives said on Tuesday they favor a carbon border adjustment mechanism that raises the U.S. price of "dirty" steel produced in China and other countries with high carbon emissions.
- The Portland Cement Association released its roadmap for the cement industry to achieve 'Carbon Neutrality' by 2050. The plan marks a major step to engage U.S. policymakers, industry partners, and non-governmental organizations. Concrete Contractor, October 12

Stage	Product			Construction		Use					End-of-life				Beyond
	A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	C1	C2	C3	C4	D
Embodied	Raw material supply	Transport	Manufacturing	Transport	Construction and installation	Use	Maintenance	Repair	Replacement	Refurbishment	Demolition and deconstruction	Transport	Waste processing	Disposal	Credit for Reuse, Recycling and Recovery Potential
Operational						B6	Energy use								
						B7	Water use								

EPD scope
- Cradle-to-gate →
- Cradle-to-handover →
- Cradle-to-grave →
- Cradle-to-cradle →

WISCONSIN & EMBODIED EMISSIONS ACCOUNTING

Information and Resources for Wisconsin Construction Project Implementers

Construction project implementers are becoming aware of the need to reduce the carbon content of their projects. Wisconsin communities are already experiencing significant impacts from global climate change, including more extreme rainfall and extreme heat events, which contribute to harmful algal blooms and flood events. To mitigate the impacts of climate change, greenhouse gases emitted during human activities need to be reduced.

Embodied emissions refer to the carbon dioxide and other greenhouse gases emitted during construction of new buildings, roads, and other infrastructure. Embodied emissions include the emissions produced during extraction of raw materials, material transport, production of construction materials, and the construction process itself. Embodied emissions of specific construction materials are calculated using life cycle assessments.

There is currently no way to track embodied emissions and how they are changing in Wisconsin's construction industry.

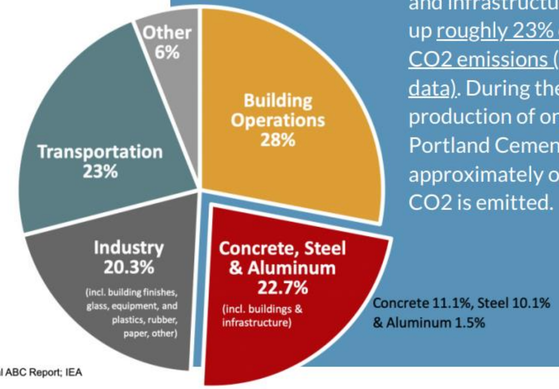
Life cycle assessments (**LCAs**) estimate the total impact of a product during its life cycle, including production and the use and end-of-life phases. It is the standard methodology used to estimate embodied and life cycle emissions. Learn more about LCA here, here, and here.

Environmental product declarations (**EPDs**) calculate and disclose the cradle to gate environmental impact of a product. Established Product Category Rules (**PCRs**) dictate the data and methods required to create an EPD for specific products. See the concrete PCR here.

There are three types of EPDs and you can learn more about each here. EPDs have increased in popularity because of their recent integration with LEED v4. However, EPDs only disclose the impact of products up to their delivery to a construction site and don't account for the lifetime emissions impact of materials, which is impacted by the durability and recyclability of products. Read about EPD limitations here.

The Wisconsin Division of Facilities Development and Management's latest Sustainability Guidelines for Capital Projects (released September 2020) requires that new construction and major renovation projects include a life cycle assessment and use a minimum of twenty materials with EPDs.

Global CO_2 Emissions by Sector



Source:
2018 Global ABC Report; IEA

Concrete, steel, and aluminum used in building and infrastructure make up roughly 23% of global CO2 emissions (2018 data). During the production of one ton of Portland Cement, approximately one ton of CO2 is emitted.

How are others addressing embodied emissions?

National policies addressing embodied emissions in construction are on the horizon. The aim of the federal Climate Leadership and Environmental Action for our Nation's (CLEAN) Future Act, introduced by the House Committee Energy & Commerce in March 2021, is to "achieve net zero greenhouse gas pollution no later than 2050, with an interim target of reducing pollution by 50 percent from 2005 levels no later than 2030."

"Buy Clean" legislation is also underway in several states at varying levels. The Oregon Dept. of Environmental Quality started a voluntary program to help concrete producers obtain EPDs, providing a free EPD web tool and a monetary reimbursement incentive for participating suppliers. In 2017 the Buy Clean California Act began requiring EPDs from suppliers bidding on state projects for four specific materials, each with a material-specific impact limit. Similar Buy Clean legislation in Washington and Minnesota also use EPD requirements.

Example Policy Language

- City of Portland Low Concrete Initiative Public Notice
- Buy Clean California Act
- Marin County Low Carbon Concrete Code
- Bill for Buy Clean Minnesota Act

Action Items for Clients

Ask Suppliers for EPDs

The main reason that many suppliers don't have EPDs or haven't looked into EPDs is that clients don't ask for them. Ask contractors to provide EPDs for concrete, asphalt, and steel if available. This lets contractors know that EPDs are useful to clients, even if EPDs aren't explicitly required by clients at this time.

Research Design Alternatives

Use LCA tools to estimate embodied emissions of projects and explore which design and material choices have the biggest impacts and evaluate specific design choices.

- Athena LCA tools - for roadways and buildings
- The FHWA's Pavement Life Cycle Assessment Framework - for roadways
- ASCE's Envision Tool - for infrastructure projects
- The Embodied Carbon in Construction Calculator (EC3) - for buildings

Encourage Low Emission Practices

Even if emissions cannot be quantified, there are still many strategies in place that can reduce material impacts. For example, one of the most effective strategies for minimizing embodied emissions in a project is maximizing the use of recycled materials. Encouraging low impact design alternatives can help prepare your suppliers for forthcoming policies.

Estimate Project Impacts

If you already do a life cycle cost analysis, or if you know the mass of materials used in your projects, you can easily begin to understand a ballpark figure of what the embodied emissions of a project may be by using industry-average impacts for materials (listed below). Keep in mind these don't necessarily represent the impact from your specific suppliers. Remember to keep in mind the lifetime of your projects and materials.

- Portland cement: 922 kg CO2 eq/ tonne
- Asphalt: 40-50 kg CO2eq/tonne
- Ready mix concrete: 200-300 kg CO2eq/tonne
- Steel plate: 1710 kg CO2eq/tonne
- Gypsum board: 280 kg CO2eq/1000 sqft

You can also do a project case study with suppliers who already have EPDs or complete a more in-depth analysis for a single project.

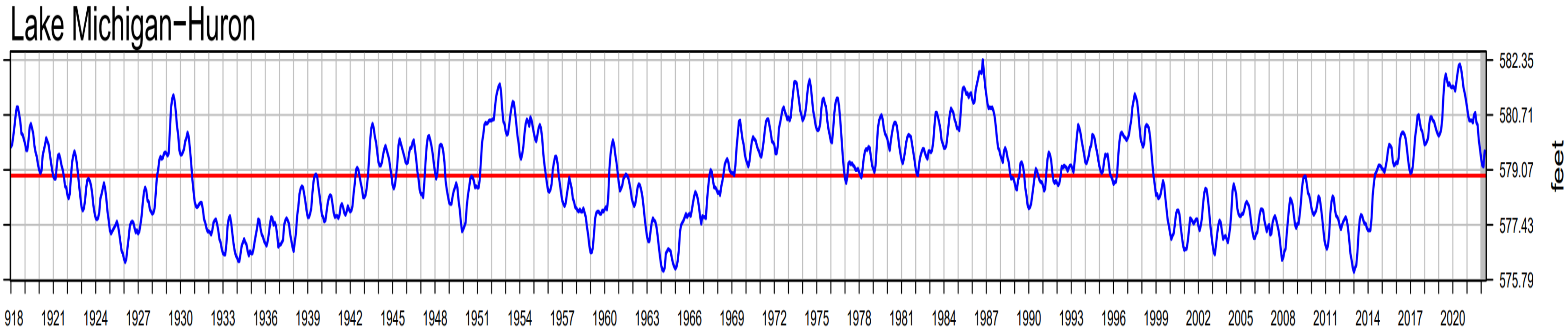
Additional Resources

- The FHWA's Infrastructure Voluntary Evaluation Sustainability Tool (INVEST), which is aimed at state DoTs and other agencies.
- 10 Steps to Reducing Embodied Carbon
- Procurement Policies to Reduce Embodied Carbon
- Sustainable Procurement in UC system

Moving forward to reduce embodied carbon

- Important objective but complex issue
- Need to consider life cycle
- Focus on most important materials
- Embodied carbon in construction materials manufactured and installed on site is NOT the main GHG emission in steel and concrete projects – energy use during project life cycle is

Coastal impacts (from Coastal Resilience WG)

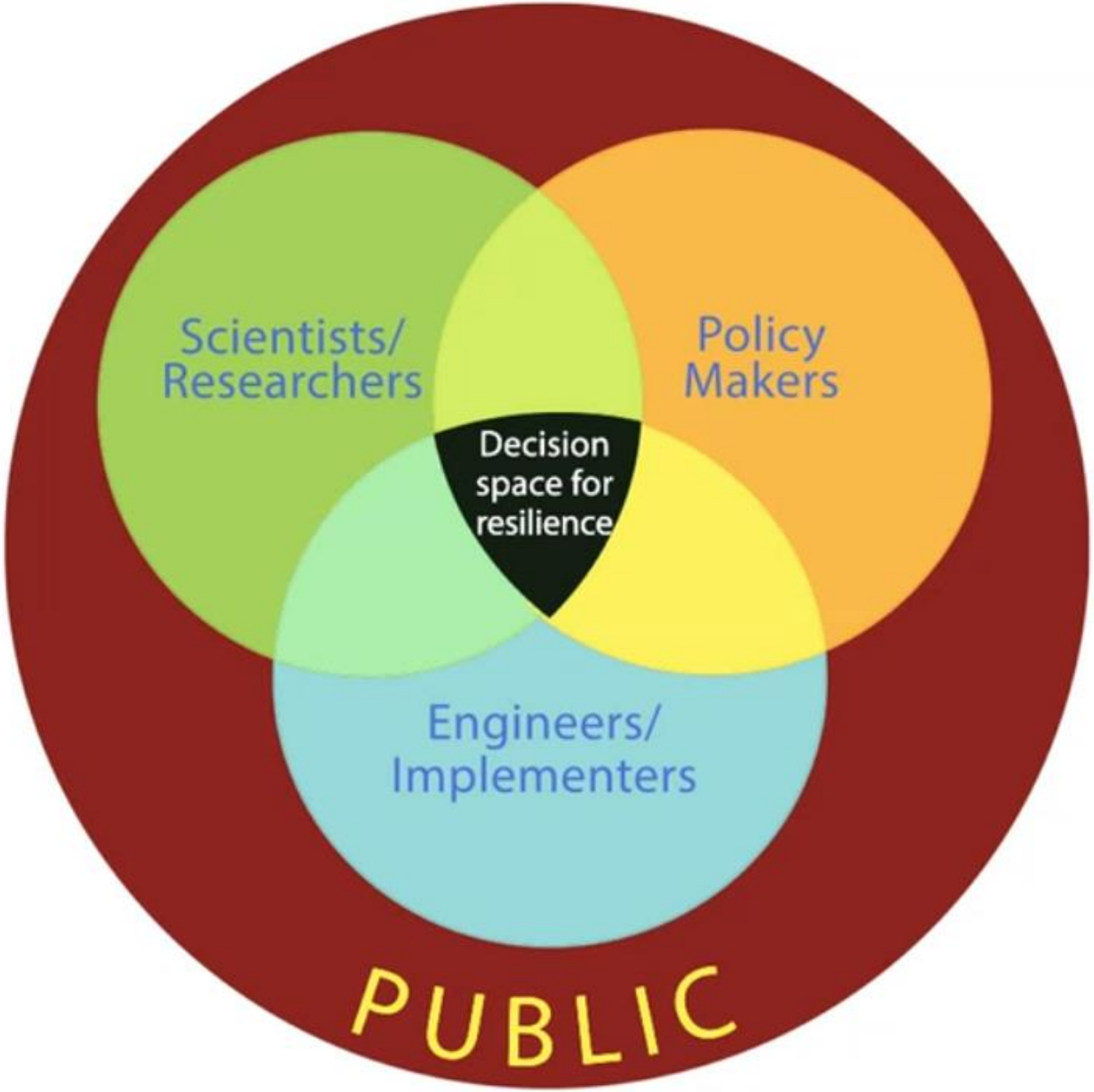


- Lake levels vary episodically due to complex water balance
- Future water levels may have more variability- resilient design should accommodate
- No clear future trend in water levels

“Green the Grid, Electrify Everything”

- EVs and heat pumps will substantially reduce GHG emissions next few decades
- BUT Greening the Grid is essential to reaping the mitigation benefits
- Need to make sure community plans support non GHG energy generation

Planning is integral to climate resilient infrastructure



PDH Quiz time

- Climate change projections: target date and emissions scenario
- where to find data on Wisconsin climate change
- what do infrastructure managers have on their mind now?
- Evaluating future flooding – Complexities, Risk, and adaptation
- Embodied carbon emissions: important, but even more important is the GHG emissions for use of building and transportation infrastructure
- Accommodate well planned energy generation
- Planning is a key activity