EFFECTS OF CLIMATE CHANGE/EXTREME EVENTS ON WATER UTILITIES

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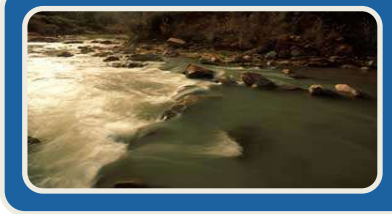
Water Research Foundation

advancing the science of water

Background



Issues of Concern to Water Utilities

Climate Change and Water Quality

Case Studies

Resources

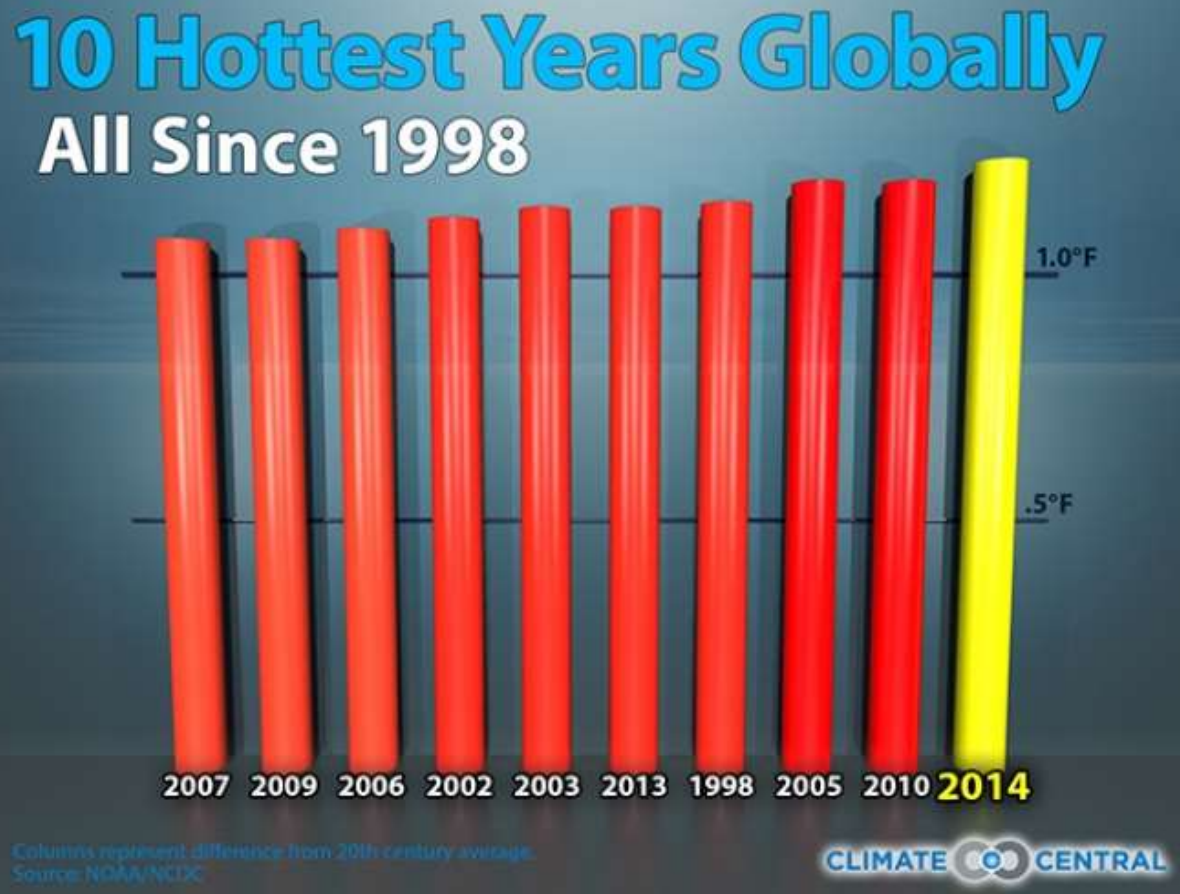
WaterRF Subscribers and Partners

Issues Facing the Water Industry

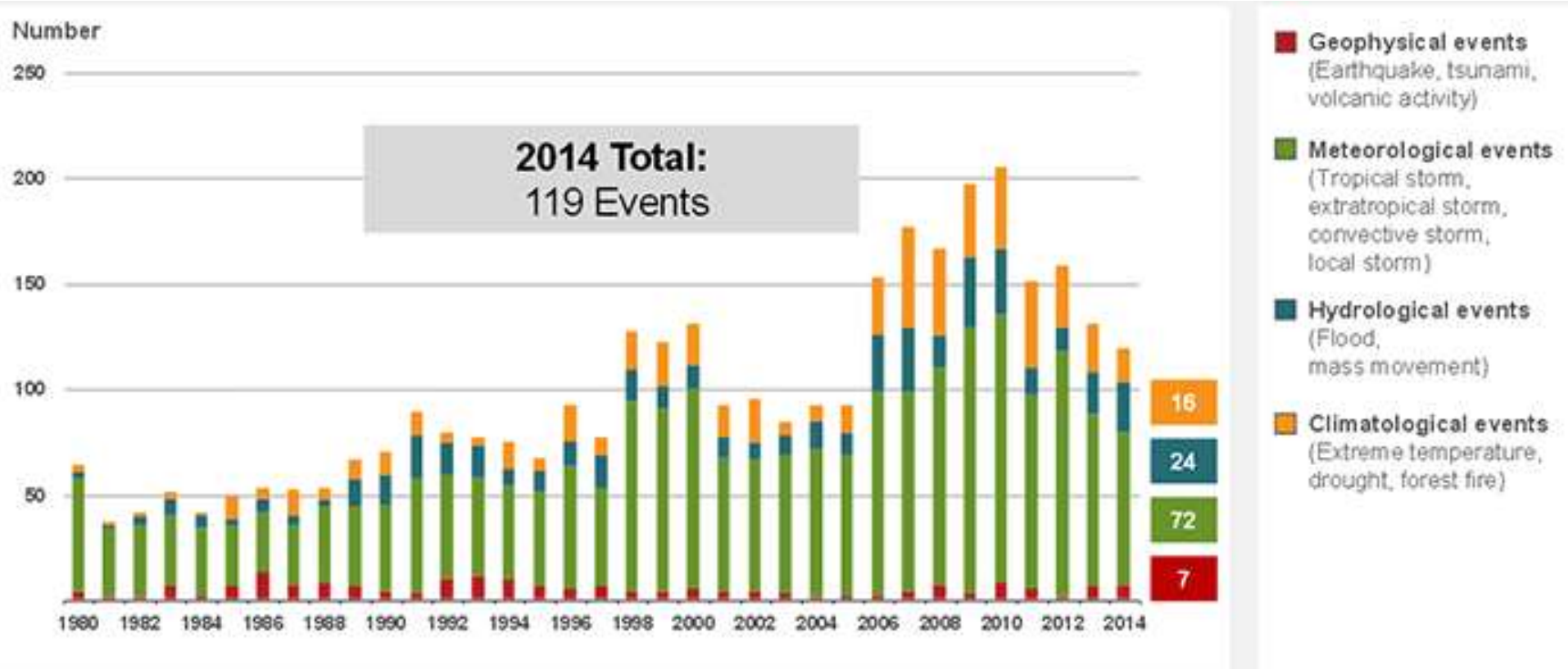
(2014 AWWA State of the Water Industry Report)

- State of water and wastewater infrastructure
- **Long-term water supply availability**
- Financing for capital improvements
- **Groundwater management and overuse**
- Watershed protection
- **Drought or periodic water shortages**
- **Emergency preparedness**
- Compliance with current regulations
- Water loss control
- Aging workforce
- Certification and training

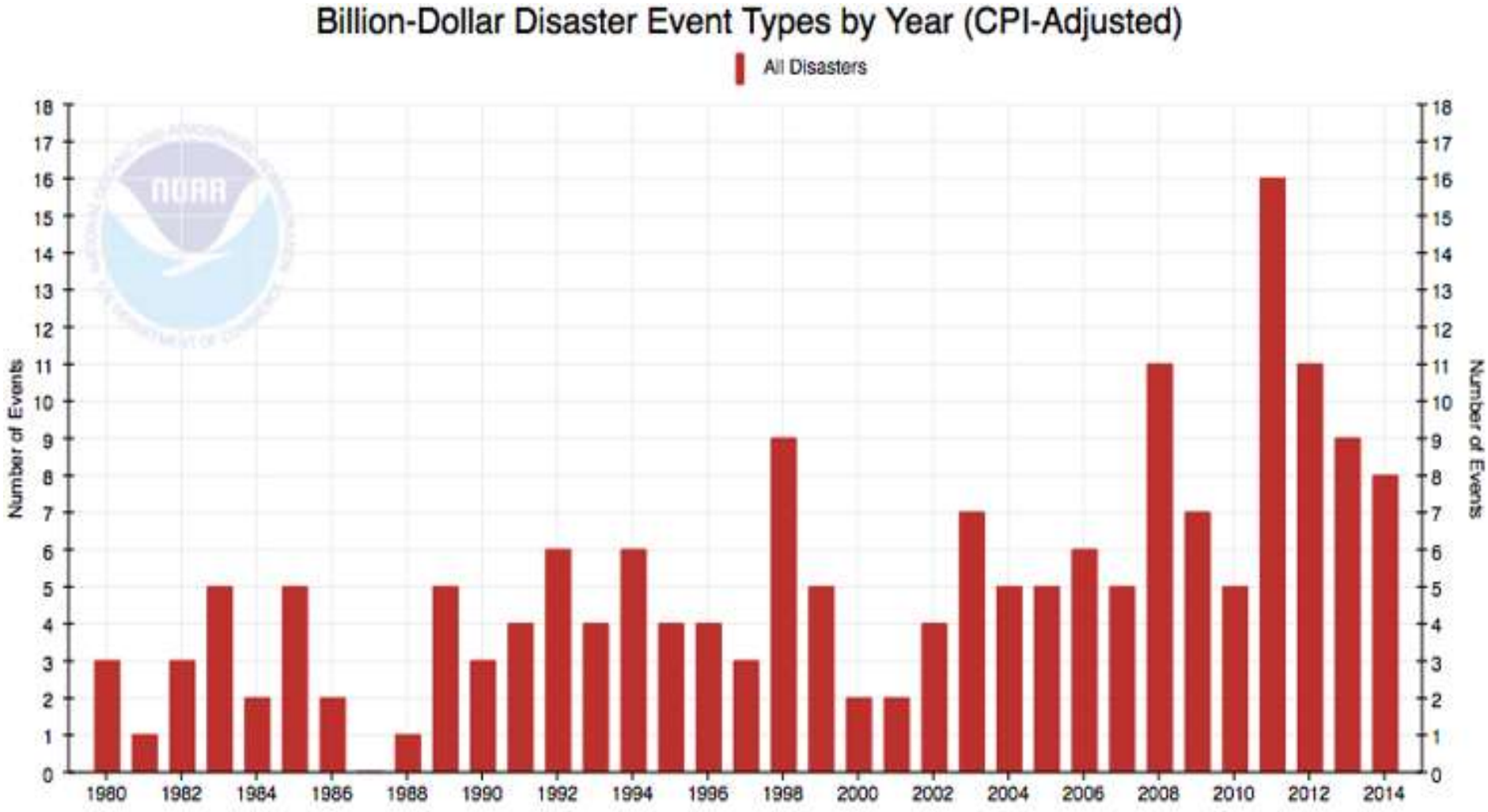
10 Warmest Years on Record



Number of Natural Disasters on the Rise



Source: Munich Re



Source: NOAA

Climate Change

Climate Variability (Drought and Extreme Precip)	Warmer Temperatures	Sea level Rise

Issues of Concern to Water Utilities

- Water Quantity
- Water Quality
- Rising Sea Levels
- Water Supply Infrastructure
- Financial and Institutional Impacts

Climate Change and Water Quality

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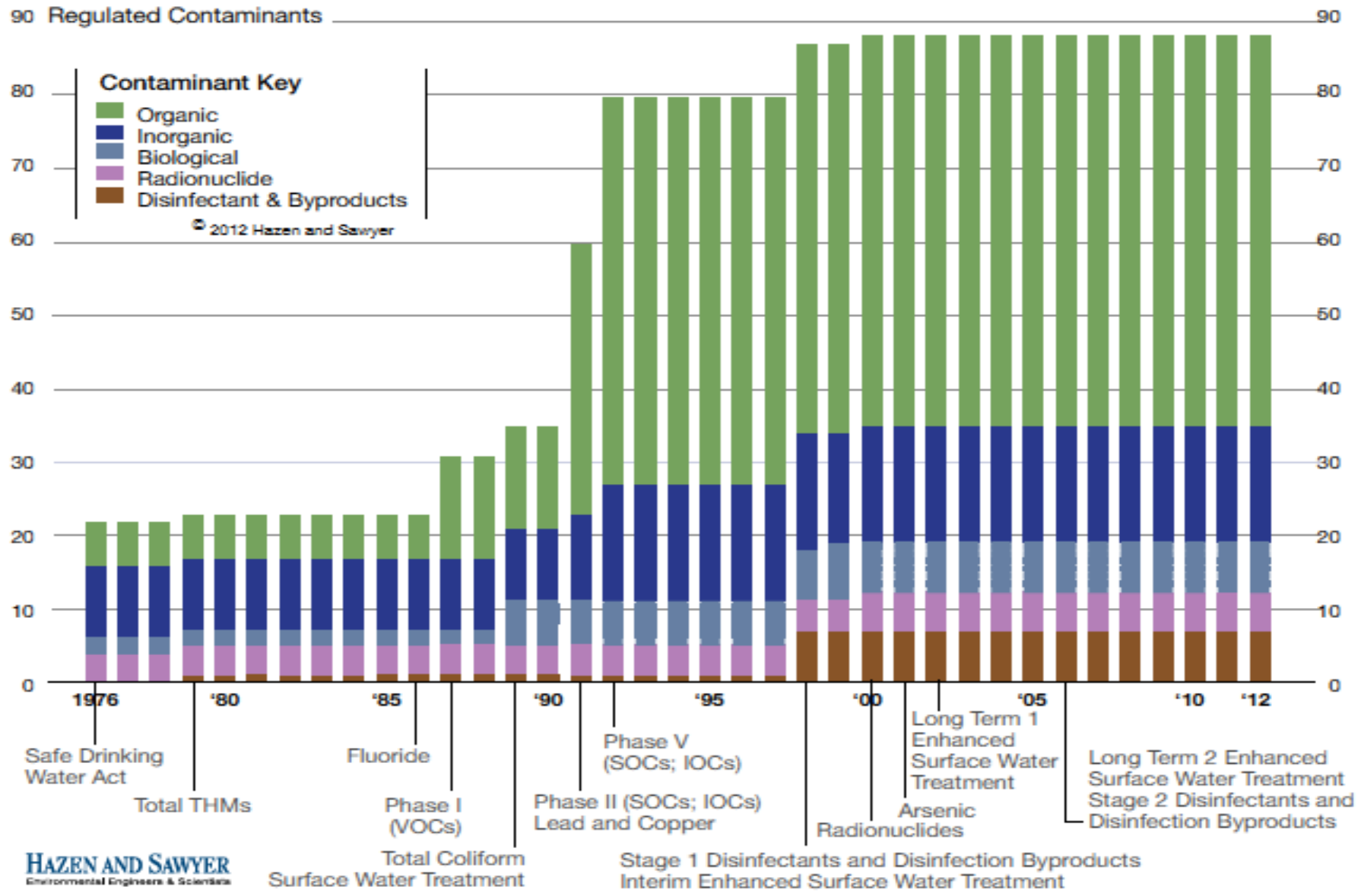
Safe Drinking Water Act

- Enacted In 1974 and amended in 1986 and 1996
- Is the foundation which lays the ground work for determining, regulating, and enforcing Maximum Contaminant Limits, Treatment Technologies etc.
- This is a national regulation which states are expected to achieve at a minimum

Number of Regulated Contaminants and Drinking Water Guidelines



HAZEN AND SAWYER
Environmental Engineers & Scientists

DBP Formation

Precursor(s) + Oxidant(s) ⟶ DBPs

Natural organic matter	Cl_2	pH	THMs
Algal organic matter	ClO_2	Temperature	HAAs
Effluent organic matter	NH_2Cl	Time	ClO_2
Bromide	O_3	Oxidant Dose	BrO_3
			-
			Nitrosamines

DBP Formation

Precursor(s) + Oxidant(s) → DBPs

Natural organic matter
Algal organic matter
Effluent organic matter
Bromide

Cl2
ClO2
NH2Cl
O3

pH
Temperature
Time
Oxidant Dose

THMs
HAAs
ClO2
BrO3
-
Nitrosamines

Nitrosamines

- Nitrosamines are Known Carcinogens
  - 0.7 ng/L NDMA 10−6 lifetime excess cancer risk)
- Widespread Occurrence of NDMA
  - Results from UCMR2 indicate that NDMA and other nitrosamines are present in at least half of U.S. chloraminated drinking waters
- DBPs of Chloramination

Nitrosamine Formation

Importance Of Different Precursors For Nitrosamine Formation In Drinking Waters	
Precursor	**Importance**
Amine-containing coagulation polymers	High
Effluent-impacted source waters	High
Pharmaceuticals and personal care products	Moderate/High
Distribution system materials	Moderate
Anion exchange resins	Moderate
Soluble microbial products	Limited
Agricultural chemicals	Limited
Bulk DON	Low
Algae	Low

Source: Krasner et al., 2013

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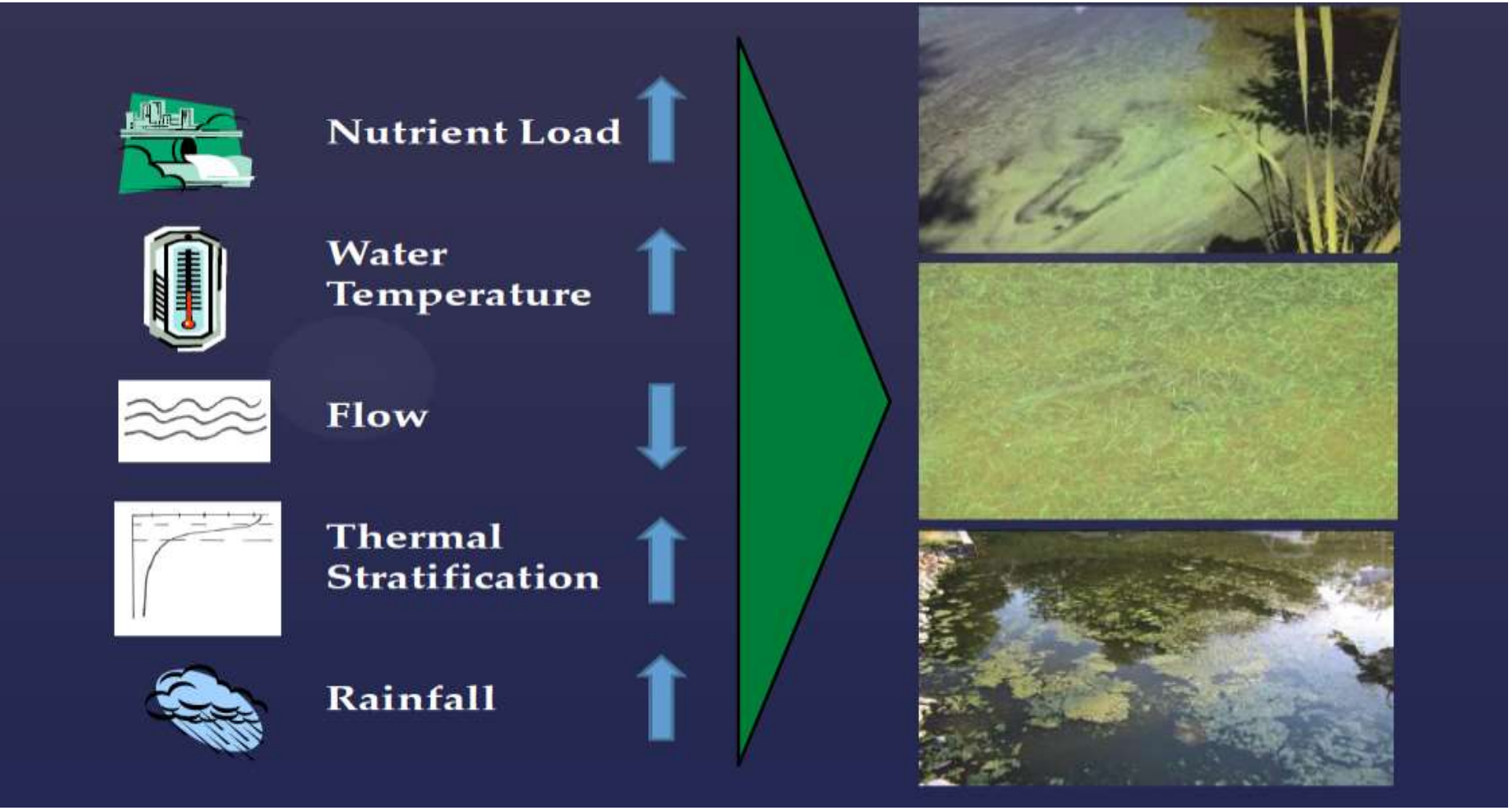
Algae



Source: WRF webcast on Algal Toxin

Emerging Chemical Contaminants

- Sources
  - Wastewater treatment facility (WWTF) outfalls
  - Stormwater, CSO & Industrial outfalls
  - Overland urban & rural (agricultural) runoff
  - Septic fields and landfill leachate
  - Irrigation using WWTF effluent
  - Land-applied WWTF biosolids

Climate Sensitive Agents of Water-Related Illness

Salmonella enterica *Campylobacter* species Toxigenic *Escherichia coli*	Temperature, heavy precipitation, and flooding
Enteroviruses, Rotaviruses, Noroviruses	Heavy precipitation, flooding, and temperature
Cryptosporidium	Heavy precipitation and flooding, temperature
Naegleria species	Temperature
Cyanobacteria	Temperature, precipitation patterns

Source: **The Impacts of Climate Change on Human Health in the United States: A Scientific Assessment (2015)**

Groundwater

- Saltwater intrusion
- Increased salinity
- Release of contaminants
  - Nitrites, arsenic etc.
- Quality of recharge water

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Case Studies

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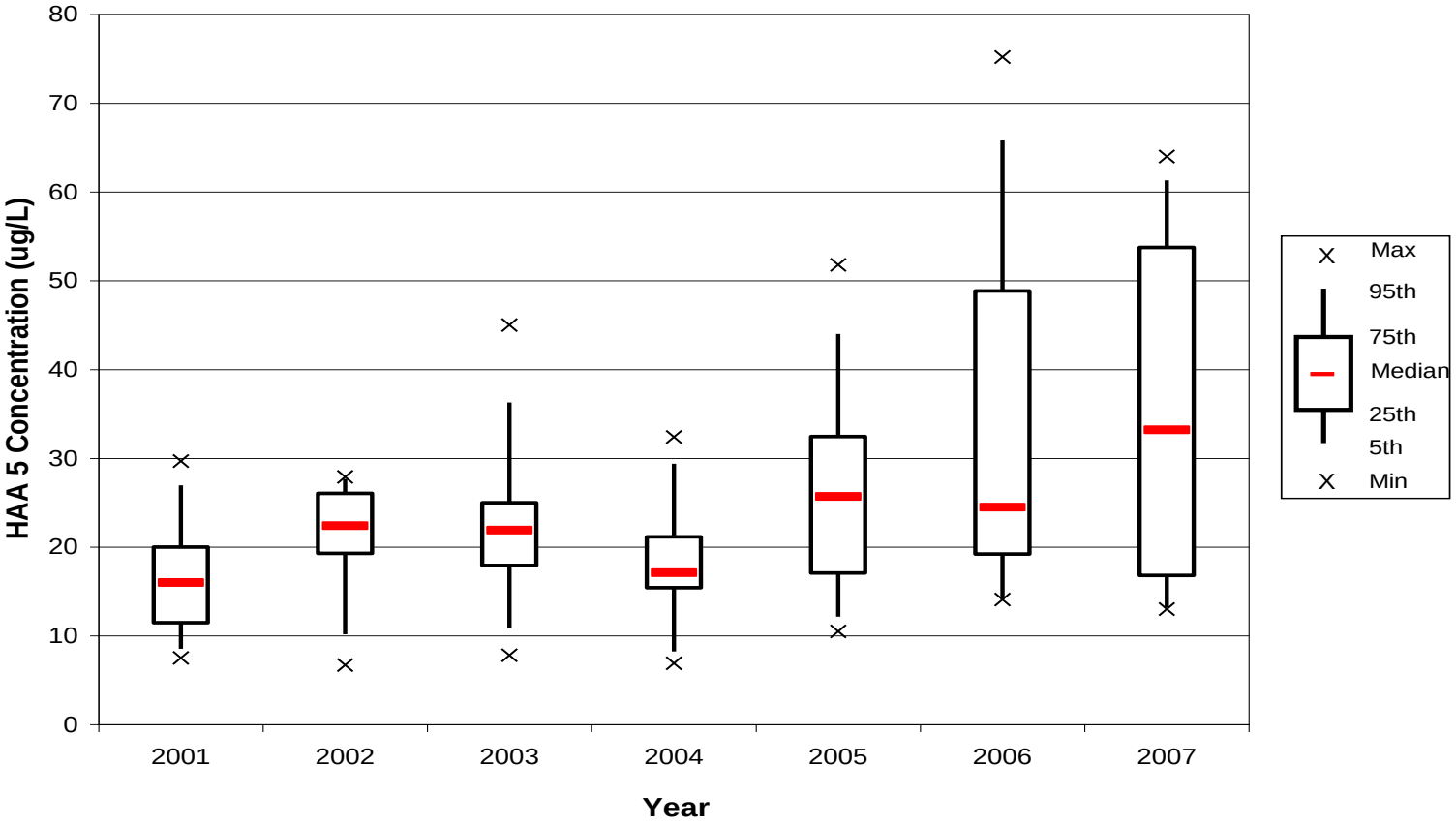
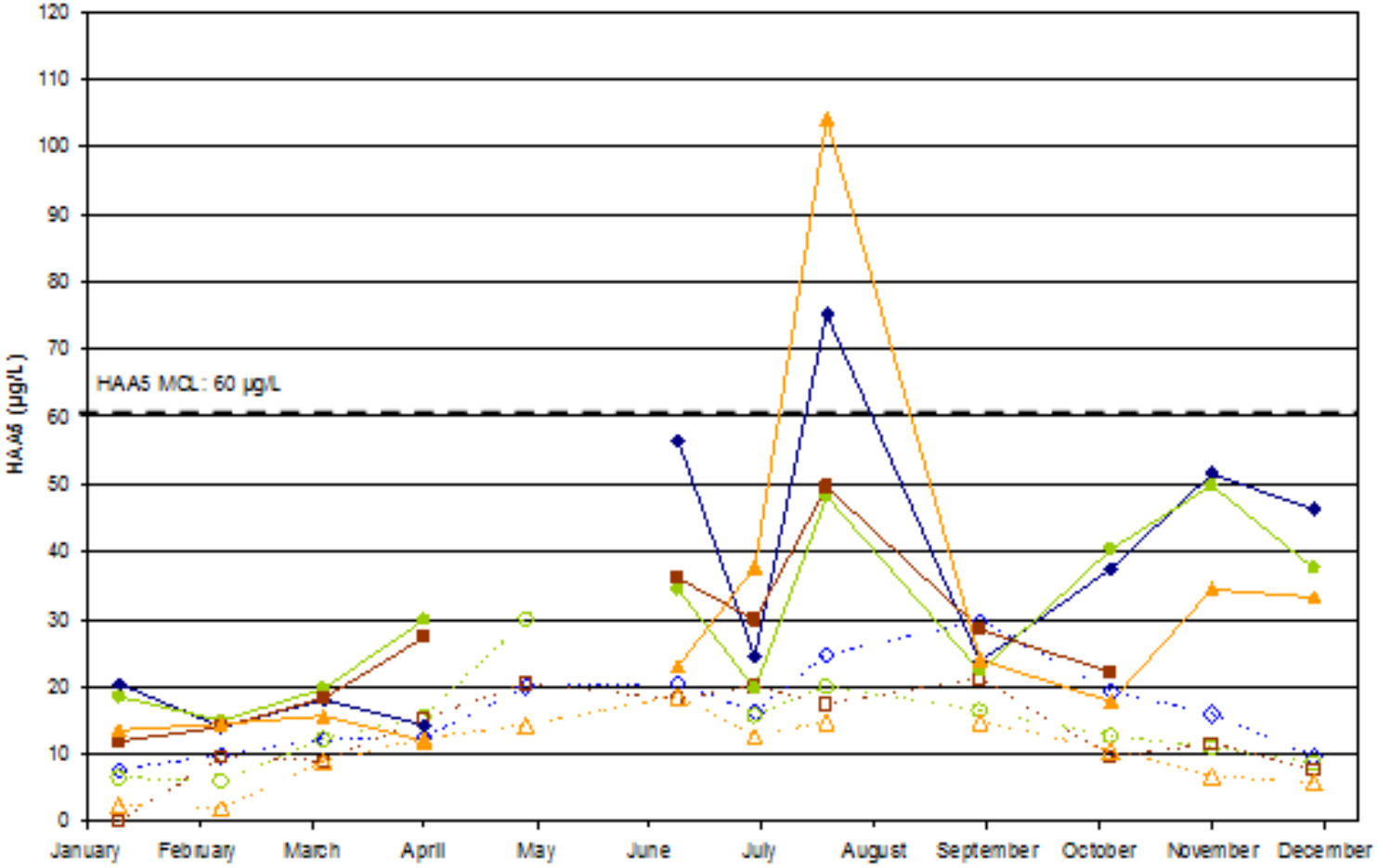
Case Study 1 – Background

- The utility is located in mid-West
- Raw water source – Lake Erie
- Since 2006, the utility has experienced elevated concentration of halo-acetic acids
- Through examination indicated that while DOC levels went down, reactivity of DOC has increased (SUVA)



HAA5 concentrations at the closest compliance location for all four WTPs for 2001 and 2006

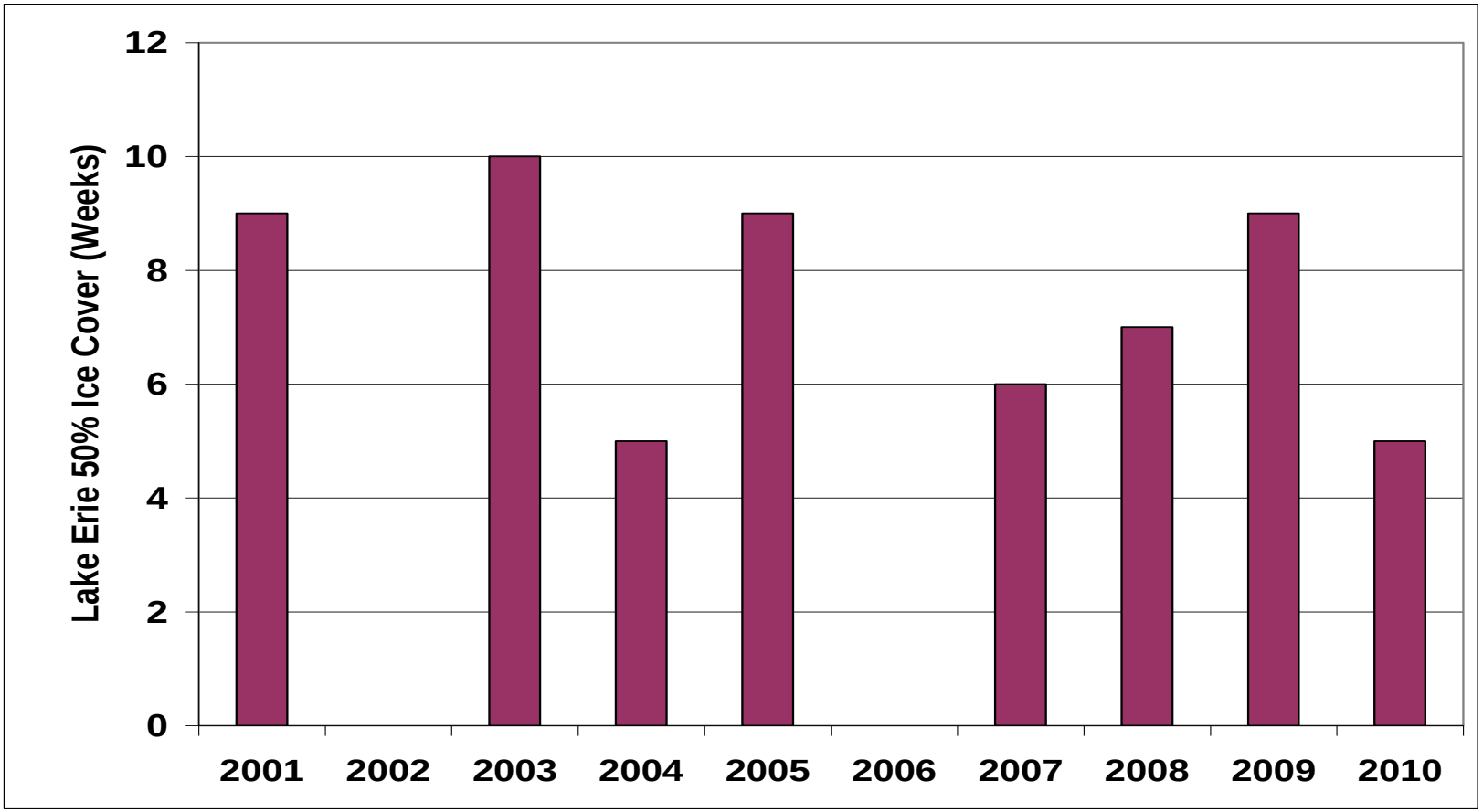


Increased Reactivity

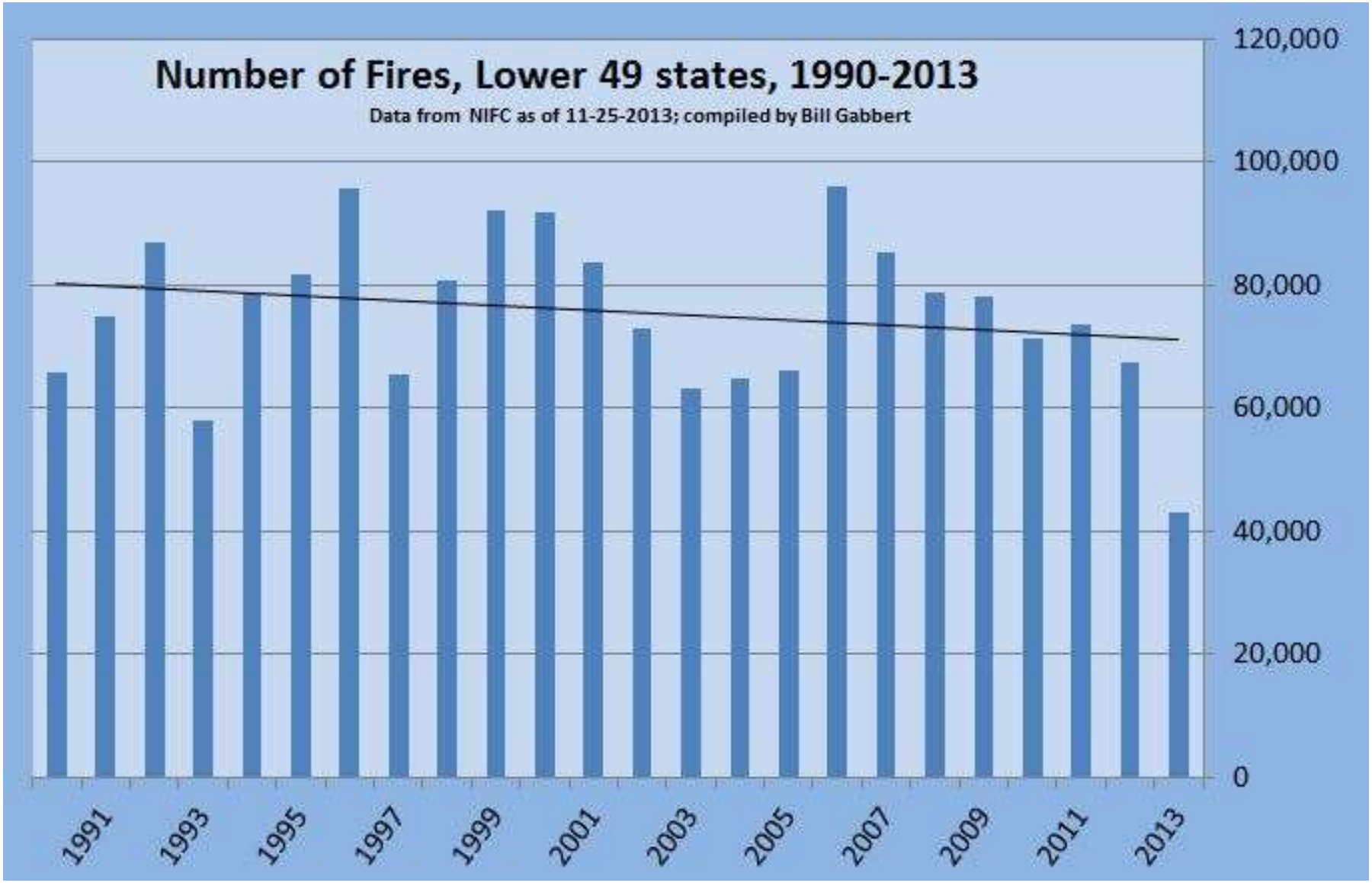
- SUVA = UV254/DOC

Year	DOC mg/L	SUVA L/mg.m	DOC mg/L	SUVA L/mg.m	DOC mg/L	SUVA L/mg.m	DOC mg/L	SUVA L/mg.m
2004	2.0	3.4	2.0	4.3	2.0	2.8	1.9	2.5
2005	1.6	5.6	1.6	5.1	1.6	4.1	1.5	4.6
2006	1.7	5.2	1.7	4.8	1.7	3.7	1.6	4.5

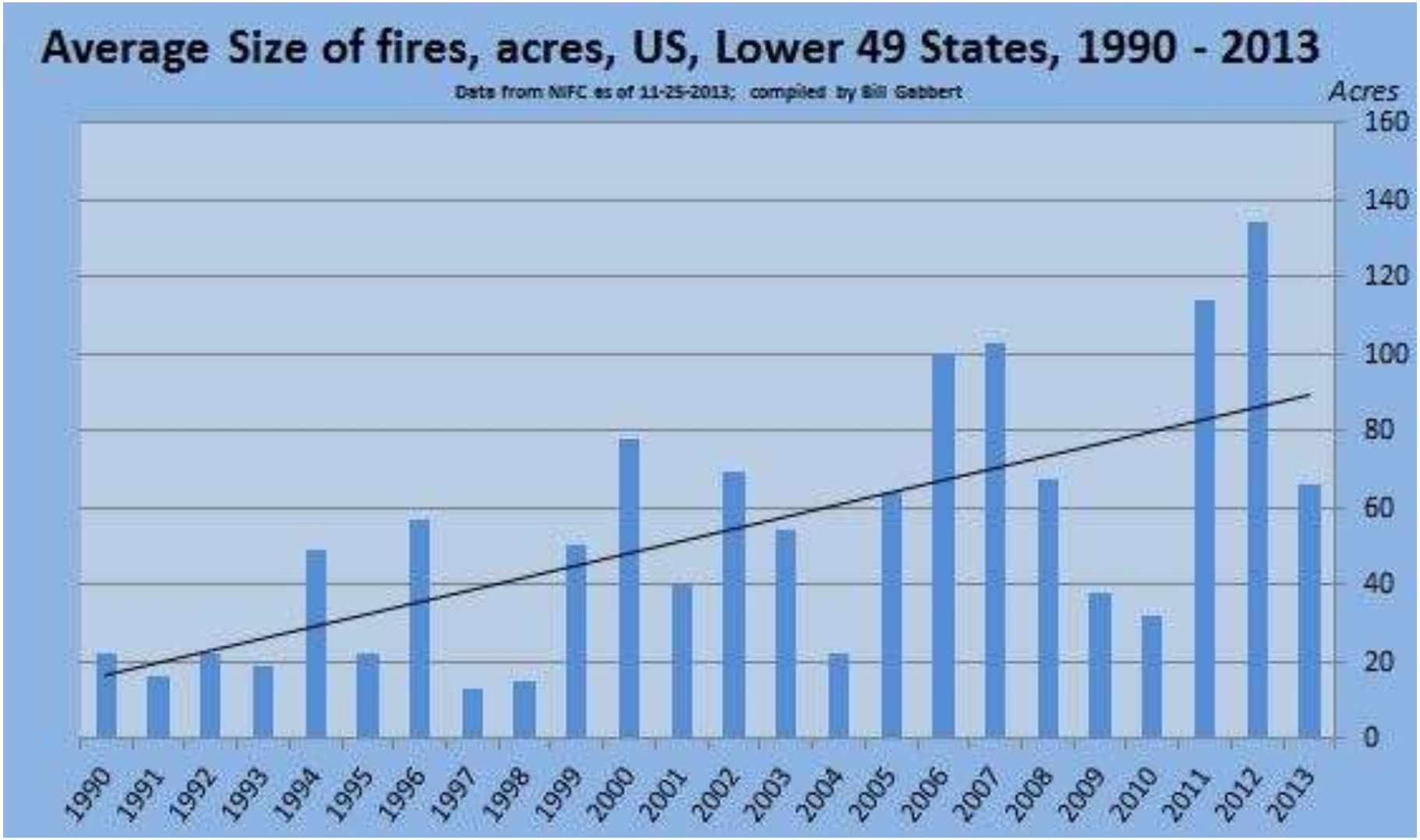
Number of weeks that 50% or greater of Lake Erie was covered with ice



Wildfires



Source: Wildfiretoday.com



Source: Wildfiretoday.com

Why Are Fires Getting Larger?

- Fuel changes
  - Successional growth
  - Exotic invasive species
  - Insect and Disease
- Climate change
  - More severe episodic drought
  - Longer fire seasons
  - More severe high temperature/dry air mass events
  - More severe wind events

Wildfire - Water Quality Impacts

- Wildfires can cause changes in a number of water quality parameters including
  - Nutrients
  - Chloride, Sulfate
  - pH
  - Total dissolved solids
  - Turbidity
  - Organic carbon
  - Iron
  - Mercury
  - Algal Growth

Treatment Implications

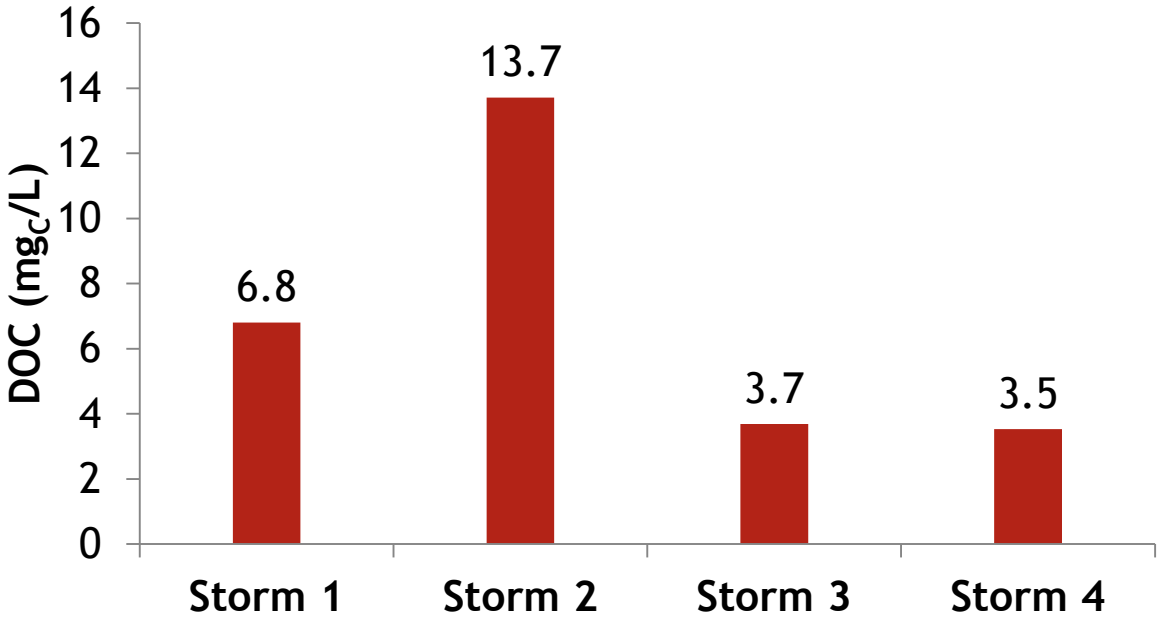
Impact on Treatment \ Parameter	Turbidity	TP	DON and TKN	Hg	DOC	Chl.-*a*
need for solids removal (C/F/S)	✓	✓			✓	✓
↑ coagulant demand	✓				✓	✓
↑ sludge production	✓				✓	✓
↑ oxidant demand	✓		✓		✓	✓
↑ DBPs	✓		✓		✓	✓
↑ fluence required for UV			✓		✓	✓
↑ microcystins		✓				✓
↑ taste and odor concerns			✓		✓	✓
compliance concerns	✓		✓	✓	✓	✓
↑ operating costs	✓	✓	✓	✓	✓	✓

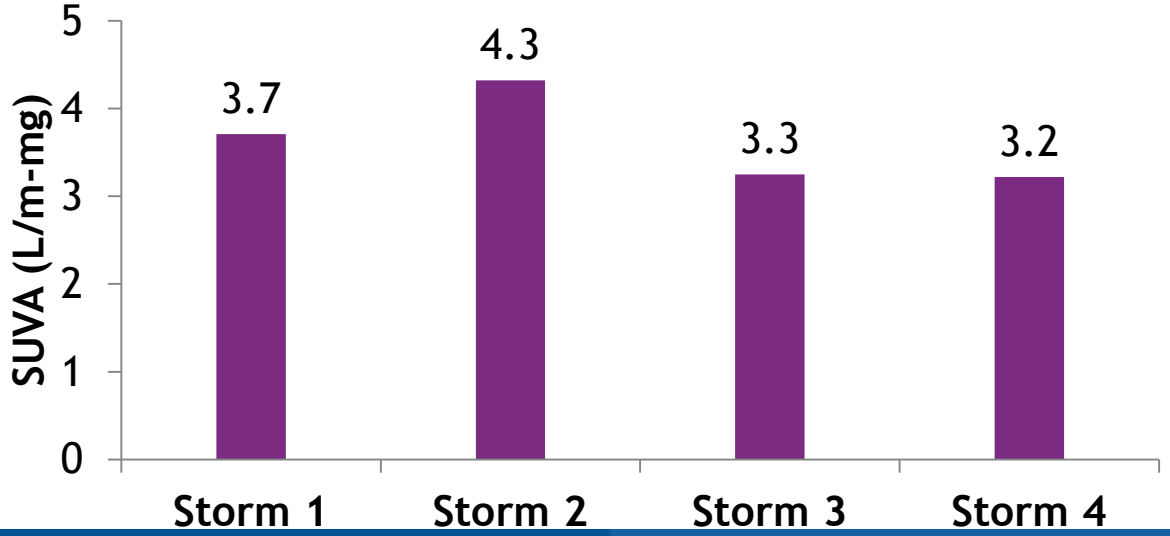
Adapted from Emelko et al., 2011

High Park Fire 2012

- Burned from June 9th -July 10, 2012
  - Lightning strike
  - Low humidity
  - High winds
- Burned approx. 87,000 acres
- Impacted the Cache La Poudre (CLP) watershed
  - Source waters for three major water utilities in northern Colorado, including the City of Fort Collins

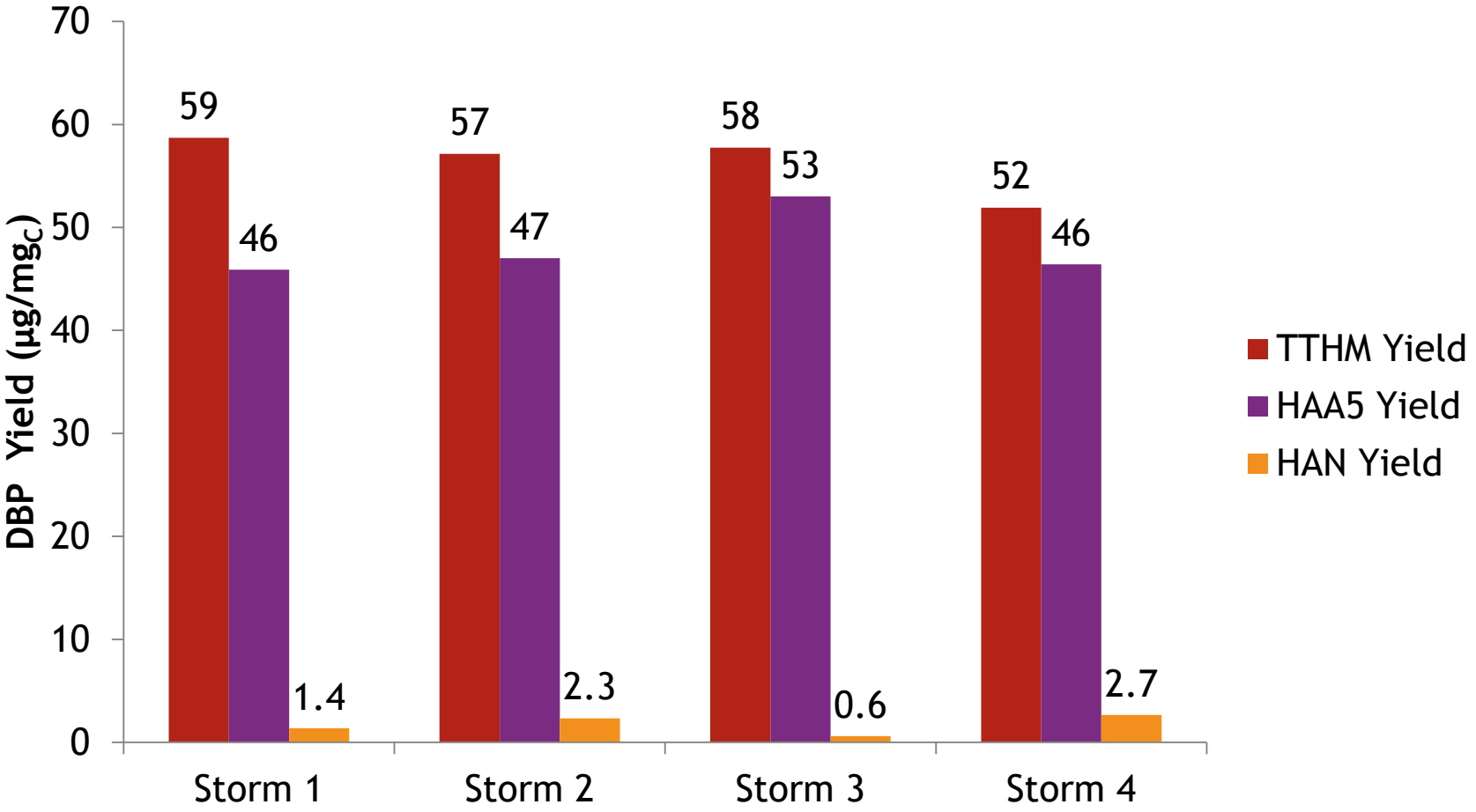
Storm Events 2012





- Baseflow DOC of 3.0 mg/L from previous CLP work
- Baseflow SUVA of 2.4 L/m-mg from previous CLP work

Storm Events 2012: DBP Yields



WRF Project 4590 Objectives

1. Assess the impact that a wildfire has on source water quality within a recently-impacted watershed
2. Develop and apply a lab-based approach to simulate the effects of a wildfire on water quality and treatability
3. Evaluate the implications of a wildfire for full-scale operation and design

Resources

WRF 4324: Water Quality Impacts Of Extreme Weather-Related Events

- Objective: identify and characterize water quality impacts from extreme weather-related events
- Collect institutional knowledge and data on events, impacts, and responses
- Identify strategies for utilities to better prepare for extreme weather-related events
- Not explicitly a climate change project
- Findings may, however, benefit subsequent climate change analyses

Tools for Adaptation and Planning: WaterQIEWE Tool

Water

Quality

Impacts from

Extreme

Weather

Events

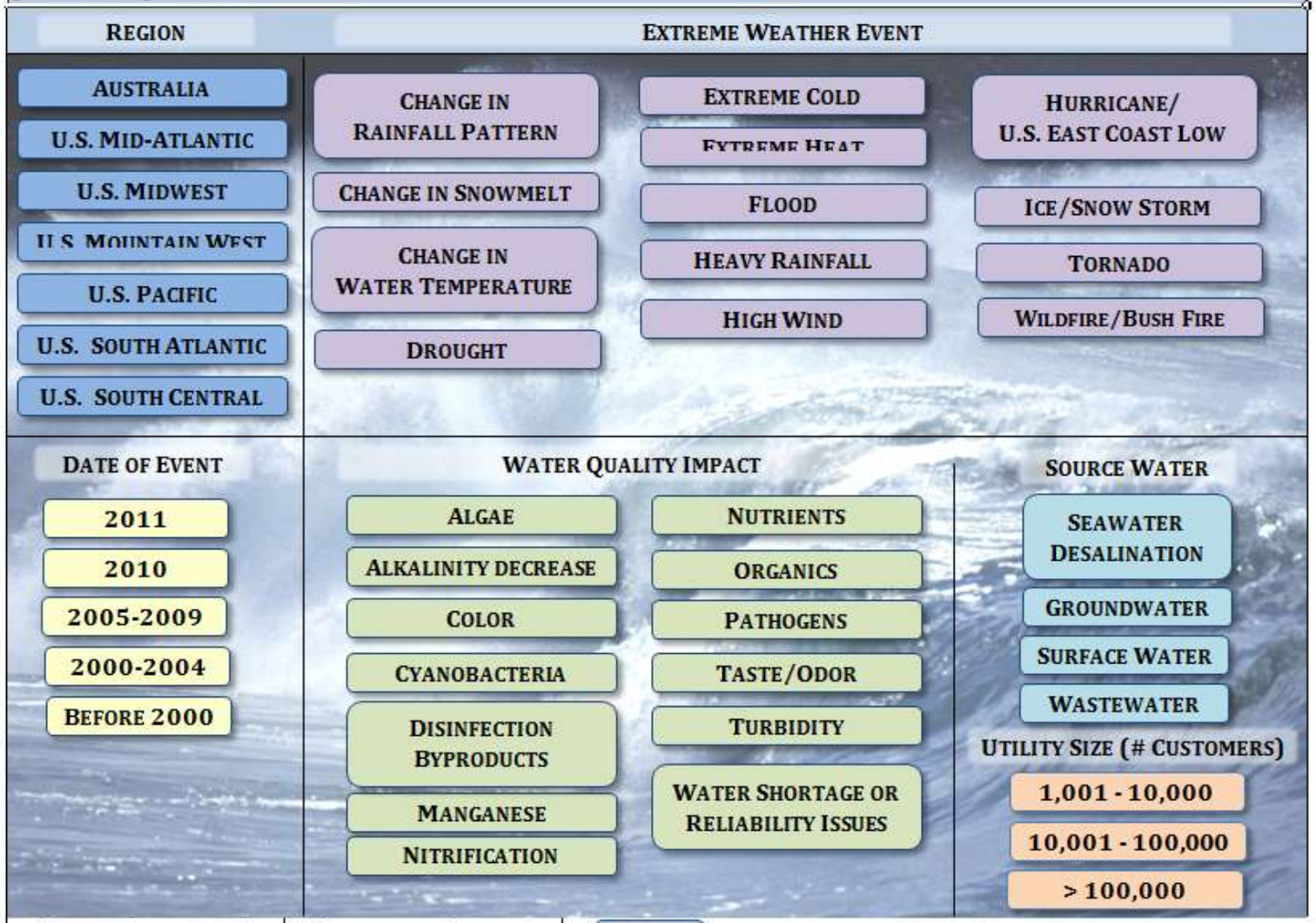
- Database of case studies and data results from project to assist utilities and support agencies in preparing for and adapting to the impacts associated with extreme weather-related events

Instructions:

1. Click on a button below to find other utilities with your parameter(s) of interest.
2. The tabs of utilities with the selected parameter will be moved upfront to the left of the tab list and will be highlighted. Click on a highlighted tab to read a utility's abstract.
3. Select another parameter, or click the "Clear Selection" button above to clear all previous queries.

CLEAR SELECTION

VIEW GRAPHS



Additional Keywords: *Select Keyword*

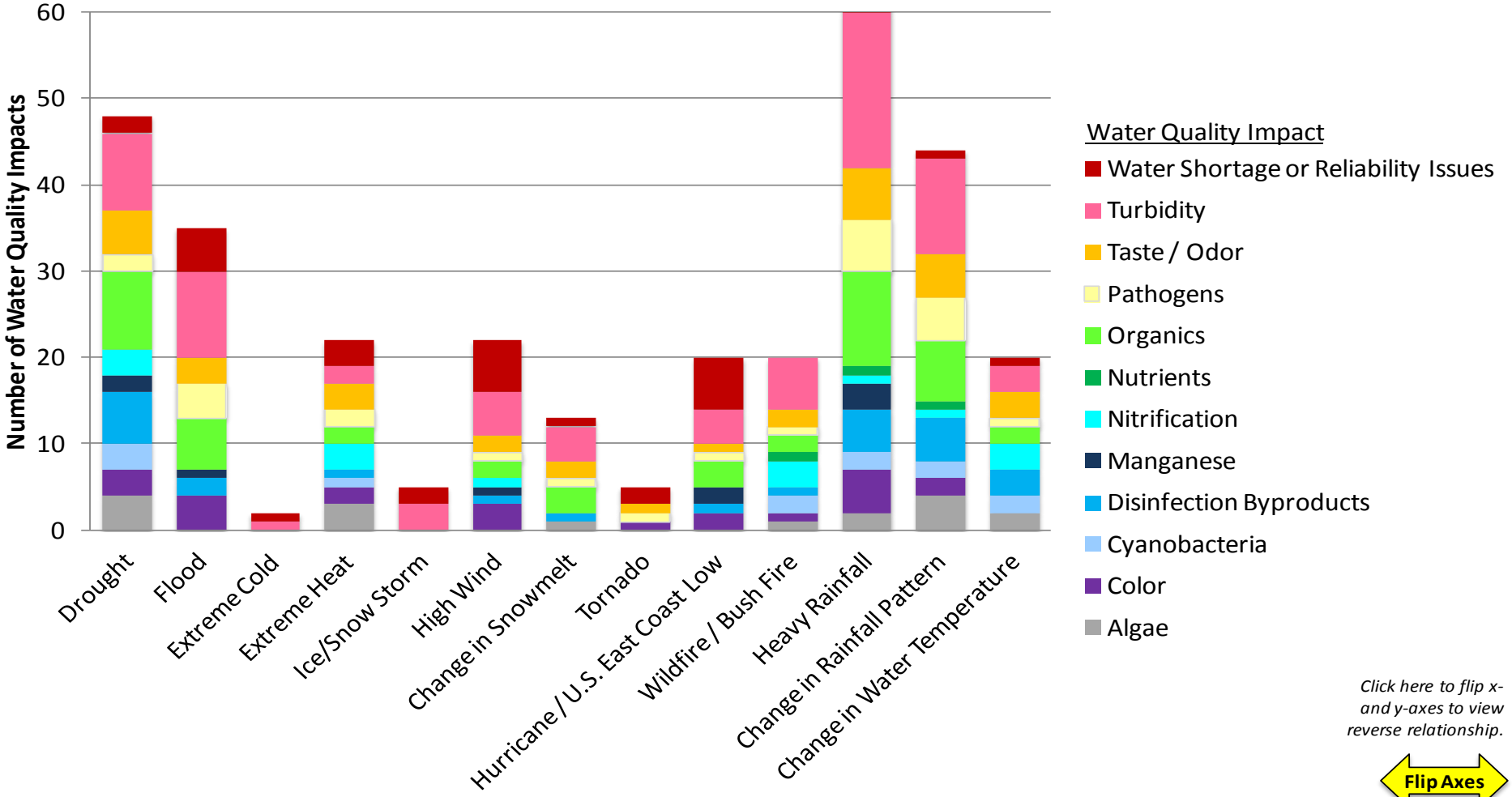
SEARCH

Data Summary Functionality

Back to Graph Menu

Back to Query

What water quality impacts have occurred during a specific extreme weather event?



Click here to flip x- and y-axes to view reverse relationship.

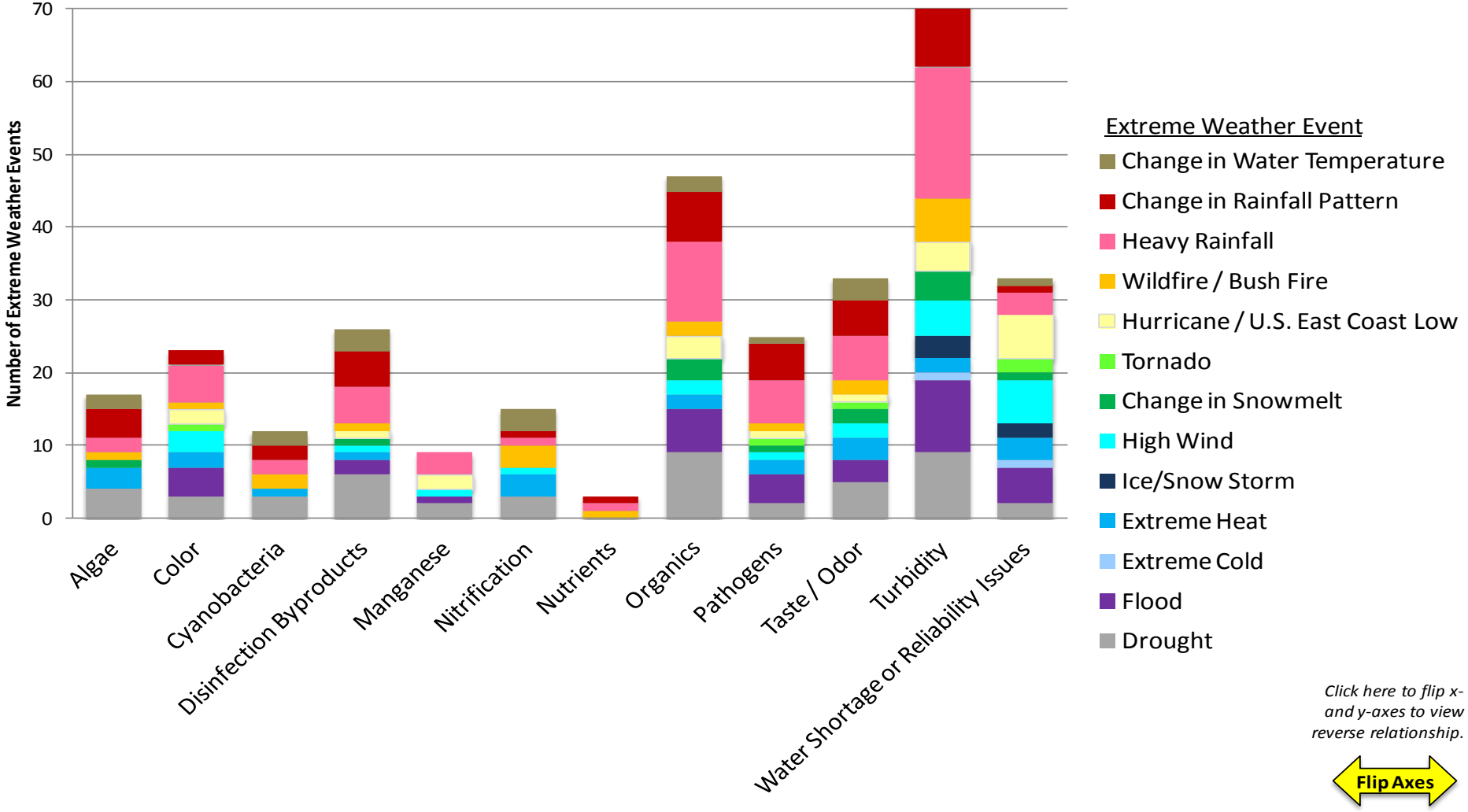
Flip Axes

Data Summary Functionality

Back to Graph Menu

Back to Query

What extreme weather events have triggered a specific water quality impact?



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Flip Axes

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Knowledge Portals: Climate Change

- Asset Management
- Climate Change
- Disinfection By-Products
- Distribution System Management
- Energy Management
- Microbials
- Utility Finance

Projects & Reports (27) | Webcasts (0) | Case Studies (5) | Web Tools (0)

While it is safe to say that the impacts of climate change on water resources will vary widely by region, it is also relatively certain that no area will be untouched by these impacts. Potential climate change impacts on water utilities have been widely reported in publications by the Water Research Foundation.

Executive Tool Kit

Topic Overview

Media Library

Fact Sheets

Vulnerability Assessment

Adaptation

Mitigation

Communication

External Resources

WRF and Climate Change Research

- Since 2003, over 30 project are funded
- Projects focused on
  - **Enhancing and improving water industry awareness of climate change issues and impacts**
  - **Developing effective adaptation strategies**
  - **Developing effective mitigation strategies**
  - **Communicating climate change impacts to internal/external stakeholders**

WRF - Climate Change Research

- Identifying and Developing Climate Change Resources for Water Utilities: Content for Central Knowledge Repository Website
- Climate Change Impacts on the Regulatory Landscape: Evaluating Opportunities for Regulatory Change
- Vulnerability Assessment and Associated Risk Management Tools for Climate Change: Helping Water Utilities Assess Potential Impacts and Select Adaptation Options
- Impacts of Underground Carbon Geological Sequestration on the Water Quality of Groundwater
- Analysis of Changes in Water Use Under Regional Climate Change Scenarios
- Developing a New Approach to Planning and Design of Water Assets to Ensure Sustainability Under Climate Change

WRF - Climate Change Research

- Analysis Of Reservoir Operations Under Climate Change
- Groundwater Sustainability Under Climate Change
- Drinking Water Pump Station Design And Operation For Maximum Life Cycle Energy Efficiency
- Water Quality Impacts Of Extreme Weather-Related Events
- Responding to Climate Change by Applying Adaptive Management Techniques to Infrastructure Management
- Water Footprint/Value of Water
- Impact of Climate Change on the Ecology of Algal Blooms
- Effective Communication of Climate Change Effects to Stakeholders

Conclusions

- Climate change will impact both quality and quantity of source waters
- Water quality changes will challenge treatment processes
- Water utilities are equipped to deal with treatment challenges
- Monitoring is the key to developing a timely response

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THANK YOU

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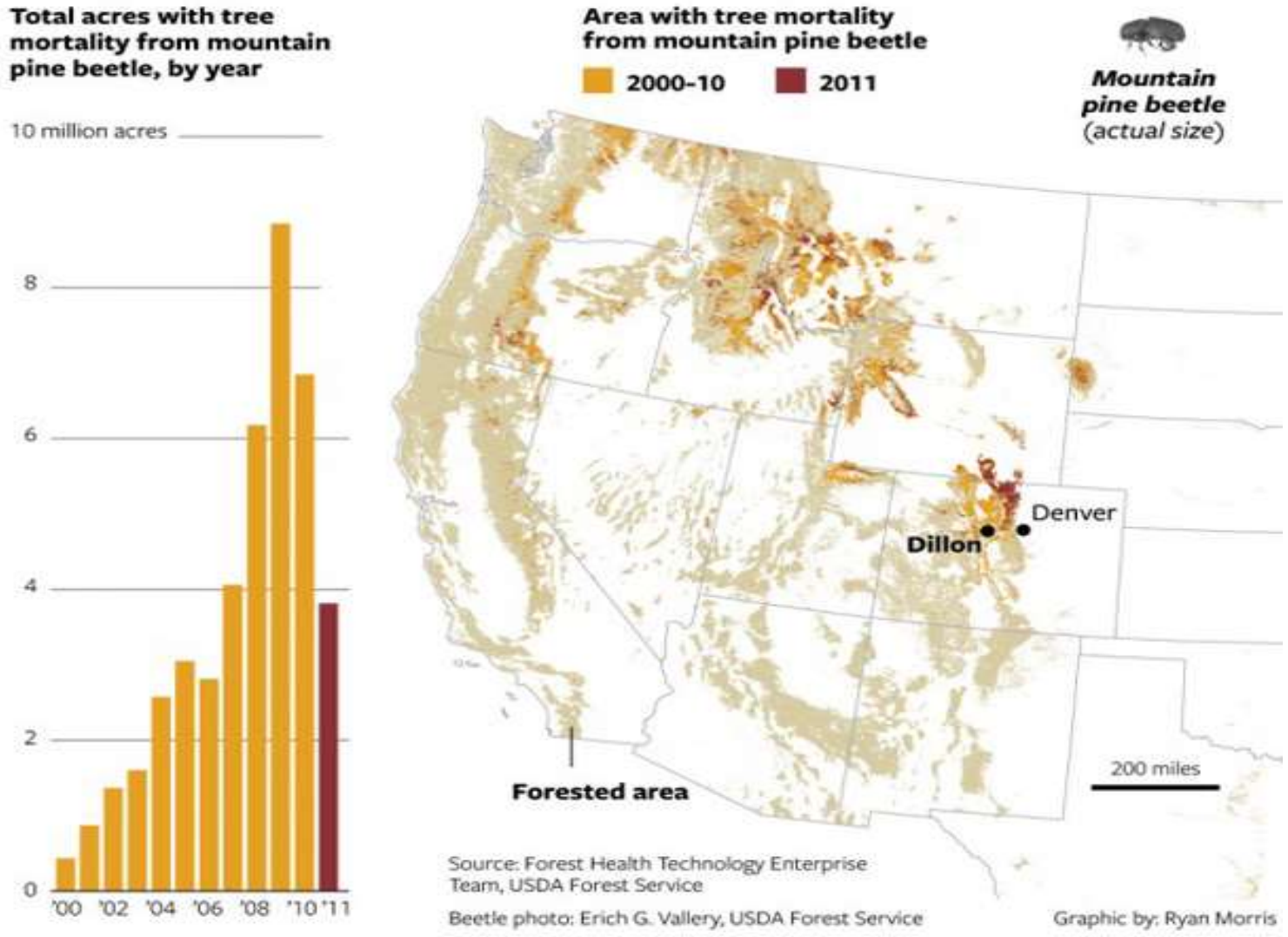
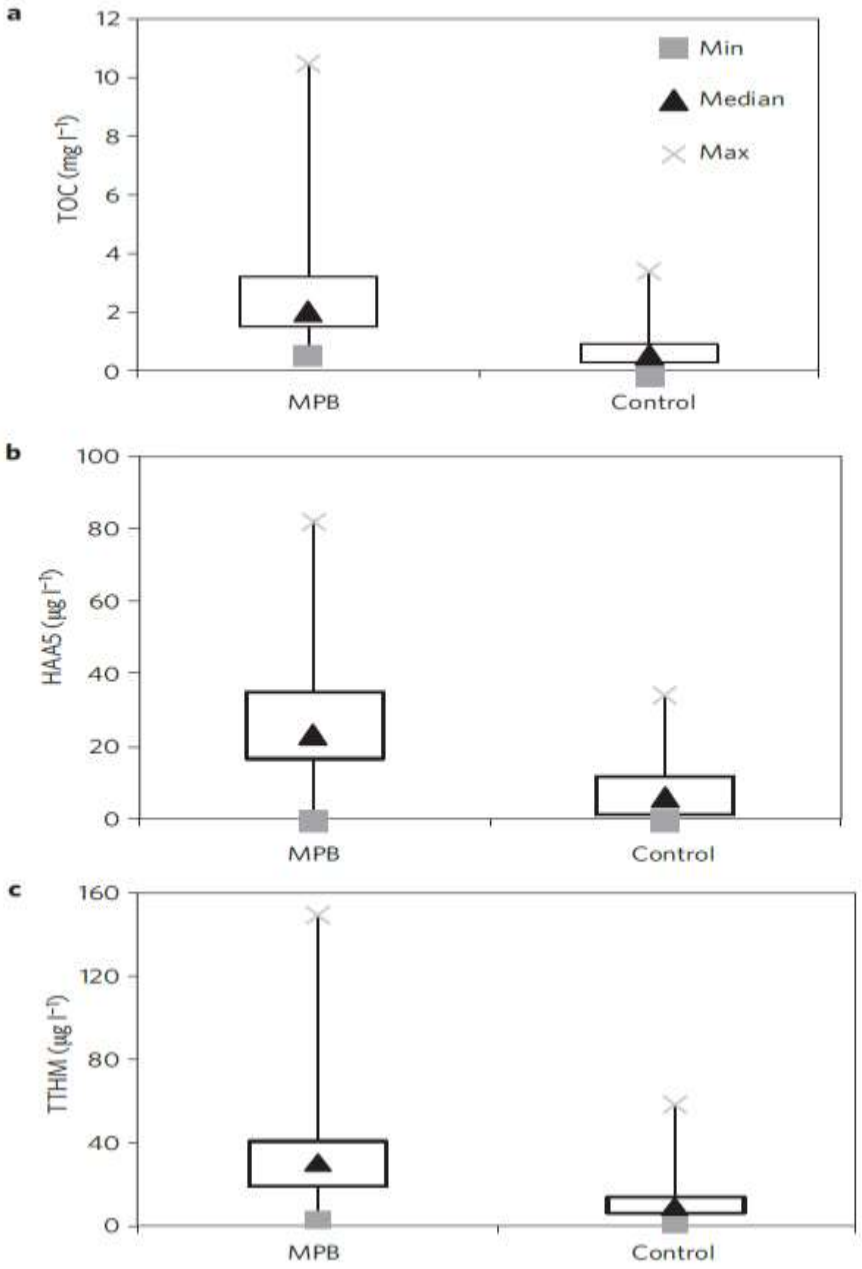
Water Quality Impacts from Climate Induced Forest Die-off

- Pine Beetle epidemic in the Rocky Mountains
- In British Canada alone, the insects gutted and killed about 13 million hectares of trees in about a decade
- Evidence suggests that elevated temperatures at high elevations across western North America have allowed mountain pine beetle populations to develop in a single year in areas where two or more years were previously required

A Destructive Pest

Mountain pine beetles have infested millions of acres of forest in Western states, killing millions of trees. Scientists suspect climate change has contributed to the outbreaks.





MPB – Mountain Pine Beetle

Source: Mikkelson et al, 2013

Utility Concerns