MAGEEP Education Network

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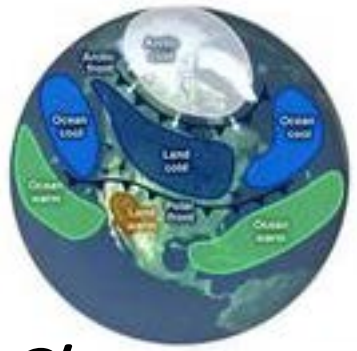


Water System Adaptation To Hydrological Changes

Module 8
Regulatory Framework Intersections: Past, Present, and Future

Y. Jeffrey Yang, Ph. D.

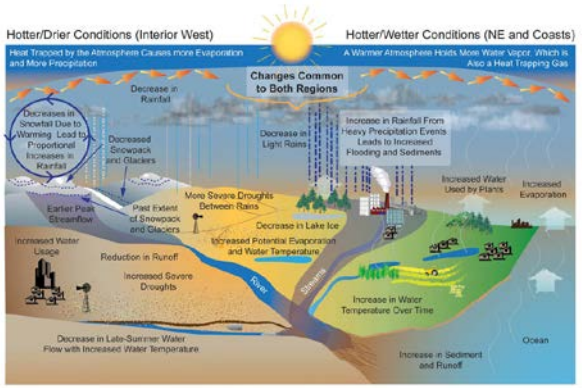
U.S. Environmental Protection Agency

Audrey Levine, Ph.D.

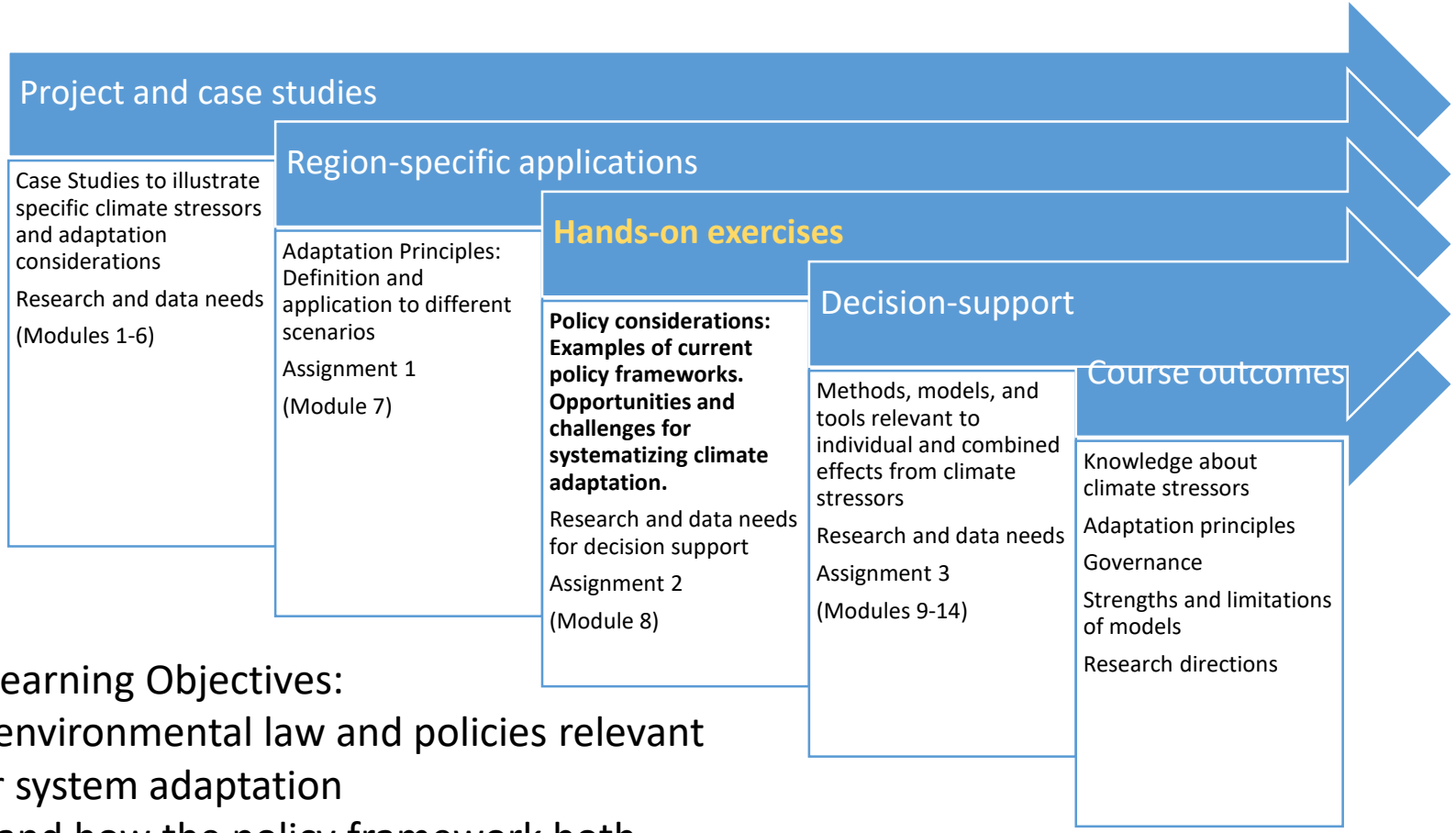
University of California, Santa Cruz

James A. Goodrich, Ph.D.

U.S. Environmental Protection Agency



Course Roadmap



Module 8 Learning Objectives:

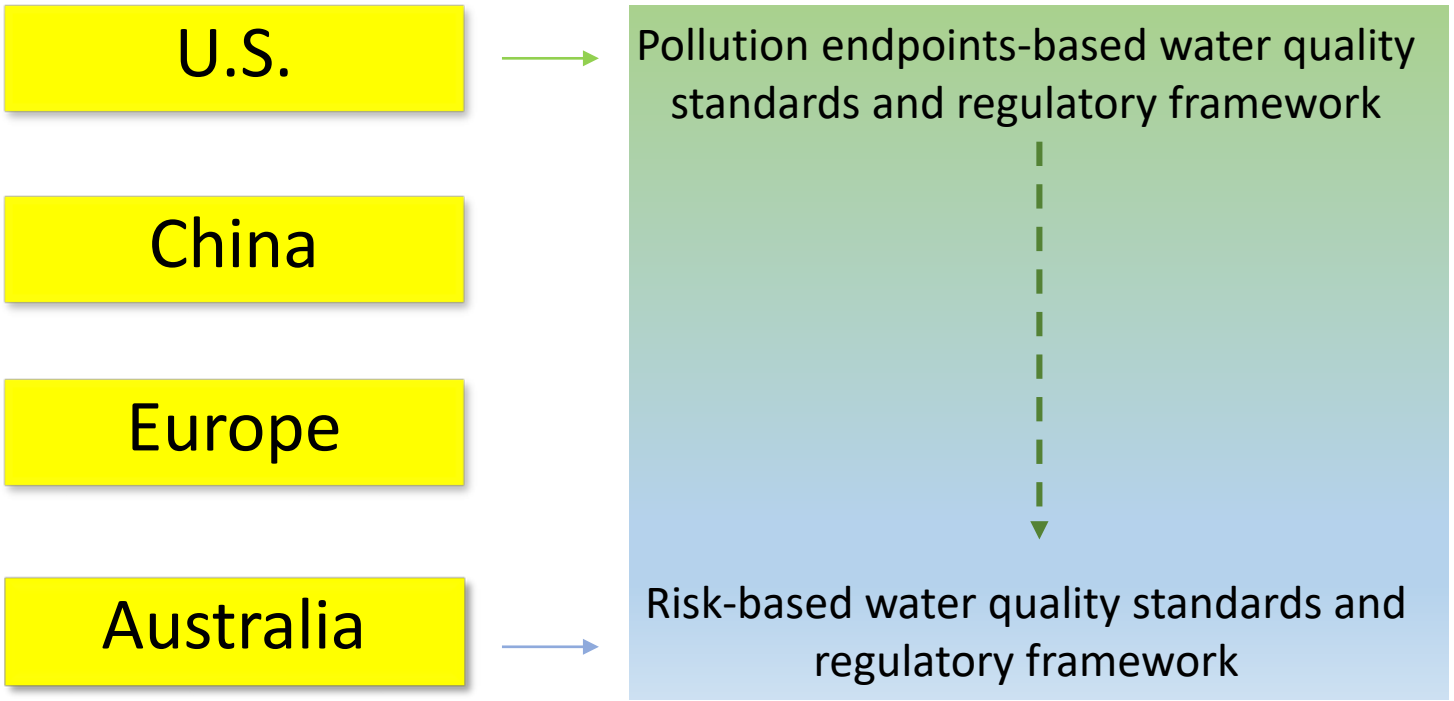
- Review environmental law and policies relevant to water system adaptation
- Understand how the policy framework both presents challenges and offers opportunities
- Go over U.S. examples, with some illustrations from other countries

Policy Overview – United States

- Climate change is not rated as the highest priority, but as an important concern
  - A lack of actionable science often impedes immediate planning and engineering actions
- Vulnerability to precipitation change is compounded by the deterioration of aging water infrastructure, which lags behind socioeconomic change.

Then how are climate and its changes related to policy and regulations?

Policy Overview – Other Countries



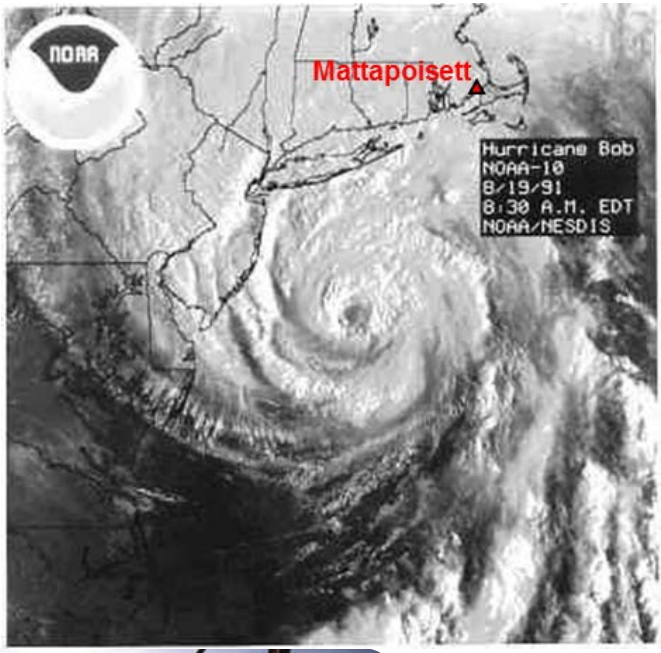
The different policy frameworks manage water system risk differently due to their variable environments and state of knowledge

The Perfect Storm

The confluence of major factors –

"climate and hydrological impacts, aging water infrastructure, regulatory programs, demographic changes, and utility priority setting"

forms a "perfect storm" with implications for desired service functions and for the long-term sustainability of a nation's water infrastructure



Uncertain Energy Policy – Another Dimension of Water Infrastructure Adaptation

Electricity production consumes 5-7% of total water usage. Some additional potential future impacts include:

- Significantly increased water usage in parts of the country to accommodate agriculture and processing costs associated with biofuels (NRC, 2006).
- Increased construction costs due to increased energy costs and petrol-based products such as PVC and HDPE pipes.
- Potential (unknown) impacts of renewable energy methods (wind, solar, hydro power) and increased nuclear power generation.
- Increasing global energy usage and its likely impact on energy availability and cost. This may force water and wastewater utilities to achieve greater energy efficiency in order to offset energy costs.
- Possibly, increased frequency in energy shortages. Water and wastewater systems will need increased capability to switch to alternate or backup energy supplies (Means et al., 2005b).
- The possibility that new energy-intensive treatment technologies may not achieve their expected potential despite their advantages (Means et al., 2005b).

Principal Climate and Hydrological Impacts

Direct Climate Impacts:

- Changes in watershed hydrology
  - Source water for water supply (quality and quantity): Surface water and groundwater changes
  - Stream carrying capacity limiting water discharge
  - Stream erosions and overland runoff
- Changes in coastal hydrology
  - Inundation from sea level rise and storm surges
  - Coastal flooding and salt water intrusion

Human Interactions:

- Water demand change in a warmer climate: human and agricultural consumption, minimum ecological stream flow, and so on
- Compounding between urban development and precipitation change, affecting catchment/watershed hydrology

U.S. Environmental Regulations

How can regulatory approaches address climate impacts and adapt to evolving nature?

Safe Drinking Water Act (SDWA) of 1974

- Maximum Contaminant Levels (MCLs) and Treatment Technologies established for public water system customer consumption

Clean Water Act (CWA), 1972

- Regulates pollution discharged into U.S. streams, lakes, and estuaries

Clean Air Act (CAA)

- Regulations on the emissions of greenhouse gases (GHG) and other pollutants

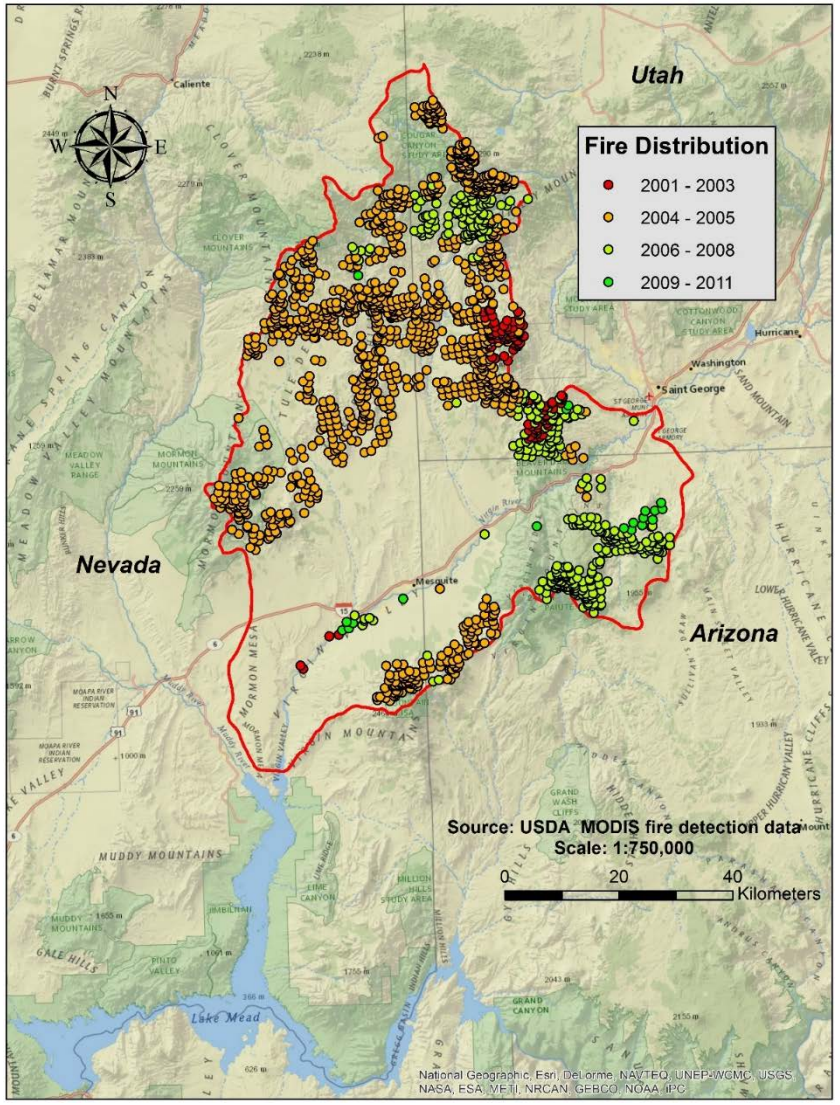
Impacts on Drinking Water Utilities

Drought

- Higher water temperatures
- Reduced dissolved oxygen (DO)
- Increased harmful algae blooms (HABs)
- Decreased microbiological quality
- Concentrated chemical contaminants
- Higher evapotranspiration
  - Less surface water available
  - Greater irrigation demands (urban and agricultural)

Wildfires

- Increased turbidity
- More debris in reservoirs
- Increased pollutant loadings
- Chemical contaminants from firefighting



Wild fire location in Lower Virgin River watershed. Courtesy of Chen et al. (2015)

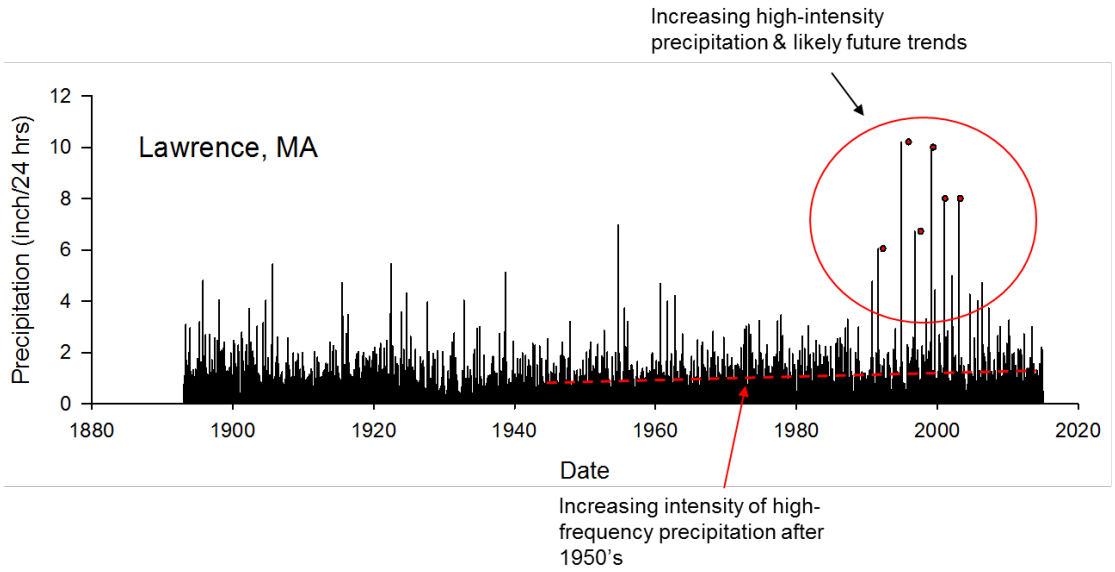
Impacts on Drinking Water Utilities

Increase in the frequency and intensity of storm events

- Flooding (facilities off-line, loss of power/pressure)
- Acute (and chronic) source water quality changes
  - Increased turbidity
  - Increased nutrient loadings
  - Changed NOM characteristics

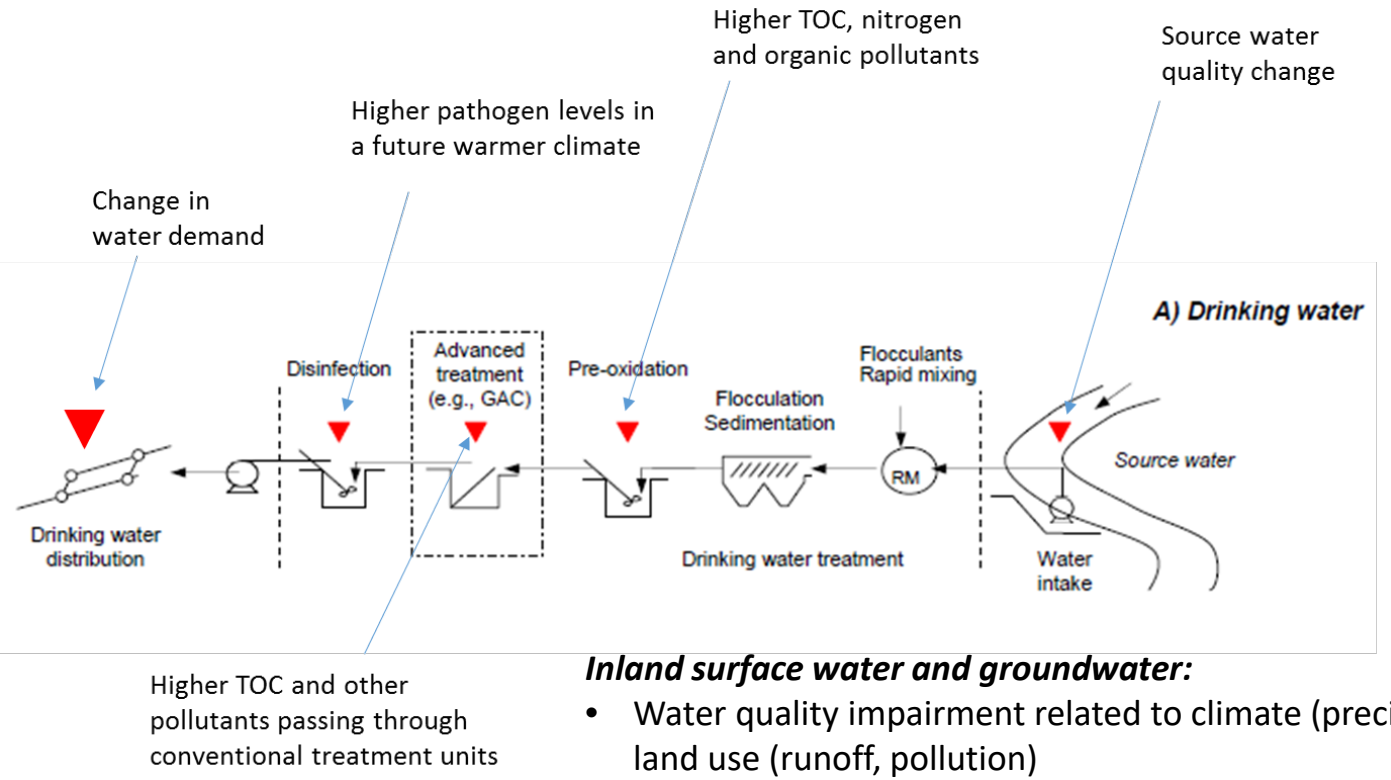
Snowpack and seasonal rainfall pattern changes

- Decreased spring runoff/reservoir storage
- Inland flooding
- Decreased summer supply
- Less groundwater recharge



Yang et al. (2016)

Impacts on Drinking Water Utilities



Inland surface water and groundwater:

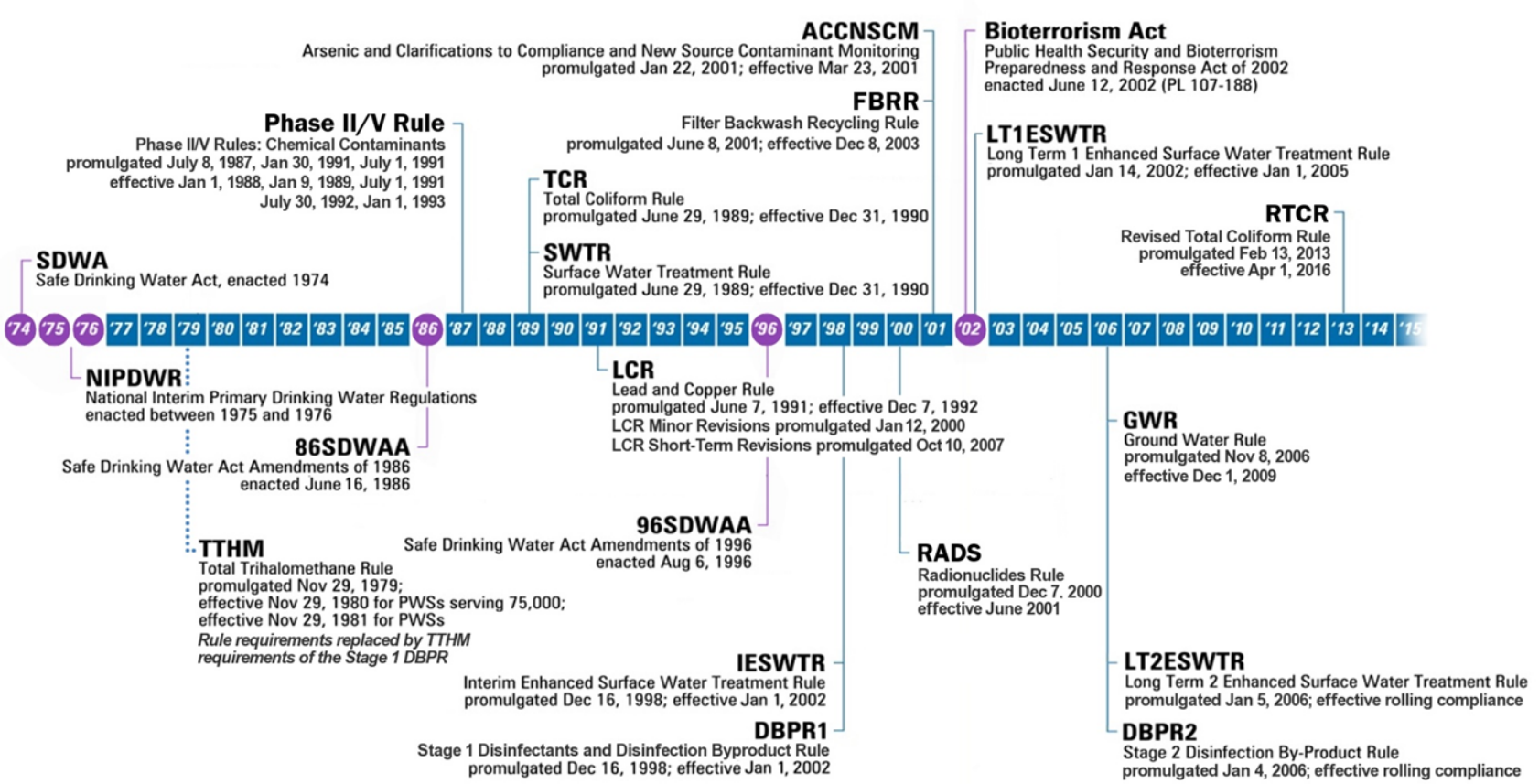
- Water quality impairment related to climate (precipitation, ET) and land use (runoff, pollution)
- Water quantity and water availability

Source water in coastal regions:

- Sea level rise and storm surge leading to: inundation and service impairment; physical damages; flooding-induced contamination
- Salt water intrusion into surface water and groundwater
- Nutrients, TOC and turbidity in surface water due to changed coastal hydrology

The Safe Drinking Water Act

- The U.S. SDWA and regulations are health-based with defined control points
- It has been amended continuously through the years
- Hydrological changes risk our ability to achieve these regulatory standards sustainably
- Both water quality and water quantity or water availability are concerns



The Safe Drinking Water Act

- Total Coliform Rule (TCR, 1990) and the Revised Total Coliform Rule (RTCR, 2013)
- Surface Water Treatment Rule (SWTR, 1990)
- Lead and Copper Rule (LCR, 1992)
- Disinfectants/Disinfection By-Products Rule (DBPRs, 2002)
- Ground Water Rule (GWR, 2009)

Climate and Hydrological Impacts May Affect the Ability of Water Utilities to Comply with Many of These Regulations

Relevance to Public Health Protection

Lead and Copper Rule

- Higher water temperature impacts on pipe corrosion are not clear
- Additional DBP chemical changes could affect corrosion control

Ground Water Rule

- Recharge rates and groundwater depletion could change water quality and increase vulnerability to microbial and chemical contamination

Chemical Rules

- Increases in inorganic, synthetic, and volatile organic chemicals and nitrification

Relevance to Public Health Protection

Total Coliform Rule

- Higher bacterial levels in source water and increased HABs not handled by treatment plant

Surface Water Treatment Rule

- Deteriorated water quality (turbidity, nutrients, TOC) not able to be treated adequately by existing unit processes
- Large sediment and pollutant loadings could overwhelm treatment

Disinfectants/Disinfection By-Products Rule

- Disinfectants (chlorine, chloramine, ozone, chlorine dioxide) not as effective with changing NOM characteristics and TOC levels
- Higher DBP formation in distribution systems

Relevance to Public Health Protection

Other Impacts

- New source water supplies likely to be from unconventional sources, often those of lower quality (e.g. groundwater TDS)
- Candidate Contaminant List
  - New emerging contaminants
- Underground Injection Control Program
  - GHG geological sequestration
  - Hydrofracturing wastes
  - Aquifer Storage and Recovery
    - ✓ Remobilization of indigenous contaminants
    - ✓ Non-native contaminants introduced

The Water Industry Priority Consensus

Table 1-22. Top 15 Issues from the 2014 and 2013 SOTWI Surveys*

	2014			2013	
Rank	Issue	Avg. Score	Rank	Issue	Avg. Score
1	State of water and sewer infrastructure	4.6	1	State of water and sewer infrastructure	4.6
2	Long-term water supply availability	4.5	2	Lack of public understanding of the value of water	4.3
3	Financing for capital improvements	4.4	3	Capital costs and availability	4.3
4	Public understanding of the value of water resources	4.3	4	Water supply and scarcity	4.1
5	Public understanding of the value of water systems and services	4.3	5	Aging workforce/ talent attraction and retention	3.9
6	Groundwater management and overuse	4.2	6	Drought	3.9
7	Watershed protection	4.2	7	Customer, constituent, and community relationships	3.9
8	Drought or periodic water shortages	4.1	8	Cost recovery	3.9
9	Emergency preparedness	4.1	9	Regulation and government oversight	3.8
10	Cost recovery	4.0	10	Emergency preparedness	3.8
11	Acceptance of rate increases	3.9	11	Energy demand/use/costs	3.7
12	Talent attraction and retention	3.9	12	Climate risk and resiliency	3.6
13	Compliance with current regulations	3.9	13	Security	3.5
14	Compliance with future regulations	3.9	14	Declining water demands	3.0
15	Water conservation / efficiency	3.9	15	Privatization and out-sourcing	3.0

From EPA (2016)

- Several national surveys of water utilities done recently
- University of Cincinnati in 2008, USCM in 2005, AWWA 2014, WRF 2012, and so on
- Most respondents rated issues of water supply operation (e.g., infrastructure, water availability) as top concerns
- Climate change and resiliency is not a high priority (e.g., right table), but is closely related to regulatory compliance and infrastructure operations

USCM – U.S. Conference of Mayors
AWWA – American Water Works Association
WRF – Water Research Foundation

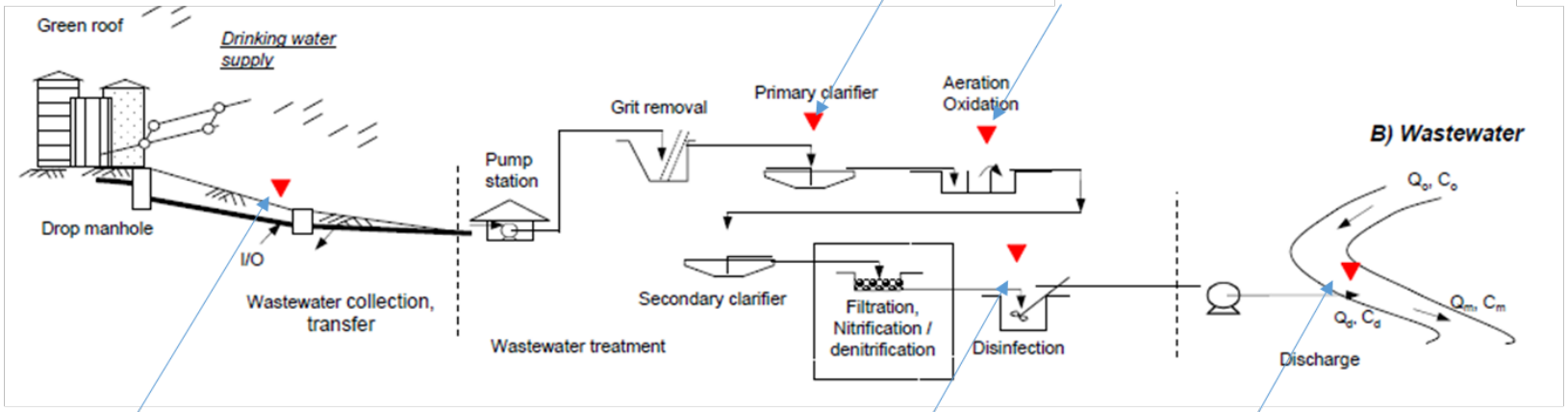
The Clean Water Act

- The primary relevance of the CWA to precipitation change is the regulatory and non-regulatory mechanisms it offers for managing climate impacts to surface waters, rather than climate change mitigation (i.e., reduction of GHG emissions) (Craig, 2010)
- Water quality standards (WQS) can be used to address climate impacts in several ways.

Precipitation Change Impacts on Wastewater and Stormwater Utilities

High solids from higher runoff may impact grit removal

Higher organics, nutrients, etc. likely affect biological oxidation



Intense precipitation could impact collection systems by infiltration and exfiltration (I/O)

Pathogens at warmer temperature, but impact uncertain and potentially low

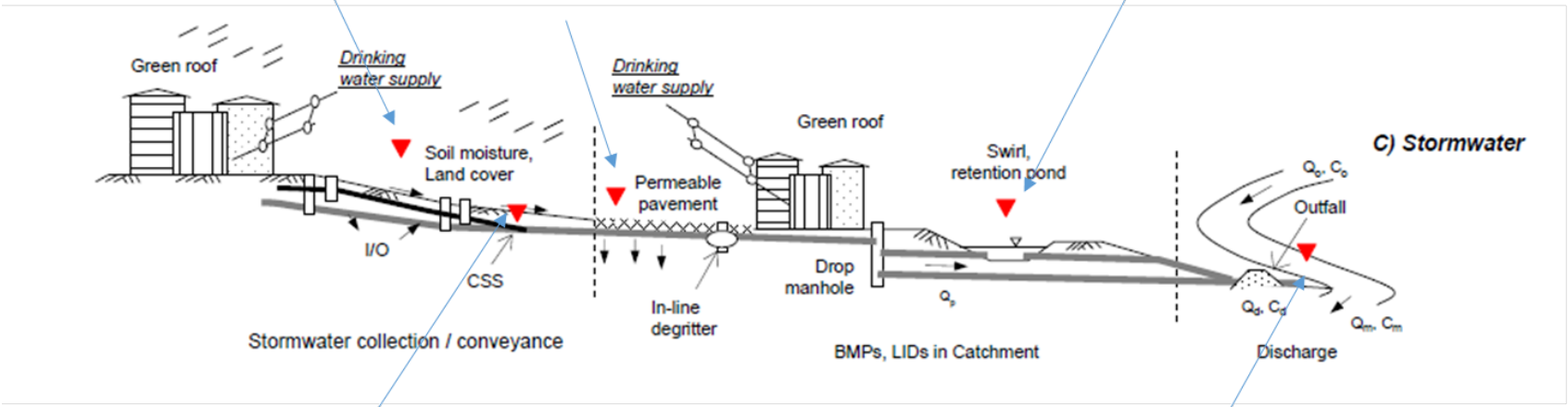
Discharge to surface water body likely to be more restrictive, without further surface water impairment

Precipitation Impacts on Wastewater and Stormwater Utilities

Changes in precipitation and land cover can significantly affect surface runoff properties

Changes in precipitation can affect green infrastructure designs (e.g., permeable pavement, green roof, etc.)

Changes in precipitation and hence runoff can significantly impact BMP designs, such as swirl and retention ponds



Changes in precipitation and land cover can impact combined sewer system (CSS) in combined sewer overflows (CSO)

Stormwater discharge limits may change due to stream's carrying capacity in future climate

The Clean Water Act

Water Quality Standards (WQS). New WQS can be updated for each of the three WQS components

- Designated uses
  - ✓ Ecological flow
  - ✓ Wetlands, estuary wetlands
- Numeric/narrative criteria
  - ✓ Temperature criteria changed to reflect new thermal regime in a new climate
- Anti-degradation provisions
- Protect existing designated uses if susceptible to precipitation change impacts

The Clean Water Act

National Pollutant Discharge Elimination System (NPDES) Permits

- New effluent limitations must now consider precipitation change
  - ✓ Shift from historic precipitation and flow data to incorporating projected future conditions
  - ✓ Changes of stream base flow and thus different NDPES permitting limits

Total Maximum Daily Loads (TMDLs)

- Waste load allocations (WLA) and load allocations (LAs) can incorporate climate scenarios
- Alternative water quality targets, other than current TMDLs, to reflect precipitation changes

State Revolving Funds (SRF) program

- Supports for water infrastructure development at local levels
- The funding review and approval process can include hydroclimate resilience as one criteria

The Clean Air Act (CAA)

- CAA includes both adaptation and mitigation actions to control air pollutant emissions and GHG.
- Six GHG and motor vehicle gases were found to threaten public health and welfare
- Indirect implications for water resource management and infrastructure adaptation
  - New power plant production limited by lack of reliable cooling water supply
  - Power plant production limited by receiving water temperature regulations (CWA criteria)

The Clean Air Act (CAA)

Power plants also further regulated

- Carbon pollution to be reduced by 30%, necessitating:
  - Improved efficiency of existing coal-fired power plants
  - Increased utilization of existing natural gas-fired power plants
  - Expanded use of wind, solar or other alternatives
  - Increased energy efficiency in homes and businesses

Transition from coal or natural gas-fired boilers

- Reductions in water use

Perspectives from International Law and Regulatory Framework

Policy Overview – International Views

International Climate Agreements

- Introduces border adjustments (tariffs) to maintain business competitiveness
- Consumption based approach vs. production for emission allocations to combat GHG
  - encourages mitigation, cleaner production
  - covers global emissions
- Non-technical behavioral and lifestyle changes vs. technical measures and 'end-of-pipe' approach
- Only indirectly impacts water resource adaptation similar to U.S. Clean Air Act

Policy Overview – European Union

Directives

- Legal acts that require member states to achieve particular results without dictating the means of achieving the result – similar to the U.S. Clean Water Act

First Wave of Directives (1970's – 1980's) – surface water and drinking water directives

- Water quality standards

Second Wave of Directives (1990's)

- Standards and emission levels to achieve standards
  - Urban Wastewater Management
  - New Drinking Water Quality
  - Nitrates
  - Integrated Pollution and Prevention

Policy Overview – European Union

<u>Third Wave</u> (2000's) – Common EU Water Policy

- Water Framework Directive - 2000
  - Assure good qualitative and quantitative status of all water bodies
  - Shift from government to governance
  - Base management on river basins – combines previous Directives
  - Link physical planning with water resource planning
  - Increase public participation involvement
  - Turn provisions into legislation

Policy Overview – European Union

Floods Directive

- Risk Assessment and Risk Management Plans
  - Traditional solutions to managing urban flooding are likely too costly and alternatives are needed
  - Building precipitation sensitivity allowances into urban development plans
- For example, changing design floods/recurrence in Germany

Tools becoming available for appropriate building design incorporating hydrological changes

Policy Overview – Australia

Council of Australian Government Reforms of 1994

- Many laws creating organizations to extract, distribute, and use water in each state
- 14 different types of corporate organizations supplying water in Australia
- Formal and informal institutions, policies, and laws
- A response to the 7 Principles of Ecologically Sustainable Development (ESD) (National Strategy on Ecologically Sustainable Development, 1992)

Policy Overview – Australia

National Water Initiative of 2004

- Objectives
  - prepare water plans with provision for the environment
  - deal with over-allocated or stressed water systems
  - introduce registers of water rights and standards for water accounting
  - expand the trade in water
  - improve pricing for water storage and delivery
  - meet and manage urban water demands.
- Full implementation of the NWI aims to deliver:

  "Effective water planning: transparent and statutory based water planning that deals with key issues such as the natural variability of water systems, major water interception activities, the interaction between surface water and groundwater systems, and the provision of water to achieve specific environmental outcomes."

Summary

- Precipitation change, aging water infrastructure, regulatory programs, demographic changes, and utility priority setting may result in a “Perfect Storm” for water systems trying to be resilient and sustainable
- Regulatory frameworks vary by country from prescriptive environmental endpoints to risk assessment guidance
- Differing regulatory approaches may or may not be able to mitigate hydroclimatic change impacts impeding water system adaptation

Research Questions

- Identify or relate how environmental regulations are linked to examples in the previous case study modules
- How do the environmental regulations in your country resemble those of the U.S., EU, or Australia?
- How does your country's or local government's attitude towards hydroclimatic impacts its environmental policies
- Characterize your country's water infrastructure in terms of # of systems, size, and ownership

Looking ahead to the next module…..

- Next module: Water system resilience and security under climate uncertainty
- Scoping of project topics