USDN Urban Water Learning Project
Topic: Water System Adaptation
Draft 1

January 14, 2014

Adaptation Research Process and Progress to Date

- *Identify topic and sub-questions (Done)*
- *Conduct initial research (Done)*
- *Produce first draft of findings (Done)*
- **Review findings with advisors - identify additional questions & resources (We Are Here)**
- Revise report & review with advisors
- Complete report for dissemination to advisors & others

NOTE TO ADVISORY BOARD:

- **As you review the information:**
  - What's new and interesting?
  - What further questions does it raise?
  - What, if anything, would you want to share with your city's water people?

Questions We Started With

1. What are the categories of climate-change risk in water systems?

- Where are the different **types of vulnerabilities** in each of the 3 main water system classifications (water supply, wastewater, and stormwater)?
- How can we focus **on improving system efficiencies** that reduce energy dependence, allowing for increased resilience to environmental changes?
- How can systems often fragmented under different governance **be influenced by local government sustainability goals**?
- Where is **the nexus between the different systems** that brings the value of a local and regional focus to bear and takes into consideration broader community goals? For example:
  - In areas that are wet, **what impacts is climate change having or predicted to have on infrastructure** (i.e., the cost of levee replacement in updated flood zones, the ability to sell green infrastructure concepts when rain events are consistently above first flush (1"/hour) and absorption isn't as important as getting it into the river system for removal)?
  - When a city **redlines a business district from redevelopment** due to a FEMA rezone of the flood plain, it's important to fix infrastructure (levees) before the 100-year flood comes. Is there a way for cities to work together on funding the restructuring of the Nation's network of older flood levees with the federal government?
  - In dry areas, how can cities best deal with competing demands, address water transport and shortage issues, and **change the conversation from "we need more", to "we need to be efficient"** with resources and long term development planning?

2. What are the adaptation strategies for addressing the risk categories?

- What **lessons can we learn** from others engaged in Adaptation / Resilience work to scale and replicate in other regions?
- What is the **new set of standard best practices** we should be developing in light of climate change impacts in the face of:
  - Institutional constraints?
  - Lack of information?
  - Scientific and economic uncertainties?
  - Inadequate case studies useful in practical applications?

3. How can the public be engaged in understanding the system's adaptation requirements?

- How do **we best address difficulties in engaging stakeholders** on climate change, which it is still an especially polarizing topic in some regions? How does this conversation impact public approval of fund expenditure on local water systems?
- How do we **redefine the conversation** so it's not just about urban/economic growth, with water as an afterthought, but it's about water as a community asset to be protected and an economic driver to be considered with land use?
- What are the best ways to communicate adaptation goals to the broader community? How can the community be engaged so that conditions are created for understanding and approval of adaptation work/investment in water systems? How can **we best align long-term sustainability goals with water systems goals?**

Summary of Initial Findings

1. **Adaptation planning is very different from traditional water system planning and is not yet a standardized practice**
    1. looking at projections, rather than historical trends
    2. taking integrated approach, rather than fragmented silos
    3. requiring new types of institutional collaboration (watershed/basin players; multiple urban systems; multiple levels of government)
    4. stakeholders must agree on desired level of physical resiliency [how much is enough?]

2. **Adaptation will dramatically impact practically every aspect of water management, putting a premium on efficiency and demand management**

3. **Many water utilities do not have the capacity (awareness, expertise, capital, planning sophistication) to become climate ready and there's little organized capacity to help them**

4. **Adaptation will challenge water utilities' financial condition — increasing costs (operational and capital costs, costs of financing and insuring) and, therefore, requiring rate increases and new revenue sources**
    1. There will be social-economic effects; winners and losers in cities
    2. May require adjustment to utility business models

5. **Water utilities are unlikely to achieve sufficient resilience without engaging and bringing along regional stakeholders, community members, and ratepayers**

6. **Future water management/planning may be increasingly adaptive—continuously shifting on the basis of performance monitoring**

7. **Climate readiness of a city's water systems is a potential comparative advantage for the city (think: investment, not cost)-**

8. **Certain adaptation investments can generate additional community benefits (e.g., neighborhood improvements; job creation) and help to avoid costs (reducing demand; reducing need for gray infrastructure)**

9. **Adaptation should be linked with carbon mitigation efforts (e.g., reduction in energy use and increase in renewable energy supply)**

Framework for Adaptation Planning in Water Systems

section by section

Section 1 **Climate Effects** ***Appendix with More Information***	• **Slides 6 – 9** • **Slides 41 - 50**
Section 2 **Risks: Natural and Financial**	• **Slides 10 - 19**
Section 3 **Planning Process: Integrated, Adaptive, and Engaging**	• **Slides 20 - 32**
Section 4 **Solutions and Options**	• **Slides 33 - 40**

Section 1
Climate Effects

Note: Appendix 1 contains more information

Climate Change Impacts on Water Resources: Advisory Group

Dryer / Burning

- Already affected and worsening with **declining runoff and groundwater recharge**. The Southwest, parts of the Southeast, and Great Plains:
  - Denver, CO
  - El Paso, TX
  - Santa Monica, CA
  - Tucson, AZ

Wetter / Sinking

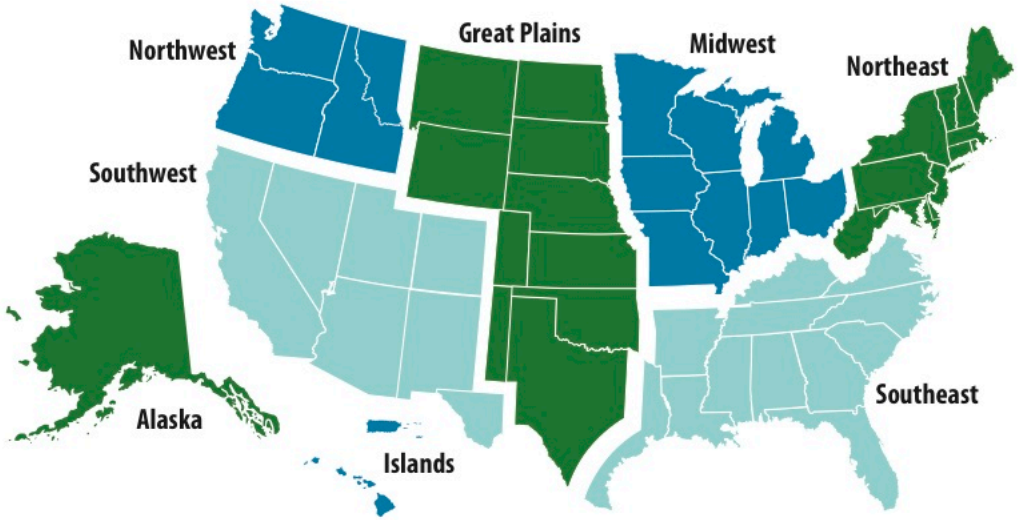
- **Increased flood risk** affects safety and health, property, infrastructure, economy, and ecology. Parts of the Southeast, west, and east coasts, island states / territories:
  - Ann Arbor, MI
  - Boston, MA
  - Cincinnati, OH
  - Dubuque, IA
  - Iowa City, IA
  - Knoxville, TN
  - Los Angeles, CA
  - Miami, FL
  - Milwaukee, WI
  - Washington, D.C.

The regional adaptation conversation is not not just "wet" or "dry", but the focus is on resiliency and efficiency in all situations – a conversation change overall.

Climate Change Effects on Water

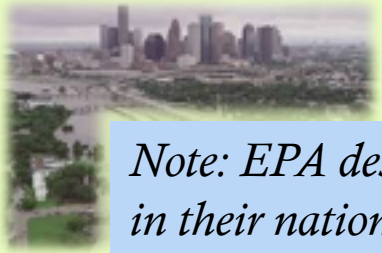
- Some effects vary regionally, some occur across regions:
  - Flooding
  - Salt Water Intrusion
  - Drought
  - Reduced Groundwater Recharge
  - Lower Surface Water Levels
  - Changes in Seasonal Runoff
  - Loss of Wetlands / Ecosystems
  - Fires
  - Water Quality Degradation
  - Ecosystem Changes
  - Service Demand and Use

- Climate change is causing and is projected to cause significant, widespread, enduring changes in the water cycle—increasing variation far beyond historical norms.



Challenges Across Regions

- **Challenge Group: Drought**
  - Reduced Groundwater Recharge
  - Lower Lake and Reservoir Levels
  - Changes in Seasonal Runoff and Loss of Snowpack
- **Challenge Group: Water Quality Degradation**
  - Low Flow Conditions and Altered Water Quality
  - Saltwater Intrusion into Aquifers
  - Altered Surface Water Quality
- **Challenge Group: Floods**
  - High Flow Events and Flooding
  - Flooding from Coastal Storm Surges
- **Challenge Group: Ecosystem Changes**
  - Loss of Coastal Landforms / Wetlands
  - Increased Fire Risk and Altered
  - Vegetation
- **Challenge Group: Service Demand and Use**
  - Volume and Temperature Challenges
  - Changes in Agricultural Water Demand
  - Changes in Energy Sector Needs and Energy Needs of Utilities



Note: EPA designated these 5 general categories in their national adaptation planning document. See Appendix 1 for climate impacts by region.

Section 2
Risks: Natural and Financial

Overall Challenges

- **Challenges to increasing resiliency and adaptive water management include:**
  - Competing demands = **stricter management of water supply**
  - Maintaining / improving water quality and habitat = **better storage**
  - Understanding habitat and species destruction **impacts on water quality** and supply
  - Institutional constraints = **difficulty in budget and jurisdiction**
  - Lack of data or access to data = scientific and **economic uncertainties**
  - Inadequate information = difficult to plan for **practical applications**
  - Difficulties in engaging stakeholders = rising rates with **lack of big picture understanding**

Northeast: high temps, flooding, sea rise, intense storm surges, shorter winters

Southeast: sea rise, ecosystem loss, intense storms

Midwest: heat waves, surface water temp and rainfall increase

Great Plains: increase in temps and rainfall

Southwest: increased temps, flooding from snow melt, invasive species increase, more wildfire, more drought

Northwest: temp and sea level rise, increased seasonal flooding / drought

Alaska: temp and sea level rise, drier overall conditions, season flooding

Islands: increased temps, decreased rainfall, intense and more frequent storms

Categories of Risks

Physical	• Infrastructure failure • Property damage
Environmental	• Increased pollution • Altered ecological systems *(that can no longer perform important water filtration functions)*
Management	• Supply shortages
Economic	• Financial stress on utilities / customers • Loss of insurability
Social	• Institutional frictions • Customer equity

Financial Standards & Adaptation

- **Financial implications for city / utility of climate adaptation:**
  - Not just about physical infrastructure
  - It affects the economics of the utility
  - Very relevant to the overall 'financial risk' of climate change
- **Standards are slowly coming:**
  - Water Standards are **emerging slowly** and adoption of a disclosure framework by the credit industry could result in a two-stage dynamic.
    - Utilities would have to **disclose their current practices**
    - Depending on how credit analysts / bond buyers react to the information, utilities would have to **modify practices** so they would be investment-ready

Water Disclosure Standards

- **Supply Security (analyzing reliability):**
  - Scenario analysis informing supply management
  - Assessment of climate change effects
  - Standing of water rights relative to other users
  - Volumetric conditions of water resources (surface and groundwater)
  - Condition assessment of the watershed feeding supply
  - Historic and planned investment into watershed protection
- **Demand Management (conservation and efficiency)**
  - Assumptions underlying demand projections
  - Sensitivity of demand projections to price
  - Percent of supply from conservation/efficiency and progress against demand management goals
- **Asset Management (characteristics of facilities):**
  - Water loss rates
  - Asset condition assessment and replacement
  - Valuation and budgeting for natural infrastructure management (forested lands, wetlands, constructed green spaces)
- **Water Quality**
  - Steps being taken to comply to anticipated regulation
- **Energy Use / Generation (may present operating cost constraints or benefits):**
  - Energy intensity for water treatment and delivery
  - Energy generation
- **Rates (rising supplies and treatment is leading systems to redesign rates to create pricing incentives for demand reduction)**
  - Drinking water rate structure for all customer sectors.
  - Structure of stormwater and wastewater rates

Insurability

- Insurance **preservation and enhancement** is key to the economic stability of an area
- **Overall insurability** is impacted if a community's resilience is low
- In certain geographies (Miami, New Orleans), **current insurance loss trends threaten overall insurability**
- Risks associated with severe weather impact are **not adequately reflected** in rates

The Cost of Doing Nothing

- **Inaction will affect cost of public programs for disaster relief and recovery**
- **Liabilities of these programs and the bottom line costs to taxpayers**
  - Disaster assistance appropriations
  - Flood insurance
  - Crop insurance
  - Wildfire protection
  - State-run 'residual market' insurance plans
- **Only 50% of damages in U.S. are caused by extreme weather events are privately insured, and more extreme weather is the new normal for the U.S.**
- **Indirect damages (example of dry extremes):**
  - Long term drought causes restricted water availability, limitations on hydropower generation / power plant production, disruption to navigation, increased fire risk (longer and more severe wildfire seasons), and price increases for basic needs.
- **Longer Term Indirect Costs:**
  - Business losses from office closures and reduced productivity
  - Lost tax revenues
  - Cancelled business and tourist travel
  - Loss of wages from closed businesses
  - Neighborhood flight

- *Note: This and more information on this topic can be found in the Ceres Report Ceres . "Inaction on Climate Change: the Cost to Taxpayers". October 2013.*
- **In years with a small number of natural catastrophes, typically taxpayers assume annual estimated costs as follows:**
  - $20 billion related to federal expenditures on disaster assistance
  - $9 billion reflecting the taxpayer share of premiums paid to the Federal Crop Insurance Program
  - $5 billion in annual federal and state expenditures on wildfire protection

Vulnerability Analysis

A Note on Models

- Climate change will accelerate the pace of the hydrological cycle, and **models try to account for direct, indirect and compound impacts**
- **Climate models exhibit the least consistency** with one another in predicting precipitation at a regional level, and especially in the mid-latitudes
- Two approaches to Vulnerability Analysis:
  - **Top Down:** do climate change forecasting (using models) at the front end of planning:
    - There are tradeoffs involved in downscaling precipitation projections
    - Forecasts must be converted to changes in water runoff and groundwater recharge
  - **Bottom Up:** build a long term response by examining connectivity of systems

Data Inputs and Outputs

Traditional Planning	Adaptation Planning
Historical water data	Climate change models/projections
Static climate conditions	Dynamic climate conditions
Probability/scenario analysis	Multiple outcomes analysis of future conditions/vulnerability (e.g., portfolio of future conditions/vulnerability
Internal/expert process	Stakeholder engagement

Budgeting for Resilience

- Water and wastewater **utilities are tied together by cost and billing**, and capital resources and ratepayer resources are constrained.
  - **Wet weather extremes**: programs require expensive re-sizing to manage higher flows, it may reduce influent challenges for water utilities, but will still have an impact on the water supply side of the business through this financial connection.
  - **Dry weather extremes:** discharge permits and waste load allocations are quite often grounded in the low flows documented in the historic hydrologic record.
- **For utilities, financing infrastructure upgrades on their own is challenging**, due to:
  - Limitations on their capital expenditure imposed by regulators
  - Their own revenue-raising models

- **Cities are a system of interacting systems**
  - One single stakeholder rarely stands out as having sufficient motivation to organize the required collaboration on their own.
- **The question of who pays for physical resilience improvements depends on whether the resilience benefits go to the private property owner or the community**
  - What is the impact of resilience investment on disadvantaged communities and how can social equity be achieved / maintained

A Note on Inundation

- **Inundation Risk**
  - Sea-level rise, intense storms
  - River flooding intensified by catastrophic rains and glacial melt-off
  - Lowered groundwater tables from pumping

- **Transportation infrastructure at risk**

- **Residential development in river valleys and along sea costs at risk**

- **Adaptive responses to inundation risks:**
  - Raising dikes, levees, tide gates, and sea walls; raising and reinforcing structures at risk of scour or inundation;
  - Relocating roads, water mains, power lines and other infrastructures at higher elevations or further inland;
  - Absorbing more rainfall and/or increasing evapotranspiration through urban forestry programs, green roofs, pervious surfaces, swales and detention ponds.
  - Prohibiting development in most vulnerable areas; creating 'space for the river' by opening land for periodic inundation; creating/supporting insurance mechanisms to spread risks and send price signals; implementing 'soft grid' semi-autonomous systems that can survive failure of centralized systems

- Case: **Miami is the most vulnerable city worldwide** in terms of dollar-value of assets exposed if a 1-in-100-year surge-induced flood event were to happen today. One of the top 10 cities worldwide for population exposure related to coastal flooding. There are 2.5 million people in the metro area served by 35 cities, various water districts, and multiple governments with infrastructure portfolios.

Section 3

Planning Process: Integrated Adaptive, and Engaging

Current Planning Approach

- In most U.S. regions, water resources managers and planners will encounter risks, vulnerabilities, and opportunities that cannot be managed with existing practices. Water systems have to **engage in new types of planning**—anticipating climate effects and risks specific to their situation

- **There's a mismatch between systems' planning time** horizons for:
  - Operations, capital projects, financial planning
  - Between service territories, natural watershed/basin boundaries, and controlling jurisdictions

- There's a **need to engage stakeholders, community members, and ratepayers in the process**, because:
  - Few water systems can address all of their risks by themselves
  - Adaptation will to require money that will have to come from ratepayers and other revenue sources

- **Much of a plan will be adaptive:**
  - Decisions that move in a general direction
  - Monitor and change based on performance data (because of the uncertainties involved in projecting climate effects, the complexities of the risks, and the inadequacies of planning processes)

Changing the Planning Field

- **Advice on adaptation to climate change begins with the same message:**
  - Employ a portfolio approach to maintain a maximum degree of flexibility and resiliency
- **Integrated Resource Planning**: now based on stakeholder engagement
- **Re-thinking the business structure**: in some cases, it will be necessary to form new institutional structures / methods of collaborating to meet multiple objectives / constraints on a changing playing field
- **Triple Bottom Line**: not just for sustainability directors anymore
- **Regional Partnerships**: climate change will create situations where there are clear advantages to operating at a regional scale so more options are available.
- **Efficiency before Overhaul**: plan operating strategies first to expand ways to manage supply, deferring capital project investment
- **Recycle**: many water suppliers turning to energy-intensive membrane treatment processes to desalinate and reuse highly treated effluent

EPA Strategy Frame

- "Many utilities will try to cope with change by **assessing their options to expand operational flexibility** to meet the changed operating parameters driven by climate threat."
  - ***Minimal Cost: examine system for flexibility of use***
- "Some systems **can operate beyond design or current capacity without making large changes** to their system."
  - ***Medium Cost: make small changes to the system to increase flexibility***
- "After the existing system has **reached the limit of its capacity to absorb climate impacts, it becomes necessary to augment** or optimize capacity through adoption of new practices and resources."
  - ***Maximum Cost: overhaul system or expand it to meet new demand***

Case Study: NYC

Example of Adaptation Planning

- New York City's Department of Environmental Protection (DEP) provides drinking water, wastewater treatment, and stormwater management services to approximately **9.2 million people** in its metropolitan region. DEP plans to adjust its adaptation strategies as it develops tools and programs to manage existing demands and continues an iterative planning process to anticipate future challenges.

- To establish sound decision making tools in light of climate uncertainty, DEP is involved in local and national efforts to study and plan for climate change, including collaboration with:
  - **Other utilities** as part of the Water Utility Climate Alliance
  - Members of **the research community**
    - Water Research Foundation
    - NOAA's Regional Integrated Sciences and Assessments)
    - Columbia University and the City University of New York

- Using downscaled projections from three General Circulation Models, DEP **performed a vulnerability assessment**:
  - Demonstrated that future challenges will reflect an increased probability of a current challenge (i.e., high turbidity events caused by intense precipitation erosion).
  - Warming winters are projected to lead to less snow accumulation and increased winter stream- flow. This may result in more nutrients and sediment entering the reservoirs during the winter as opposed to the spring.

- Existing DEP programs enhance resilience to challenges that may arise in the future (i.e., acquisition of land in the Catskill Mountains and Delaware River watersheds, and conservation efforts with landowners helps protect the areas surrounding reservoirs and controlled lakes). Other strategies being implemented to enhance the resilience of DEP's systems include:
  - **More frequent sewer maintenance**
  - **Enhancing green infrastructure to decrease stormwater runoff**
  - **Promoting water conservation**

Global Impact Lessons: Australia – Water and Climate

- **Climate change increases the risks** of:
  - Wrong decisions
  - Poor allocation of capital
  - Potential for stranded assets, and/or missed opportunities for efficiencies

- Different **adaptation approaches** are based on:
  - 'Soft fail' alternative operating modes
  - Multiple redundant or decentralized systems
  - Community resilience
  - Adapting urban form
  - Active engagement to re-prioritize community expectations
- **Adaptation framework** based on:
  - Diversifying water sources to avoid water restrictions
  - Network connectivity to share and trade water to maintain supply
  - Strategic plans to ensure public water services are resilient to climate change
  - Accounting for reductions in asset life
  - Water conservation and efficiency
  - Urban Planning and Form (water sensitive urban design; planning for coastline impacts)

Key Elements in a Climate Change Scenario (Denver)

Hot Water Scenario (Key Assumptions: temp increase 5 degrees by 2050)	
Supply	Average annual streamflow declines. Evapotranspiration increases. Potential loss from a Colorado River Compact call.
Reuse	High demand for reuse.
Demand	Movement away from bluegrass.
Water Quality	Decreases due to sedimentation from forest fires, more intense rainfall, increased turbidity, and concentration of contaminants.
Regional Role	No binding change. Pressure increases to help others and provide leadership.
Economic Impacts	Growth slows in region.
Regulatory	Increasing complexity. Relaxed in response to increasing scarcity.
Social Tenor	Paradigm shift in water use. More customer activism.
Supply Competition	Dramatic increase.
Cost of Energy	Dramatic increase

No and Low Regrets

- Model results **are inconsistent, but provide better information than none** at all
- The goal is to **develop a range of future conditions that go beyond understanding current trends** and represent surprising but plausible conditions
- **Scenarios are treated as equally likely to occur**, rather than assigned probabilities (i.e., classic decision analysis)
- Implications and future needs of each scenario are identified and adaptation **strategies are developed to meet the needs of each scenario**
- Ideal adaptation strategies have near- term actions that are common to all or most scenarios
- *Signposts* can be established to monitor the development of the scenarios and determine when adaptation measures are no longer common to all or most scenarios

Knowledge to Decisions

- **Local government has varying adaptive capacities:**
  - Accessible information base
  - Existing infrastructure
  - Quality of institutions and governance
  - Financial and technical resources
- **Adaptation processes:**
  - Increase public awareness and engage stakeholders
  - Systematic review of climate trends and projects, and range of likely impacts
  - Assessment of water system vulnerabilities and potential costs of climate impacts
  - Identification of range of options for reducing vulnerabilities; development and implementation of adaptation strategy

- **Challenges for local officials:**
  - How to translate knowledge into decision making
  - Identify and prioritize adaptation measures
  - Secure financial commitment
  - Positively shape water sector development
  - Existing infrastructure sized on historic weather norms and under pressure due to population increases and age

Other Planning Challenges

- In most metro areas, **spatial planning and water services are handled by separate agencies**
- There is a need to **manage land development for disaster prevention** and to climate-proof water and sanitation services
- Cities must **consider building codes**, as well as planning, management, zoning, and infrastructure
- Construction **permits are still given in "at risk" zones**. This is one of the more difficult obstacles to climate change adaptation for urban areas
- Changes in spatial planning and building codes, together with the need to assist re-settlement present unprecedented challenges for local government especially where:
  - People are too poor to have viable options
  - Communities have lost resilience from repeated disasters
  - Commercial interests exert political pressure for imprudent investment

Portfolio Planning

- Portfolio planning – developing **parallel strategies and assessing each option** in terms of life-cycle costs (including energy footprint) and regulatory and environmental hurdles

- Examples of measures that can be ramped up or down as they prove feasible and cost-effective:
  - Building more storage
  - Conjunctive use of surface water and ground water, with ground water recharge
  - Desalination
  - Rainwater harvesting/stormwater harvesting
  - Use of recycled water including industrial process water and treated wastewater
  - Private vendors
  - Acquisition of water rights from agriculture
  - Matching use of water to quality
  - Decision support tools for matching portfolio development to climate variability: www.watersim.asu.edu

Community Engagement

- **Changing focus from risk management to performance investment**
  - 'Costly risk management' to 'investing in performance enhancement'
  - Making climate resilience a competitive issue (a place for business to operate with fewer interruptions; a safer place for people; more stable demands on municipal budgets)
  - Achieving this in response to risks not yet acutely felt is new territory for policy-makers, planners, utilities, and insurers
  - This is not just a way to change the paradigm/conversation about adaptation, it's also a link to economic development
- **Increase community awareness by explaining water issues and local dependencies with your utility (through established public outreach mechanisms)**
- **Link water issues to other issues of great importance to the community:**
  - Economic development/growth
  - Neighborhood quality & improvement
  - Equality for all Communities
  - Environmental, Physical, and Social Heath

- **Develop a regional message about water adaptation with other cities facing similar vulnerabilities**
- **Optimize efficiency / demand management strategies and other no- to low-cost approaches, so you have credibility when asking for additional funds**
- **Identify and communicate the system's adaptation/resilience requirements (i.e., why your community should care)**
  - Infrastructure investments are ultimately passed to the rate-payer
  - Federal support is increasingly connected to resilience

State of the Union

- *From NRDC Issue Brief: "Ready or Not: An Evaluation of State and Climate Water Preparedness Planning". April 2012.*
- Full analysis for this NRDC brief provides a state-by-state focused on **how state governments preparing for the water- related impacts of climate change**.
- Based on the actions of state government entities, all 50 states have been categorized into **one of four categories**.
- Categorization differentiates best prepared states on climate change (i.e., Category 1 and 2) from those that are unprepared (i.e., Category 3 and 4).
- Although many states have yet to address climate change (Category 4), some of **these states have existing water policies or programs (i.e. water conservation or efficiency policies) that- if recognized within the context of climate change- could be beneficial**.

Category 1	Category 2	Category 3	Category 4
Alaska*	Colorado	Arizona	Alabama
California	Connecticut	Georgia	Arkansas
Maryland	Delaware	Florida	Indiana**
Massachusetts	Hawaii	Idaho	Iowa
New York	Maine	Illinois	Kansas**
Oregon*	Michigan	Kentucky	Missouri
Pennsylvania*	Minnesota	Louisiana	Montana
Washington	New Hampshire	Mississippi	North Dakota
Wisconsin*	New Jersey	Nebraska	Ohio
	North Carolina	Nevada	South Dakota
	Rhode Island	New Mexico	Texas**
	Vermont	Oklahoma	Utah**
		South Carolina	
		Tennessee	
		Virginia	
		West Virginia	
		Wyoming	

Section 4
Solutions and Options

Demand and Delivery Efficiency

- Water system planners **see solutions through a model based on the cost and flexibility** of the solution
  - "No Regrets" solutions (must do under all circumstances and/or no- to low-cost) come first
- Although there are many possible responses to climate effects/risks, several stand out in pursuit of resilience:
  - **Demand management** to reduce supply needs
    - Few systems have maximized demand management (conservation). Getting customers to use less water is far cheaper than supplying them with the water. This usually runs into rate structure challenges
  - **Delivery efficiency** to reduce loss of/non-revenue water
- For systems challenged with supply sufficiency:
  - Maximize demand management
  - Explore water reuse/recycling

Advice About Where to Start

- Understand **there is still a disconnect** between the knowledge generated by the scientific community and the specific needs of practitioners (e.g., water managers)
- Understand **model projections are a tool to inform**, not absolutely accurate, and their results cannot be used directly for infrastructure design adaptation
- Start with **no- and low regrets investments**, and operational adjustments, and understand that adaptation is about learning to live with floods and drought efficiently
- Limit scope of decisions to **20-30 years** (uncertainty is relatively low and partially quantifiable)
- Develop an **economic impact assessment** of risk reducing measures, reflecting costs of disaster relief financing and long-term impacts of economic growth of disasters with low resilience
- Demonstrate **commonality of purpose between resilience plans and overall development** so that the funding streams in development budgets can be made available for climate adaptation
- **Engage the insurance market**. It could be possible to enable new private sector insurance products that aggregate insured parties into new purchasing groups at a local area scale, forming 'insurance pools' – this would be a direct result of collaboration between local government and insurance companies

Dealing with Water Competition

- Heightened competition for water
  - Between **cities and other interests** (agriculture)
  - Within cities **between rich and poor** (socioeconomic tensions)
- Strategies: Integrated Water Resource Management participation in which **cities have a voice in river basin water allocations or processes**.
- Market-based mechanisms that **allow cities to buy water rights**, from irrigators by paying for irrigation efficiency improvements
- Option contracts for urban/agriculture tradeoffs in low water years (CA model).
- A **sub-district within a city** may be designed with sustainable, 'closed loop' water services to reduce the intra-city competition for water resources.

Ecological and Human Health

- **Threats to Water Quality:**
  - Industrial wastes and other pollutants (including heat) may be released by extreme storm events (downstream ramifications)
  - Human waste disposal systems are vulnerable to high water tables and inundation
  - Invasive species
  - Turbidity from landslides and erosion or low flows due to drought

- **Possible adaptations:**
  - Sewage treatment plants at higher levels or on protected levees
  - Decentralized close-loop wastewater treatment
  - Waterless or low-water disposal
  - 'Polluter pays' strategies
  - Nonconventional wastewater treatment (self-composting toilets, septic systems; membrane bioreactors).
    - These methods are used in the Great Lakes region and in Boston
- **Biodiversity and Human Health Vulnerabilities:**
  - Altered distribution of water-related diseases
  - Loss of aquatic biodiversity and associated resource-based livelihoods
  - Heat waves and exacerbated urban heat island effect
  - Algal blooms and water quality problems from new temperature regimes
  - Deterioration of environmental services from degradation of coastal and riparian areas and loss of wetlands

Adaptation and Energy

- **Resilience Zone:** a special improvement district, precinct, neighborhood, or corridor designated in official planning documents for comprehensive risk management and upgrading to be resilient in weather extremes. The concept of district-scale energy is especially relevant in a resilience zone.

- The consistencies of climate change (regardless of region) lie in discovering how to **operate more effectively and efficiently** – reducing energy waste and consumption, which both reduces carbon and adjusts to carbon increases.

- The days of big system creation and large expansion are over. Adaptation is about efficiency within the system, and **smaller scales than we've been used to** in the past:
  - **Small scale storage**
  - **Small scale generation**
  - **Ecodistrict, or Resiliency Zones**

Water Systems and Emissions

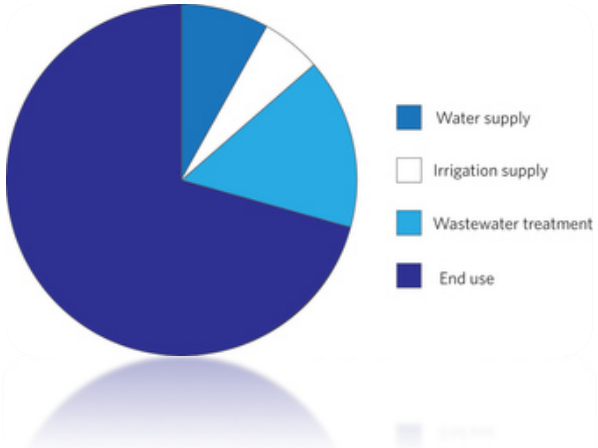
Energy Use in Water Treatment / Distribution:

- It's estimated that the U.S. consumes 50,000 GWh in water treatment / distribution, representing 1.4 % of the total national electricity consumption, and cost over $4 billion /yr
- Municipal systems are among the most energy-intensive facilities owned, accounting for about 35% of energy used by municipalities.
- This 35% accounts for roughly 75 -80% of the cost of water processing / distribution.
- U.S. water systems use an estimated 3-4 percent of the nation's energy to move and treat water and wastewater, with the portion much higher in some places such as CA.

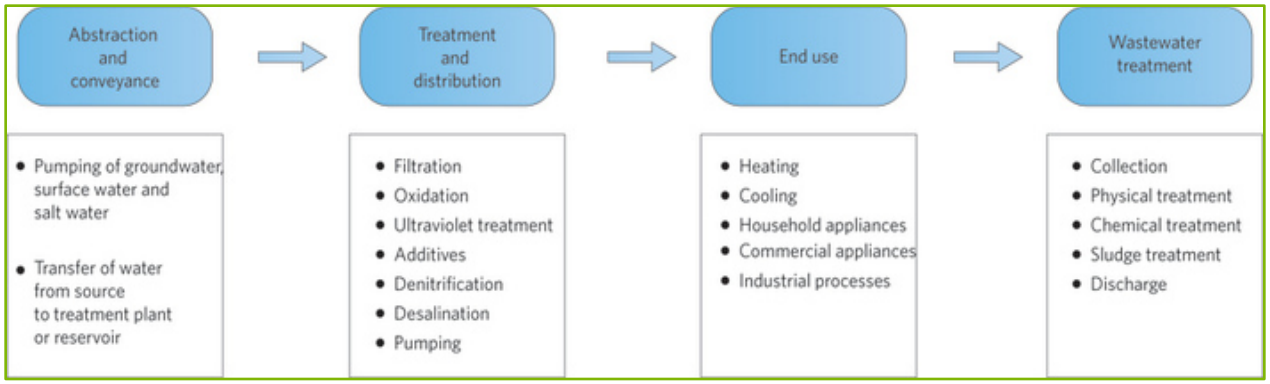
Water Use in Energy Creation:

- The California Energy Commission created a policy in 2003 that discourages the use of freshwater for power plant cooling, encouraging exploration of different generation mythologies.

Distribution of carbon emissions from energy use in the US water sector (%):



A conceptual model of water-sector processes involving energy use:



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Appendix 1
Climate Effects Case Studies

Climate Change Impacts on the Water Cycle

- **Annual precipitation and runoff increases:**
  - Observed now in the Midwest and Northeast regions
  - Projected to continue or develop in northern states
  - Projected to decrease in southern states
- **Summer droughts:** expected to intensify across the U.S., with longer term reductions in the Southwest, Southeast, and Hawaii, in response to both rising temperatures and changes in precipitation.
- **Floods:** projected to intensify in most regions of the U.S., even in areas where average annual precipitation is projected to decline, but especially in areas that are expected to become wetter, such as the Midwest and the Northeast.
- **Groundwater:** expected changes in precipitation and land use in aquifer recharge areas, combined with changes in demand for groundwater over time, will affect groundwater availability in ways that are not well monitored or understood.
- **Sea level rise:** storms and storm surges, and changes in surface and groundwater use patterns are expected to challenge the sustainability of coastal freshwater aquifers and wetlands.
- **Water Quality:** more intense runoff and precipitation will increase river sediment, nitrogen, and pollutant loads. Increasing water temperatures and intensifying droughts can decrease lake mixing, reduce oxygen in bottom waters, and increase the length of time pollutants remain in water bodies.

Climate Change Impacts on Water Resources

- **Surface and Groundwater:**
  - Supplies are **already affected and are expected to be reduced** further by declining runoff and groundwater recharge trends, increasing the likelihood of water shortages for many off-stream and in-stream water uses.
  - Areas impacted: Southwest, parts of the Southeast, the Great Plains, and the islands of the Caribbean and the Pacific (including Hawaii)
- **Flooding:**
  - Increasing **flooding risk affects human safety and health**, property, infrastructure, economy, and ecology in many basins across the U.S.

Climate Change Impacts in the Mountain West

- **Warmer and drier summers**
  - Changes in vegetation of watershed and aquifer recharge areas
    - Altered recharge of groundwater aquifers
    - Changes in quantity and quality (e.g., TOC, alkalinity) of runoff into surface waters
  - Increased water temperature
    - Increased evaporation and eutrophication in surface sources
    - Water treatment and distribution challenges (disinfection, byproducts, re-growth)
  - Increased water demand
    - Increased irrigation demand in longer growing season
    - Increased urban demand with more heat waves and dry spells
    - Increased drawdown of local groundwater resources to meet the above

- **Warmer and shorter winter seasons**
  - Increased glacial melting
  - Decreased seasonal snowpacks
  - More rain, more rain-on-snow, and earlier spring snowmelt
    - Altered recharge of groundwater aquifers
    - Earlier runoff into surface waters
      - Lower summer/fall base flows in surface waters
      - Lower summer/fall reservoir levels

- **More frequent and intense rainfall events**
  - Increased turbidity and sedimentation
    - Loss of reservoir storage
      - Shallower, warmer water; increased evaporation and eutrophication
      - Potential conflicts with flood control objectives
    - Water filtration or filtration/avoidance treatment challenges
  - Increased risk of direct flood damage to water utility facilities

Climate Change Impacts in the Southwest

- **Warmer and probably drier overall with more extreme droughts and heat waves**
  - Likely reduced quantities of surface water available from local runoff
  - Likely reduced quantities of water available to recharge groundwater aquifers
  - Very likely increased evaporative losses in inter-basin transfers of surface waters
  - Changes in vegetation of watershed and aquifer recharge areas
    - Altered recharge of groundwater aquifers
    - Changes in quantity and quality (e.g., TOC, alkalinity) of runoff into surface waters
  - Increased water temperature
    - Increased evaporation and eutrophication in surface sources
    - Water treatment and distribution challenges (disinfection, byproducts, regrowth)
  - Increased water demand
    - Increased irrigation demand
    - Increased urban demand with more heat waves and dry spells
    - Increased drawdown of local groundwater resources to meet the above
    - Increased difficulty of maintaining minimum in-stream flows in surface waters

- **More intense rainfall events**
  - Increased turbidity and sedimentation
    - Loss of reservoir storage
      - Shallower, warmer water; increased evaporation and eutrophication
      - Potential conflicts with flood control objectives
    - Water filtration or filtration/avoidance treatment challenges
  - Increased risk of direct flood damage to water utility facilities

Climate Change Impacts in the Humid East and Midwest

- **Warmer overall**
  - More rain with seasonal shift
    - More rainfall in winter and late spring
    - Potentially less rainfall in late summer and fall with more extreme droughts
      - Lower summer/fall base flows in surface waters
      - Lower summer/fall reservoir levels
  - Changes in vegetation of watershed and aquifer recharge areas
    - Altered recharge of groundwater aquifers
    - Changes in quantity and quality (e.g., TOC, alkalinity) of runoff into surface waters
  - Increased water temperature
    - Increased evaporation and eutrophication in surface sources
    - Water treatment and distribution challenges (disinfection, byproducts, re-growth)
  - Increased water demand
    - Possible increased urban demand during drought periods

- **More intense rainfall events**
  - Increased turbidity and sedimentation
- Loss of reservoir storage
- Shallower, warmer water; increased evaporation and eutrophication
- Potential conflicts with flood control objectives
  - Water filtration or filtration/avoidance treatment challenges
- Increased risk of direct flood damage to water utility facilities

Climate Change Impacts in Coastal Regions

- **Warmer Overall**
  - Changes in discharge characteristics of major rivers due to upstream changes
  - Changes in recharge characteristics of major groundwater aquifers due to upstream changes
  - Increased water temperature
    - Increased evaporation and eutrophication in surface sources
    - Water treatment and distribution challenges (disinfection, byproducts, re-growth)
  - Possible increased water demand
    - Increased irrigation demand
    - Increased urban demand with more heat waves and dry spells
    - Increased drawdown of local groundwater resources to meet the above

- **Rising Sea Levels**
  Increased saline intrusion into groundwater aquifers
  - Water treatment challenges: increased bromide; need for desalination
  - Increased salinity of brackish surface water sources
  - Water treatment challenges: increased bromide; need for desalination
  - Increased risk of direct storm and flood damage to water utility facilities

- **More intense rainfall events**
  - Increased turbidity and sedimentation
    - Loss of reservoir storage
      - Shallower, warmer water; increased evaporation and eutrophication
      - Potential conflicts with flood control objectives
    - Water filtration or filtration/avoidance treatment challenges
  - Increased risk of direct flood damage to water utility facilities

Case Study: Ft. Collins

Example of Approach to Incorporate Climate Change into Long-Term Planning

- Following flash floods in 1997, the City of Fort Collins Utilities (FCU), CO, refocused their planning efforts around extreme precipitation events. As a mid-sized, combined drinking water, wastewater, stormwater and electric utility service provider, FCU has identified a need to adopt an integrated approach to adaptation and risk assessment. This approach would complement established integration of shifting weather patterns into utility design and management processes.

- FCU initiated a Climate Change Adaptation Study to examine impacts of shifts in weather patterns. The purpose of this study is:
  - Understand the impacts of possible climate shifts
  - Design a framework to incorporate climate adaptation into asset management

- FCU adopted the goal of integrating planning into daily business practices by:
  - Embracing a dynamic, iterative process
  - Minimizing staff and resource burden by continually refining the process
  - Leveraging ties to asset management

- FCU used the Joint Front Range Climate Vulnerability Study (CWCB 2011) as a source for climate scenarios based on model results, including a range of possible futures: hot and dry; warm and wet; extreme drought; extreme precipitation; and an average or "median conditions" scenario. Model scenarios informed on impacts and potential flood events.
  - Example: warmer and wetter winters may lead to decreased winter snowpack, increased rainfall, and earlier spring melt and runoff for the area. With this information, FCU has:
    - Identified the risks related to these impacts
    - Considered consequences with respect to customers, operations, and the environment
    - Evaluated adaptation options to address these risks and build a more resilient operation

Scenario Planning Case Study: Phoenix, AZ

- The Phoenix Water Services Department used scenario planning in their 2005 Water Resources Plan
- The plan, updated every 5 years, looks at a variety of factors that may affect water demand projections and water supply conditions. Three key factors were identified based on their potential significance for water resource planning:
  - **delivery of surface water supplies**
  - **growth and development patterns**
  - **water conservation levels**

- Phoenix then identified the variables that influence these three factors and put those variables in defined ranges of future possible conditions. These factors were combined to generate 144 scenarios of water supply and demand. Of these 144 scenarios, 9 varied the climate. They identified two types of adaptation strategies:
  - **Robust short-term strategies**
  - **A worst case infrastructure time line for drought response**
- Robust strategies that work well across a wide range of scenarios were identified for implementation. The basis for the worst case time frame was to assume that current precipitation trends in the watersheds reflect what could be the early stages of the **most severe water shortage scenario, a 30-year dry period.**
- A time line of critical trigger points for deployment of new infrastructure / water resources were identified based on different growth or user demand scenarios.

GHG Reduction: 3 examples

- **Sonoma County Water Goals:**
- Carbon Free Water
  - Water conservation
  - System efficiency
  - Develop/procure renewable energy
  - Projects of Regional Benefit

- **Santa Clara Valley Water District Goals:**
- Achieve carbon neutrality by 2020: Establish a District-wide internal carbon offset methodology to facilitate emission reduction including properly crediting emission reductions from water conservation programs, habitat restoration or enhancements renewable energy production and contributions to countywide emission reduction efforts.

- **Seattle Public Utilities Goals:**
  - Enhance knowledge by engaging the science
  - Assess impacts and vulnerabilities ,
  - Establish collaborative partnerships
  - Strengthen institutions and people,
  - Mainstream adaptation into decision-making
  - Develop portfolios of approaches
  - Quantify and reduce our emissions

- **Resources on Carbon Neutral Water Systems:**
  - EPA- *Energy Efficiency in Water and Wastewater Facilities: A Guide to Developing and Implementing Greenhouse Gas Reduction* [14]
  - Water Environment Federation: Energy and Water, Access Water Knowledge Center – *The Energy Roadmap: A Water and Wastewater Utility Guide to More Sustainable Energy Management* [15]