


Module 5
Water Systems

CLIMATE IMPACTS & ADAPTATION STRATEGIES FOR MUNICIPAL WATER SYSTEMS

Overview

1. Current and future challenges
2. Adaptation strategies
   - Issues to consider
   - Stormwater control measures (SCMs)
   - Flood prevention
   - Wetlands
   - Drainage and conveyance
   - Inflow & infiltration prevention
   - CSO management
3. Case studies

Current and future challenges

CURRENT CHALLENGES

& PROJECTED CLIMATE IMPACTS

Current and future challenges

Current management challenges

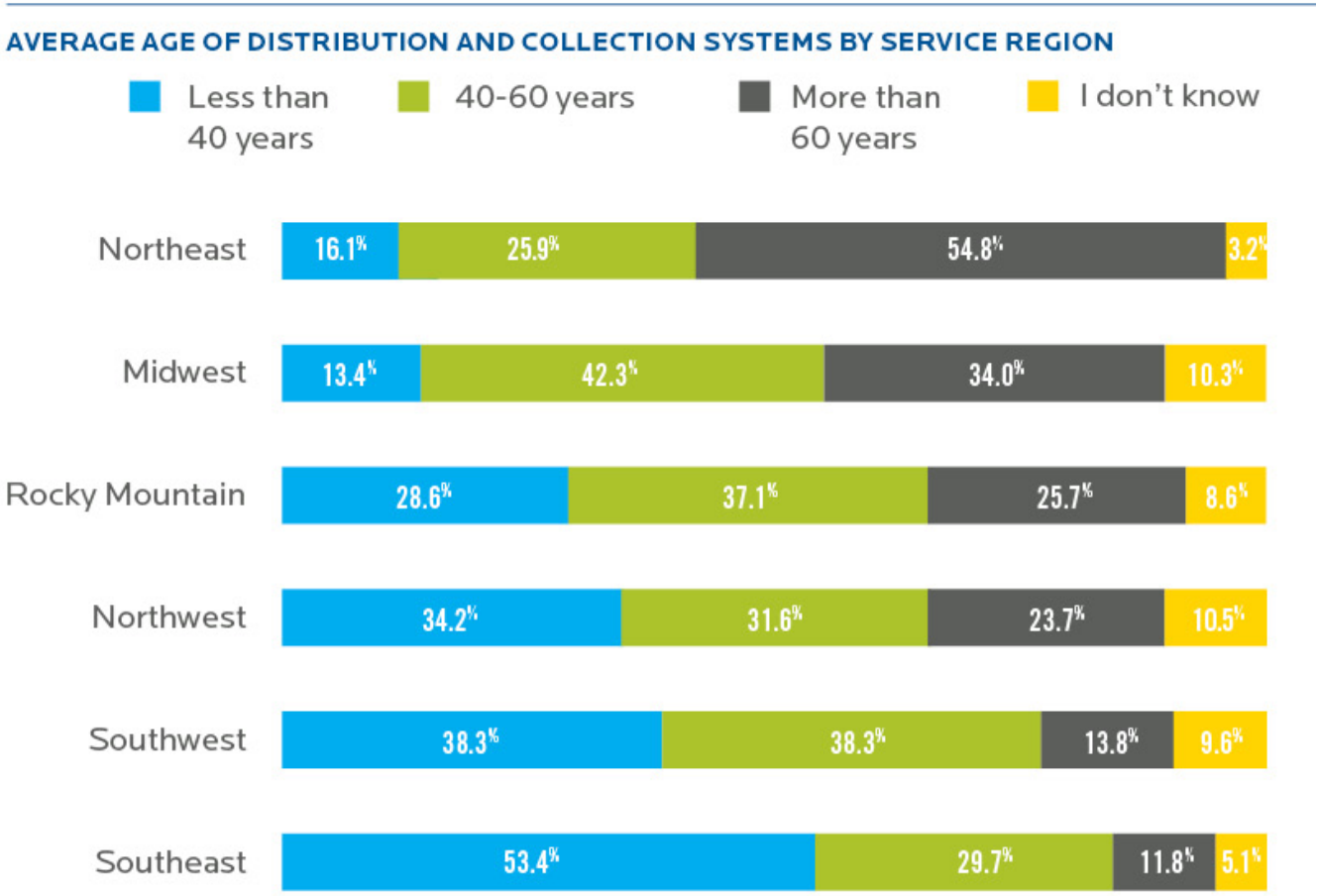
Issues that we're already dealing with:

- Aging collection and distribution infrastructure
  - Over 70% of systems in US Midwest and Northeast are over 40 years old

Urban population growth and sprawl

- Lack of impervious surfaces
- Combined sewer & stormwater overflows

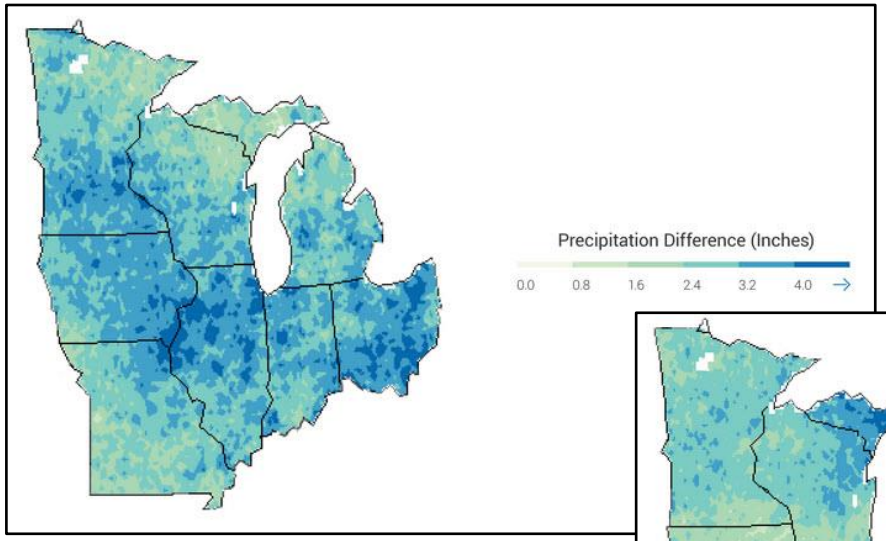
Today's challenges will be exacerbated by climate change in the coming years



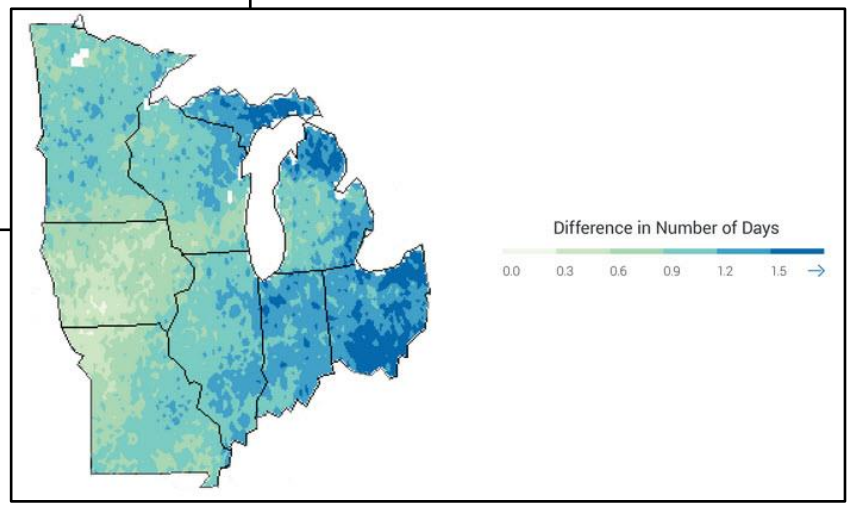
Current and future challenges

Climate change projections: Increase in heavy rainfall

HIGHER ANNUAL AVERAGE PRECIPITATION



INCREASE IN DAYS WITH HEAVY PRECIPITATION



Projected changes 2041-2070 relative to 1971-2000: Increase in heavy precipitation

CHALLENGES BY GROUP		DW	WW
Drought	Reduced groundwater recharge	💧💧	
	Lower lake and reservoir levels	💧💧	
	Changes in seasonal runoff & loss of snow-pack	💧	
Water Quality Degradation	Low flow conditions & altered water quality		💧
	Saltwater intrusion into aquifers	💧	
	Altered surface water quality	💧💧	💧💧
Floods	High flow events & flooding	💧💧	💧💧
	Flooding from coastal storm surges	💧	💧
Ecosystem Changes	Loss of coastal landforms / wetlands	💧	💧
	Increased fire risk & altered vegetation	💧	💧
Service Demand & Use	Volume & temperature challenges	💧💧	💧💧
	Changes in agricultural water demand	💧💧	
	Changes in energy sector needs	💧💧	
	Changes in energy needs of utilities	💧💧	💧💧

Click on a group name above to read more about these challenges or click on a water drop above to read more about a specific challenge.

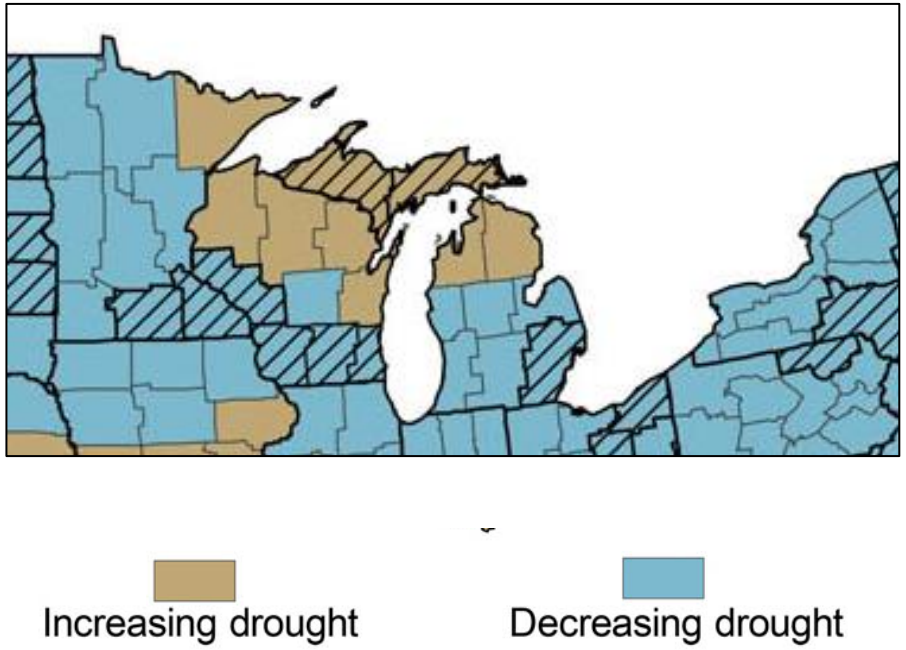
💧💧 = Particularly relevant to the Midwest 💧 = Somewhat relevant

Image source (left): National Climate Assessment 2014, Figure 18.6 “When it rains, it pours”; (right) EPA Climate Ready Water Utilities, “Midwest” (page 42)

Current and future challenges

Climate change projections: Increased likelihood of droughts

BOTH WET AND DRY PERIODS INCREASE



PROJECTED CHANGES INCLUDE VARIABILITY IN WATER SUPPLY IN GREAT LAKES REGION

Frequency of both droughts and flooding are expected to increase.

Between heavy rainfall, longer periods without precipitation.

Increasing air temperature + changes in evaporation and evapotranspiration → more variability of water supply in region.

Image source: Impacts on Water Cycle and Water Demand (United States EPA & USGCRP 2009)

Current and future challenges

Implications for local government

IMPACTS ON WATER INFRASTRUCTURE:

Original systems designed for past climate extremes, which do not represent future (nor even current) conditions. This can lead to:

- Shorter life span of systems
- Increase in maintenance and operating costs
- More frequent and intense CSOs and sewage treatment plant overloads

SECONDARY IMPACTS:

- Disruption to additional municipal operations and services
- Flood related damage to private and public property; business disruption
- Evacuation, relocation, homelessness
- Flood related damage to urban ecosystems
- Increase in insurance costs and liability among municipalities

Bottom line: Without appropriate adaptation measures, municipalities may be faced with severe and unanticipated economic losses and public health crises due to damaged or overwhelmed storm water and waste water systems

Current and future challenges

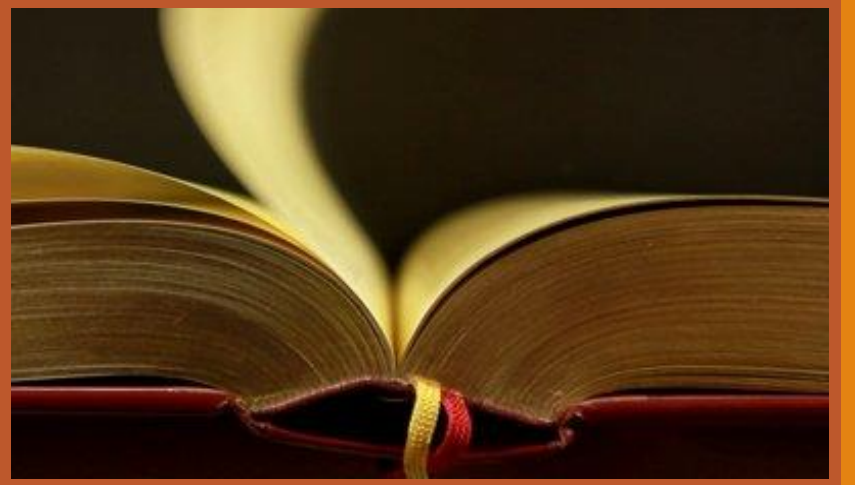
In the news: Water quality compromised in Lake Eerie

CLIMATE CHANGE & INCREASED RUNOFF TRIGGERING POTENTIALLY TOXIC BLOOMS

- Algae and bacteria responsible for blooms need warm temperature and phosphorous + nitrogen to grow. Climate change creating warmer waters.
- Some blooms (such as the one in Toledo in 2014) can produce toxins that produce neurological problems like paralysis and seizures in people.
- When blooms die, bacteria feasting on decaying matter can result in ecological dead zones.
- Municipalities forced to deal with compounding factors: stormwater runoff, increasing temperatures, agricultural activity, etc

Image source: (Left) Peter Essick, National Geographic, 2011; (Right) Joshua Lott, Reuters, 2014

Climate Impact & Risk Assessment Resources:

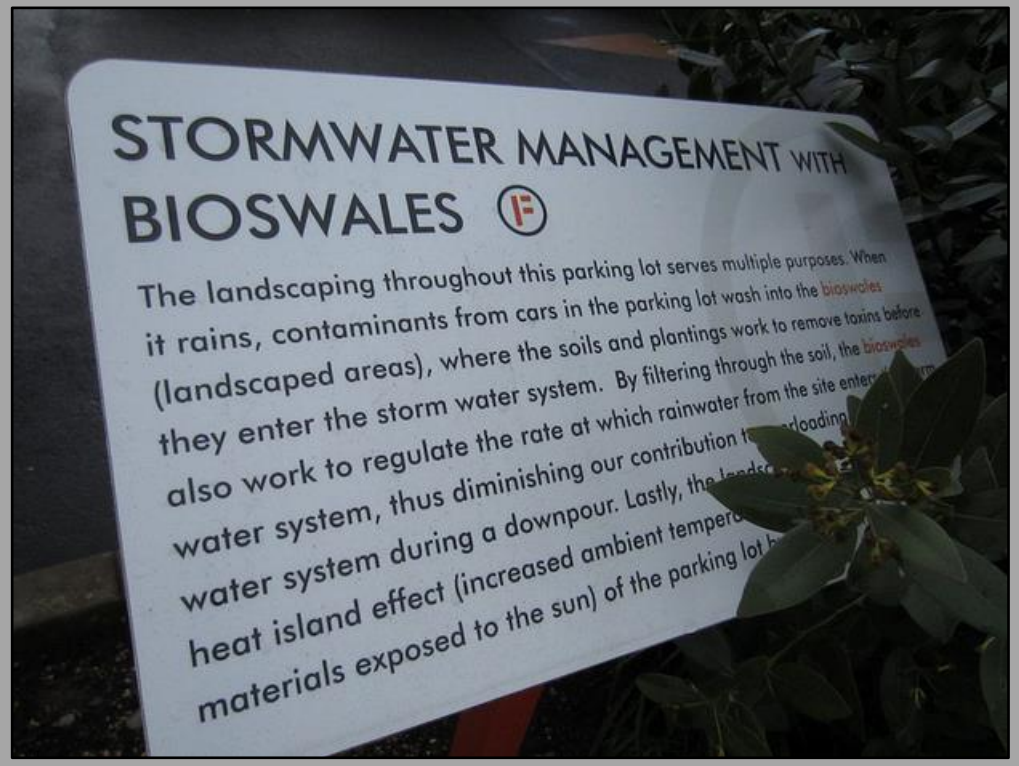


Climate Resilience Evaluation & Awareness Tool
(CREAT)
Software tool created by the EPA to assist drinking water and wastewater utilities in understanding potential climate change threats and evaluating adaptation options. Free of charge.

EPA National Stormwater Calculator
Desktop application that estimates the annual amount of rainwater and frequency of runoff from a specific site anywhere in the United States. Estimates are based on local soil conditions, land cover, and historic rainfall records.

National Climate Assessment 2014: Midwest
See sections:

- Water Resources
- “Key Message 5: Increased Rainfall and Flooding”



Adaptation strategies

Adaptation strategies

Issues to consider

- "No regrets" strategies: Look for secondary social, economic, and environmental benefits
- Find the right balance between upsizing "grey" infrastructure (pipes, overflow sites, treatment plants) and implementing "green" infrastructure
  - More info: The Value of Green Infrastructure – Center for Neighborhood Technology

Important: There will never be enough capacity in municipal stormwater systems to completely capture all extreme events. Municipalities now deploying complementary strategies that lighten the burden on traditional systems.

Adaptation strategies
Stormwater control measures (SCMs)

SCMs:

- Reduce runoff volume and peak flows
- Remove pollutants from runoff
- Can be:
  - **Structural:** any facility constructed to mitigate the adverse impacts of stormwater and urban runoff pollution
  - **Non-structural:** planning and design approaches that limit imperviousness and reduce stormwater and urban runoff pollution

Image: Bioswale in a municipal parking lot in Mt Clemens, MI

Adaptation strategies

SCMs: Best Practices

- SCM implementation works best when designed as a system incorporating both structural and non-structural SCMs on a regional or watershed scale
- Consider nonstructural SCMs before structural practices. Land use planning can reduce runoff and, thus, the need for structural SCMs
- SCMs that harvest, infiltrate, and evapotranspirate stormwater are critical to reducing the volume and pollutant load of small storms

Adaptation strategies

SCMs: Summary of structural strategies

SCM	What it accomplishes	What it replaces	How it works
Bio-swales	Runoff Reduction	Curb/gutter and storm drainpipes	Shallow, well-drained bio-retention swales that help remove silt and pollutants
Wet and Dry Ponds	Runoff Reduction	Positive drainage from impervious surfaces to gutter	Grading front yard to treat roof, lawn, and driveway runoff using shallow bio-retention
Stormwater Wetlands	Peak reduction and runoff treatment	Large detention ponds	Long, multi-cell, forested wetlands located in the storm water conveyance system
Green Roofs	Runoff reduction	Concrete roofs	Use of vegetation on a roof, placed over a waterproofing membrane, to absorb rainwater as it falls
Pervious Pavement	Increase permeability of impervious cover	Hard asphalt or concrete	Use of permeable pavers, porous concrete, and similar products to decrease runoff generation from parking lots and other hard surfaces

Adapted from: National Research Council Report, 2008, "Urban Stormwater Management in the United States"

Adaptation strategies

SCMs: Summary of non-structural strategies

SCM	What it accomplishes	What it replaces	How it works
Earthwork Minimization	Conservation of soils and contours	Mass grading and soil compaction	Construction practices to conserve soil structure and only disturb a small site footprint
Watershed Planning	Off-site stormwater treatment or mitigation	On-site waivers	Stormwater retrofits or restoration projects elsewhere in the watershed to compensate for stormwater requirements that cannot be met onsite
Conservation of Natural Areas/Reforestation	Maximize forest canopy and green space	Mass clearing	Preservation of priority forests and reforestation
Impervious Cover Minimization	Runoff reduction	Large streets, lots and cul-de- sacs	Narrower streets, permeable driveways, clustering lots, and other actions to reduce site impervious cover

Adapted from: National Research Council Report, 2008, "Urban Stormwater Management in the United States"

Adaptation strategies

Flood prevention: Know your risks and vulnerabilities

- Define historic and projected precipitation rates
- Use maps to spatially define vulnerabilities:
  - Estimate future financial losses due to flood damages
- Structural flood prevention, e.g. Bio-retention practices, permeable pavement, water conveyance and drainage
- Non-structural flood prevention. E.g. Planning measures to direct growth to less vulnerable areas; Conservation easements; wetlands protection

Resources:

- NOAA Coastal County Snapshots
- NOAA Critical Facilities Flood Exposure Tool
- EPA National Stormwater Calculator
- FEMA HAZUS

Adaptation strategies

Wetlands help manage water quantity and quality

WETLANDS PROVIDE MANY STORMWATER MANAGEMENT SERVICES:

- Reduce peak flows by delaying/storing water
- Detain polluted floodwaters and improve their quality
- Stabilize shorelines and buffer against storm surges

CLIMATE CHANGE IMPACTS ON WETLANDS:

- Earlier ice-out and snow melt, lower summer lake levels, and more intense flooding threaten wildlife cycles and water quantity/quality in wetlands
- Smaller, isolated, rainfall-dependent inland wetlands are most threatened

NEARLY TWO THIRDS OF WETLANDS IN GREAT LAKES BASIN HAVE BEEN DESTROYED

Efforts should focus on protecting AND revegetating wetlands

- Select native species that are able to withstand warmer temperatures, frequent floods, and droughts
- Restore or maintain connection between lakes and rivers
- Implement water conservation and development regulation designed to minimize landscape fragmentation

Adaptation strategies

Inflow and infiltration (I&I) prevention

REDUCING I&I REQUIRES CONSTANT VIGILANCE AND VARIOUS METHODS:

- Manhole testing with low-pressure air and vaccuum tests
- Inspection via closed circuit television (CCTV)
- Flow monitoring
- Focused electrode leak location system (FELL)

Information source: Water & Wastes Digest, Preventing I&I; RedZone Robotics, Sewer Inflow & Infiltration
Image source: NPCA, Vacuum Testing Backfilled Manholes

Adaptation strategies

Water conveyance and drainage

- Increase capacity of downstream systems to carry increased runoff
- Design to take advantage of natural systems
- Improvements can include:
  - Replacing existing pipes and storm systems with larger facilities
  - Armoring to prevent erosion
  - Removing debris
  - Installing smooth liners that reduce channel friction and increase capacity

However, these measures do not address water quality threats! They should be paired with SCMs.

Image source: Amy Greene Environmental Consultants

Adaptation strategies

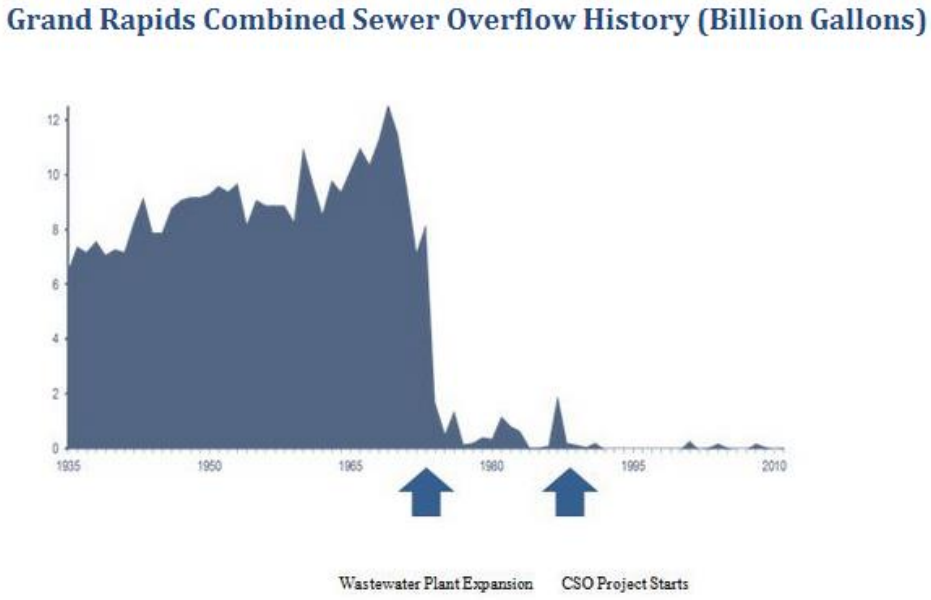
CSO Management

Decreasing cost

- Separate stormwater conveyance system from wastewater conveyance system
- Build a CSO storage facility
- Build a screening & disinfection facility
- Install a retention treatment system
- Reduce amount of stormwater runoff through stormwater control measures (SCMs or Green Infrastructure)

Grand Rapids CSS Separation:

- City was issued long term CSO control program by State of MI in 1988
- Goal: Eliminate all CSOs by 2019



- By 2011, 99% of all the city's CSO volume was eliminated at a cost of $360M
- Costs are reflected in Grand Rapids' sewer rates

Adaptation strategies

Engaging homeowners and businesses

Most property is privately owned--it's critical to engage private property owners in becoming part of the solution.

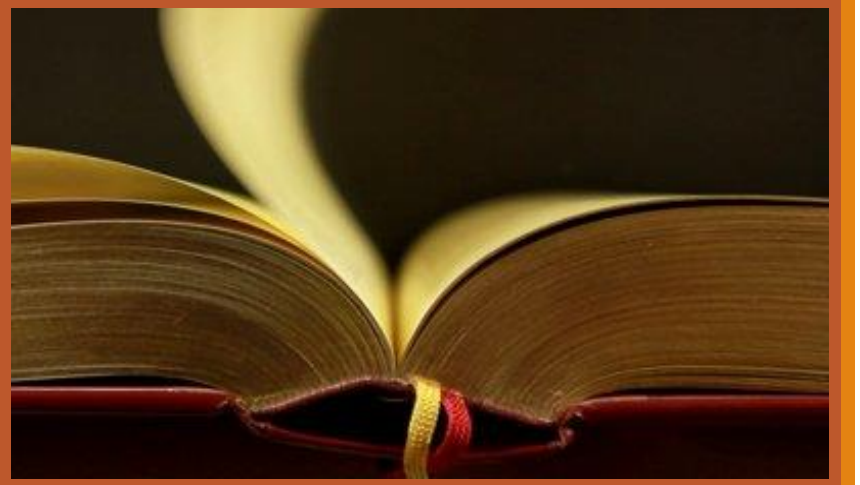
Rain Ready for Homeowners
Home assessment, insurance, yard improvements, etc

Stormwater Communications Toolkit
Useful guide that includes sample talking points, "everyday terms", and sample fact sheets

Example programs focusing on property owners:

- Huron River Watershed Council: Work with neighborhood residents to implement low-impact development techniques
- Superior, WI Stormwater Flood Control Program: free site inspection, $150 grants for service lateral inspection, free backwater valve installation
- Milwaukee, WI: adoption of stormwater management fee based on amount of impervious surface

Stormwater Management Resources:



- **EPA System for Urban Stormwater Treatment and Analysis Integration (SUSTAIN)** (Complex model)
  Decision support system to assist stormwater management professionals in developing implementation plans for flow and pollution control to protect source waters and meet water quality goals.

- **GLSLCI: Stormwater Management in the Great Lakes & St Lawrence Basin**
  Report focusing on specific stormwater practices in the Great Lakes and St Lawrence watershed.

- **EPA Green Infrastructure**
  EPA tools, case studies, and researches on green infrastructure.

- **NRDC: How Water Ready is Your State or City?**
  Interactive map that displays risks and readiness actions by state.

- **Rain Ready**
  CNT's Raiindividuals and communities work together with policies and guides to solve the problem of too much or too little waternReady initiative helps.

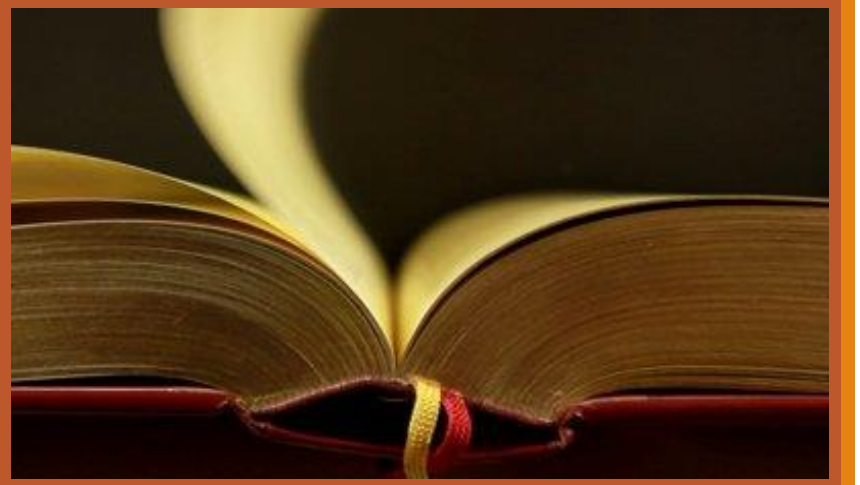
- **WERF Whole Life Costing Models**
  The models provide a framework for calculating capital and long-term maintenance costs of individual best management practices and low impact development techniques.

Case Study

MILWAUKEE, WI

Image source: Brian Koprowski, 2013 <https://flic.kr/p/g3LxVj>

Other Resources



- **EPA Climate Ready Water Utilities Toolbox** (CRWU)
  CRWU Toolbox provides access to resources containing climate-related information relevant to the water sector, including activities, funding information, reports, models, and seminars.
- **EPA Adaptation Strategies Guide for Water Utilities**
  The guide provides adaptation options for drinking water, wastewater, and stormwater utilities based on region and projected climate impacts.
- **Climate Adaptation Knowledge Exchange (CakeX)**
  Hared knowledge base for managing natural and built systems in the face of rapid climate change. Just as importantly, it is intended to help build an innovative community of practice. Features extensive case study library and tools.