Operational and Economic Impacts of Hurricanes on Drinking Water Systems

Kim Linton
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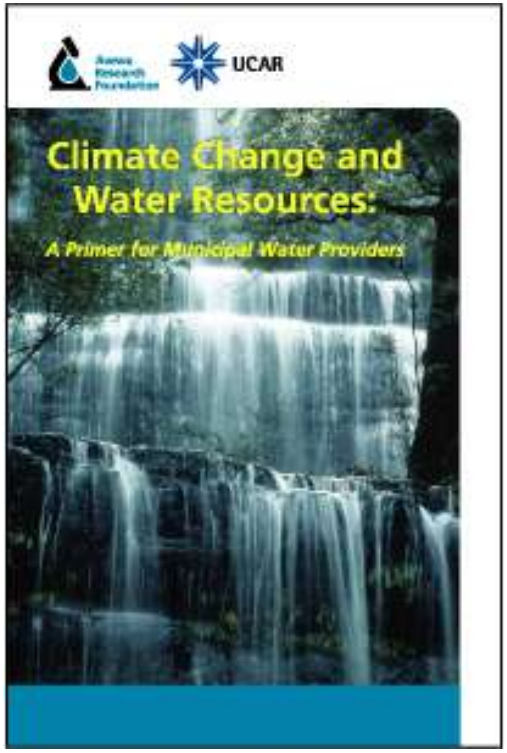
Water Research Foundation℠

Climate Change and Water Resources:

A Primer for Municipal Water Providers

AwwaRF publication 91120



- Current state of climate change research
- Assesses water supply vulnerabilities
- Case studies of water utilities planning for climate change.
- Lessons from extreme events such as wildfires; droughts; floods
- Develops range of adaptation strategies

Humans and greenhouse gases

Carbon Dioxide (CO_2) and Methane (CH_4)

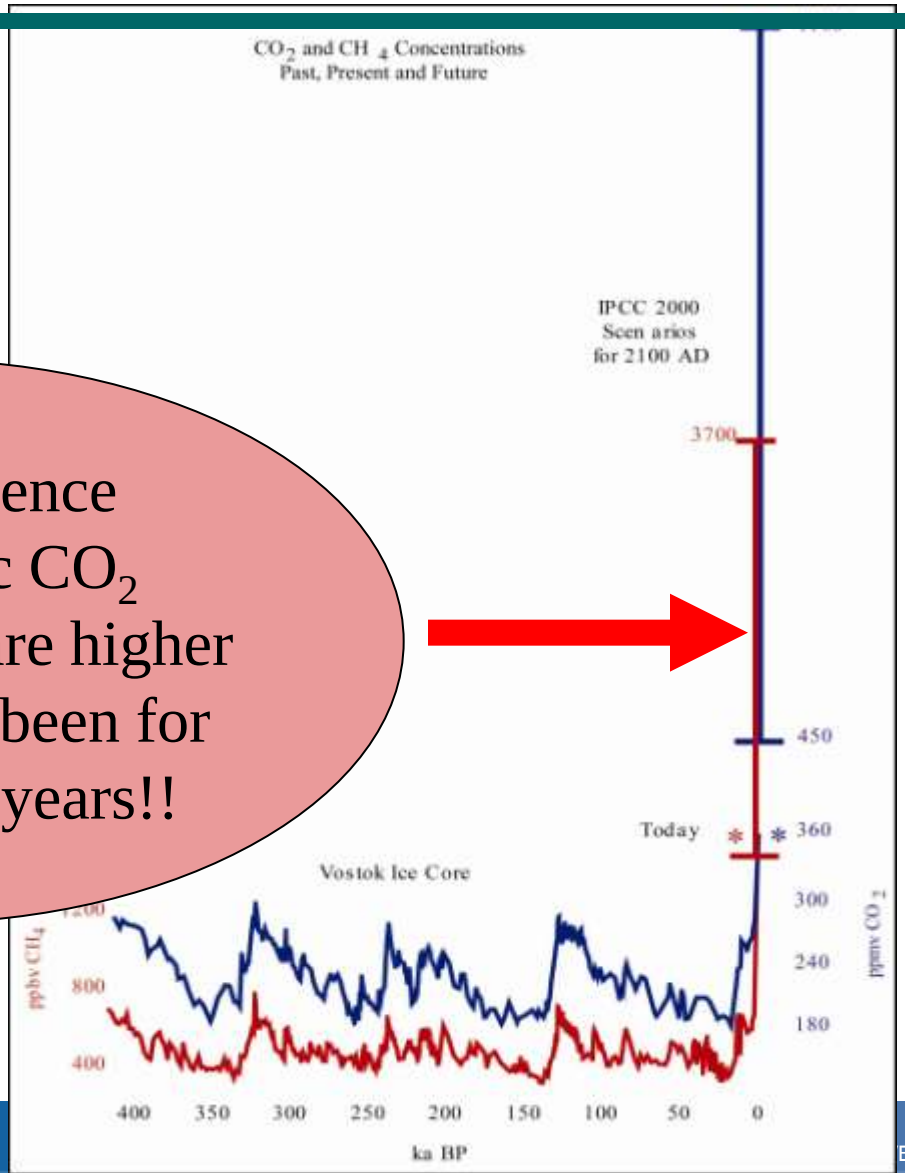
<u>Now:</u>

concentr

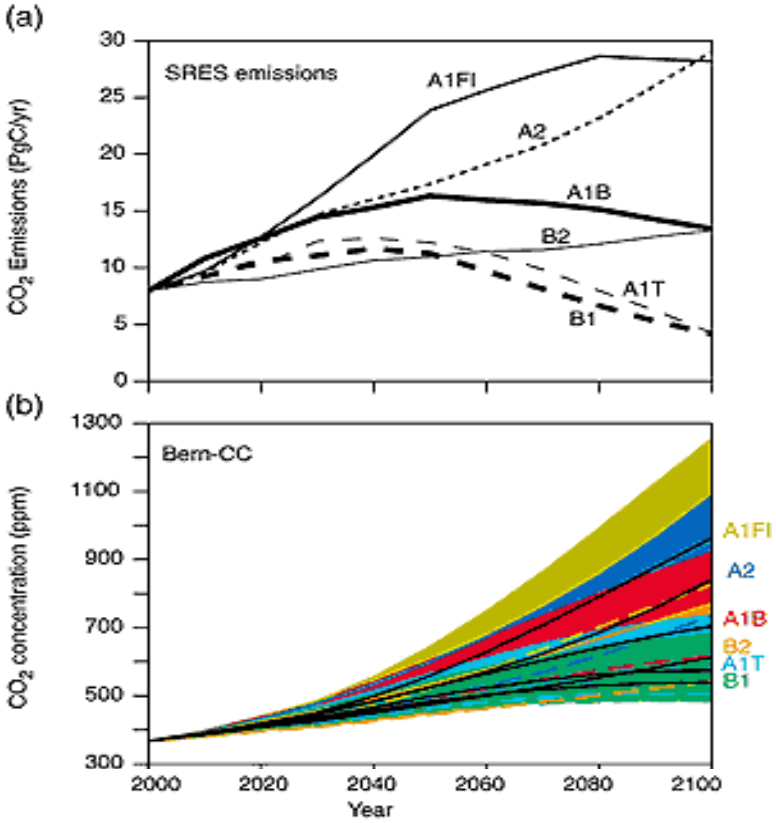
higher tha

range over past 400,000 years

Strong evidence Atmospheric CO_2 concentrations are higher than they have been for 400 thousand years!!



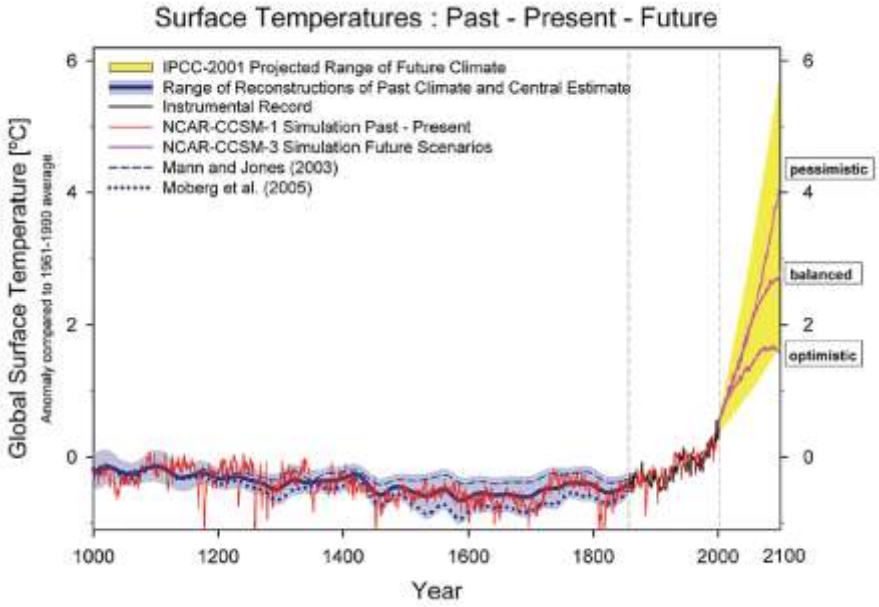
Warming will depend on emissions



Possible range of carbon dioxide emissions and the resulting changes in atmospheric carbon concentrations.

Major source of uncertainty:

Future path of development, technology & policy



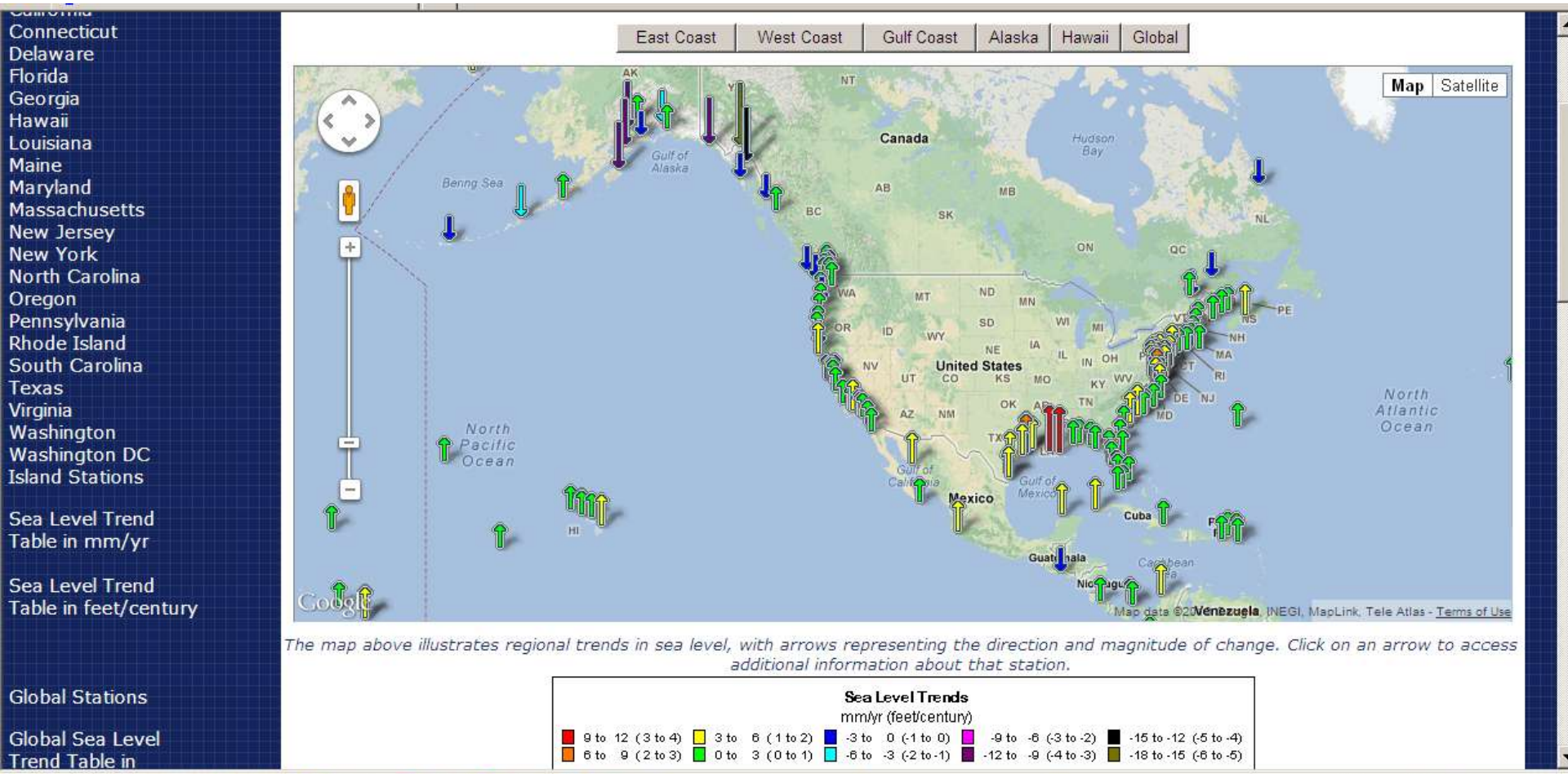
Melting Ice in Greenland

A satellite image of Greenland's ice sheet taken on July 8, 2012, depicts a large core of solid ice (white) surrounded by areas of melted ice (dark pink) and probable melted ice (light pink).
Nicolo E. DiGirolamo, SSAI/NASA GSFC, and Jesse Allen, NASA Earth Observatory

http://www.britannica.com/EBchecked/topic/281171/ice-sheet

Sea Level Rise Mid-Atlantic

http://tidesandcurrents.noaa.gov/sltrends/sltrends.shtml



Operational and Economic Impacts of Hurricane Irene on Drinking Water Systems

Hurricane Irene – August 27 – 29 2011

Presented by: Kim Linton,
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Project Investigators:
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Rebecca Weidman, and Jaime Rooke
The Cadmus Group, Inc.

Acknowledgements:

Photos courtesy of Nancy Trushell
Critical infrastructure inundated

United Water (N.Y., N.J., Penn.)
New York City Water Supply, N.Y.
Regional Water Authority, Conn.
Aquarion Water Company, Conn.
Deerfield Fire District, Mass.
Norwich Public Utilities, Conn.
Colrain Fire District #1, Mass.
Shelburne Falls Fire District, Mass.
Westfield Water Resources Department, Mass.
Aquaria Water LLC, Mass.
Mattapoisett Water and Sewer, Mass.
Sandwich Water District, Mass.
Middlesex Water Company, N.J.
Town of Bethlehem, N.Y.
City of Plattsburgh, N.Y.
Chester Water Authority, Pa.
Abbey Lane Community Association, R.I.
Shady Harbor Fire District, R.I.
North Kingstown Water, R.I.
Woonsocket Water Division, R.I.
East Smithfield Water District, R.I.
Glendale Water Association, R.I.
Oakland Association Inc., R.I.
Smithfield Water Supply Board, R.I.
Quonochontaug East Beach Water Association, R.I.
Johnston Water Control Facility, R.I.
Newport News Waterworks, Va.
Virginia Beach Department of Public Ut., Va.

Project Description

Photos courtesy of Jim Glozzy
Woodcliff Lake Dam
of United Water New Jersey

- Identify magnitude of impact
- Lessons learned
- Economic evaluation
- Administered March 15, 2012 to April 12, 2012
- Sent to over 200 water systems in Northeast
    - WRF Membership
    - State staff
    - Safe Drinking Water Information System (SDWIS) database
- Follow-up interviews conducted after survey closed

Water Systems Interviewed

- United Water (New York, New Jersey, Pennsylvania)
- New York City Water Supply, N.Y.
- Regional Water Authority, Conn.
- Aquarion Water Company, Conn.
- Deerfield Fire District, Mass.

Spillway flooding

Photo courtesy of Charles Darling

Survey Respondents

State	Did Not Experience Operational or Economic Impacts	Did Experience Operational or Economic Impacts	Total
Rhode Island	9	10	19
Mass.	3	7	10
New Jersey	1	4	5
New York	0	4	4
Connecticut	0	3	3
Pennsylvania	1	1	2
Virginia	0	2	2
Delaware	1	0	1
North Carolina	1	0	1
Did Not Specify	10	7	17
Total	27	38	65

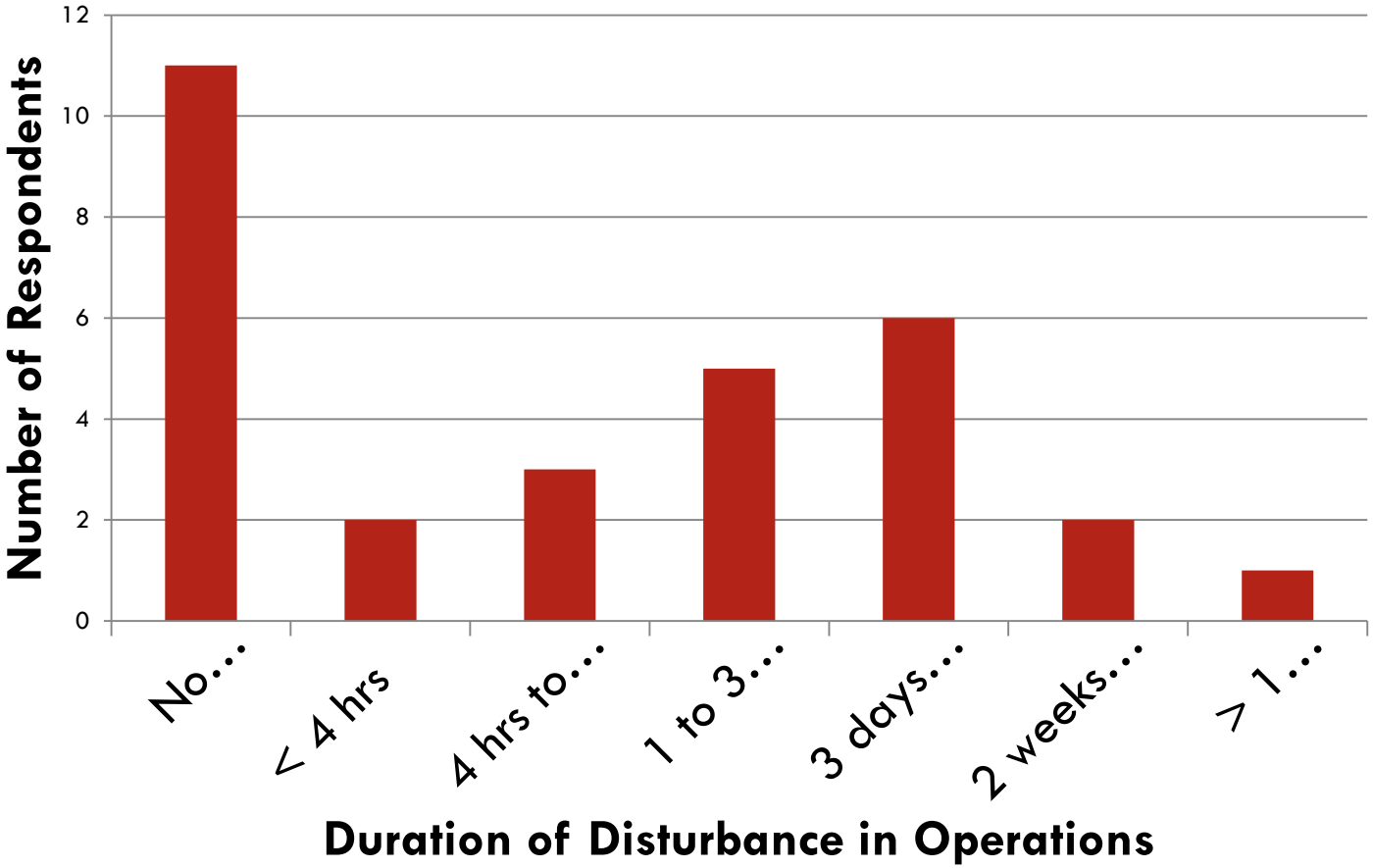
Note: Blue highlighting identifies states in which more than half the respondents experienced operational or economic impacts.

Survey Respondents

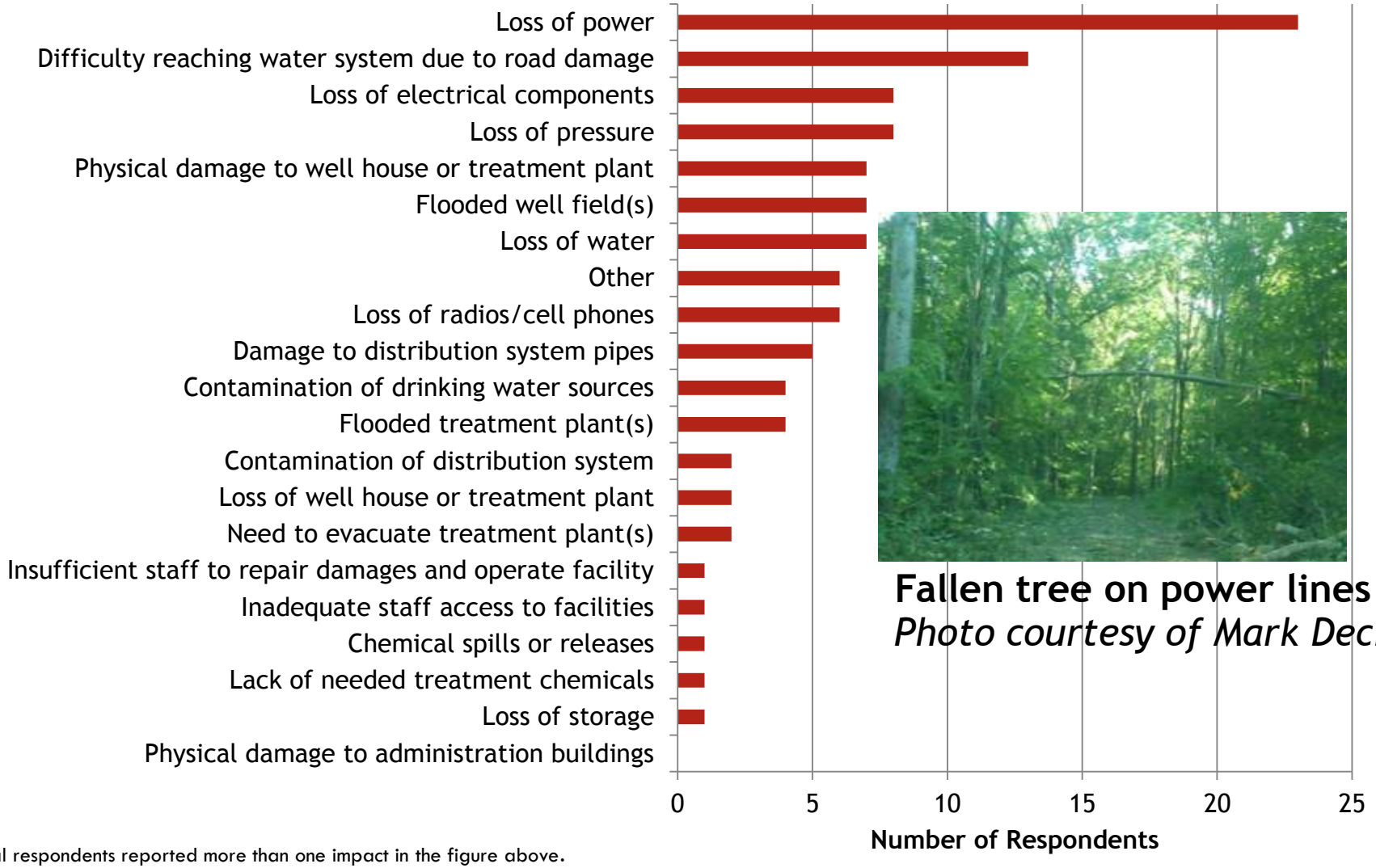
Population Range	Did Not Experience Operational or Economic Impacts	Did Experience Operational or Economic Impacts	Total
a. 25-500	4	6	10
b. 501-3,300	2	2	4
c. 3,301-10,000	2	4	6
d. 10,001-100,000	4	9	13
e. >100,000	5	10	15
Not Available	10	7	17
Grand Total	27	38	65

Source: Population estimates retrieved from the Safe Drinking Water Information System (SDWIS) online at http://www.epa.gov/enviro/facts/sdwis/search.html.

Amount of Time Required for Systems to Become Fully Operational Following Hurricane Irene



Types of Problems Experienced During and Following the Storm



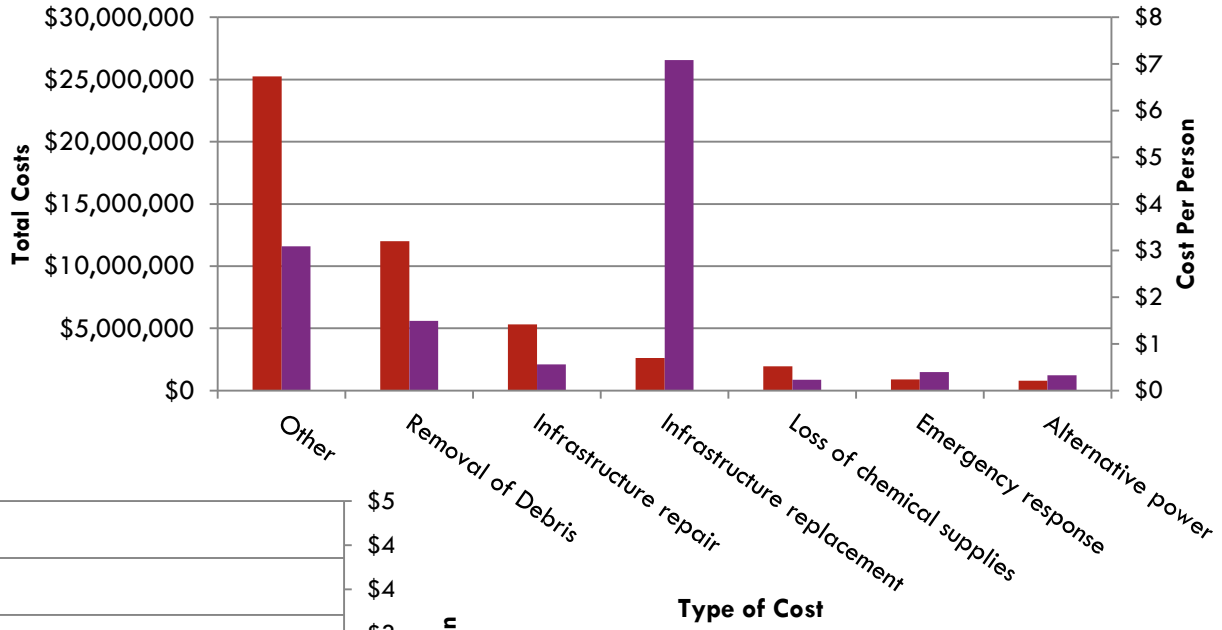
Fallen tree on power lines
Photo courtesy of Mark Decker

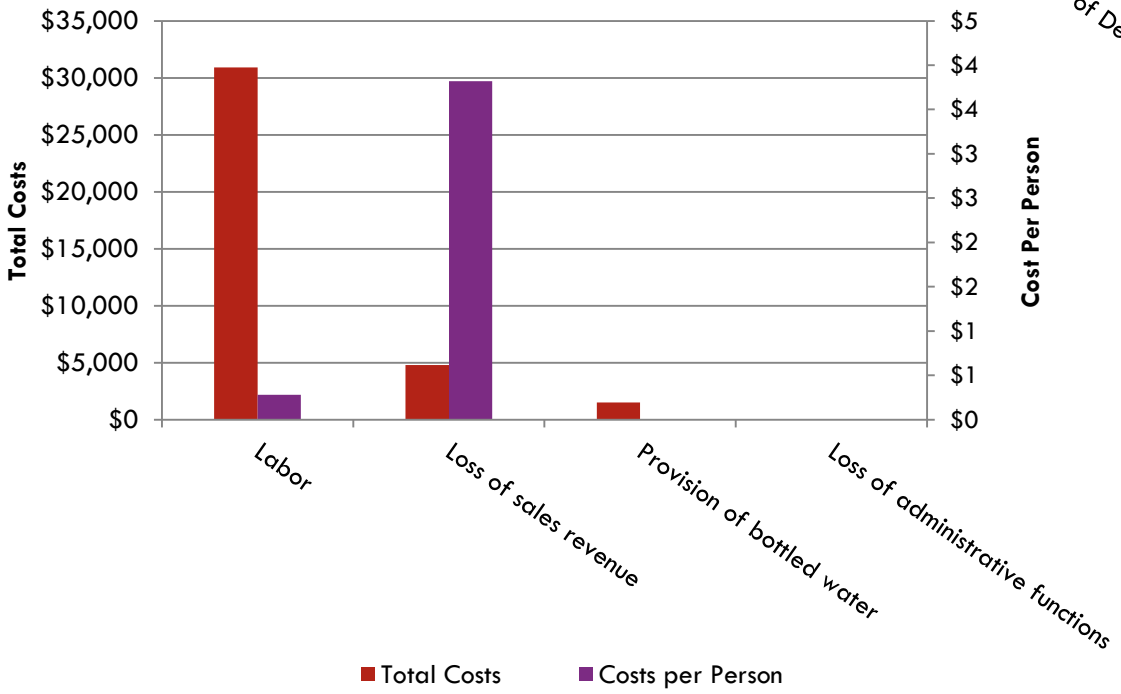
Note: Several respondents reported more than one impact in the figure above.

Cost Summary

Item	Per Utility	Average
Greatest total cost	$40 million / 1 utility	$5.37 / person
Average cost for impacts reported	$2.3 million / 38 utilities	$4.60 / person
Average cost for all utilities responding	$751,878 / 65 utilities	$3.33 / person
Highest cost – A – infrastructure replacement	$2,609,000 total	$521,800 avg./5 ut. -
Alternative energy costs	$792,000 total	$66,000 avg. /12 ut.

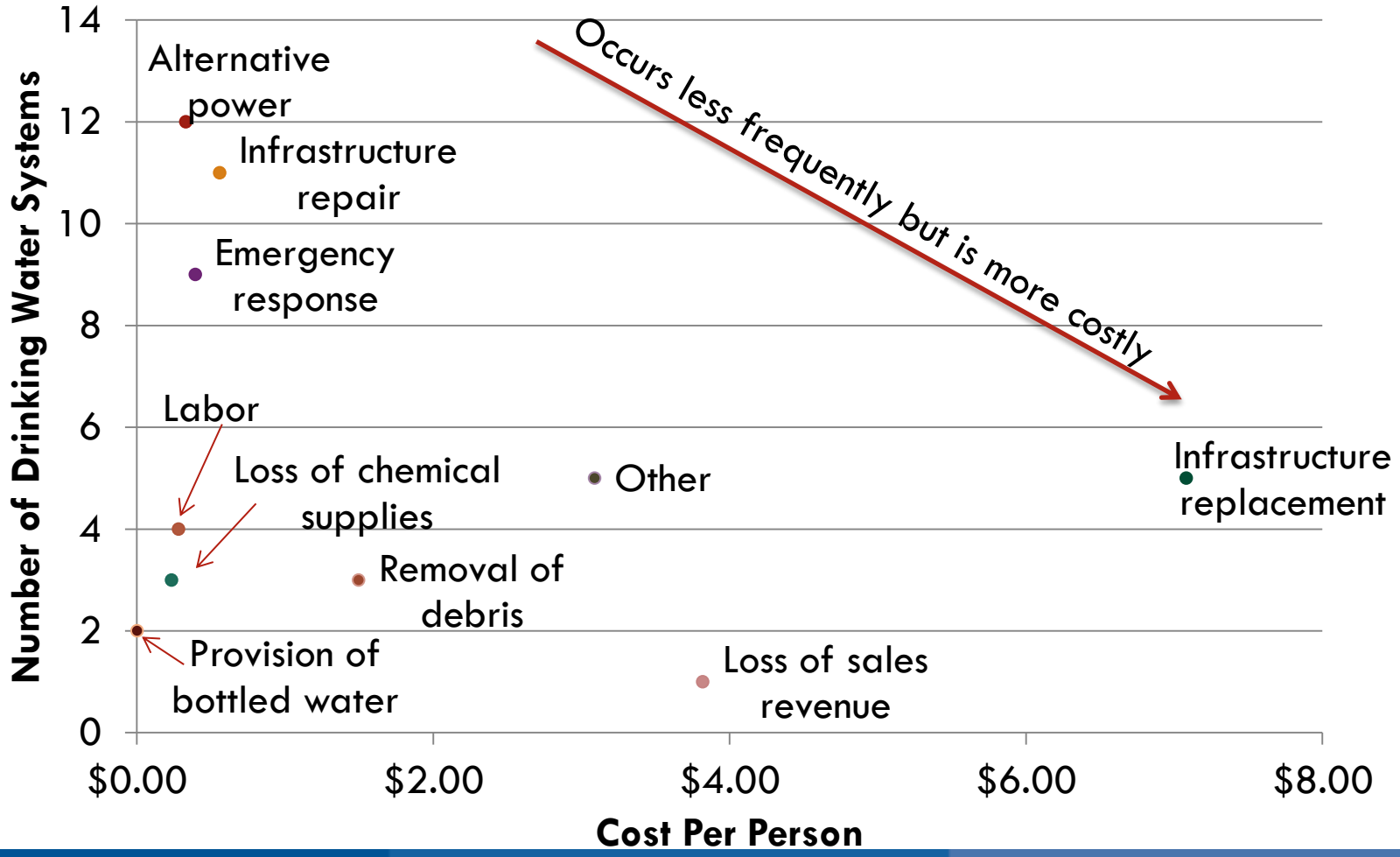
A - replacement of water treatment, storage, or distribution system equipment or components





Magnitude of Costs Reported by Drinking Water Systems

Comparison of Damages According to Frequency and Costs per Person



Hurricane Irene Costs by State

State	Number of Drinking Water Systems		Total Costs Reported	Average Costs Reported by Systems with at Least Some Cost (21)	Average Costs Reported for all Respondents (64)	Population of Drinking Water Systems that Reported at Least Some Cost (21)	Average Cost Per Person
	In Survey	Reporting Costs					
CT	3	3	$412,727	$137,576	$137,576	796,388	$0.52
DE	1	None					
MA	10	6	$1,905,307	$317,551	$190,531	75,534	$25.22
NC	1	None					
NJ	5	3	$1,172,000	$390,667	$234,400	922,847	$1.27
NY	4	4	$45,372,500	$11,343,125	$11,343,125	8,325,173	$5.45
PA	2	None					
RI	19	4	$3,550	$888	$187	50,605	$0.07
SC	1	None					
VA	2	1	$6,000	$6,000	$3,000	446,067	$0.01
Total	65	21	$48,872,084	$2,327,242	$751,878	10,616,614	$4.60

Hurricane Irene Costs by Drinking Water System Size

Population Served	Total Cost Reported	Number of Water Systems Reporting Costs	Average Cost per Water System that Reported Costs	Total Population of Survey Respondents at Water Systems that Reported Costs	Average Cost per Person Served by Drinking Water Systems that Reported Costs
a. 25-500	$2,740	3	$913	475	$5.77
b. 501-3,300	$94,079	2	$47,040	3,492	$26.94
c. 3,301-10,000	$807,408	2	$403,704	11,172	$72.27
d. 10,001-100,000	$2,476,357	7	$353,765	228,740	$10.83
e. >100,000	$45,491,500	7	$6,498,786	10,372,735	$4.39
Not Available	$0	0	$0	N/A	N/A
Total	$48,872,084	21	$2,327,242	10,616,614	$4.60

Source: Population estimates retrieved from the Safe Drinking Water Information System (SDWIS) online at http://www.epa.gov/enviro/facts/sdwis/search.html.

Lessons Learned and Recommendations

Transmission main washout
Photo courtesy of Jim Glozzy

- An increased sampling regimen - most frequently reported precaution.
  - Prepare by having water sampling supplies on hand.
- Additional staff/staff hours required….can be costly.
  - Prepare a staffing plan for emergencies
  - Establish clear expectations with vendors and contractors
- Communication is key.
  - Establish clear channels of communication with regulators, neighboring drinking water systems, other utilities, media outlets, and other local emergency responders.
- Road Blocks (literally) are inevitable
  - Include evacuation and alternate access routes to assist crews during emergency situations in your emergency response plan.

Example Preparation Checklist Actions, United Water

- Prepare staffing availability schedule for all departments
  - Employees Safety and Customer Service
- List of emergency generators and their current locations
  - Locate portable generators at key locations in case of transportation issues
  - Test run all generators and top off fuel tanks
  - Contact (via RCOEM) the National Guard for generator availability
- Test Emergency Hydraulic Pump
- Perform Dam Inspections
- Prepare water quality check list
  - Top off all treatment chemicals
  - Keep chlorine residuals elevated in case of sewage run-off
  - Clean and calibrate turbidimeters, flush head loss gauges
  - Prepare for jar testing to confirm coagulant dosages
  - Coordinate sampling procedures with Haworth lab
  - Maintain high level in storage tanks

Financing an Emergency

Photo courtesy of Susan Licardi

Electrical flooding at well house

- Medium-sized systems (3,301-10,000) - greatest per person cost as a result of Hurricane Irene.
- Small systems (<3,301) - most vulnerable to increased operating costs as a result of Hurricane Irene.
- FEMA reimbursements can take time;
  - Develop a business continuity plan/contingency plan
  - Work with your FEMA representative ASAP
    - photo log of your damages.
- Insurance coverage (actual and required) will impact your emergency response funding eligibility. Determine if your insurance coverage is appropriate.

Requesting Reimbursement in New Haven, Conn.

- Regional Water Authority in New Haven, Conn. **requested relief** funding from FEMA following Hurricane Irene.
- It took nearly **three months** for FEMA to contact the drinking water system regarding their application.
- System heard back from FEMA in November, **delays experienced** working through the required documents due to the **holiday schedule**.
- The Regional Water Authority suggested:
  - maintaining good expense records would improve the request process.
  - taking photos during the event serves as a helpful reminder about who was involved at any given point and what equipment was used.

Partnerships and Planning

Road block due to storm damage
Photo courtesy of John Triana

- **Strategic partnerships** can provide drinking water systems with support and resources needed to address unexpected failures during an emergency.
  - Utilities, Department of Public Works, and Public Service providers in neighboring towns can help supplement the local availability of emergency assistance.
  - Regulators and local government officials
  - Utilities providers (electricity)
- **After Action Report** Document your lessons learned
- **Plan regularly and practice more often**, including reviewing safety measures with staff frequently.

Sample After-Action Report (**Norwich Public Utilities, Connecticut)**

1. Pre-Storm Checklists:

- Update Pre-storm Checklists with lessons learned

2. Emergency Plans

- Update Incident Command Structure (ICS) plans with lessons learned from storm
- Communicate safety chain of command
- Issue Storm chart Org chart with backups
- Other resources allocated through ICS
- Procedure / Guideline for declaring NPU emergency

3. Stockroom

- Procure more air mattresses
- Have additional cell phone vehicle chargers on hand
- Add more staff in stockroom during storm
- Have necessities available for employee families (Water, flashlights cots etc.)

4. Contractor and Mutual Aid

- Create system overview, standards and safety guidelines package
- Train all contractors and mutual aid crews prior to starting work
- Improve checking in / checking out procedure

Sample After-Action Report (Norwich Public Utilities, Connecticut)

5. Communication Improvements

- Investigate communication systems or tools for coordinating Field control room and EOC
- Post storm status in public areas for crews and employees
- GIS map updated and available CS & EOC
- Hold morning tailgates prior to starting work day
- Radio communication
- Engage new tools - Twitter, Face book, outbound calling, website other
- PowerPoint updates in lunchrooms and EOC
- Provide customers with pre storm communication and safety information

6. Damage assessment teams

- Utilize crews of two whenever possible.
- Provide sectionalized circuit maps for assessment teams
- Train additional people (Meter readers and others) and utilize non-trained as drivers
- Investigate Trimble handhelds as solution for communicating damage

Sample After-Action Report (Norwich Public Utilities, Connecticut)

7. EOC improvements:

- Increase clerical staffing
- Train in ICS, roles and responsibilities, with all necessary departments present
- Perform tabletop drills more frequently 1-2 times per year

8. Facilities Hardening:

- Investigate Hurricane Windows or shutters for EOC
- South Golden Street Generator
- CNG Generator
- Install generator at Royal oaks pump station
- Fiber system on generators
- At plants test generators under load monthly
- Obtain sandbags in advance
- Add transfer switch and quick generator connect at well site

9. Equipment

- Additional portable light trailer / generator
- Individual tracking of assignments and equipment used

Additional point:

Staff safety issues faced by the water systems and how those should be incorporated into their preparedness planning.

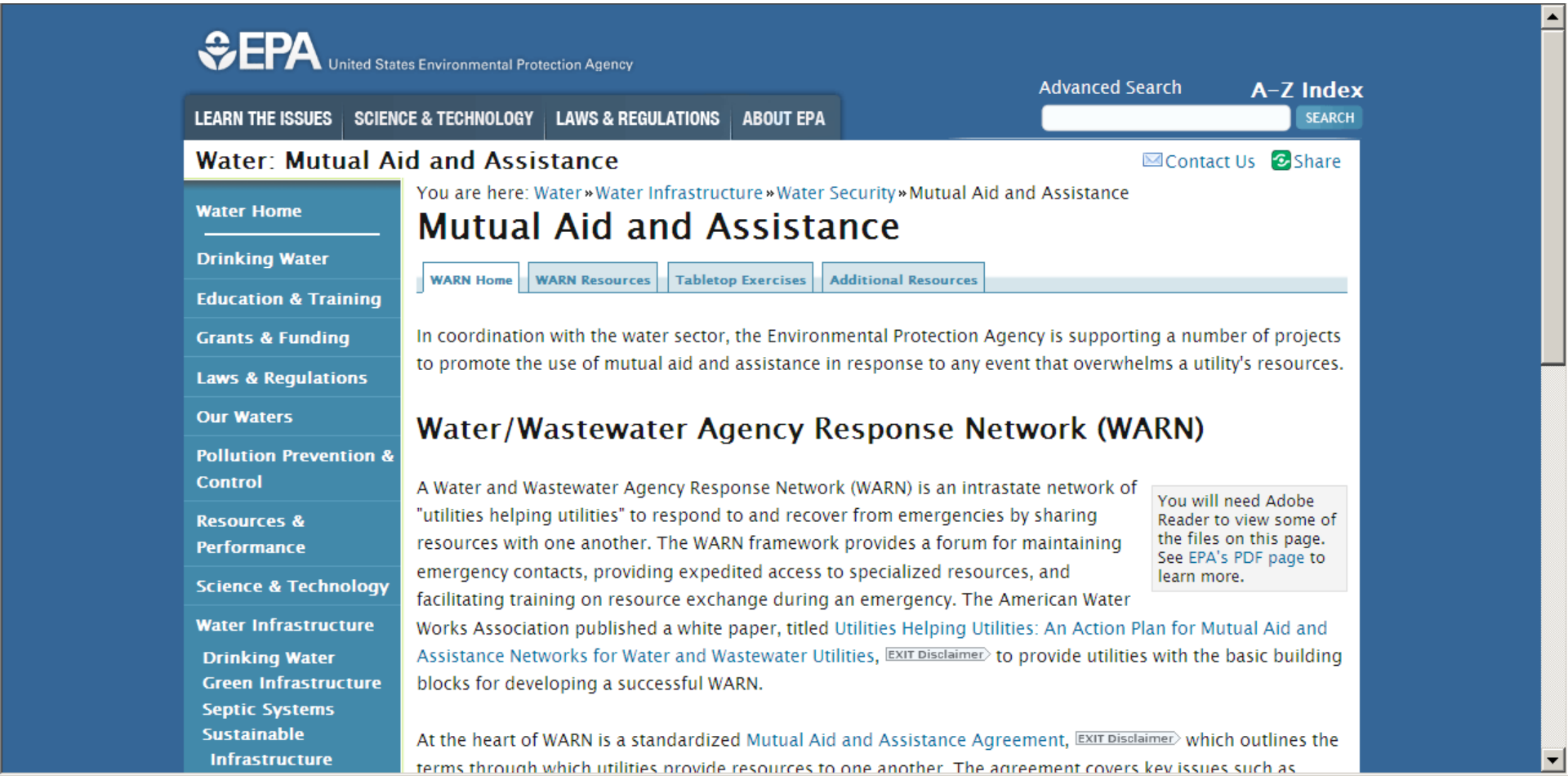
In many cases, the conditions of the storm prevented water system staff from addressing problems during the storm.

Following Hurricane Irene, one water system revised the maximum wind speed under which they would allow staff to go outside.

Conclusions: Partnerships and Planning

- **Strategic partnerships** can provide drinking water systems with support and resources needed to address unexpected failures during an emergency.
  - Utilities, Department of Public Works, and Public Service providers in neighboring towns can help supplement the local availability of emergency assistance.
  - Regulators and local government officials
  - Utilities providers (electricity)
- **After Action Report** - Document lessons learned
- **Plan and practice** - Include reviewing safety measures

WARN



WaterRF Related Research

- Impact of Hurricane Irene – topic of this presentation
- New survey on Hurricane Sandy – on-going
- Climate studies
  - Strategic initiative
  - Studies funded
- Extreme weather events
  - Hurricanes & tropical storms on mid-Atlantic Virginia Beach, Norfolk
  - Potential impact on District of Columbia from Hurricane Sandy
- Vulnerability Assessments / Security
- Business Continuity Planning
- Telemetry

http://www.waterrf.org/resources/Lists/PublicSpecialReports/Attachments/6/Hurricane_Irene_Survey_Report.pdf

Photo courtesy of Alan Weland

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