Drinking Water Vulnerability Assessment and Resilience Plan

Fairfield, New Haven, Middlesex, and New London Counties

November 2018

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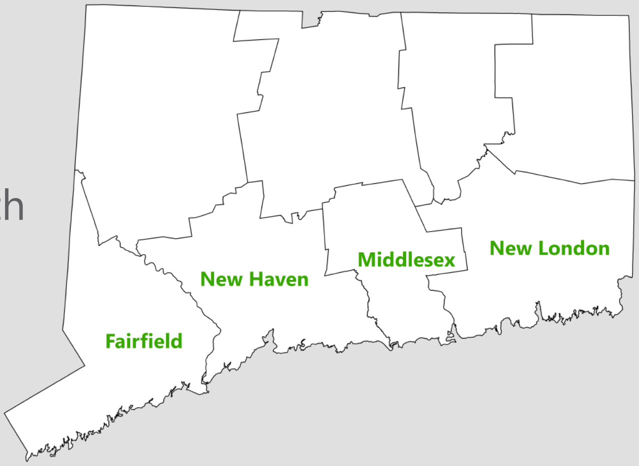

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Cover Photo Credit: **Connecticut Department of Public Health**

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BCA	Benefit-Cost Analysis
CAES	Connecticut Agricultural Experiment Station
CAT	Capacity Assessment Tool
CDBG-DR	Community Development Block Grant Disaster Recovery
CFS	Cubic Feet Per Second
CGS	General Statutes of Connecticut
CIRCA	Connecticut Institute for Resilience and Climate Adaptation
CL&P	Connecticut Light and Power
COG	Council of Government
CPC	Climate Prediction Center
CT	Connecticut
CtWARN	Connecticut Water/Wastewater Agency Response Network
CWS	Community Water System
CWSP	Coordinated Water System Plan
CWSRF	Clean Water State Revolving Fund
DEEP	Connecticut Department of Energy and Environmental Protection
DEMHS	Division of Emergency Management and Homeland Security
DESPP	Connecticut Department of Emergency Services and Public Protection
DMP	Daily Maximum Precipitation
DOH	Connecticut Department of Housing
DOT	Connecticut Department of Transportation
DPH	Connecticut Department of Public Health
DPH-DWS	Connecticut Department of Public Health Drinking Water Section
DPUC	Department of Public Utility Control
DWINSA	Drinking Water Infrastructure Needs Survey and Assessment
DWS	Drinking Water Section
DWSRF	Drinking Water State Revolving Fund
DWVARP	Drinking Water Vulnerability Assessment and Resilience Plan
EAP	Emergency Action Plan
ECP	Emergency Contingency Plan
EMS	Emergency Medical Services
EOC	Emergency Operation Center

EOP	Emergency Operation Plan
EPA	U.S. Environmental Protection Agency
ERP	Emergency Response Plan
ESF	Emergency Support Function
FEMA	Federal Emergency Management Agency
FFRMS	Federal Flood Risk Management Standard
GCM	Global Climate Model
GHG	Greenhouse Gas
GIS	Geographical Information Systems
HDE	Hybrid Delta Ensemble
ICS	Incident Command System
IDW	Interagency Drought Workgroup
LOCA	Localized Constructed Analogs
MACA	Multivariate Adaptive Constructed Analogs
MCL	Maximum Contaminant Level
MPH	Miles Per Hour
NHMP	Connecticut Natural Hazard Mitigation Plan
NIMS	National Incident Management System
NOAA	National Oceanic and Atmospheric Administration
NTNC	Non-Transient Non-Community
OEM	Office of Emergency Management
OPM	Connecticut Office of Policy and Management
PET	Potential Evapotranspiration
PHC	Public Health Code
PHERP	Public Health Emergency Response Plan
PURA	Public Utilities Regulatory Authority
PWS	Public Water System
PWSID	Public Water System Identification
RCAP	Resources for Communities and People
RCP	Representative Concentration Pathways
RCSA	Regulations of Connecticut State Agencies
RL	Repetitive Loss
RTRM	Relative Thermal Resistance to Mixing
SDWA	Safe Drinking Water Act

SEOC	State Emergency Operations Center
SOP	Standard Operating Procedure
SRF	Connecticut State Response Framework
SWP	State Water Plan
TNC	Transient Non-Community
UCONN	University of Connecticut
USGS	United States Geological Survey
WEAR	Water Emergencies Assessment and Response Team
WSP	Water Supply Plan
WUCC	Water Utility Coordinating Committee

Drinking Water Vulnerability and Resilience Plan for Connecticut

Executive Summary

THE DEVELOPMENT OF A DRINKING WATER VULNERABILITY ASSESSMENT AND RESILIENCE PLAN

The mission of the Connecticut Institute for Resilience & Climate Adaptation (CIRCA) is to increase resilience and sustainability of vulnerable communities in Connecticut. The Connecticut Department of Public Health (DPH) is a member of the State Agency Fostering Resilience Council (SAFR Council), which works collaboratively to strengthen the state's resiliency to extreme weather events. With DPH a member of SAFR, CIRCA is dedicated to providing DPH with science-based and forward-thinking risk analysis on inland and coastal flooding as well as other climate-related risks. This project advances the goals of DPH, CIRCA, and SAFR through the assessment of the changing risks to the state's public and private drinking water infrastructure posed by climate change.

The overall objective of the Drinking Water Vulnerability Assessment and Resilience Plan (DWVARP) was to conduct a vulnerability assessment of Connecticut Community Water Systems (CWSs) in the four coastal counties (Fairfield, New Haven, Middlesex, and New London) impacted by Superstorm Sandy. The assessment identifies options and alternatives to mitigate the vulnerabilities identified and to improve resiliency. All findings and options are compiled into a comprehensive Public Water System (PWS) resiliency plan. The findings and recommendations from the DWVARP will play a vital role in building resiliency into CWSs throughout the four counties or better preparing these systems for future storm impacts.

The development of an emergency response plan for the Drinking Water Section (DWS) was based on interview findings from in-state and out-of-state drinking water staff, an assessment of current practices, and collaboration between DWS staff and the project team. The development of this plan aims to improve the resiliency of the DWS's internal procedures.

To foster integration with this plan, the State Water Plan (SWP), and the Water Utility Coordinating Committee (WUCC) planning process, outcomes were reviewed and compared to the objectives of this plan. The DWVARP expands the scope of the common themes.

The DWVARP utilizes a slightly different climate change projection than the SWP, with the projection focused on recommendations to improve infrastructure and source resiliency.

Helpful Acronyms

DWVARP: Drinking Water Vulnerability Assessment and Resilience Plan
DPH: CT Department of Public Health
DWS: Connecticut Department of Public Health Drinking Water Section
WUCC: Water Utility Coordinating Committee
PWS: Public Water System
CWS: Community Water System
NTNC: Non-transient non-community system
TNC: Transient non-community system

THE TOP 10 VULNERABILITY PLAN THEMES

The DWVARP has provided a unique opportunity to assess multiple aspects of the current state of public water systems and private water supplies and the impacts due to climate change. The findings and recommendations of the study were aggregated into "themes." The 10 themes of the study are as follows, with relative findings provided on the subsequent pages:

1. Lessons Learned from Past Events
   Recent severe storms and droughts have provided important lessons regarding risks and resiliency, leading to key conclusions.
2. Flood Risk to Community Water System Infrastructure & Critical Facilities
   CWS infrastructure and sources are currently located within zones of flood risk. Risks can be addressed to make these assets more resilient.
3. Water Quality and Quantity Vulnerabilities
   A review of water quality and quantity metrics points to potential trends that indicate vulnerabilities and existing risks to PWSs.
4. Climate Change Impacts
   Climate change projections demonstrate that drought and flood risks will increase and suggest that source water quality will be threatened.
5. CWS Vulnerabilities and Emergency Preparedness
   A review of current CWS vulnerability assessments and emergency response plans found opportunities for planning-level improvements.
6. Drought Planning and Resilience
   Climate change projections and recent drought experiences together point to needed improvements for resilience.
7. Interconnections and Infrastructure Upgrades
   Source and storage redundancies along with interconnections can increase resiliency even as risks are changing.
8. DPH Drinking Water Section Emergency Preparedness
   Interviews with surrounding state agencies and Connecticut drinking water staff provided guidance for a new emergency response plan, which the department can utilize during severe storm and drought events.
9. State and Local Laws Affecting Drinking Water
   A review of current laws affecting drinking water analyzed the current state of regulations and suggests improvements.
10. Private Well Vulnerabilities
    Sea level rise and riverine flood risks will affect private wells. Steps can be taken to make private water supplies more resilient.

1. LESSONS LEARNED FROM PAST EVENTS

Many CWSs across the state have at one time or another experienced an emergency or felt the impacts of a drought or storm. In order to understand the past impacts of storms or drought and assess PWS capabilities, a survey was developed, and interviews were conducted to cover a range of topics. Questions revolved around each system's general risk and vulnerabilities, storm and drought preparedness and recovery, planning for climate change, and the capacity of the system to cope or mitigate future risk.

In total, 85 systems responded to the survey, with over half of the respondents having 15 or more years' experience in the industry. Across the systems that responded, 30% were large (10,000+ customers), 30% were medium (500-9,999 customers), and 40% were small (<500 customers). Of these various system sizes, 22% use surface water as their primary source, 77% use groundwater, and 7% purchase their water from neighboring PWSs.

Interviews covered 24 CWSs including five small, seven medium, and nine large systems.

The past experiences demonstrate existing risks to PWSs, their critical infrastructure, and to the critical facilities that are served by these systems. During an extreme weather event, municipalities and critical facilities rely on having water without interruption. Critical facilities might include shelters, hospitals, fire departments, and care facilities; these are addressed on the next page. Specific findings of the surveys and interviews include the following:

1A. Recent Storm Impacts

The most prominent storm events of the past 10 years have included October Snowstorm Alfred, Superstorm Sandy, and Tropical Storm Irene. Other events such as the tornadoes in May 2018 show that storms can strike at any time.

Of the systems surveyed, nearly 72% either lost power or utilized a generator, and over 50% found it necessary to implement their emergency response plan during recent events. While power outages were common, generators and more reliable electricity supplies have decreased the perceived risk of power loss. A small percentage of these systems also experienced flooding; according to interviewees, flooding is not a significant concern for most CWSs. About a quarter surveyed (23%) found difficulty with staff reporting to work during an event.

1B. Recent Drought Impacts

CWSs have experienced impacts due to drought, including the very significant drought of 2015-2016. However, few systems experienced severe impacts. Over half (57%) of the systems surveyed implemented voluntary water restrictions while nearly a fifth (18%) implemented mandatory water restrictions. Roughly 1/3 of the systems experienced some level of reduced supply, with 61% of large systems reporting they experienced reduced supply. It was also noted that 39% of large systems surveyed experienced misalignment with drought messages from the governor's office.

1C. Recommendations

Recommendations associated with the interviews and survey findings include the following:

- Generators are widely used and are helpful during power outages, but water systems are increasingly concerned about access to fuel during multiday outages and the possibility of a generator failure during an event. Additional redundancies may help many PWSs.
- There should be coordination with local emergency management directors (EMD) to ensure systems are on the priority service restoration list even if they have standby power.
- Drought communication is not uniform, which can lead to confusion among the public. Efforts to improve coordination between the state and CWSs about drought messages and to better communicate to the public when messages differ should be made.
- Water use restrictions are effective during drought, but small systems have difficulty enforcing use restrictions when household water is not metered. Small systems may require additional technical and financial assistance for addressing droughts.
- Some systems found United States Department of Agriculture (USDA) funding not helpful to building resiliency. Additional funding channels may be needed. Support for small systems to acquire funding is also needed.

2. FLOOD RISK TO COMMUNITY WATER SYSTEM INFRASTRUCTURE & CRITICAL FACILITIES

CWSs rely on critical infrastructure located throughout their service area, which could span as large as multiple municipalities, or as small as a mobile home park. Certain infrastructure components may be more vulnerable than others due to their structure and more at risk depending on the proximity to a flood zone.

2A. Current Risks

Floods present risks to both riverine and coastal infrastructure. While many CWS source wells have been elevated on mounds to prevent inundation, these levels may no longer be sufficient with climate change. Many reservoirs also have well-designed dams and spillway; however, with climate change projections anticipating an increase in precipitation and severe future storms, these dams and spillways may be pushed beyond limits leading to damage or failure. Treatment plants and pump stations may also be vulnerable if they are located in flood zones and not properly floodproofed. However, water storage tanks are typically elevated and therefore have a lower flood risk.

While some systems are more resilient than others, those that lack redundancies are more vulnerable overall, in turn leaving critical facilities served by them also vulnerable. By identifying those critical facilities served by a system, both DPH and the system can be prepared to respond and assist those facilities during an emergency.

2B. Identifying Vulnerable CWS Infrastructure

Spatial data layers representing all geo-located treatment plants, intakes, pump facilities, and wells were overlaid onto a Federal Emergency Management Agency (FEMA) flood map to identify CWS infrastructure potentially at risk to flooding. Overall, 8.8% of treatment plants, 40% of intakes, 4.5% of pump facilities, and 7.9% of wells fell within a FEMA flood zone. Summarizing across systems, 185 systems had at least one system component within a flood zone, corresponding to 81 CWSs, 70 transient, TNC water systems, and 34 NTNC water systems. There was a high degree of variability with respect to the vulnerability of the systems at large. For example, some CWSs had a single well within a flood zone while others had multiple treatment plants, multiple intakes, and multiple wells within a flood zone.

2C. Identifying Vulnerable Critical Facilities

The first step in identifying critical facilities was linking each facility to a PWS. Initially, it was assumed that a facility would be served by the closest PWS. This was determined by calculating the distance from the critical facility to the nearest PWS footprint (pipe network for large systems and areas derived from the addresses of customers served for small systems) and the nearest PWS well and then linking them to the closest CWS.

Critical facilities were identified as vulnerable if the linked PWS had infrastructure within a FEMA flood zone. Approximately 80% of facilities were linked to a PWS potentially at risk to flooding. Specifically, six were linked to a NTNC well that fell within a flood zone, four were linked to a TNC well that fell within a flood zone, and the remaining 1,281 facilities were linked to one of 30 CWSs previously identified as potentially vulnerable.

If a critical facility was linked to a CWS identified as vulnerable, the analysis for the facility was refined. The distance from each facility to the closest treatment plant, intake, and pump facility for the linked system was determined. Facilities were designated as potentially vulnerable if the nearest treatment plant, pump facility, or intake was identified as vulnerable; this reduced the number of potentially vulnerable facilities linked to a CWS from 1,281 to 912 (29% reduction).

2D. Recommendations

Some options to reduce risks include the following:

- Vulnerable pump stations and treatment plants should be made more resilient by floodproofing or utility hardening. These mitigation efforts will reduce the flood risk to the system.
- Reservoirs with aging infrastructure, such as dams and spillways, should be assessed for their capacity in dealing with future flooding and heavy precipitation events. By assessing the structural integrity and water flow capacity, upgrades and improvements can be made to the components to withstand climate change effects.
- By identifying those wells that are located within a flood zone and ensuring sufficient protective mounding, the risk of flooding will be reduced. If wells are found to be inadequately prepared for a flooding event, improvements should be made so the well head is above the 500-year flood event, plus appropriate freeboard.
- Improved data could show which portions of CWSs serve certain critical facilities. To better identify this connection, there should be guidelines to assess critical facilities that are located far from their sources; this would determine on what infrastructure facilities rely, thereby making service restoration easier. A Geographic Information System (GIS) database would also be beneficial in improving resilience. This database should represent critical facilities and by which system they are served and also identify those facilities that are their own public water system.
- Wherever possible, natural systems should be restored to help minimize flooding.
- A program should be established that will ensure adequate protected and undeveloped land.

3. WATER QUALITY AND QUANTITY VULNERABILITIES

A review of water quality and quantity metrics points to potential trends that indicate vulnerabilities and existing risks to PWSs. Extreme conditions, such as a flood or drought, may result in changes to drinking water quality and quantity. Flooding events can potentially cause inundation of well sources, contaminated runoff into surface water supplies, or inundation of infrastructure causing a disruption in service. Droughts have the potential of reducing water availability and increasing the occurrence of harmful algal blooms.

3A. Drought and Storm Impacts on Water Quality

Surveys and interviews were described under "Lessons Learned from Past Events." These methods were used not only for understanding past events but for understanding how sources were affected.

Among all survey respondents, 6% and 4% indicated recent droughts impacted finished water quality and source water quality, respectively, while 5% indicated recent storms caused finished water quality problems. Experiencing finished water quality problems during droughts and storms is associated with issuing boil water advisories. While few systems perceive that their source or finished water quality is threatened now, systems perceive that water quality problems will increase in the future.

3B. Reservoir Water Quality Changes

Water quality data from six drinking water reservoirs in south central Connecticut together with air temperature data were analyzed. Data analysis indicates that surface dissolved oxygen saturation, surface water temperature, thermal stratification, and specific conductivity are increasing. Overall, this means that biological growth (algal productivity) is increasing, and lakes are becoming hotter and less well mixed as the climate warms. Hotter, more stable lakes are more likely to experience harmful algal blooms, especially if blooms are already a problem.

3C. Water Quality Violations Summary and Trend

An analysis was conducted of drinking water quality violations from January 1, 2006, to December 31, 2016, including 4,066 maximum contaminant level (MCL) violations across 2,487 PWSs. The most common MCL violations include exceeding bacterial count limits (i.e., violating the Total Coliform Rule), limits for turbidity, and allowable limits for disinfection byproducts.

Among PWSs that use groundwater, NTNC systems experience the most (40%) MCL violations. Across all PWSs that rely on groundwater, privately owned systems experience the most (90%) MCL violations.

3D. Sanitary Survey Review and Summary

An analysis of sanitary survey reports between 1996 and 2016 was conducted including reports for 450 PWSs. We found that 730 significant deficiencies occurred over the 10-year period and that 15% were violations that a PWS incurred repeatedly during the period of analysis. Over half (55%) of all violations involved source water wells (55%) including wells not being watertight (23%), evidence of flooding (12%), or wells not screened (9.5%). A quarter (26%) of all significant deficiencies involved storage tanks not adequately protected from contamination.

3E. Recommendations

Some options to improve water quality and quantity resiliency include the following:

- Increase testing frequency for smaller systems.
- Incorporate a resiliency metric into the sanitary surveys.
- Create a baseline for water quality and violations and use from here on out. This baseline can prioritize land use decisions based on quality of adjacent watersheds and water bodies.
- Use source water protection and the Drinking Water Quality Management Plans as a source of resiliency and increase funding and support for investments in watershed protection.
- Increase source water quality monitoring in surface water supplies that already experience algal blooms.
- Invest in science to explore the relationship between water quality violations and sanitary survey deficiencies with boil water advisories and waterborne disease outbreaks.
- Provide more support to NTNC and private systems to reduce MCL violations.
- Analyze impervious surface percentage surrounding water sources before developing further.
- Establish land acquisition or easement programs to revert developed land surrounding sources to more natural systems.
- Consider green infrastructure applications versus grey infrastructure.

4. CLIMATE CHANGE IMPACTS

The previous three pages describe how flood, storm, drought, and water quality risks are already affecting PWSs and critical facilities. While we often think of these risks as stationary, they are believed to be changing as our climate changes.

To evaluate future risks associated with climate change, local and regional changes were assessed. The most up-to-date climate projections were developed and used and focused on precipitation extremes, drought, and water availability with a mid-century time frame. For this plan, the RCP8.5[11] scenario was chosen as the focus. Although this projection is considered a "high" emission scenario, greenhouse gas emissions in recent years have closely tracked the projections of this scenario. The State Water Plan also includes a climate change analysis with a somewhat different focus but similar results.

4A. Changes to Flood Risk

The daily maximum precipitation (DMP) for all modeled return periods (5, 10, 20, 50, 100 years) is projected to increase, with a larger increase of extreme precipitation for longer return periods. Five of the six models project a DMP relative increase of more than 50% for most of Connecticut for all five return periods. Some portions of the state are projected to experience a doubling in the DMP for a 20-year return event and tripling for a 100-year return event. In the past climate, roughly 15% of total precipitation was accounted for by heavy rain events. It is projected that future climate could experience an additional 2 to 10% of precipitation attributed to heavy rain events.

4B. Changes to Drought Risk

While projections anticipate an increase in total precipitation, much of the increase can be accounted for by winter precipitation rather than summer. Also, with temperatures projected to rise, so does the potential evapotranspiration (PET). The projected PET exceeded the projected precipitation increase, primarily accounted for during warm seasons. The seasonal trends display a clear contrast with slight increases of water budget during winter and a drastic decrease during summer.

Overall, the models project a decrease in average summer potential water availability, resulting in an increase in extreme summer droughts. The models do however differ regarding the severity of longer duration future droughts, leaving a high degree of uncertainty regarding long-term droughts.

4C. Source Water Protection

An increase in precipitation may potentially increase flooding events and associated risks to public water system wells while an increase in stormwater runoff and in seasonal droughts poses a risk to surface water sources. There is also potential for a longer algal bloom season (starting earlier and ending later) and for more harmful algal blooms with the rise in temperatures as warmer temperatures favor blue-green algae that may produce toxins as well as compounds that impact taste and odor. Stringent source water protection measures will help maintain resiliency of some sources while new and innovative source water protection methods or plant treatment process changes will achieve resiliency even as climate changes.

4D. Recommendations

Some options to address climate change and improve resiliency include recommendations previously mentioned, such as further elevating wellheads, incorporating a resiliency metric into sanitary surveys, and enhanced source water protection. Others include:

- Provide specific targeted nonregulatory guidance to PWSs regarding how to incorporate changes to flood risks into planning and operations.
- Provide specific targeted nonregulatory guidance to PWSs regarding how to incorporate changes to drought risks into planning and operations.
- Begin tracking harmful or potentially harmful algal bloom data in Connecticut and provide technical assistance to CWSs to address these events.
- Promote and help fund additional source water protection measures and the Drinking Water Quality Management Plan for voluntary collaborative water quality protection.
- Consider green infrastructure strategies to improve resiliency.

1 The Representative Concentration Pathway (RCP) as cited by the latest projections from the Coupled Model Intercomparison Project phase 5 (CMIP5) is numbered according to the change in radiative forcing that results by 2100. This model was the primary source for the 5th Intergovernmental Panel on Climate Change (IPCC) report.

5. CWS VULNERABILITIES AND EMERGENCY PREPAREDNESS

Available CWS vulnerability assessments were reviewed, along with emergency contingency plans that are prepared by systems serving over 1,000 persons. These plans were reviewed to identify system vulnerabilities and strategies taken to mitigate the risks and to assess to what level these systems are prepared for an emergency.

5A. Vulnerability Assessment Review

Many systems maintain a separate assessment with sensitive and confidential system vulnerabilities; these documents were not released as part of the water supply plan. Therefore, this analysis is limited to the available data and may not be representative of all of a system's vulnerabilities. However, some systems chose to include a document or chapter that included general vulnerabilities, such as "power outage." Because of this gap in data availability, vulnerabilities were primarily identified by using the emergency response procedures.

The review of these documents showed that systems consistently do not acknowledge climate change as a factor in their vulnerability assessments. However, it is clear that many of the large systems have redundancies built into their systems to avoid infrastructure going offline during an event and that these redundancies reduce vulnerability.

5B. Emergency Contingency Plan Review

Thirty-six system Emergency Contingency Plans (ECP) were reviewed to gather information on mitigating the impacts of flooding, drought, and climate change. In general, most systems are prepared for an event. Many have looped transmission mains to assist in small break isolation and are able to repair small breaks with in-house parts. The systems that are not able to repair breaks typically have contractors that are able to assist during an emergency. It was also found that most utilities are capable of functioning normally if one or more primary sources are offline, and if there is total failure, most have at least 24 hours of storage. Surface water dependent systems also have emergency action plans in the event there is dam failure due to flooding and have dam monitoring programs in place for implementation during events.

The ECPs also included lists of "priority facilities"; however, water utilities have broad latitude in deciding which customers should be listed. Priority facilities are often synonymous with critical facilities but could also include major employers or industry.

5C. Drought Response Plans

The majority of large utilities with submitted drought response plans utilize a five-stage drought response; however, Aquarion Water Company and Connecticut Water Company use a four-stage response plan. These two companies account for a large number of smaller community systems operated by these utilities. Drought triggers varied and were dependent on factors such as season, depth of water in well, reservoir storage capacity, or well output compared to demand. The table below displays the response levels and their respective water restrictions.

Four-Stage Response	Five-Stage Response
Alert - Voluntary light use	Alert - Voluntary reductions
Watch - Mandatory light restrictions	Advisory - Light mandatory reductions
Warning - Mandatory moderate restrictions	Emergency - Phase 1 increased reduction
Emergency - Heavy mandatory restrictions	Emergency - Phase 2 increased reduction
	Emergency - Phase 3 increased reduction

5D. Recommendations

It is apparent that with the climate changing and vulnerabilities becoming more prominent, systems should begin to acknowledge climate change and the associated vulnerabilities in their water supply plans. By acknowledging these vulnerabilities, emergency response procedures can also be created.

ECP priority facility lists should include all critical facilities. Typically, critical facilities are shelters, healthcare facilities, emergency response facilities, etc. as noted previously in this summary. Local hazard mitigation plans should be consulted to compile these lists.

A reasonable level of drought response uniformity is needed to avoid confusion regarding drought responses. Stronger communication between the state and CWSs is needed to better convey drought responses to the public. The next page addresses droughts in more detail.

6. DROUGHT PLANNING AND RESILIENCE

With severe droughts occurring recently (2015-2016) and projected to become more frequent, PWSs need to be prepared for changes that may occur in both surface and groundwater sources. Some of these changes have been described on previous pages.

6A. Drought Triggers for Response

Drought triggers vary between systems based on demand, source type, and drought response stages. During past droughts, these triggers were adequate for some systems while other systems found their triggers were provoked faster than anticipated. Among respondents to the survey described under "Lessons Learned from Past Events," 8% found drought triggers to be inadequate overall while among large systems 26% found drought triggers inadequate. With climate change projections anticipating an increase in severe droughts, drought triggers may need revision.

Complicating matters, the review of ECPs described above noted that a large percentage of large CWSs with drought response plans utilize a five-stage drought response; however, many use the preferred four-stage response plan, and at least one uses a hybrid.

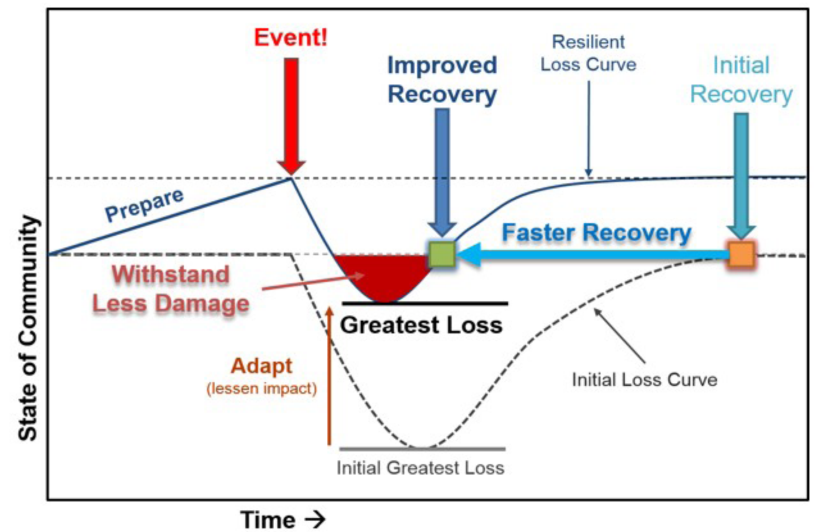
The State Water Plan and the Coordinated Water System Plan both address droughts as a central topic beyond their shared emphasis on promoting a water conservation ethic. With droughts a central theme of those two plans and the DWVARP, the timing is appropriate for making changes in how PWSs address droughts. However, climate change projections need to be incorporated into the thought process, and PWSs need to adopt changes that do not rely on stationarity and to adopt a mindset that involves ongoing learning and adaptation as risks change. Not relying on stationarity means not using past events to project future events.

6B. Drought-Resilient Systems

A system can increase drought resiliency by the following:

- Reevaluating its drought triggers, especially systems that have experienced serious impacts in the past
- Investing in drought modeling that includes not only consideration of recent climate but also future climate changes
- Ensuring that multiple sources and interconnections are available for conjunctive use of supplies and sharing of water
- Investing in conservation as well as public education and better communication

Given that drought risks are changing, systems should periodically reevaluate drought triggers and drought response.



6C. Recommendations

Climate change and projected changes in drought should be taken into account during water supply planning processes.

7. INTERCONNECTIONS AND INFRASTRUCTURE UPGRADES

CWSs are comprised of integral infrastructure that ensures reliable and good quality water delivery to customers. Some of these systems, typically the smaller ones, lack internal redundancies. This makes them vulnerable during an extreme weather event. Systems were evaluated based on their level of resilience and on which assets are present. Based on this assessment, recommendations were made on which systems should pursue infrastructure upgrades. Possible future interconnections were also assessed, which may create source redundancy for smaller systems that often rely on limited sources.

7A. Critical Asset Assessment

A preliminary analysis was conducted to assess the infrastructure inventory of small CWSs. System inventory varies widely: some systems have multiple sources while others have one source, and many systems have multiple storage tanks while others have minimal storage.

7B. Potential Future Interconnections

Of the systems surveyed, over half (53%) are interested in interconnections. Interconnections provide small systems an option to increase redundancy though for some systems increasing supply or redundancy may not be feasible due to environmental, economic, or hydrologic factors or due to lack of space and land.

A GIS assessment was conducted to identify the potential for interconnections. If the distance between systems was less than 1,000 feet, it was deemed feasible. However, if this potential interconnection was between two small systems, a potential interconnection was mapped to the nearest large system, which offers greater redundancy and resources. By reviewing potential interconnections from the Coordinated Water System Plans and evaluating potentials between small unaffiliated[2], small affiliated[3], and large systems, recommendations were made regarding the most feasible interconnections according to the mapping.

7C. Recommended Interconnections

A total of 78 systems were identified as priorities for interconnections based on source capacity, amount of storage, scorecard rank[4], and daily demand. Out of the 78 systems identified for prioritization, 37 have interconnections, and multiple others are complete or are under consideration. Of those 37 interconnections, seven were also explored in detail for the WUCC planning process.

Table 1. Prioritized interconnections

Source CWS	End CWS
Aquarion Water Company - Brookfield	Whisconier Village Association, Inc.
SCCRWA	Crestview Condominium Association
Aquarion Water Company - Mystic	Whipples Mobile Home Park
East Lyme Water & Sewer	Deer Run Supply
SCWA-Montville	Freedom Village Elderly Housing
Montville WPCA	Mountview Apartments
SCWA-Montville	Oakridge Gardens, LLC

7D. Future Infrastructure Planning

It is beneficial for systems to incorporate more redundancies into their infrastructure by improving internal redundancies, developing adequate storage, or developing interconnections. The Drinking Water State Revolving Fund could be a potential source of funding for future projects; however, small systems have difficulty applying for these funds. Solutions to this problem identified by drinking water stakeholders include the following:

- Hiring an entity such as Resources for Communities and People (RCAP) to prepare applications for systems or to assist in progressing ideas.
- Streamline programs in a similar way to the generator program.
- Conduct workshops on how to apply for these funds.

7E. Interconnection Challenges

While interconnections are important options, there are potential challenges and risks including: 1) irregular use of interconnections may create water quality issues because of differences in water chemistry; 2) interconnections that are emergency use only must be maintained so that they are ready when needed; and, 3) routine use interconnections may create disincentives for the recipient system to conserve or manage for the long term due to a lack of control.

2 A small unaffiliated CWS is not affiliated with a large CWS.
3 A small affiliated CWS is affiliated with a large CWS and therefore has access to that system's parts and expertise
4 The system scorecard rank is based on economic, managerial, and system performance; a lower rank indicates a great chance of system failure or disruption in the future.

8. DPH DRINKING WATER SECTION EMERGENCY PREPAREDNESS

An Emergency Response Plan template was developed for use by the DWS. In order to establish the practices and procedures to include in the plan, both in-state and out-of-state interviews were conducted with relevant drinking water staff. The DWS also collaborated with the project team to identify areas for improvement.

8A. Current In-State Practices and Procedures

In the event of a statewide emergency, an Incident Command System (ICS) is established by the Connecticut State Department of Emergency Services & Public Protection, Division of Emergency Management and Homeland Security (DEMHS), and the Office of Emergency Management (OEM). During this emergency, the State Emergency Operations Center (SEOC) is activated, and DPH-DWS has a representative at the SEOC. A water task force is also activated during an emergency, which includes various drinking water stakeholders. If the task force finds an issue, this concern is forwarded by DPH-DWS to the SEOC so it can be addressed by regional coordinators and leaders.

Everbridge, an emergency notification system, is utilized by DPH-DWS prior to an emergency to disseminate mass communications to CWSs, including emergency preparedness tasks. DPH-DWS also makes an after-hours phone line available for systems to use for updates or questions; this information is also included in the mass communication. The key recipients of this information are the designated emergency response leads for each large CWS. Typically, small systems are sent multiple notices to ensure receipt. The DWS has also created a contact information form for systems to fill out annually.

While it is not yet online, WebEOC is an automated system that will allow systems to easily and efficiently report their status during an emergency.

The drinking water website provides information to help systems with the planning and response to an event. Typically, the website is where a majority of systems found information during past storms.

The Public Health Emergency Response Plan (PHERP) was developed to identify appropriate department responses to public health emergencies. The plan also helps to manage emergency support function (ESF) #8 to allow the state to operate and provide services effectively during an emergency.

8B. Out-of-State Best Practices and Lessons Learned

A total of 29 interviews were conducted with state drinking water staff from Maine, Vermont, Rhode Island, Pennsylvania, Massachusetts, New Jersey, New Hampshire, and Ohio. These interviews identified proven actions for before, during, and after an emergency. Some notable findings include the following:

- Establish who needs to be involved during an emergency depending on the nature and extent.
- Identify staff from other state agencies with which the department typically works, and maintain a list of current contact information.
- Maintain Standard Operating Procedures (SOPs) and keep them available in a SharePoint folder for all staff to access.
- Automated communication with water systems such as calls, emails, or online status submissions have proven effective.
- Utilize reverse 911 in the event a system is unable to notify consumers of a water advisory (boil water, etc.).
- Assist systems with communicating with FEMA and encourage them to take pictures of all damage to facilitate getting funding.
- SOPs and emergency response plans are updated annually and built upon based on experiences and lessons learned.

8C. Recommendations to Improve

The PHERP has not been revised since 2011. The Response Plan should be revised as departmental changes occur, for example, the WEAR team is named in the PHERP; however, this team is no longer operating during an emergency.

The DWS should also fully implement WebEOC as a communication tool. Also, the protocols and flow charts developed under the DWVAR process should be used, and drills and exercises should be conducted annually.

The Emergency Response Plan developed under the DWVARP should be implemented and updated routinely, and drills should be conducted annually to ensure the plan is up to date and relevant.

9. STATE AND LOCAL LAWS AFFECTING DRINKING WATER

A review of state and local laws was conducted to understand and assess the current state of regulations in regard to critical infrastructure vulnerability, resiliency, planning, and emergency preparedness.

9A. Existing Laws

The analysis revealed that there are some existing PWS laws (statutes and regulations) that include resiliency and some that do not. There are also some resiliency laws that include PWSs, and some that do not. It is apparent that very few statutes or regulations address both resiliency and public water systems.

Law	Critical Public Infrastructure	Infrastructure Vulnerabilities and Resiliency	Planning	Emergency Preparedness
Public Act 10-158 (HB-5208)			X	
Public Act 11-242 (HB-6618)	X		X	
Public Act 12-101 (SB-376)			X	
Public Act 12-148 (SB-23)				X
Public Act 13-15 (SB-1010)			X	
Public Act 13-78 (SB-807)		X	X	
Public Act 13-197 (HB-6441)	X	X		
Public Act 14-94 (SB-357)	X			
Public Act 14-163 (HB-5424)			X	
Public Act 15-1 (SB-1501)		X		
Public Act 15-89 (SB-569)	X	X		
Public Act 16-197 (SB-288)	X	X		
Public Act 16-199 (SB-301)		X		
Public Act 17-211 (HB-7221)			X	
Regulation 2015-21	X	X		X
Special Act 13-9 (SB 1013)			X	
Public Act 18-82 (SB-7)		X	X	

This table shows recent public acts and their applicability to four project-related categories.

Public Act 18-82 was one of the most recently passed bills that addressed resiliency, and components of the Act will affect PWSs. However, there may be a need for more regulations and/or guidance that directly links PWSs and resiliency. This has happened in the past relative to sanitary sewer systems and water pollution control facilities, demonstrating that it may be possible for PWSs.

The Public Health Code (PHC) has been amended as needed to incorporate resiliency. For example, the standby power supply regulations were incorporated into the PHC.

9B. Recommendations

While statutory and regulatory changes are not always the most preferred method of advancing resiliency, they are sometimes needed.

- Local regulations should more directly address construction of wells in flood zones, and requirements should be uniform across the state. Guidance should be provided to the local commissions on revising these regulations to make well construction in flood zones more stringent.
- Regulations could be developed to specifically link public water systems to certain resiliency or planning standards. For example, the Water Supply Planning Regulations should be modified to incorporate climate change and resiliency in several areas.
- The water planning council should help promote and advance PWS/CWS resiliency. This could be accomplished by ensuring that resiliency is included in the consideration of new laws, regulations, and policies and by promoting greater education of PWSs about the importance of resiliency.

10. PRIVATE WELL VULNERABILITIES

The DPH estimates that approximately 23% of the state's population relies on private drinking water wells. With minimal data available in digital format, one of the biggest challenges in assessing vulnerability is identifying where these thousands of wells are located. By utilizing current public water system service area data and open space data, assumed private well parcels were found outside of these areas. Once identified, neighborhoods across the study area were assessed for vulnerabilities based on their assumed private well status and then by utilizing FEMA flood zone maps.

10A. Private Well Data Gaps

As part of this assessment, local health directors were contacted to take part in the process and provide their comments on where private wells may be located in their respective town or district and if there was any knowledge of private well areas that experience flooding. Most comments received regarding well location were minimally informative, with a majority of those who responded offering a review of paper completion records. Fairfield was the only town that offered a GIS shapefile with private well locations at the parcel level.

10B. Identifying Private Well Locations

PWS service areas are mapped in GIS, with larger systems showing the pipe network beneath roads and smaller systems using a general footprint that includes homes/facilities served within the boundaries. It was assumed that any residential parcel outside a 100-foot radius of a PWS is a private well location, resulting in 213,269 assumed wells throughout the four coastal counties. Newtown appears to have the highest number of wells, with an assumed count of 8,266. New London appears to have the fewest with an assumed count of 21 wells.

10C. Assessing Areas of Concern

With the assumed wells throughout the area identified, neighborhoods that typically experienced flooding were identified. The FEMA flood maps were used to narrow down areas with a number of wells within a flood zone. A total of 12 areas were found, one of those being downtown West Redding, which was identified by the town health officer. The towns with areas of concern included the following:

- Southbury
- Newtown
- Westport
- Old Lyme
- Redding
- Middlebury
- Griswold
- Weston
- Brookfield
- Guilford/North Branford
- Haddam
- Oxford

10D. Coastal Vulnerability Assessment

A more concentrated assessment was also conducted on the three coastal towns of Guilford, Old Lyme, and Stonington; these towns appeared to have the highest concentration of private wells along the shoreline. Assumed well parcels were first identified with a 100 year plus 7 foot of sea level rise GIS layer, resulting in 1,468 parcels in this flood zone. By using satellite imagery, homes were then identified on each parcel with a point and given a 100-foot buffer to assume a wellhead was within that buffer. Then this buffer was used to identify vulnerable wells within the flood zone. Based on this visual identification, it was assumed there were actually only 1,020 wells among the assumed well parcels. Because of the buffer, the analysis went from parcel level to a more refined boundary, which resulted in only 857 visually identified wells being in this coastal flood zone.

1,468
Parcels within the flood zone

→

1,020
Well locations within the parcels

→

857
Wells actually located within the flood zone

10E. Mitigation and Resiliency Strategies

There are some general best practices that private well owners can follow to ensure a safe drinking water source: elevate the well head, test their well water frequently, connect to a public water supply if available, and have a backup generator or a plan for storage in the event of an emergency. By following these best practices and others, well owners can create a safer source of water.

There are also specific resilience strategies that can be implemented that are more area specific. These strategies may include the following:

- Drainage projects: to alleviate flooding
- Property acquisition: this eliminates both well and property damage.
- Water main extension: public water is reliable and consistent.
- Well protection: retrofitting a well can provide flood protection.
- Well relocation: moving a well out of a flood zone may eliminate issues.
- New PWS: this would create a small reliable system.
- Smart Development: by designing new construction outside flood zones, risk to wells can possibly be avoided altogether.

Other mitigation strategies can be implemented by town or health officials.

- Educate residents and developers on the importance of upgrading older wells and locating wells outside the flood zone.
- Identify a portable water provider for private well areas during an emergency.
- Ensure that private well regulations reflect flood proofing standards.
- Support the extension of a PWS to coastal areas that are at risk.
- Incentivize annual residential private well testing.

1.0 Introduction

The Connecticut Department of Public Health (DPH) was awarded federal funding from the Community Development Block Grant Disaster Recovery (CDBG-DR) Program, which was administered by the Connecticut Department of Housing (DOH). These funds were appropriated to prepare a Drinking Water Vulnerability Assessment and Resilience Plan (DWVARP).

1.1 Purpose of the Plan

Connecticut's coastline experienced serious impacts from past storms such as Superstorm Sandy and Hurricane Irene, and inland drinking water systems have also been seriously affected by the impacts of recent severe storms. The overall objective of the DWVARP is to conduct a large-scale analysis to assess current vulnerabilities of drinking water systems[1] and private wells in Connecticut's four coastal counties (Fairfield, New Haven, New London, and Middlesex) and to identify strategies to mitigate future storm impacts on areas with drinking water supplies.

1.2 Goals of the Plan

The primary goal of the DWVARP is to increase the preparedness of public water systems (PWSs) for future storm events, drought, and climate change. The DWVARP primarily focuses on community water systems (CWSs) as these PWSs typically serve residential populations as well as critical facilities such as hospitals and residential care facilities. Secondary goals are to develop an emergency response plan (ERP) for the DPH Drinking Water Section (DWS) under separate cover and to create a resilience plan to ensure storm- and climate change-resilient drinking water systems and sources.

The vulnerability assessment aims to identify past storm and drought impacts by way of surveys and interviews and utilizes climate change projections and document reviews to provide options and alternatives for future storm mitigation[2] and adaptation. The ERP was developed specifically for the DPH DWS through a review of current practices within the department, in addition to results from interviews conducted with out-of-state drinking water staff. This final resilience plan is a culmination of all methods and results to make recommendations on mitigation strategies, emergency preparedness strategies, and policy modifications.

1 Specific types of drinking water systems (community vs. noncommunity) will be defined later in this report.

2 This report does not address climate change mitigation, which largely includes greenhouse gas emissions reductions.

1.3 Risk and Resilience Concepts and Terminology

In the context of natural hazards such as flooding and severe windstorms, "risk" is commonly defined as the product or the sum of vulnerability and frequency (risk = vulnerability x frequency or risk = vulnerability + frequency). Thus, if an event has a low frequency and infrastructure is not vulnerable to the effects of that event, then the risk is assumed to be low. If an event has a high frequency and infrastructure is vulnerable to the effects of that event, then the risk is assumed to be high. Either low frequency coupled with high vulnerability or high frequency coupled with low vulnerability will produce moderate risk.

In the context of flood, wind, snow, and ice hazards and the need for developing climate resilience, risk will change over time because the frequency will increase. Certain storms are believed to be increasing in frequency, bringing more intense precipitation, winds, and heavier snow; flooding will increase in frequency as sea level rises and more intense precipitation runs off. Thus, even if water system infrastructure vulnerabilities remain static by doing nothing, risks will increase.

Therefore, PWSs are at a crossroads with regard to reducing risk. Vulnerabilities can remain static and risk can increase, or vulnerabilities can be reduced to hold risk at bay. If vulnerabilities can be reduced even further, then risks could be lowered in the face of climate change, leading to increased resilience. The least desired combination of all would be the development of increased vulnerabilities while frequencies increase because risks could rise faster than expected; this is the possible outcome if PWSs do not maintain and harden infrastructure. Private wells are also susceptible to these outcomes if owners do not ensure that their wells are becoming less vulnerable over time.

"Resilience" is typically defined as the ability of a system, population, or community to prepare for, withstand, recover from, and adapt to stresses like natural disasters and climate change. Resilience can be measured in different ways, but one common method of measuring resilience is the number of days or months to recover from an event. A more resilient community or infrastructure system can recover more quickly. In the case of a PWS, heightened resiliency shortens the recovery time.

The resiliency of PWSs and private wells to climate change and natural hazards is a significant concern particularly given the extensive power outages that occurred throughout the state during Tropical Storm Irene, Winter Storm Alfred, and Hurricane Sandy. Many smaller systems may not have standby power facilities, and numerous small systems issued boil water notices during the power outages associated with these events. While programs and regulations have been recently enacted by DPH to address standby power facilities for CWSs, all PWSs continue to be at risk from natural hazards, and many continue to have poor resilience to the effects of such hazards.

Resiliency is not a one-time effort. It must be continuously maintained and improved over time due to the risks associated with climate change. The Resilience Loss Recovery Curve (below) helps explain how community or system function is affected by an acute disturbance such as a hurricane and depicts response and recovery curves. Before fostering resiliency, a community may experience a severe event (red arrow) and an "initial greatest loss" that decreases its "state" of being; the gray dashed line represents this community and the loss. The community has not recovered until it reaches the tan box on the far-right side of the graph, representing a significant amount of time to recovery.

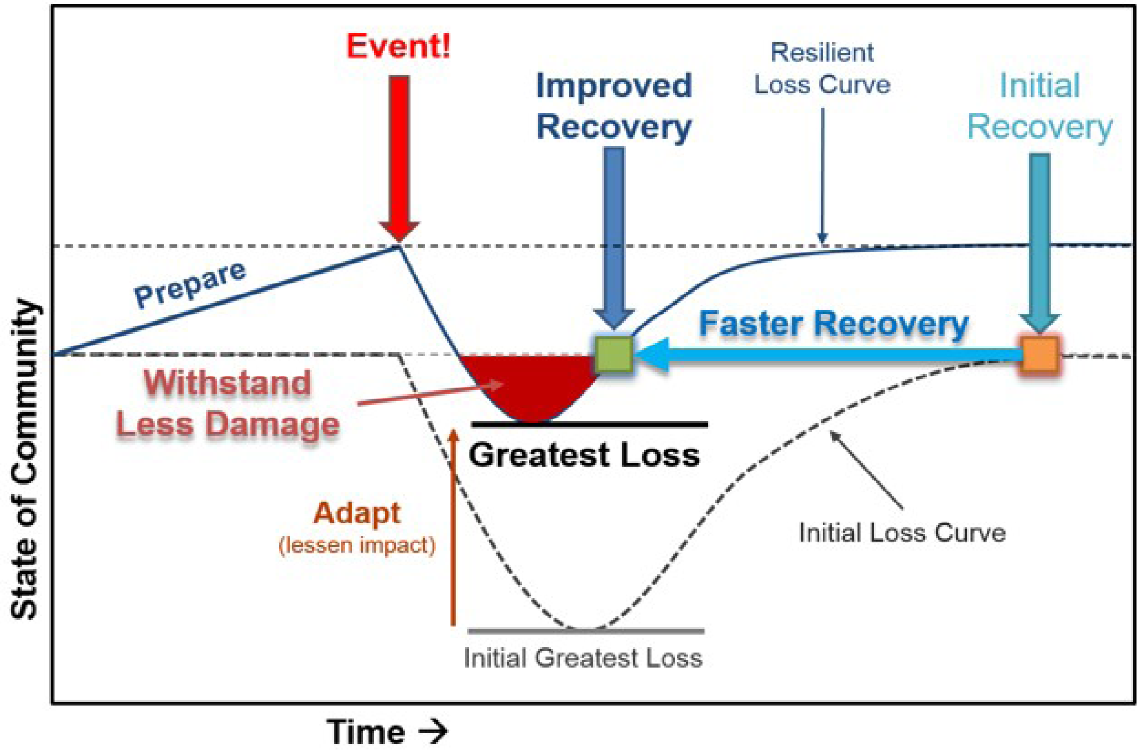


Figure 1-1 Resiliency Loss Curve

A more resilient community prepares before the event, which allows its "state" to begin higher when a disaster (red arrow) strikes. A resilient community has also adapted (brown arrow). The sum of the preparing and adapting will cause a decrease in the overall loss, leading to a rapid restoration to the state represented by the green box. The time span between the green box and the previous tan box represents the faster recovery.

Resilient communities and systems may find opportunities to transform themselves and grow. Thus, a resilient water system's "new normal" may be a higher level of function (solid blue, upper line), or it may be able to return to a level of function existing before the disturbance (dashed gray, lower line). Ultimately, this cycle repeats itself both before and after each disturbance resulting in opportunities to incrementally increase resilience.

1.4 Consistency with Other Planning Documents

1.4.1 Consistency with Coordinated Water System Planning

The Coordinated Water System Planning process (also known as "WUCC process," which refers to the Water Utility Coordinating Committees) is an effort by the state and water utilities to conduct water supply planning on a regional scale. A formal 2-year planning process was completed in June 2018 for the three WUCC planning regions in Connecticut. Typically, larger water systems serving more than 1,000 customers or more than 250 service connections are required to prepare a Water Supply Plan (WSP) and submit it to DPH for approval. The WSP evaluates the ability of a system to serve its customers now and in the future. It includes policies and procedures regarding water conservation and how the system will respond to emergencies. As smaller water systems are typically not required to conduct this level of planning, the majority of smaller systems have not prepared WSPs. The WUCC process evaluated the ability of both small and large systems to meet demands and identified areas where additional sources of supply or interconnections may be necessary.

Large PWSs ordinarily have full-time staff, redundant sources of supply, available emergency power, multi-tiered treatment systems, and strict regulatory oversight, which help produce a safe and reliable water supply. However, some parts of the state do not have access to large PWSs due to various factors: geographical constraints, low population density, etc. Small PWSs operate throughout the state and serve customers in areas without access to large PWSs. Well maintained small PWSs can provide excellent service to customers, but compared to large PWSs, these small utilities have less access to financial, technical, and labor resources.

Several of the recommendations of the WUCC process were aimed at increasing the resiliency and stability of public water supplies. This may be accomplished through grants and loans or even through the coordination and allocation of resources between large and small PWSs. For example, the WUCC process has encouraged small systems to consolidate with large systems or to consolidate with adjacent small systems when feasible. This potentially gives the combined system more redundancy, especially if sources of supply are maintained rather than retired. The WUCC process has also encouraged both large and small systems to explore additional interconnections with each other in order to increase resiliency.

While the DWVARP takes a more detailed look at the factors that can exploit systems that lack resiliency, the goal of the plan is similar to one of the goals of the WUCC process: that is, to ensure that PWSs are as resilient as possible so that water service is not interrupted during extreme conditions. While the WUCC process focused more on how utilities can coordinate with one another, the DWVARP focuses on the natural phenomena that will increasingly threaten PWSs. These threats are expected to increase in frequency and severity due to the impacts of climate change.

1.4.2 Consistency with State Water Plan

Like the WUCC process, the State Water Plan (SWP) was constructed with PWS resiliency in mind. However, the plan transcends the scope of water system planning. The SWP identifies the ways the state is managing water supplies as it pertains to human consumption, environmental impact, water basin stress, and other factors. Using data from public water utilities, industrial usage, agricultural consumption, and other sources, the SWP attempts to map the use of water throughout the state and identify areas of over and under allocation. The plan then further delves into future objectives ranging from source protection to water conservation to drought management to water for ecological needs.

The SWP does cover the effect of climate change on water resources in Connecticut; however, it does not address the ways that climate change directly stresses individual water systems. Rather, the state plan has invaluable projections on precipitation, temperature, and weather patterns. While this information is critical to many water utilities, especially large-scale operations, climate change may pose more insidious risks to small system operators, such as saltwater intrusion for systems along the coast.

1.4.3 Consistency with the State Natural Hazard Mitigation Plan

The Connecticut Natural Hazard Mitigation Plan (NHMP) 2014 update identified a detailed mitigation strategy that is based on three goals: Promote sound floodplain management and other natural hazard mitigation principles, implement effective natural hazard mitigation projects, and increase research and planning activities for natural hazard mitigation. These goals should be achievable at both the state and local level. The DWVARP, like the NHMP, has goals to reduce or prevent damage to infrastructure due to natural hazards.

1.4.4 Consistency with the State Emergency Operations Plan

The Connecticut State Response Framework (SRF) describes the response and coordination efforts between state government and local, federal, and tribal governments. The framework outlines how the state will work to support local governments and residents during emergencies and disasters.

The DPH has specific responsibilities and duties under this framework, some of which are specifically geared toward drinking water. The DPH regulates public water supply and is responsible for assessing public drinking water systems; specifically, the DWS is responsible for regulating public water supply provided by CWSs, non-transient non-community (NTNC) systems, and transient non-community (TNC) systems. Private wells (typically wells serving less than 25 people each day or less than 15 service connections) are the responsibility of the well owner although local health departments have authority over the siting and approval processes for private well installation.

The DWVARP, like the SRF, evaluates emergency preparedness to a certain extent. However, the DWS ERP (under separate cover) is designed specifically for the DPH DWS, with a more specific goal of enhancing DWS response to a drinking water incident or emergency.

2.0 Community Water System Vulnerability and Risk Assessment

The process of establishing system vulnerability and risk included evaluating impacts from past storms and droughts, exploring current regulations and protocols, and evaluating available system vulnerability assessments and emergency contingency plans. The process also included compiling best practices from other states' drinking water agencies, assessing the CT DWS emergency responses processes, and gathering insight from CWSs themselves regarding preparedness and resiliency. To assess future risk to system water quality and quantity, a climate change projection was executed specifically for Connecticut. Spatial analysis was also conducted to identify critical infrastructure that may be vulnerable to a 100- or 500-year storm, and links were made between these vulnerable systems and the critical facilities that might be located within their service area.

2.1 Impacts of Recent Severe Storms and Events

Connecticut has seen several extreme weather events since 2011, which have caused widespread impacts throughout the state. Although it is impossible to link any particular storm to the effects of human activities and greenhouse gasses, it is important to note that the recent trend of severe storms could be indicative of a changing climate. Many models have indicated that Connecticut could see more powerful storms as the available heat energy in the atmosphere increases. Fortunately, the State of Connecticut and its PWSs have responded with improvements to infrastructure, emergency preparedness, and legislation as a result of these extreme events. Below are some extreme weather events that have significantly affected Connecticut's water supply system.

2.1.1 Recent Severe Storms

The year 2011 was a monumental year in Connecticut's meteorological history. The end of the winter of 2010-2011 brought record-breaking snowfall, which collapsed roofs in January and February 2011 and hampered travel. The extreme weather continued into the summer and fall, when Hurricane Irene (striking as a Tropical Storm and described below) and the Halloween Nor'easter of 2011 (Winter Storm Alfred, also described below) impacted the state. Both storms caused significant damage to state infrastructure and exposed a fundamental lack of preparedness and coordination by major utilities within the state. Between the two storms, there were over 1.6 million power outages, and significant travel disruptions, which lasted for over a week after each event. In response, the Two Storm Panel, an agency of government officials and other professionals, worked to identify weaknesses and produce suggestions as how to best respond to future emergencies.

Since 2011, several other major weather events have impacted the region, including Hurricane Sandy (striking as a post-tropical system), the February 2013 blizzard, and the 2015-2017 drought, among others. While it is impossible to compare subsequent natural disaster response fairly due to how different each situation is, the state at least demonstrated increased proactivity and communication during those events that occurred since 2011.

Hurricane Irene

Hurricane Irene was a powerful storm that impacted Connecticut on August 28, 2011. Although it had weakened by the time it reached Connecticut, it was still classified as a tropical storm, with wind gusts of over 50 miles per hour (mph) in many parts of the state. The storm coincided with a spring high tide and hit the region in a month with already above average rainfall. These and other factors enhanced the ability for the storm to do damage despite its relatively modest tropical storm status. The state suffered severe coastal flooding, with communities like Fairfield and East Haven hit especially hard. Riverine flooding was also significant, especially in western Connecticut. According to the Connecticut Department of Energy & Environmental Protection (DEEP), the Connecticut, Farmington, Housatonic, Pomperaug, and Pequabuck Rivers experienced the most severe flooding. Tree damage was widespread, with downed power lines occurring in most communities throughout the state. Over 700,000 customers in Connecticut lost power, with wind-damaged trees and flooded infrastructure both responsible for outages.

Halloween Nor’easter

The Halloween Nor’easter was an unusually early winter storm that struck Connecticut from October 29-30, 2011. This storm impacted the state with heavy snow and strong winds. The heavy, wet snow fell on trees that had not yet shed their autumn leaves and led to significant breakage of limbs. Since many limbs were overhanging power lines, the breakage of limbs caused extensive power outages, nearly 900,000 throughout the state. The damage to trees was significantly greater than that of Hurricane Irene just 6 weeks prior as were the number of power outages. The storm caused the greatest loss of power in Connecticut history, and many customers did not see power return for 1 to nearly 2 weeks. Damage was most widespread in the northern and western sections of the state while the marginal temperature profile kept snow totals down along the coast.

Review of Two Storm Report

In the wake of Hurricane Irene and the Halloween Nor'easter, state officials and utility companies came under intense scrutiny due to the length of time that many residents were left without power, heat, and water. Total damages were estimated to be nearly 1 billion dollars from both storms. To identify improvements that the state could make to its disaster response, Governor Dannel Malloy initiated the Two Storm Panel. This panel was composed of elected officials, emergency responders, military representatives, and other professionals who met for several months after the disasters. The end result of their meetings was the Two Storm Report, a 42-page document that explores the failures of the disaster response to the two storms and provided recommendations to mitigate a similar situation in the future. Key recommendations of the Two Storm Report included the following:

- Tree Trimming – In both storms, tree damage was responsible for the vast majority of power outages. Connecticut's dense tree canopies and infringement on utility pole right-of-way led to damaged poles and lines. Trees also fell and blocked roadways during storms, halting travel and delaying emergency services. The Two Storm Report recommended conducting statewide tree assessments and increasing the Department of Transportation (DOT) tree maintenance budget substantially.

- Infrastructure Hardening – Infrastructure vulnerability exacerbated the effects of the tree damage from both storms. The report recommended that the undergrounding of utilities be studied by DEEP. Although the report acknowledges that complete undergrounding is not feasible, selective undergrounding should be recommended to the Connecticut Public Utilities Regulatory Authority (PURA).

- General Communications and the Sharing of Information between Utilities and Municipalities – Poor communication between municipalities and utilities was a source of frustration for both residents and first responders after the storms. Due to the lack of information regarding the timing and extent of outages, municipalities and community providers experienced difficulties maintaining shelters and other human services. For example, shelters were unsure of when to discharge individuals whose power may have returned while opening up shelter space to those whose power may have still been interrupted. The Two Storm Report recommended the formation of a Municipal/Utility Working Group. This group would allow utilities and municipalities to establish procedures that would allow the two entities to work as a team during emergencies and increase communication throughout the event and the recovery process.

- Regular Meetings of Stakeholders – The Two Storm Report found that the utility representatives that were assigned to act as liaisons for each town were often unfamiliar with the town and did not possess adequate access to pertinent information such as timetables for power restoration. The report also found that disaster response officials within municipalities were often unfamiliar with other officials and had not planned coordinated disaster response efforts. The Two Storm Report recommended each town hold annual emergency preparedness meetings. These meetings would include key emergency response personnel such as first responders, government officials, school superintendents, and shelter coordinators, as well as representatives from the utilities. The report also recommended that utility representatives thoroughly understand the communities in which they serve and are able to update the communities with useful information by identifying how that municipality is connected to the overall grid.

- Statewide Communications – Recognized in this report were the State Emergency Operations Center (SEOC) and WebEOC. The SEOC is the coordination center for the State of Connecticut during any major emergency. This center provides a central location that allows a coordinated response from the Governor, Division of Emergency Management and Homeland Security (DEMHS), and state and federal representatives assigned specific emergency management responsibilities. The SEOC operates under the National Incident Management System (NIMS) and is only activated at the order of the Governor or the Commissioner of DEMHS. WebEOC is a web-based emergency management system utilized by the state to record both routine and emergency activity. This system provides real-time information from those facilities that are registered and can be accessed during an emergency or a drill.

  The Two Storm Report commended the state Emergency Operations Center's (EOC) media presence in briefing residents on disaster relief updates. The EOC was able to use TV, internet, radio, and print media to effectively distribute information after the storm. The report did note some deficiencies in the WebEOC, noting that there lacked a detailed local component, which would allow for better coordination between local, regional, and state resources. The report recommended that the state continue to bolster the dissemination of disaster information through the use of social media and other forms of communication. The report also recommended that the United Way of Connecticut expand its communication capacity through several technical updates. The report recommended that community provider organizations be prioritized in emergency situations so that services can be delivered in the homes of those needing assistance rather than transporting individuals to shelters. Lastly, the report recommended that the state provide public service announcements on the proper use of emergency generators as carbon monoxide poisoning was prevalent after the disasters.

- Municipal Issues – A variety of issues related to municipalities were identified in the Two Storm Report, including the following:
    - *Preparedness and Training* – The main recommendations of the report involved the training of municipal officials. As was noted previously, it was often found that the key emergency response officials in municipalities were not accustomed to working together and formulating a seamless disaster response plan. The report recommended that all elected officials undergo training in emergency preparedness within 45 days of assuming office. The report also recommended that towns create a "town center district" in which the zoning laws would mandate that emergency backup power be included in commercial buildings.

    - *Road Safety and Downed Tree Removal* – Both storms presented major challenges to municipalities due to the vast quantity of limbs and trees that fell during the storm. Many town public works departments maintain the staff and equipment to clear such debris. Unfortunately, the number of trees that fell on power lines made it impossible for towns to remove debris without the assistance of the power company. Consequently, each power company truck had limited resources on board to remove the massive amounts of debris crossing the roads. The report recommended that municipalities and utilities ensure that sufficient technicians are available for each municipality so that roadway clearance is not halted by downed utilities. The report also recommended that local municipalities make "truck to truck" communication possible so that multi-municipality response is available. This would allow multiple municipalities to respond to especially hard-hit areas.

    - *Shelter Operations* – Shelters were needed after both storms due to the extended power outages. The Halloween Nor'easter provided a greater challenge as the low temperatures and longer duration power outages caused more to seek shelter. The report recommended that shelters be better suited to accommodate those with disabilities and to identify "at risk" groups such as those who require oxygen or others who are medically compromised. The report also recommended seeking the assistance of nonprofit groups, who might be able to provide greater resources to shelters.

    - *Utilization of Volunteers* – The report recommended creating a volunteer unit within DEMHS to enhance response capabilities. It also recommended that mechanisms be developed to encourage citizen awareness of disaster preparedness.

- Use of Geographical Information Systems (GIS) – A common frustration during the recovery efforts for both storms involved the lack of graphical representation as to which areas were affected and to what extent. For example, there was little statewide information on which roads were blocked off, which poles were damaged, and which areas were without power on a local level. The report recommended the expansion of Connecticut's GIS Council to include utility companies. The report also recommended that the Connecticut Office of Policy and Management (OPM) integrate GIS information from all utilities to create a comprehensive planning platform. Other recommendations include better mapping by utilities and better dissemination of mapping to local EOCs.

- Health Care and Community Provider Issues – Health care personnel and community providers, such as organizations that assist individuals with disabilities, faced enormous challenges during the storm. Since many residents rely on these service providers for basic needs, it was only by the hard work of such individuals that residents in need were able to be relocated to facilities where critical services could be provided. The report contains several recommendations that would help shelters for at-risk populations ensure that they have access to supplies during emergencies. The report also recommended funding for permanent standby generators in places where at-risk populations may be served so that shortages of gasoline or diesel do not compromise the ability of these facilities to give care during extended outages.

- General State Issues – Other findings of the Two Storm Report included the following:
  - *Regulation of Utilities* – A major finding of the Two Storm Panel involved PURA's inability to enact and enforce orders regarding emergency response procedures by utilities. As an example, the report noted that PURA reviewed both UI's and CL&P's emergency response plans. Both plans varied; however, PURA lacks any enforcement capabilities regarding the planning structure of either utility.

  - *Equipment Maintenance Issues* – Standards of equipment maintenance, tree trimming, system redundancy, and enforcement varies from town to town and utility to utility. PURA had limited ability to effectively create and enforce related regulations. The report recommended that an enforcement division be created within PURA for this purpose.

  - *Review of Connecticut Department of Emergency Services and Public Protection (DESPP)* – A strong DEMHS division of DESPP is recognized as being critical to robust disaster response. The report recommended that the Deputy Commissioner position should be filled immediately. The report also recommended at least one exercise per year per region, in which all Office of Emergency Management (OEM) staff participate and evaluate the response to the exercise.

- *Strengthening the Interaction between the State and the Community* – The plan recommended that a Public/Private Initiatives Unit be formed within the DEMHS that facilitates a "culture of preparedness." This involves private industries and government agencies working harmoniously to provide enhanced disaster response.

DPH Three Storm Strategy

Following Hurricane Sandy (October 2012), DPH built upon the state's Two Storm Report and prepared its "three storm" strategy[3] in order to ensure safe and adequate public water supply and address vulnerabilities, emergency preparedness needs, resiliency, and system capacity in CWSs. Since that time, DPH has been addressing its "three storm" strategy through a variety of initiatives such as requiring emergency generators (and providing funding assistance to secure generators); requiring development of an emergency plan for all CWSs; updating critical facilities lists; developing and implementing methods to evaluate technical, managerial, and financial capacity of small CWSs; and facilitating the Coordinated Water System Planning process. Ongoing actions include workshops to assist with the emergency plan requirement, implementing new ideas for sharing information between utilities and DPH during an emergency, updating Certified Operator responsibilities, streamlining funding for small CWSs, developing regulations requiring asset and fiscal management and hydropneumatic tank assessments, and revising the process for ordering takeovers of failing water systems.

2.1.2 Recent Droughts

Drought of 2015-2017

The recently resolved drought that affected much of the northeastern U.S. was one of the most severe in recent memory. Hot summer temperatures and a stubborn precipitation deficit meant that many streams and rivers experienced historically low flows. Although late summer through fall of 2016 saw the most severe drought conditions in the state, the drought traces its origins to early May 2015. The U.S. Drought Monitor, run by a consortium of federal agencies including the National Oceanic and Atmospheric Administration (NOAA), the U.S. Department of Agriculture, and others, maintains an archive of its drought classifications, which were useful in identifying the extent and severity of the drought. The Drought Monitor classifies drought conditions through a combination of the Palmer Drought Severity Index, Climate Prediction Center (CPC) Soil Moisture Models, United States Geological Survey (USGS) Weekly Stream Flows, Standardized Precipitation Index, and Objective Drought Indicator Blends. These individual components give some sense of the hydrologic conditions experienced throughout the state and region.

3 "DPH Drinking Water Section Strategy to Address the Effects of Storms Irene, Alfred, and Sandy on Connecticut's Public Water Systems" originally dated December 2011, last updated April 2018

On the week of May 5, 2015, the Drought Monitor placed most of Connecticut in the "Abnormal Dryness" category for the first time in several months. This low-level indicator signifies that short-term dryness has taken place, with effects mostly limited to agriculture. Just 2 weeks later, with little subsequent rainfall, the Drought Monitor had classified Connecticut under a moderate drought condition. The National Weather Service Records indicated that May 2015 received approximately 1.25 inches of rain, on average, for the entire month. This is a nearly 3-inch departure from normal. The May 19, 2015, report shows the southern 2/3 of New England and much of the Hudson Valley under moderate drought conditions as well.

Throughout June, July, and early August of 2015, there was some recovery in most of the northeast. An exceptionally rainy June helped alleviate many of the short-term effects of the recent dryness. Drought conditions were lifted in most of interior New England by early August, with just patchy areas of abnormal dryness and moderate drought. Connecticut, however, remained abnormally dry, with some areas of moderate drought persisting along the coast. By late September 2015, abnormal dryness had encompassed much of southern New England again, with moderate drought conditions thoroughly covering Connecticut. While much of northern New England recovered throughout the fall, Connecticut could not shake the moderate drought classification for the remainder of 2015.

The beginning of 2016 brought some improvement to Connecticut's conditions. Late season snow helped reduce the moderate drought conditions in the state, leaving just patches of abnormal dryness. February 2016 had a rainfall surplus of approximately 2.5 inches in most of the state. Six-month rainfall departures, however, remained at 3 to 4 inches below average. In contrast to February's surplus, March 2016 was very dry, with a deficit of 1.5 to 2 inches throughout the state. The spring and early summer continued to feature below-average precipitation, and by July 5, 2016, the entire state was classified as abnormally dry, with moderate drought extending through north central and northwest Connecticut. Central Massachusetts began to exhibit even dryer conditions, with severe drought classifications extending through southeastern New Hampshire.

In 2016, Aquarion Water Company was experiencing a public water supply emergency in southwestern Connecticut resulting in heavy water user restrictions and water audits of the largest users.

A moderately wet August of 2016 could not halt the progression of drought conditions. Hot temperatures helped extend moderate drought conditions throughout the entire state by August 30. Mild temperatures and marginal rainfall propelled the state to severe drought conditions by mid September. At this point, public water supplies in the state started feeling greater effects. The Aquarion Southwestern Fairfield County Region (New

Canaan, Darien, Stamford, and Greenwich) was deemed by the DPH Commissioner to be experiencing a public water supply emergency on September 29, 2016. The emergency declaration levied heavy water use restrictions, as well as water audits of the largest users within the system. CT DPH again declared a water supply emergency for the Danbury Water Department on October 25, 2016. By mid November, with many streams and rivers nearing record low flows, much of western Connecticut had reached extreme drought criteria. While eastern Connecticut remained under severe drought conditions for the remainder of the year, western Connecticut continued to carry the extreme drought designation.

Early 2017 began dry; however, late season snowfall in February and March began to weaken the effects of the drought conditions. By March 7, 2017, the extreme drought designation was dropped throughout the state, and by mid May 2017, only small patches of abnormally dry conditions remained as artifacts of the drought. By early June 2017, there were no drought indicators declared by the Drought Monitor, and the State of Connecticut Interagency Drought Workgroup (IDW) ended the Statewide Drought Advisory on June 14, 2017. Despite the severity of the drought of 2016-2017, it was not believed as severe as the drought of record in the 1960s.

Drought of 2005

The drought of 2005 was a relatively brief but locally severe drought that originated in May 2005 and resolved abruptly with the exceptionally heavy rain events of October 2005. After a wet start to 2005 with respect to precipitation, May was dry, with just 1.73 inches of rain recorded at the Connecticut Agricultural Experiment Station (CAES) gage in Hamden. While June featured average precipitation, it was very hot, with eight 90+ degree days. At this point, the Drought Monitor began to show some areas of abnormal dryness in the state.

July precipitation was underwhelming, but enough precipitation fell to ease any abnormal dryness. Temperatures were extremely hot, however, especially toward the end of the month. There were 7 days over 90 degrees, with 2 days of 93 degrees and 2 days of 95 degrees in the month's final week. By early August, the abnormal dryness had returned according to the Drought Monitor, as had the heat. August featured an additional 9 days of heat over 90 degrees and very little precipitation, with departures from average approaching 2.5 inches. Temperatures in September remained summerlike, and by mid month, the Drought Monitor had upgraded Connecticut into a moderate drought. Moderate drought conditions persisted in certain parts of the state until mid October, when an active weather pattern brought several bouts of heavy rain to the state. October rainfall approached 15 inches, effectively erasing any rain deficit and restoring river flows to normal and flood conditions.

The drought was unique in that despite not registering exceptionally severe by most metrics (hence the Drought Monitor peaking at a "moderate drought") the effect on stream flow was very pronounced. Many mid-size rivers throughout the state saw flow decrease to low single-digit cubic feet per second (cfs) or lower. This led to water shortages in some of the most strongly affected areas.

2.2 Review of Laws, Practices, and Protocols

2.2.1 Summary of Applicable Laws

Appendix A contains an extensive summary of laws and policies that relate to PWS regulation, climate change, and resiliency. The federal government has established many laws and regulations concerning water quality and quantity of public water supply systems. Most notable is the federal Safe Drinking Water Act (SDWA) of 1974. This act and its subsequent amendments have authorized the federal government to set national drinking water standards, conduct special studies, and to generally oversee the implementation of the act. The act has led to the testing of public water supplies and has established source water protection areas, among many other functions. While resiliency has not traditionally been directly addressed in the SDWA and its amendments, elements of resiliency are included.

At the state level, the authority for regulation of public drinking water is established under Section 25-32 of the Connecticut General Statutes (CGS) and implemented through the Regulations of Connecticut State Agencies (RCSA) by DPH. These requirements are consistent with federal regulations and have additional requirements such as annual watershed surveys, annual cross connection surveys, monitoring of raw and finished water, and public notification. Like the SDWA, resiliency has not traditionally been directly addressed in the RCSA, but elements of resiliency can be found within the RCSA.

State Oversight and Enforcement

Connecticut has traditionally managed its water through four regulatory agencies with separate and sometimes conflicting legislative mandates and authorities. These agencies include OPM, DEEP[4], DPH, and PURA, formerly known as the Department of Public Utility Control (DPUC).

4 Public Act 11-80, "An Act Concerning the Establishment of the Department of Energy and Environmental Protection and Planning for Connecticut's Energy Future" combined the former Department of Public Utility Control (DPUC) and an energy group from the Office of Policy Management (OPM) with the Department of Environmental Protection (DEP) to form the Department of Energy and Environmental Protection (DEEP) to better address the challenges of the modern environmental world and energy market. The former Department of Public Utility Control is now called the Public Utility Regulatory Authority (PURA) and continues to perform the regulatory functions of the former DPUC. The Act also required that the DEEP establish a Bureau of Energy and Technology Policy – the first energy policy office in decades for the state.

- Department of Public Health – Responsible for protecting and regulating the quality and quantity of the state's drinking water by regulating the adequacy and purity of all public water systems in the state, including the ownership and use of water utility-owned lands, under its DWS. DPH has been granted primacy by the U.S. Environmental Protection Agency (EPA) and has many regulatory duties under the SDWA and the RCSA but also possesses key state statutory authority in the direct oversight of public water systems and planning authority relative to individual WSPs and coordinated water system plans, as well as source water protection. DPH has the statutory authority to develop regulations for private residential wells and semi-public use wells. DPH also has a role in the distribution of funds under the Drinking Water State Revolving Fund (DWSRF). DPH oversees certain subsurface sewage disposal systems, but DEEP oversees the largest of these as described later in this paper.

- Department of Energy and Environmental Protection – Responsible for the protection of the state's natural resources, which include inland and coastal waters. DEEP manages water quality and quantity through numerous programs such as the Water Quality Standards. Like DPH, DEEP possesses regulatory, planning, enforcement, and funding authorities. Regulatory programs address water quantity and water quality, including many of the programs described in this report. Planning programs address mainly water quality (for example, overseeing watershed management plans) rather than water quantity, which has typically been managed through regulatory programs. DEEP funding program examples include the Clean Water State Revolving Fund (CWSRF), the Potable Water Program, and the Section 319 grants for impaired waters, among many others.

- Public Utilities Regulatory Authority – Regulates the rates and services of Connecticut's investor-owned water companies and is part of the Energy Branch of DEEP. PURA directly regulates the investor-owned water and wastewater utilities in Connecticut and formerly participated in the review and approval of new public water systems (with DPH). PURA regulates other utilities that have a bearing on water (for example, electricity generation).

- Office of Policy and Management – Prepares periodic revisions of the Conservation and Development Policies Plan for Connecticut and oversees various planning and environmental review processes that address water. OPM plays a key role in the approval of Environmental Impact Evaluations prepared under the Connecticut Environmental Policy Act, ensuring that state actions are consistent with the Conservation and Development Policies Plan for Connecticut as well as other planning documents. OPM is also a key agency relative to oversight of various funds that affect water. According to various sources[5], OPM has general responsibility to coordinate all activities of DEEP, DPH, and PURA with respect to the state's water resources policies.

5 For example, https://www.cga.ct.gov/2003/pridata/Studies/PDF/Stream_Flow_Final_Report.PDF

The State of Connecticut has taken a progressive approach to adapt to a changing climate. In 2012, the Connecticut General Assembly passed Public Act 12-101, "An Act Concerning the Coastal Management Act and Shoreline Flood and Erosion Control Structures." This legislation combined a number of initiatives to address sea level rise and to revise the regulatory procedures applicable to shoreline protection. For the first time, the concept of sea level rise was incorporated into the Connecticut Coastal Management Act relative to the general goals and policies of coastal planning.

Since then, several other key public acts and initiatives have addressed climate change and severe storms. Many of these are described in Appendix A. However, one recent key piece of legislation (Public Act 18-82) is described below due to its forward-thinking content and potential ramifications, and one specific PURA action is described below due to its immediacy.

Public Act 18-82 ("An Act Concerning Climate Change Planning and Resiliency") established a new greenhouse gas (GHG) emissions reduction requirement and integrates GHG reductions into various state planning documents and efforts, such as the state's Integrated Resources Plan and its Plan of Conservation and Development. The bill integrates sea level change projections (determined by UConn's Marine Sciences Division as an update of existing federal projections) into various municipal and state planning documents such as state and municipal plans of conservation and development and municipal evacuation and hazard mitigation plans. It also applies these projections to the state's coastal management and flood management laws. The bill renames the state's Comprehensive Energy Strategy as the Comprehensive Climate and Energy Strategy and requires it to be updated to account for the state's GHG reduction requirements. The bill establishes the Connecticut Council on Climate Change as a statutory council, which must facilitate and coordinate efforts with various parties to reduce GHG emissions and increase the state's resiliency to climate change.

Public Act 18-82 also made many technical and conforming changes to statutes including those to account for the council's renaming and incorporate the revised content, eliminated obsolete provisions such as a law on the Governor's Steering Committee subcommittee on climate change, and most notably replaced a reference in the flood management statutes to "one-hundred-year flood" with "base flood." The act defines the base flood as the level of the 1% annual chance flood for "activities" and the 0.2% annual chance flood for "critical activities." This essentially requires most critical facilities to be evaluated against the 0.2% annual chance flood elevation.

Going further, the act amends the definitions in Chapter 476A, Floodplain Management (CGS 25-68[b] through 25-68[o]) to incorporate freeboard directly into the definition of floodproofing as follows:

> *(6) "Flood-proofing" means any combination of structural or nonstructural additions, changes or adjustments which reduce or eliminate flood damage to real estate or improved real property, to water and sanitary facilities, and to structures and their contents, including, but not limited to, for properties within the coastal boundary, as established pursuant to subsection (b) of section 22a-94, not less than an additional two feet of freeboard above base flood and any additional freeboard necessary to account for the most recent sea level change scenario updated pursuant to subsection (b) of section 25-68o, as amended by this act.*

This act therefore requires that critical actions and critical facilities should be elevated or floodproofed at least 2 feet above the 500-year flood elevation, which will help build resilience into state-funded and state-sponsored projects.

Finally, PURA issued its biennial "Request for Emergency Service Restoration Plans" in May 2018 pursuant to CGS Section 16-32e as tracked through Docket 18-03-29. CGS Section 16-32e requires, no later than July 1, 2012, and every 2 years thereafter that each public service company, telecommunications company, voice-over Internet protocol service provider, and each municipal utility shall file with PURA, the Department of Emergency Services and Public Protection, and each municipality located within the service area of the public service company an updated plan for restoring service that is interrupted as a result of an emergency.

The purpose of this proceeding is for PURA to receive and review the emergency service restoration plans as they become available. All participants were directed to file emergency service restoration plans or revised plans with PURA that satisfy all the requirements of the CGS Sec. 16-32e on or before Friday, June 29, 2018. Exemptions include public service companies or municipal utilities that submit a WSP pursuant to CGS Section 25-32d. These water utilities are not required to submit emergency service restoration plans. However, PURA requested in 2018 that such water utilities submit a written acknowledgement of their exemption to PURA.

While DPH-DWS requires larger PWSs to have Emergency Contingency Plans developed and submitted as part of their WSPs, a new regulation effective December 2015 now requires all CWSs to develop an Emergency Contingency Plan. These plans identify critical system infrastructure and establish various emergency procedures. Another recent regulation change resulted in all systems being required to have an emergency generator. It is also important that systems realize that having the ability to hook up a generator is just as important as having the generator itself.

2.2.2 Critical Infrastructure Vulnerabilities, Resiliency, Planning, and Emergency Preparedness

There are also statutes specifically aimed toward PWS planning and dam safety. These statutes require systems to plan for future adequate supply, system growth, and resource use efficiency and to comply with dam regulations and safety requirements.

Connecticut's public water supply planning process was prompted by the state's extended drought in the early 1980s and was an outcome of a Water Resources Task Force report recommending formal water supply planning.

Individual Water Supply Planning

In the state of Connecticut, all water companies serving greater than 1,000 people are required to develop and maintain a WSP. Plans are developed in accordance with CGS Section 25- 32d-1 and RCSA Section 25- 32d and are typically updated every 6 to 9 years. These regulations and the supporting statutes recognize that planning is a critical management activity of all water utilities. The principal goals of water system planning as defined by the Connecticut DPH are to: (1) ensure an adequate quantity of pure drinking water, now and in the future; (2) ensure orderly growth of the system; and (3) make efficient use of available resources. PURA, OPM, and DEEP all provide review and comment to DPH in the agency's review of WSPs.

All WSPs begin with a description of the water utility's structure and assets. This section normally includes information on company structure, employee certifications, company finances, and assets. The next sections typically provide a description of water supply sources, supply capacity, system performance, and water quality. These sections often provide source safe yield and available water, as well as distribution system specifications and water quality records.

After describing company infrastructure and available output, the WSPs generally focus on present and future water demands, service area land use, and source protection. These sections often observe trends within current demographics and attempt to extrapolate them into the future to anticipate any improvements and changes that will need to be made to company infrastructure. WSPs help ensure that water utilities are able to adjust to changing human populations and environmental conditions within the supply area and are planning to meet projected demand over a 50-year period.

Dam Safety

The dam safety statutes are codified in Sections 22a-401 through 22a-411 inclusive of the CGS. Sections 22a-409-1 and 22a-409-2 of the RCSA have been enacted, which govern the registration, classification, and inspection of dams. The DEEP administers the statewide Dam Safety Program and designates a classification to each state-registered dam based on its potential hazard.

The state's dam safety program is closely aligned with its flood management program. Due to the relationship between dams and water supply (described above), streamflow regulations (described above), and fish passage (described below), a detailed description of the dam safety program is provided herein.

- Class AA dams are negligible hazard potential dams that upon failure would result in no measurable damage to roadways and structures and negligible economic loss.
- Class A dams are low hazard potential dams that upon failure would result in damage to agricultural land and unimproved roadways, with minimal economic loss.
- Class BB dams are moderate hazard potential dams that upon failure would result in damage to normally unoccupied storage structures, damage to low volume roadways, and moderate economic loss.
- Class B dams are significant hazard potential dams that upon failure would result in possible loss of life; minor damage to habitable structures, residences, hospitals, convalescent homes, schools, and the like; damage or interruption of service of utilities; damage to primary roadways; and significant economic loss.
- Class C dams are high potential hazard dams that upon failure would result in loss of life and major damage to habitable structures, residences, hospitals, convalescent homes, schools, and main highways, with great economic loss.

Dam inspection regulations require that hundreds of dams in Connecticut be inspected annually. The DEEP currently prioritizes inspections of those dams that pose the greatest potential threat to downstream persons and properties. Dams found to be unsafe under the inspection program must be repaired by the owner. Depending on the severity of the identified deficiency, an owner is allowed reasonable time to make the required repairs or remove the dam. If a dam owner fails to make necessary repairs to the subject structure, the DEEP may issue an administrative order requiring the owner to restore the structure to a safe condition and may refer noncompliance with such an order to the Attorney General's Office for enforcement.

Owners of Class C dams have traditionally been required to maintain Emergency Operation Plans (EOPs). Guidelines for dam EOPs were published by DEEP in 2012, creating a uniform approach for development of EOPs. Important dam safety program changes are underway in Connecticut. Public Act No. 13-197, An Act Concerning the Dam Safety Program and Mosquito Control, passed in June 2013 and describes new requirements for dams related to registration, maintenance, and EOPs, which will be called emergency action plans (EAPs) moving forward. This act requires owners of certain unregistered dams or similar structures to register them by October 1, 2015. The act generally shifts regularly scheduled inspection and reporting requirements from the DEEP to the owners of dams. At the present time, the owner of any high or significant hazard dam (Class B and Class C) must develop and implement an EAP pursuant to regulations for EAPs adopted in 2015. The EAP shall be updated every 2 years, and copies shall be filed with DEEP and the chief executive officer of any municipality that would potentially be affected in the event of an emergency.

2.2.3 State Government Emergency Preparedness and Response

Interviews were conducted to review and assess best practices and procedures for emergency situations at DPH and other regulatory agencies overseeing water supply throughout the northeast. The interviews aimed to learn how Connecticut and other states respond to and handle statewide emergencies. The questions for the interview covered four general areas: interviewee and organizational background, emergency management, resilience, and planning.

Interviews were conducted with 11 DPH staff and 18 drinking water staff from other states (Table 2-1). These interviews aimed to identify best practices from other states' drinking water departments and to incorporate these practices and lessons learned into the DWS ERP. These other departments regulate anywhere from 80 to 2,000 CWSs, and between 20 and 100 staff members regulate these systems. The larger states tend to have a central headquarters and regional office while smaller states just a central office.

Table 2-1
Summary of Other State Interviews

State	Agency(s)	Total # of Staff Interviewed
Connecticut	Department of Public Health – Drinking Water Section	11
Rhode Island	Department of Administration – Water Resources Board (1) Department of Health – Center for Drinking Water Quality (1)	2
Maine	Department of Health and Human Services – Drinking Water Program (1) Maine Center for Disease Control and Prevention – Division of Environmental and Community Health (1)	2
Vermont	Department of Environmental Conservation – Agency of Natural Resources, Drinking Water & Groundwater Protection Division	1
Pennsylvania	Department of Environmental Protection – Bureau of Safe Drinking Water	3
Massachusetts	Center for Disease Control and Prevention – Drinking Water Program (1) Department of Environmental Protection – Division of Watershed Management, Bureau of Water Resources (1) Dept. of Environmental Protection – Office of Emergency Preparedness (2)	4
New Jersey	Department of Environmental Protection – Office of Water Resource Management Coordination	1
New Hampshire	Department of Environmental Services – Drinking Water & Groundwater Bureau	3
Ohio	Environmental Protection Agency – Division of Drinking and Ground Waters	2
Total	**9 States, 13 Agencies**	**29**

Connecticut DPH – Drinking Water Section

The Connecticut DPH-DWS is responsible for ensuring that drinking water systems always provide safe and adequate water, including during emergencies, and for developing and administering policies that work to enhance system emergency preparedness. Many of these policies and regulations pertain to larger systems. For example, larger systems are required to set drought triggers and to provide contact information for an emergency response point of contact.

The DPH-DWS has a staff of 45 to 50 individuals, primarily engineers and analysts with a small number of planners and health professionals. However, the section currently does not have an emergency response coordinator. The DWS has developed an Incident Command System (ICS) structure for emergency response, which defines staff roles and therefore fills in any departmental gaps in emergency coordination.

The State Response Framework, Emergency Support Function (ESF) 12 and DPH Emergency Response Plans formally describe the current practices, responsibilities, and requirements for DPH-DWS emergency response. Connecticut's State Response Framework[6] (pages 3 to 18) formally describes DPH-DWS' responsibilities during a statewide emergency. Connecticut ESF 12 describes the Water Task Force activated during a statewide emergency and DPH-DWS' role. The CTDPH ERP[7] (page 23) formally explains the DWS's role in emergencies with respect to the Water Emergencies Assessment and Response (WEAR) Team, made up of 10 staff representatives of each DWS Program/Unit that are trained in all phases of emergency assessment and response.

Currently, when there is a state emergency, an ICS is established by DESPP, DEMHS, and OEM. This ICS provides a standardized response for organization collaboration. Also, during a large-scale statewide emergency, the Governor activates the SEOC, which coordinates emergency services. In the past, the DPH Office of Public Health Preparedness and Response was the only DPH representative at the SEOC. However, DPH-DWS has begun to have its own representative present due to past challenges and shortcomings.

When the ICS is activated, DWS also activates and leads a Water Task Force (see Connecticut Emergency Support Function 12[8] [ESF12]). The task force includes multiple stakeholders including PWSs, wastewater utilities, DEEP Municipal Facilities Section, and other Connecticut water associations. Any concerns raised by this task force are then relayed to the SEOC via the DWS representative.

6 http://www.ct.gov/demhs/lib/demhs/srf_v_4_1.pdf
7 https://portal.ct.gov/DPH/Planning/Public-Health-Preparedness-and-Response/Public-Health-Emergency-Reponse-Plan
8 http://www.ct.gov/demhs/lib/demhs/eppi/esf_12_all-hazards_energy_and_utilities_annex_final_draft_july_2012.pdf

When a credible event is likely to affect the entire state, the DPH-DWS utilizes Everbridge in advance of the event to send mass communications to CWSs using a variety of delivery methods. These communications include information and emergency preparation reminders such as checking a generator for fuel and reviewing ERPs. The DWS also provides an after-hours phone number to PWS emergency response leads so systems can call at any time with updates or questions. The DPH-DWS website is also updated to provide general and specific information for systems regarding planning and response before, during, and after an event. It has been utilized during past storms by a number of systems to obtain information.

The DWS also communicates with systems during events by either directly calling them or receiving information from systems that are experiencing challenges. Typically, larger systems are more likely to contact DWS with issues; therefore, the DWS tends to focus its outreach on smaller, more vulnerable systems. However, DWS has found that the contact information for small systems is often out of date. To reduce efforts necessary to track down system contact information during an incident, a contact form was developed for systems to fill out annually. Unfortunately, typically only half of systems respond to the form.

When issues arise, the DWS works as a mediator and connects the distressed system with a partner that can assist the system. During Hurricane Irene, the DWS found it challenging to report CWS status twice daily. Also, the automated WebEOC system Drinking Water Status Controller Board has been developed by the DWS to make the process of status reporting more efficient and is being promoted and utilized in systems serving over 1,000 to begin using this as the primary means of communicating with the DWS during emergency events.

Communication during and immediately following a storm can be challenging, resulting in the DWS conducting visits to those systems that are being unresponsive to calls and emails. Many of these systems, typically small systems, have little knowledge on procedures to utilize immediately following an event. The staff that visits the site offers assistance and testing and determines if notices such as boil water need to be issued.

While storms result in immediate response with an ICS structure, drought response is slightly different. The DWS Chief is usually in direct contact with the Governor's office, drinking water stakeholders, and the Commissioner of DPH. Within the DWS, a drought team is established, and at the state level, the IDW is assembled. The IDW includes a DWS representative and meets weekly during a drought.

Currently, systems that are required to set drought triggers do so on their own, so these triggers are system specific. Because each CWS takes this responsibility, there is often little consistency between system triggers. During the most recent droughts, multiple systems' triggers were found to be inadequate; the systems experienced reduced supply, and these systems generally failed to communicate these insufficiencies to DWS. A small number of these systems had reached less than 50% capacity and again still failed to contact DPH-DWS. As a result, DWS now monitors those systems that have experienced negative impacts from recent droughts and has also required these systems to revise their triggers to more conservative levels.

Another result of recent droughts is the requirement for large systems to monitor groundwater levels, along with surface levels, on a weekly basis. Prior to these droughts, systems only monitored surface water levels; however, since recent events, the requirements have changed. These water level reports are sent to DWS monthly; however, DWS is currently working on creating a database that will allow this information to be more readily available.

Before CWSs are impacted by drought, they should work with their local municipalities to get ordinances in place in order to be able to enforce any necessary water usage reductions. The IDW has promulgated a model ordinance[9] that towns can use, which is located on the IDW website.

At times, a system is unable to manage its water supplies effectively during a drought due to several regulations and restrictions However, a "declaration of emergency" by DPH temporarily suspends these restrictions allowing for better management. DPH-DWS has the authority to declare an emergency on behalf of the system under CGS 25-32b and to sign off on emergency orders, eliminating the need for the DPH Commissioner to sign off and therefore reducing process time. Water system emergencies are declared on a case-by-case basis and involve communications with DEEP and PURA. The DPH-DWS drafts and issues orders specific to the situation, which allow temporary changes to be made to existing rules, court orders, regulations, etc. for a period of 30 days; emergency declarations can be renewed if needed up to 150 days.

<u>Other State Interviews</u>

The responsibilities of other state drinking water departments during an emergency are similar to those of Connecticut DPH-DWS. Most other state agencies follow an ICS structure during an emergency and typically serve as a technical consultant for their emergency management division. The other divisions also generally serve in a supporting role during a statewide emergency just as CT DPH-DWS does.

9 http://www.ct.gov/waterstatus/lib/waterstatus/pdf/state_of_ct_model_water_use_restiction_ordinance-final.pdf

Other states' agencies are tasked with the challenge of obtaining status updates from CWSs. Both during and after a storm, these other state agencies also follow similar procedures for obtaining updates. For example, most other state agencies utilize a contact form, send out messages before an event, and assist the systems after an event. Some of these state agencies found that automated communication systems simplify and speed up the process of obtaining CWS status updates.

However, a few of the other state agencies have more advanced methods for obtaining status updates. One state agency utilizes a web-based system that tracks system status and then relays information to managers, to inspectors, and back, and to executive staff and other state departments. While these systems prove to be effective for sharing information, there is still difficulty in getting the smaller systems to input their status.

Other state agencies, just like CT DPH-DWS, typically prioritize helping larger systems get back online after a storm due to the fact that they have larger service populations and tend to serve more critical facilities. Other state agencies have noticed that some system managers may not be able to issue notices, such as boil water, so these states assist by utilizing a reverse 911 system to notify the public of the impact.

When there is a statewide emergency, some other state agencies have streamlined communication between themselves and other agencies and departments while other state agencies feel that there is room for improvement regarding this level of communication.

Some of these best practices for communication are a result of a formal ERP. This type of plan includes an ICS structure, protocols, leadership for emergency response teams, other state department contacts, and a procedure for how to hand off the emergency to another agency as it becomes too difficult to handle alone. Relationships between state agencies are well developed, and communication pathways are documented to guarantee easy communication flow. These pathways take time to develop and should be maintained over time. For these plans to be effective, they are practiced annually with all those who would be involved in an emergency. Revisions made to the plan include adding lessons learned over the past year and updating important contact information. The agencies with successful plans emphasized the importance of including other state agency staff during training. One agency pointed out the usefulness of training; for example, their staff took an online course about ICS structure, which has improved their response.

Several of the other state agencies said their storm and drought responses are not formalized due to the infrequency of the event. Some agencies also mentioned that lack of experience is a potential barrier in identifying best practices for statewide response.

Most state agencies have different time constraints regarding when a system must report a problem. A majority require a 24-hour reporting window; however, one state requires a 1-hour reporting window, and as a result, the agency feels this is essential to its department's response. State agencies also differ on who takes an emergency report after hours, with some states using a rotating schedule of qualified staff that can handle an emergency and others having a single person that handles these calls 24/7.

Smaller more routine emergencies do not typically result in the same response as a large-scale emergency. Some state agencies have written protocols for a variety of emergencies while other state agencies, like Connecticut DPH, do not. It appears agencies need the most assistance in determining when an emergency needs to be handed off to larger agencies and when it should be handled by the drinking water agency alone.

Most of the state agencies have a separate board that consists of staff from multiple agencies that handle drought response. Drought policy varies between the states. For example, some state agencies have expedited procedures for approving new supplies or getting systems money during a drought while other state agencies still rely on the drawn-out process of paperwork and approval. Also, some state agencies regulate bulk water haulers while others do not.

Drought stages have been established in some states and can be issued by the governor or the drinking water agency. These triggers are typically associated with a certain level of mandatory water restrictions. Some state agencies also mentioned that enhanced conservation efforts, repairing leaks, or developing new or diverse sources help mitigate drought impacts. During a drought, agency staff communicate with the CWSs to determine their status. Some state agencies have developed an online survey to be filled out during a drought.

All states require that large CWSs write an ERP while small systems are encouraged to but are not required. Some state agencies hold workshops or training sessions for those small systems that need assistance writing these plans. Limited staff creates a barrier for agencies to be able to review all ERPs. Typically, a system is questioned as to whether or not it has a plan written during its routine, 3-year inspection. One state does, however, have two agencies that share the load of reviewing ERPs. Agencies also feel their time is better spent providing technical assistance to systems rather than reviewing plans.

Many of the state agencies feel face-to-face sanitary survey inspections are one of the most effective ways to prepare a system for an emergency. These inspections provide an opportunity for providing technical assistance and allow staff to develop relationships with operators and learn the system.

Other planning requirements vary across states. Some require drought plans and long-term WSPs, infrastructure or asset management plans, and source water protection plans. Also, some states may request technical fixes including redundancy, alternate sources, additional intakes, and shutoff valves in critical areas. However, most states do not require systems have generators while Connecticut does.

One state agency has given out grants for CWSs and NTNC systems to write an Operations and Maintenance Manual (i.e., asset management plan). Some states, including Connecticut, utilize a point system where systems that take capacity development actions and stay on schedule earn points and are given a higher priority for state revolving funds and grants. Some agency staff feel that those systems without emergency response or asset management plans are not prepared to withstand natural hazard events. Many also feel that the asset management plans are geared toward daily operations and maintenance, which play importants role in storm resilience.

While the staff feels that these various planning requirements are useful for a system if they are practiced and reviewed, the agencies are unsure of how effective these plans are. Some of these systems hire a consultant to develop these plans, leaving the agency concerned that these reports sit on a shelf and remain unused and not reviewed.

<u>Interview Lessons Learned</u>

- <u>Lesson 1</u> – Severe weather emergencies may reduce the workforce available to respond during or directly after the storm and may require responding remotely so everything needed to respond should be portable or electronic. The Connecticut DPH-DWS during Winter Storm Alfred experienced a variety of challenges, including difficulty of staff making it to the office. These staff members lacked the information and tools necessary to respond to emergencies. Since this event, staff are now more able to work remotely and have the access they need to provide support to systems and the section.

  Another state's agency has improved its document storage by keeping standard operating procedures in a secure online location. This agency lost computers, files, and other documents due to flooding during Hurricane Irene. The agency staff is also able to now access this information remotely during an event.

- Lesson 2 – State agencies have found that CWSs are not always listed on the priority power restoration list of power utilities. Small systems, such as mobile home parks and homeowner associations, were also not listed. State agencies should assist in getting CWSs on these priority power lists even if these systems have standby power capabilities.

- Lesson 3 – Responding to a severe statewide drought may require significant department resources. While drought response is not typically an "all hands on deck" movement like other statewide emergencies such as hurricanes, a statewide drought does shift the daily work of DWS staff. For example, priorities shifted during the most recent drought when there were three emergency declarations and staff needed to monitor system status and conservation efforts. DWS staff were taken away from their daily work to contact systems for status updates; these updates are required under the emergency order.

  Other state agencies have experienced similar issues. However, other states felt that utilizing an online system to monitor system status was easier. This online system was primarily a survey that was found on the agency website. Systems could fill out this survey and request help or resources; agency staff would then contact that system to help solve the problem. This system both sped up the process and freed up agency staff time.

- Lesson 4 – Responding to statewide emergencies requires a lot of coordination between state agencies, and this is difficult to do without a formal ERP. States should formalize emergency response, include these procedures in a living document, and implement routine training exercises. The document should also include formal guidelines that specify how the department will respond to an emergency to ensure consistency. The guidelines should show how to respond to various emergencies, who should be involved, communication pathways, and a checklist of prioritized tasks. These guidelines and the plan should be updated annually or as often as necessary. To increase redundancy in the drinking water agency, multiple staff should be trained and included in reviews and practices to ensure that sufficient staff know how to respond.

- Lesson 5 – Web-based communication systems streamline and speed up status updates during both storms and drought. States have experienced a reduction in wasted staff agency time and an increase in response efficiency with assisting systems when online systems are utilized. These systems have also increased efficiency in communication between state agencies, system operators, and drinking water staff.

2.2.4 Community Water System Emergency Preparedness and Response

Community Water System Interviews

Interviews were conducted with 24 individuals, all of whom are in a management role in a range of CWSs in the four coastal counties. Of those individuals, 11 managed a publicly owned system, 10 managed a privately owned system, and 3 were certified operators that work with multiple systems. In terms of system size, these individuals represented five small systems serving less than 500 people, seven medium-sized systems serving 501 to 9,999 people, and nine large systems serving over 10,000 people.

The responses were similar throughout the group regarding storm impacts. Most of the systems have felt storm impacts, specifically power outages; however, in general they have found the addition of generators over the past few years has increased reliability. It was also apparent that flooding is not a significant concern for most drinking water systems and that primarily large or private systems conduct a poststorm analysis to update plans and procedures.

Most individuals made it clear that drought is seen as a growing concern to CWSs and that water use restrictions have proven effective during a drought, especially for small well systems. However, a few small systems do not utilize household meters, thereby making the enforcement of use restrictions difficult during a drought.

Interconnections provide system redundancy; however, there are concerns regarding the use of these interconnection. Systems that utilize interconnections for a portion of their water supply experience a lack of control and concern regarding the source water and lack incentive to conserve water below the mandatory minimums in their purchase agreements. There is also the concern about irregular use of these interconnections and the resulting scouring of pipes and a potential for increased exposure to toxins. Smaller systems tended to be more interested in interconnections or selling their system.

The interviews also addressed climate change. In general, most managers are aware of the potential changes in drought and storm frequency due to climate change. Because it is unclear how these changes will impact a system from a business perspective, many managers are waiting for guidance whether it be from DPH or another regulatory standpoint.

It was found that regulatory compliance is a significant driving force behind both investments and behavioral change for all types of CWSs. However, several managers mentioned the stress of complying with regulations during an emergency or event (i.e., a boil water advisory) while their capacity is already overextended.

2.3 Review of Water System Emergency Planning Documents

Large CWSs (greater than 1,000 people served per system or 250 service connections) were the focus of this document review; these sized systems are the only ones required to prepare and submit an Emergency Contingency Plan (ECP) per WSP Regulations. System ECPs and vulnerability assessments[10] were reviewed to identify system vulnerabilities and their strategies to mitigate associated risks. Appendix B contains the documentation associated with these reviews.

2.3.1 Review of Vulnerability Assessments

Water utilities approach the planning process differently for vulnerabilities and emergencies. Some utilities chose to utilize a vulnerability assessment as a way to convey their most sensitive and confidential system vulnerabilities, but in this case, the document was not released as part of the WSP. However, other utilities chose to create a vulnerability assessment chapter or document that articulates hazards. The assessment in this case typically covered general system vulnerabilities and mitigation efforts.

A spreadsheet (Appendix B) was compiled to list critical systems affected, vulnerabilities listed, and how the utility plans to mitigate vulnerability-associated risks. However, because these specifics were not often directly addressed, this information was essentially backed out of the ERPs. For example, a utility might note that it is vulnerable to power failures and has an auxiliary generator in place while not specifying events that could lead to this failure.

The focus of this document review was to identify vulnerabilities to natural hazards; therefore, the research was limited to vulnerabilities that could be associated with natural disasters and climate change. The important aspect is to identify whether a system has taken steps to mitigate the risk associated with certain natural hazard vulnerabilities.

The document review revealed that in some plans a vulnerability was identified; however, no mitigation strategy was presented for that specific vulnerability. The lack of mitigation strategy may indicate a system vulnerability to a certain natural hazard. Some systems did convey why no mitigation strategy was presented; however, in most instances, that information was not provided. There is also a "Hazard Level" classification found in the spreadsheet, which represents the system's subjective analysis of its risk; most plans did not have this information, leaving this column blank.

10 In this context, "Vulnerability Assessment" does not mean the vulnerability assessment developed per the Bioterrorism Act of 2002.

2.3.2 Review of Emergency Contingency Plans

Flooding

Large CWSs typically address the risk of flooding through several means, including source protection, system redundancy, and the ability to repair flood-damaged infrastructure in-house.

- **Source Protection** – Most utilities have sources of groundwater supply above the 100-year floodplain although there are some exceptions. Wells within the 100-year flood zone have typically been elevated or sealed so as to provide more reliable performance during flood events. Utilities with impounded surface water reservoirs generally have EAPs in place to address dam failure due to flooding and have strict dam monitoring protocol in place before and during severe weather events. As certain rainfall thresholds are met, crew members observe dams and supervise water releases as necessary.

Dug well with cracked cover too close to stream. Photo by DPH.

- **System Redundancy** – Most utilities are able to function acceptably with one or more primary supply sources off line for any reason. In the event of a total supply failure, many systems can meet average day demand for at least 24 hours using storage from standpipes and underground tanks. Most utilities have looped transmission mains, which allow for small breaks to be easily isolated and repaired without causing systemwide disruption. This is especially important in consecutive systems, which rely on large transmission mains to carry all of the supply to the system from adjacent systems.

- **System Repairs** – Many utilities are able to repair most main breaks in their systems with on-site replacement parts that are maintained in the equipment inventory although very large breaks may require contractors. Systems that cannot perform maintenance usually have relationships with contractors who can perform such work on an on-call basis.

Drought

All CWSs that maintain an ECP have a dedicated section on drought response. The drought response is based on thresholds established by the water utility based on safe yield or reservoir capacity. As various trigger conditions are met due to drought conditions, water conservation is requested, and eventually water use restrictions may be implemented.

Most utilities use a five-stage drought response plan. Typical stages include Water Supply Alert, Water Supply Advisory, Water Supply Emergency Phase I, Water Supply Emergency Phase II, and Water Supply Emergency Phase III. Although the exact nomenclature and water reduction requirements vary from utility to utility, the general format remains similar. Some utilities use a four-stage drought response plan, which is preferred by DPH. The five-stage plan is gradually being phased out as WSPs are updated.

Climate Change

No utilities cite climate change as a direct hazard in their ECPs or Vulnerability Assessments. It can be argued that the vulnerability of a PWS to expected sea level rise, increased strength of storms, and changing precipitation patterns will continue to increase. Since WSPs are typically updated every 5 to 9 years, it is possible that the next updates may show significant improvement in this area. Even indirect preparations for the effects of climate change (sea level rise, stronger storms, etc.) would be an improvement over the current status. However, a requirement for climate change to be evaluated would need to be included in the water supply planning regulations in order to ensure a widespread effort.

2.4 Vulnerabilities to the Quality and Quantity of Potable Water

2.4.1 General System Vulnerability

Sources:

PWSs in the State of Connecticut withdraw drinking water from either surface water reservoirs, groundwater wells, or springs. Both surface water and groundwater sources have practical applications with advantages and certain vulnerabilities. Many PWSs attempt to mitigate source vulnerabilities by maintaining multiple sources, which may be spatially distributed to reduce point source risk; however, there are many others, especially small utilities, that have obvious source vulnerabilities.

Well pump and meter. Photo by MMI.

The greatest risk to some groundwater sources is flooding. The area along rivers is typically among the most productive for water withdrawal due to the sandy alluvial deposits and shallow water table. Many wells in the state are located within the 1% annual chance flood hazard area and could be inundated during a high water event. Flooding of the well can result in contamination, which requires the well to be taken out of service while decontamination efforts are implemented. For small PWSs with little source redundancy, this could lead to water shortages while repairs are implemented.

While surface water reservoirs with well-maintained dams can be resilient to flooding, they can be susceptible to contamination from runoff or by deliberate means. Many reservoirs in Connecticut are adjacent to interstate highways or other highly traveled routes. For example, the Dean's Mill/Palmer Reservoir in Stonington is bisected by Interstate 95.

Transmission Systems:
As the arteries of the distribution system, transmission mains must be maintained thoroughly in order to ensure uninterrupted performance of the system. The greatest vulnerability of a transmission main is a catastrophic failure or breakage of the pipe wall. Failure of the transmission mains can be caused by a variety of natural events. While uncommon in Connecticut, earthquakes have the potential to rupture mains due to the immense amount of shear stress imparted by the shifting ground. Flooding can also be a major hazard to transmission mains as the ground can be washed out around the relatively fragile pipes. The most vulnerable mains are often attached to bridges over river crossings. These mains are exposed to the direct force of the floodwaters and any debris that may accompany them.

Storage:
Water utilities rely on storage volume to provide a buffer for large water demands, provide water pressure, and store water for potential interruptions in supply. Storage facilities are often aboveground metal standpipes or concrete tanks, typically located at high elevations to increase pressure. As with any piece of large infrastructure, storage facilities must be maintained diligently to ensure good operation. The extreme weight of the water imparts an enormous static load on the infrastructure. Cracks in concrete tanks, corrosion of metal tanks, and shifting ground can compromise the structural integrity of storage tanks, potentially rendering them unusable.

Power Supply:
All PWSs need electrical power for sustained long-term operation of the water supply system. Storage facilities can provide pressure and service in the event of minor disruptions in power, but long-term outages necessitate the implementation of auxiliary power. Power failures can be caused by natural hazards such as ice storms, heavy wind, lightning strikes, and flooding, as well as mechanical failures and sabotage.

Distribution:
The distribution system of a PWS usually consists of water mains, booster pumps, and storage facilities. The vulnerabilities of water mains are the same as those of larger transmission mains, namely, breakage due to events such as flooding, old age,

earthquakes, etc. While a breakage in a smaller distribution main may not cause notable systemwide effects, it can still leave an isolated neighborhood without running water.

Pump station. Photo by MMI.

Booster pumps are required to increase system pressure. Many water supply sources are found in river valleys due to the favorable hydrogeological conditions. This means that there are likely locations in the service area that are significantly higher than the supply source elevation. While well pumps do provide substantial pressure, it is not efficient to have the well pump itself provide the pressure required to reach the high service areas. Booster pumps alleviate the burden by providing an additional source of pumping power. Water pumped by the booster pumps is ordinarily pumped to the highest area of the service area, where a storage facility is located. This way, the storage facility can use gravity to provide pressure to surrounding high service areas. As noted previously, this can provide uninterrupted service during a brief power outage.

Operators/Human Capacity:
Modern water supply utilities use sophisticated equipment to precisely monitor the supply systems. These monitoring systems can provide automated alerts as to system malfunction, demand surges, or other emergency situations. Despite the automation, water supply companies still require operators to ensure that all facilities are running normally. Daily responsibilities at water treatment plants include ensuring that filters are backwashed properly and that water chemistry is within health and safety limits and the repair of any minor problems that arise.

There has recently been an increased need for water treatment plant operators in the state of Connecticut. There has been some indication that the current ranks of water treatment plant operators are aging, and there is inadequate interest in the position to replace these individuals. This is a potential vulnerability for water supply utilities as high-quality operators are required to keep plants running smoothly and to be able to service malfunctioning equipment.

2.4.2 Survey of Community Water Systems

Community Water System Surveys

A survey was developed to assess impacts on CWSs from recent severe storms and drought. This survey also aimed to assess their capabilities as a system now and for future emergency coping capabilities and incorporated topics regarding climate change. The survey was sent to 297 unique systems, and the final number of respondents was 85. Of the systems that responded, 77% are served primarily by groundwater, 22% by surface water, and 1% purchase their water. Statistics for survey responses are found in Appendix C.

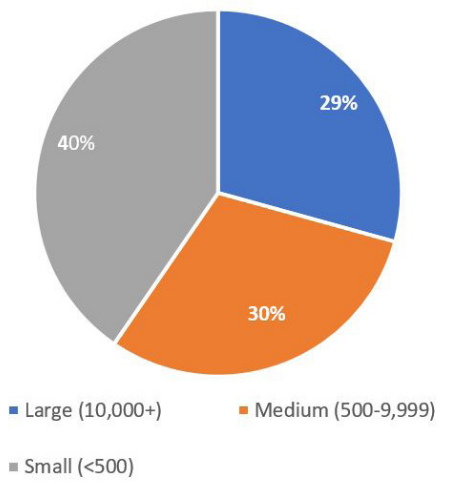


Figure 2-1 CWS size distribution from surveys

Drought Impacts

Most of the systems surveyed acknowledged that they experienced some kind of drought impact; however, few of these systems experienced severe impacts. Over half the systems implemented voluntary water restrictions, which is double the number of systems that experienced a reduced supply. Fewer systems needed to utilize an interconnection, and less than 10% of the responding systems issued a boil water advisory.

Recent Storm Impacts

The questions for recent storm impact assessment were geared toward past storms such as Superstorm Sandy and Hurricane Irene. Of the 85 responding systems, nearly 75% experienced power loss and relied on a generator for backup power, and over half of the systems implemented their ERPs. Just over 20% of systems experienced difficulties with staff reporting to work during an event; over half of these systems were large.

Only 5% of the systems responding to the survey issued boiled water advisories during a storm associated with finished water quality problems. Those that did feel these impacts were small- and medium-sized systems.

Future Help and Hindrances

When asked about the likelihood of current threats to negatively impact their system, over half felt regulations negatively impact their ability to operate their system now or in the future. Interview data suggests that regulations drive investment decisions and that some systems perceive some regulations to be overly burdensome due to the financial requirements to maintain compliance.

At the same time, regulations can have a positive impact on systems. When asked what helps systems respond to threats, over half (55%) of respondents indicate that regulations help (some or a lot) them respond to threats. As far as nonregulatory threats, storms were the most likely threat, with power failures being the next likely. Sea level rise was thought to be the least likely threat. Although droughts are perceived as a relatively low present threat, respondents typically associated drought with being a more distant future threat (20+ years). Sea level rise was again seen as a threat that will pose a decreased threat in the future.

Systems generally feel that redundancy, adequate funding, and increased investments (climate change action and conservation/watershed protection) will become increasingly useful for responding to future threats. Currently, these systems feel that funding, redundancy, and equipment are most useful for responding to threats. Among the technical aspects, systems feel that a skilled workforce, communication with customers, and watershed protection will also prove helpful during an emergency.

Overall Findings

According to the survey responses, larger systems generally experience more impacts attributed to drought while smaller systems tend to feel impacts related to storms. In general, most systems feel that their drought response plans and ERPs are adequate for managing impacts. Roughly half of the systems surveyed feel that by addressing climate change they are better able to respond to threats. Similarly, climate change adaptation ranks highest as a method to increase their ability to respond to future threats.

2.4.3 Drinking Water Vulnerability Assessment Workshop

On April 6, 2018, the Connecticut Institute for Resilience and Climate Adaptation (CIRCA) and DPH hosted a workshop at the UConn Avery Point Campus in Groton, Connecticut, to share the results of the vulnerability assessment and to obtain feedback on the implementation of a resilience plan for drinking water systems. The workshop attendees received guidance on identifying vulnerabilities to flooding, extreme weather, and drought; adaptation approaches for PWSs; and resilience strategies to address those vulnerabilities.

The workshop was advertised on CIRCA's website and through email lists targeting stakeholders for drinking water vulnerability and resilience, including CWSs staff and administrators, local health directors, councils of governments staff, municipal planners and engineers, and any other individuals involved with the WUCCs and the SWP.

The workshop was provided both as an in-person and webinar option for participation. Sixty-one people registered for the workshop, and 15 individuals registered for the webinar. Of those registered, 53 individuals attended the workshop, and 15 attendees participated via the webinar. The webinar participants were able to view the morning oral presentations, but they were not able to participate in the afternoon breakout sessions. The full list of workshop and webinar participants is in the Appendix D.

The agenda (Appendix D) featured a morning session with presentations on the best available science and local analysis at the neighborhood scale to inform decision making for CWSs to improve resilience to the impacts of flooding and a changing climate, as well as tools and resources to assist with the implementation of resilience strategies. In the afternoon, breakout sessions were held with in-depth discussion of these issues and the opportunity for in-person participants to provide feedback on the research and recommendations.

The morning presentations focused on the importance of resilience, future challenges presented by climate change, and various aspects of the vulnerability assessment; these presentations presented findings from the assessment. The afternoon presentations reviewed Connecticut's current laws and policy pertaining to drinking water, the current state of practice for CWSs, the framework for the CWS resilience plan, and an overview of the DWSRF. Full summaries of all presentations can be found in Appendix D.

Breakout Sessions

To gain feedback from participants, four breakout sessions were offered with each topic being offered twice. Full summaries can be found in Appendix D; the topics included the following:

- "It's an Emergency! Keep the Water Supply Running"
- "Redundancy = Resiliency: Options and Alternatives for CWSs & Drinking Water Policy"
- "Using Climate Data to Inform CWS Decisions"
- "What do We do About Private Well Resilience?"

The breakout sessions proved to be a valuable opportunity to gain feedback from workshop participants. Many issues were raised, and solutions for problems were also suggested. Many participants raised concerns regarding difficulties during emergencies. Points discussed included: power outages are still an issue; systems experience communication issues; there have been interruptions in receiving supply deliveries when the state closes roadways; and some experience difficulties accessing facilities during events. Some suggested solutions to these problems included: mandatory training for multiple employees in emergency response protocols; explore alternative energy sources for backup power; utilize radio communication more frequently; and utilize social media to send out messages when other means of communication may be down.

Participants were also in agreement that smaller systems need assistance with grant program participation. Some suggested solutions were to hire an entity such as Resources for Communities and People (RCAP) to prepare applications or to progress ideas, streamline programs like the generator program, or conduct workshops for small systems on the grant application process.

When discussing emergency response procedures during one breakout session, there seemed to be confusion on who the responsible party is for distribution of emergency water bottles. It appears there needs to be better coordination between utilities and the municipalities they serve to identify who should distribute the emergency supply. It was suggested that Council of Government (COG) meetings be used as a platform for emergency water supply response planning.

Water system representatives identified the importance of USGS stream gaging data for short-term decision making, long-term datasets, and model calibration and validation. Some systems are considering installing and managing their own stream gauges to ensure the necessary data collection.

During the private well breakout session, it was agreed that private well owners continue to be a vulnerable population regarding resilience challenges. It was also acknowledged that there seem to be gaps with private well location data and gaps in dispersing information to well owners. Some suggestions for bridging the information dispersal gap included educating children, imposing fees if wells are not tested, using social marketing to raise vulnerability awareness, or creating an incentive program for residents to test and maintain their wells.

These sessions aimed to gain feedback and knowledge from drinking water stakeholders to both incorporate into the report and to make recommendations within the resilience plan.

Findings and Feedback

Workshop participants generally found the event to be useful and productive. As part of the operator training credits offered for this event, an evaluation was issued to gauge the pertinence of the workshop material for both the presentations and the breakout sessions. These evaluations revealed that those participating for credits felt the presentations were informative and that the breakout sessions were a good tool for progressive discussion.

2.4.4 Existing Flooding Risk to Community Water Systems

Relative to floods, the State of Connecticut adopted a set of standards following the 1955 floods that were forward thinking and have helped lead to the current suite of regulations that help make many state-funded projects resilient. Critical facilities must be designed according to the elevation of the 0.2% annual chance (500-year) flood rather than the 1% annual chance (100-year) flood, the elevations of which are typically developed for regulatory purposes by the Federal Emergency Management Agency (FEMA). The Federal Flood Risk Management Standard (FFRMS) was issued by the Obama administration in 2015 and adopted a similar approach to be used for federally funded facilities, but the standard was rescinded in 2017 by the Trump administration. The Connecticut Public Health Code does not require that water system components or water supply wells be resistant to flooding from the 0.2% event, but water supply wells must be elevated above the 1% annual chance flood elevation.

As explained in Section 2.2.1, Public Act 18-82 became effective in 2018 and made many changes to statutes including the state's flood management statutes in Chapter 476A, Floodplain Management (CGS §25-68[b] through §25-68[o]). The act replaced a reference in the flood management statutes to "one-hundred-year flood" with "base flood." State statute now defines the base flood as the level of the 0.2% annual chance flood for "critical activities," which essentially requires critical facilities to be evaluated against the 500-year flood elevation.

Going further, the act amends the definitions to incorporate freeboard directly into the definition of floodproofing as follows: (6) "Flood-proofing" means any combination of structural or nonstructural additions, changes or adjustments which reduce or eliminate flood damage to real estate or improved real property, to water and sanitary facilities, and to structures and their contents, including, but not limited to, for properties within the coastal boundary, as established pursuant to subsection (b) of section 22a-94, not less than an additional two feet of freeboard above base flood and any additional freeboard necessary to account for the most recent sea level change scenario updated pursuant to subsection (b) of section 25-68o, as amended by this act." State statute therefore requires that critical actions and critical facilities should be elevated or floodproofed at least 2 feet above the 500-year flood elevation, which will help build resilience into state-funded and state-sponsored projects.

Notwithstanding the state's strong preexisting statutes and the revisions from Public Act 18-82, many PWS sources and components are at risk of flooding. An analysis was therefore conducted to evaluate these risks.

Vulnerability of Public Water System Components

A GIS overlay analysis was conducted to identify vulnerable PWS infrastructure; this included treatment plants, system intakes, pump facilities, and wells. The location of these assets was compared to the FEMA 1% and 0.2% annual flood event zones. In total, there were 911 treatment plants, 496 pump facilities, and 3,551 wells, all of which belonged to either a CWS, NTNC system, or TNC system. There were also 70 system intakes belonging to only CWSs.

Table 2-2 shows the analysis results regarding asset vulnerability to the 1% or 0.2% event, and table 2-3 shows the vulnerable assets between the system types. All but one pump facility belonged to a CWS, with the single exception being a part of a NTNC system.

Table 2-2
System Component Vulnerability Analysis Results of Flood Zone Location

Asset	Located within Flood Zone	Located within 1% Annual Chance Flood Zone	Located within 0.2% Annual Chance Flood Zone
Treatment Plants	80 (8.8%)	57	23
System Intakes	28 (40.0%)	24	4
Pump Facilities	22 (4.5%)	12	10
System Wells	279 (7.9%)	216	63

Table 2-3
System Component Vulnerability Analysis Results by PWS Type

Asset	Total	Community	Non-Transient Non-Community	Transient Non-Community
Treatment Plants	80	61	8	11
System Wells	279	168	74	37

A total of 185 systems have at least one component of the system vulnerable to flooding. Of these systems, 81 are a CWS, 34 are a NTNC system, and 70 are a TNC system (Appendix E).

For CWSs, the number of vulnerable system components ranged from 1 to 26, with some systems having only one asset vulnerable and some systems having multiple vulnerable assets (Figure 2-2). Also, of the 81 systems, 47 systems had a single type of vulnerable component, 31 had two distinct vulnerable component types, and only 3 systems had at least one component of each type within a flood zone.

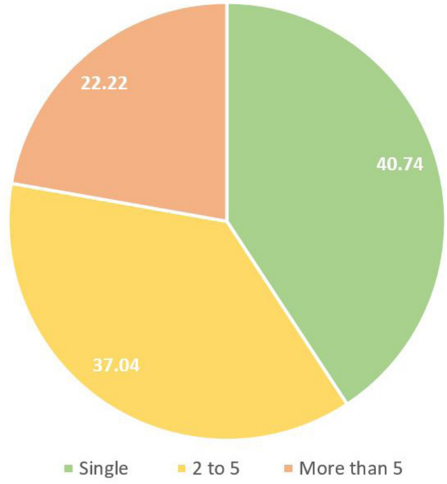


Figure 2-2 CWS total vulnerable components per system

NTNC system vulnerabilities were only associated with treatment plants and system wells. However, there was one system that was identified as vulnerable due to one single pump facility located in a flood zone. The total number of vulnerable components for NTNC systems is one to four, with most of the systems having only a single vulnerable component (27 out of 34 systems, or 79.4%). A total of 31 systems had a single vulnerable component type, and three systems had both a vulnerable treatment plant and system well.

For TNC systems, the number of vulnerable components also ranged from one to four with a majority of the systems having a single component in the flood zone (57 out of 70 systems, or 81.4%). Of the 70 systems with vulnerable components, 61 had a single component type, and nine have two components within a flood zone.

Analysis Validation

In order to validate these results, multiple efforts were made to align the GIS analysis with other data sources. First, Hurricane Irene (2011) and Hurricane Sandy (2012) GIS surge inundation data was acquired via FEMA and used for an additional overlay analysis. The use of these layers showed that four treatment plants and 23 system wells, corresponding with 14 PWSs, were inundated during these events. All but one of the 14 systems identified fell within a FEMA flood zone.

A second validation was done by identifying systems with a flood-related deficiency on a sanitary survey. This deficiency is defined as a situation when “there is physical evidence that the structure housing the well is or has been flooded.” The sanitary surveys spanned 1996 to 2016 and showed 90 S008 deficiencies, corresponding to 71 PWSs. Of these 71 PWSs, 10 (14.1%) were also identified as potentially vulnerable by the overlay analysis.

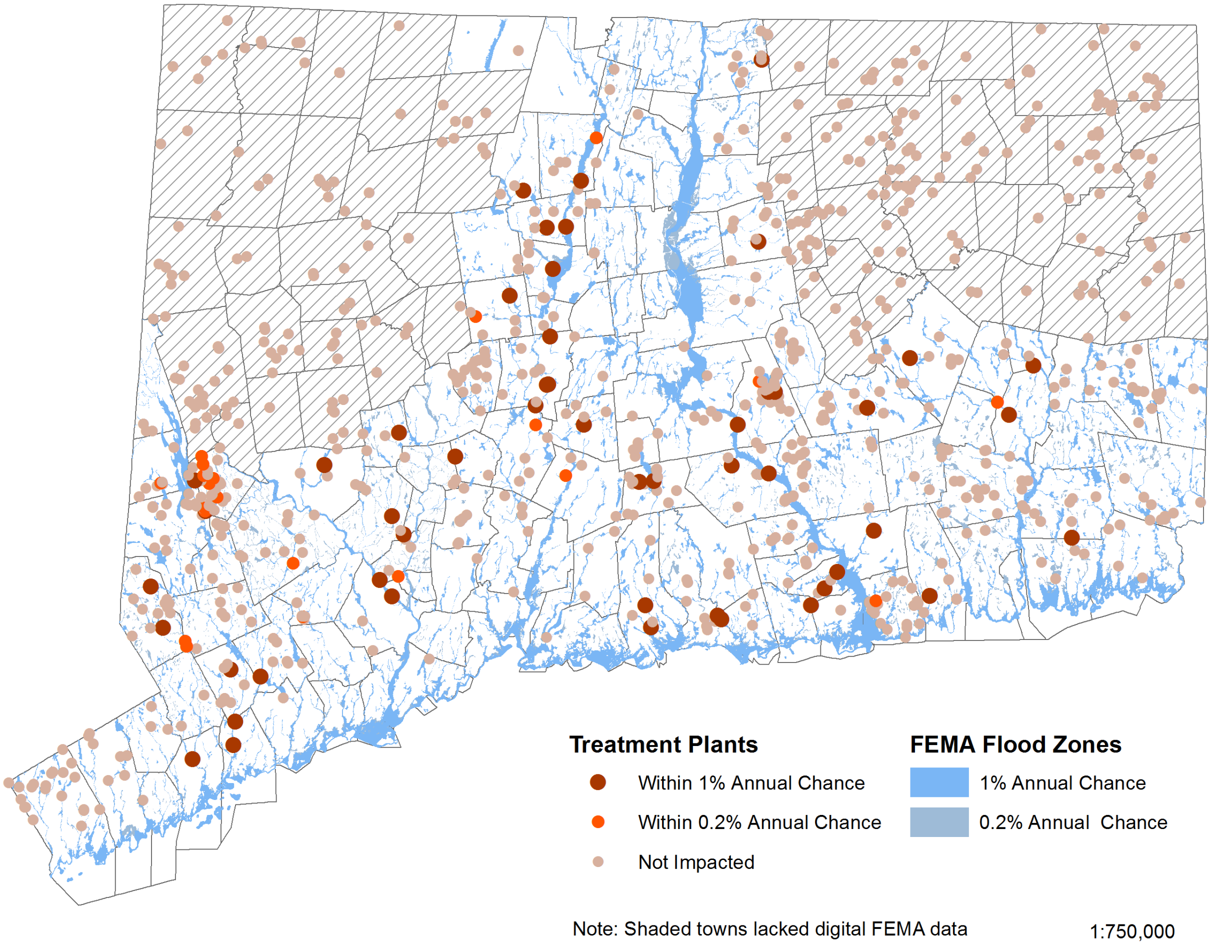


Figure 2-3 Treatment plants falling within FEMA flood zone

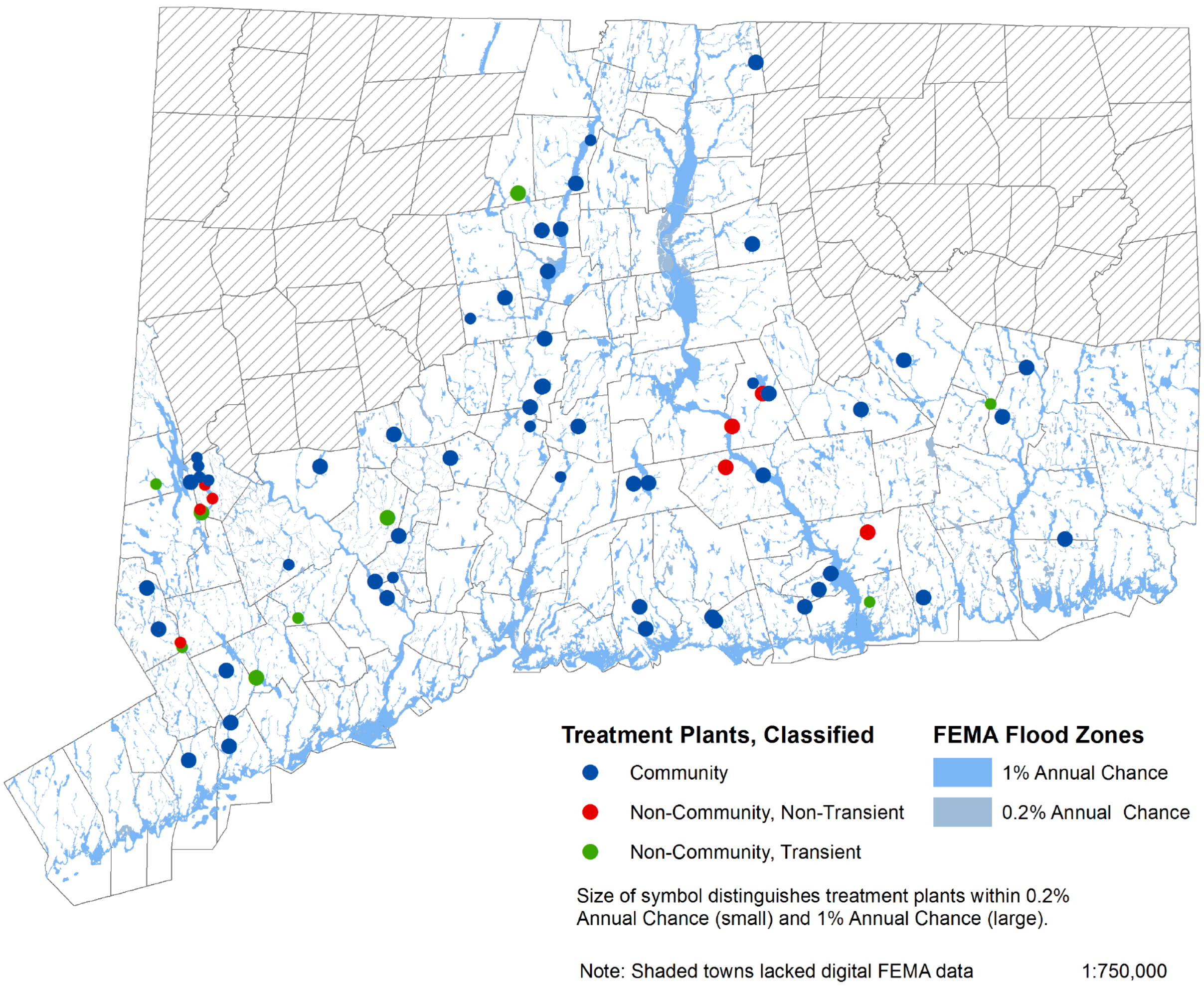


Figure 2-4 Treatment plants located within FEMA flood zones classified by system

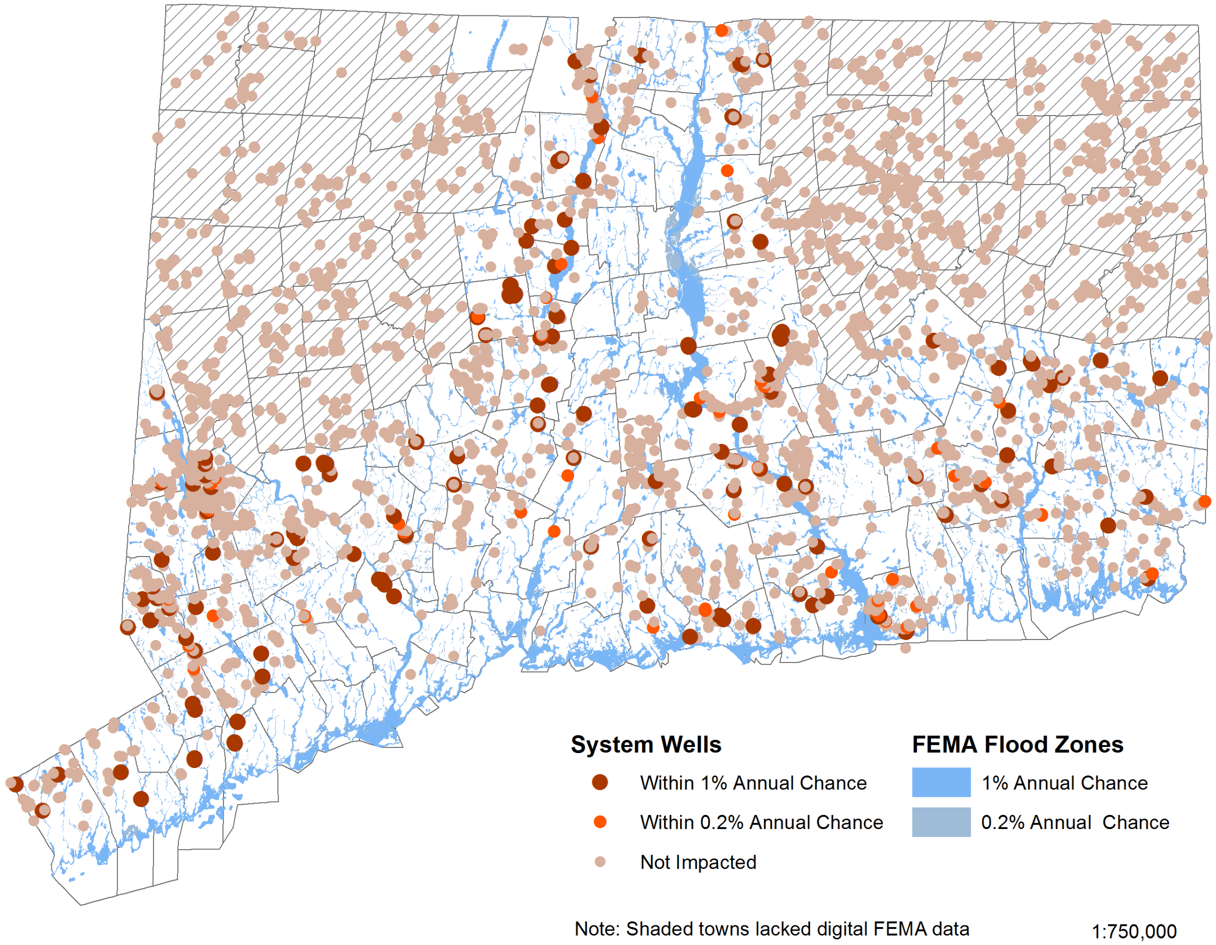


Figure 2-5 System wells falling within FEMA flood zone

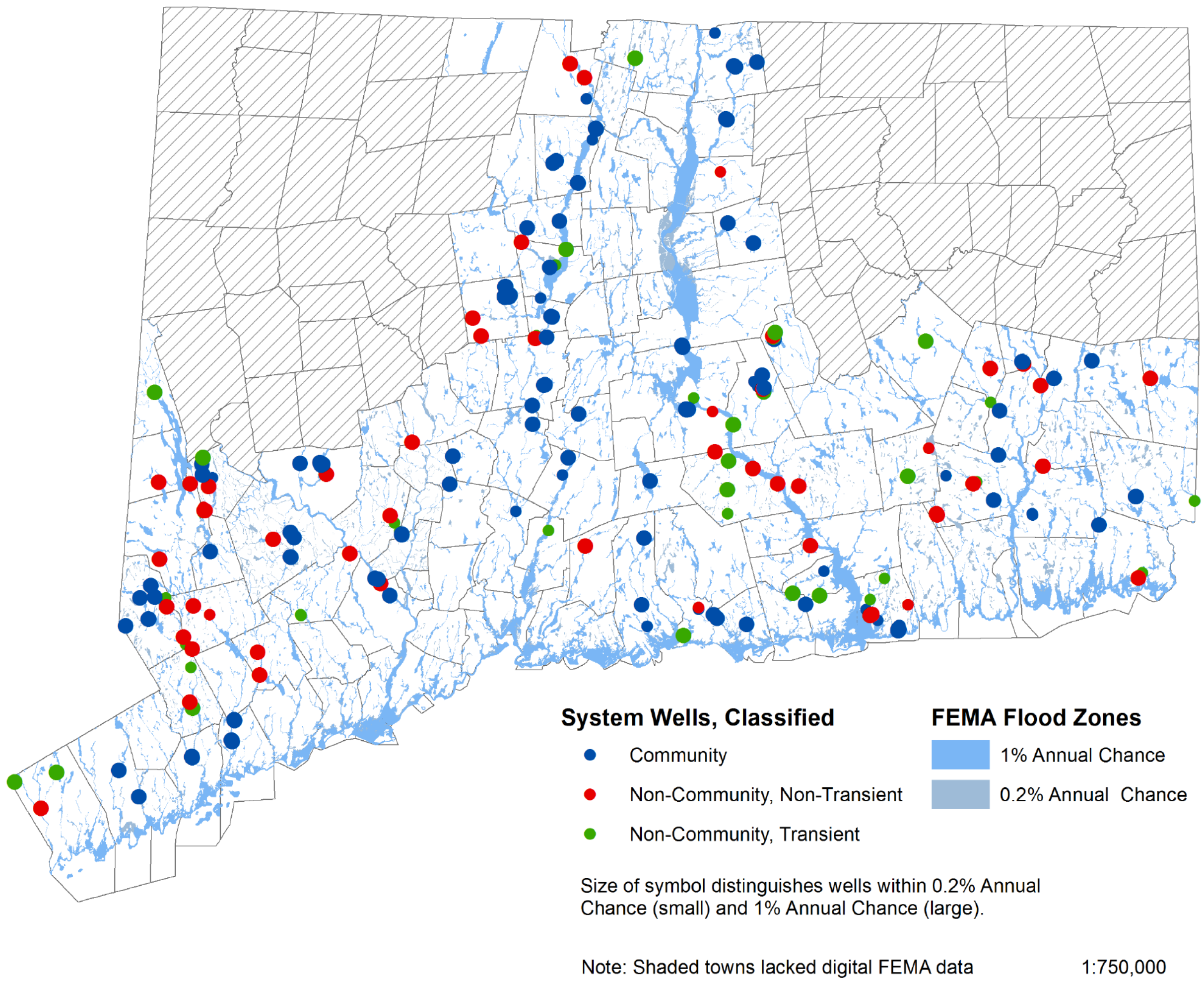


Figure 2-6 System wells located within FEMA flood zone classified by system type

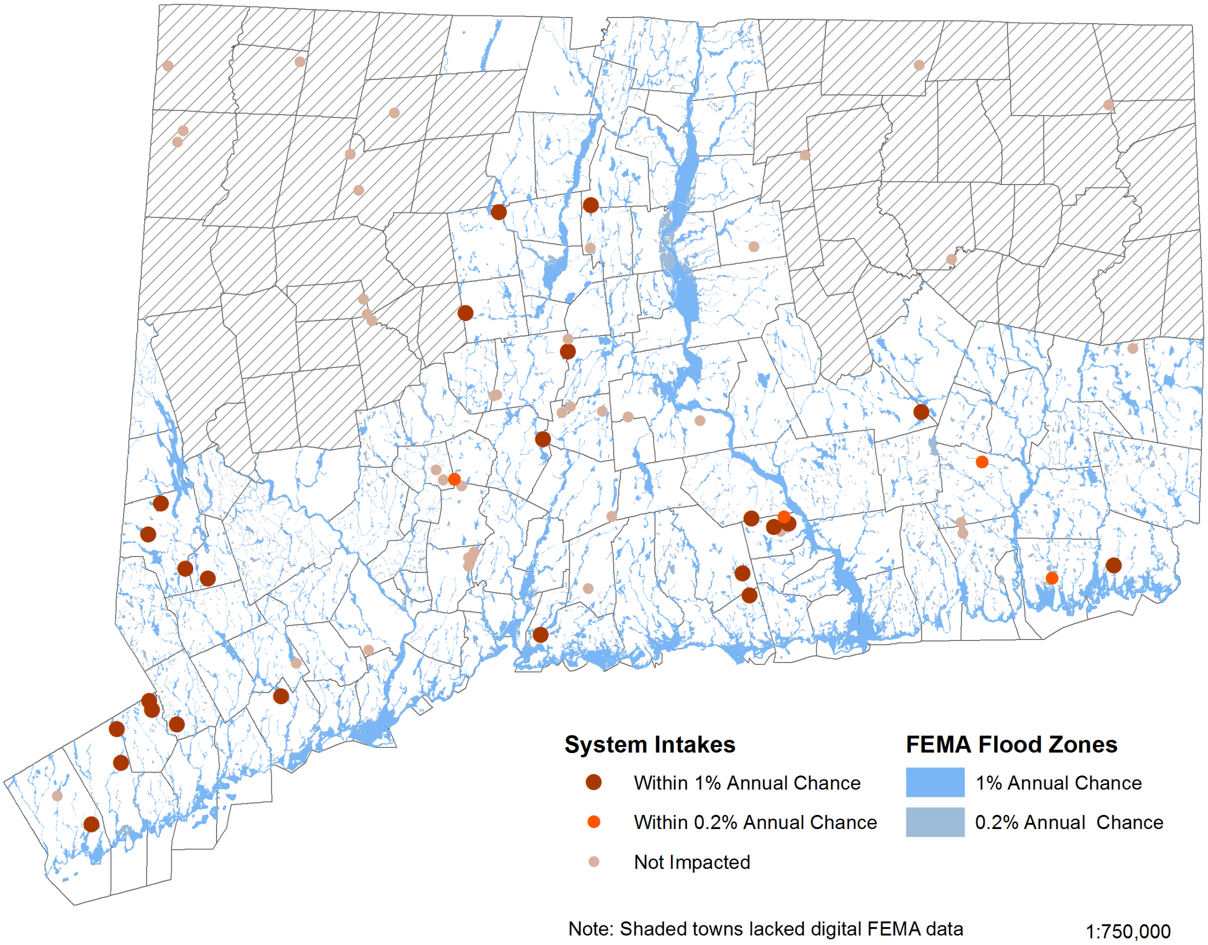


Figure 2-7 System intakes falling within FEMA flood zone

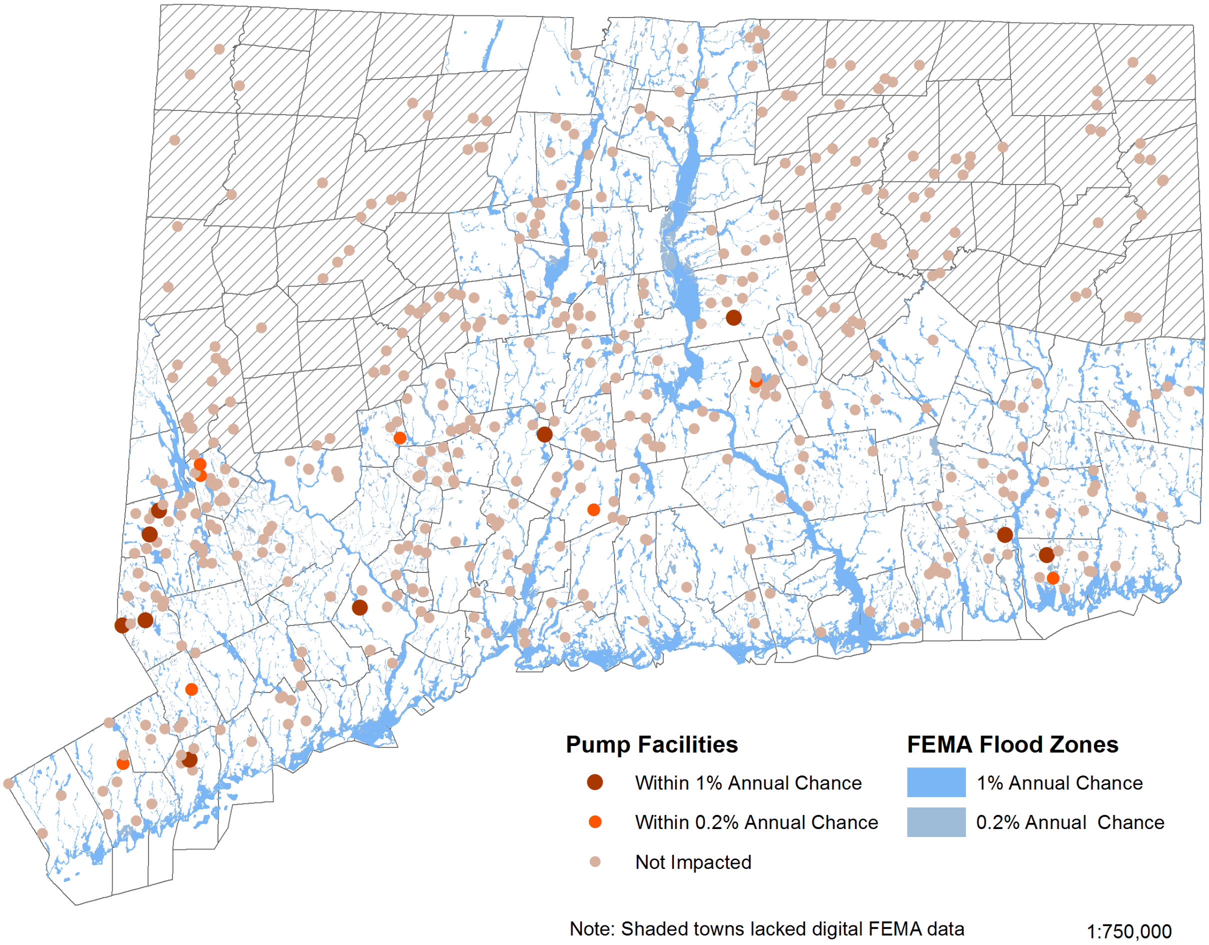


Figure 2-8 Pump facilities falling within FEMA flood zone

Finally, CWS survey results were compared to the CWS vulnerable components analysis. The CWS surveys showed that approximately 12% of the 85 respondents have experienced flooding in the past. The GIS overlay resulted in 81 of the 515 CWSs to be vulnerable, or 15.7%. While 15.7% is comparable to 12%, the overlay analysis did result in a slightly larger estimate of potentially vulnerable systems.

There are also certain limitations to consider regarding this analysis. A systems components location was based on a horizontal position (x, y location) with no vertical position, or elevation data, of the system components. Also, the analysis was restricted to five of the state's eight counties due to the lack of delineated FEMA flood zone GIS data for Tolland, Litchfield, and Windham counties. The analysis also assumes no positional errors in the GIS layers. Finally, due to the lack of elevation data for system components and the uncertainty associated with the delineated flood boundaries, the analysis is more likely to identify a component as potentially at risk rather than what might be observed during a flooding event. These results should be interpreted as a broad and more cautious estimate of potentially at-risk PWSs, particularly when considering the results of the validation efforts. Additional site-specific analysis of these systems is recommended to better evaluate specific flood risks.

Public Water Supply Well Vulnerability for Community Water Systems

As a supplement to the analysis described above, CWS wells were identified according to location within the Special Flood Hazard Area, or 1% annual chance, and 0.2% annual chance floodplains (more commonly known as the 100-year and 500-year floodplains, respectively). These wells were listed in a spreadsheet (Appendix F) and organized by Public Water System Identification (PWSID). The most recent WSP and sanitary survey for each utility were then reviewed to identify whether flood mitigation measures had been taken to protect water supply wells. This review was constrained to systems in the four coastal counties.

Bedrock well in 500-year floodplain.
Photo by MMI.

Most wells located in floodplains belong to large community systems. This is simply because some of the most productive locations for water withdrawal are along rivers and streams. Consequently, most small CWSs belong to condominium complexes, housing communities, and other buildings, which are typically located outside of the floodplain and which typically develop wells in close proximity to the facilities served rather than further away along rivers and streams. According to the mapping, 93 community wells exist in the 1% annual chance floodplain in the four coastal counties, and another 27 wells exist in the 0.2% annual chance floodplain.

Modern regulations require well casings to extend upward above the elevation of the 1% annual chance flood; however, many production wells were constructed before FEMA flood mapping was established. Although there are no historical regulatory requirements regarding existing wells in the 0.2% annual chance floodplain, new wells would be considered critical activities if state funding (such as DWSRF) is used. Therefore, state statutes would require that they be protected to the 0.2% annual chance flood elevation under state statute in existence through 2017 and higher than the 0.2% flood elevation beginning in existence after Public Act 18-82. In addition, climactic conditions and land cover changes could mean that the 0.2% annual chance storm becomes a more frequent occurrence in the near future. This makes the 0.2% annual chance floodplain an emerging concern for water utilities.

Many well casings within the 1% annual chance floodplains have been extended up above grade, have watertight turbine pump seals, or are enclosed in watertight structures. These measures provide some resilience to flooding although the optimal approach is to raise both the top of the well casing and the entire pump house well above the 1% annual chance flood elevation or 0.2% annual chance flood elevation. Some utilities had no flood protection for the wells and simply included well shutdown and decontamination as part of their ECP. Often, utilities that used this approach had other sources that were located outside of the 1% annual chance floodplain, providing some redundancy. Some utilities did not appear to acknowledge that some of their wells were within the 1% annual chance floodplain in the WSPs or sanitary surveys despite mapping to the contrary.

Flood mitigation efforts for wells located in the 0.2% annual chance floodplain (but outside the 1% annual chance floodplain) were not typically identified in WSPs or sanitary surveys. In a few cases, it was noted that access roads to the well house could be inaccessible during flooding events.

2.4.5 Potential Impact of Climate Change

Climate change is being modeled on a global and local scale. Two recent local climate change analyses were performed for the State of Connecticut. An analysis conducted by the University of Connecticut (UCONN) was done specifically for the purposes of the DWVARP to identify future risk to drinking water systems. A second analysis, conducted by CDM Smith, was done to augment the Connecticut SWP.

UCONN Analysis
A Preliminary Report on Climate Change Projections has been developed by Dr. Guiling Wang in the Department of Civil and Environmental Engineering. The report notes the lack of spatial resolution in the latest U.S. Climate Assessment, categorizing much of the Northeast U.S. into one category. At this stage, scientific evidence is not clear whether significant local variations exist; therefore, the report utilizes the MACAv2-METDATA, version two of the Multivariate Adaptive Constructed Analogs (MACA) database for high resolution (4 km). This contrasts with the U.S. National Assessment, which was based on the Localized Constructed Analogs (LOCA) database, with 6 km resolution.

Six models were utilized to formulate climate change projection in the UCONN report. The models were chosen "based on genealogy (Knutti et al., 2013), global climate sensitivity (Miao et al., 2013), climate sensitivity for the Connecticut area, and overall performance in simulating present-day climate based on assessment for multiple regions of the world (Sheffield et al., 2013; Miao et al., 2013; McSweeney et al., 2015)." The range of model lineage and inputs helped formulate a more diverse range of reasonable outputs. The climate outputs (Appendix G) for the future climates are generally based on midcentury projections, in the 2041-2070 range.

The primary results of the UConn study are the following:

- <u>Changes Related to Flood Risks</u> – The frequency deviation across all common return intervals (5, 10, 20, 50, and 100 years) was analyzed. Only one model, the MRI, projected a daily maximum precipitation (DMP) increase of less than 50% for all return periods. The remaining five models all project that the DMP will increase greater than 50% for all return periods, with the exact percent increase growing with return period. This means that the flood risk is projected to rise dramatically for all return periods but even more so for the larger return periods. For example, while 20-year DMP events can now be expected every 5 to 10 years, past 100-year events can now be expected every 10 to 50 years.

  The models also support the notion that a greater percentage of precipitation will fall in the form of heavy precipitation (>99th percentile) events, from a historical average of 15%, to 17%-25% in future climate (years 2041 to 2070). An additional 1 to 3 days per year of >1 inch precipitation events can also be expected in the future climate scenario.

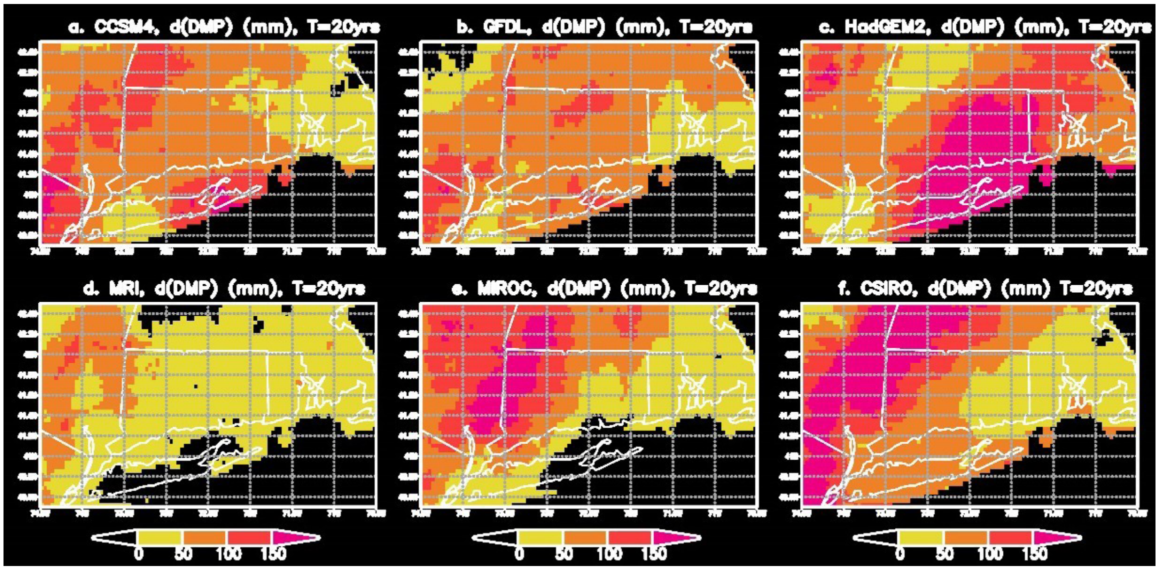


Figure 2-9 Future changes in 1-in-20 years DMP projected by the six global climate models (GCMs) for Connecticut and surrounding areas. Color shading indicates an increase in the extreme daily precipitation magnitude; in unshaded areas over land, the extreme precipitation is projected to decrease.

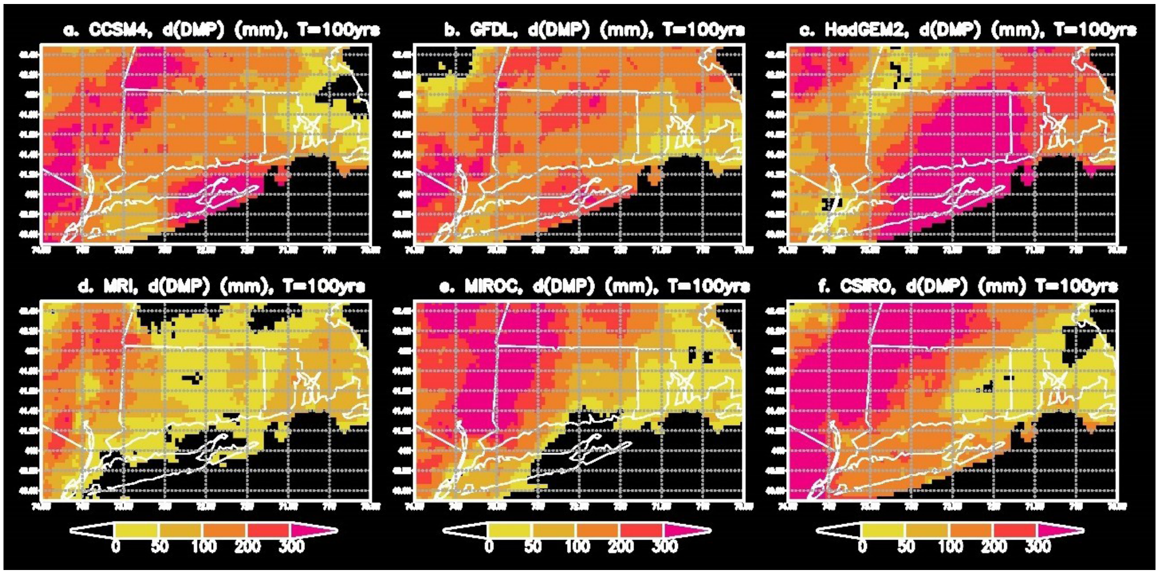


Figure 2-10 Projected future changes in 1-in-100-years DMP (in mm). Color shading indicates an increase in the extreme daily precipitation magnitude; in unshaded areas over land, the extreme daily precipitation is projected to decrease.

- Changes Related to Drought Risks – While each of the six models used in the study predicted an increase in annual precipitation, this was offset by a lower timing of heavy precipitation events and increased potential evapotranspiration (PET) from warming temperatures. As a consensus, the models predict slight changes in precipitation in the summer months and increases during the winter months. This means that as summer PET increases, precipitation will stagnate. The relationship of precipitation to PET (P-PET) is known as the potential water availability. This is expected to drop during the summer months. There is a high degree of uncertainty with the models in how climate change will affect the duration of droughts; therefore, follow-up studies are required in this area.

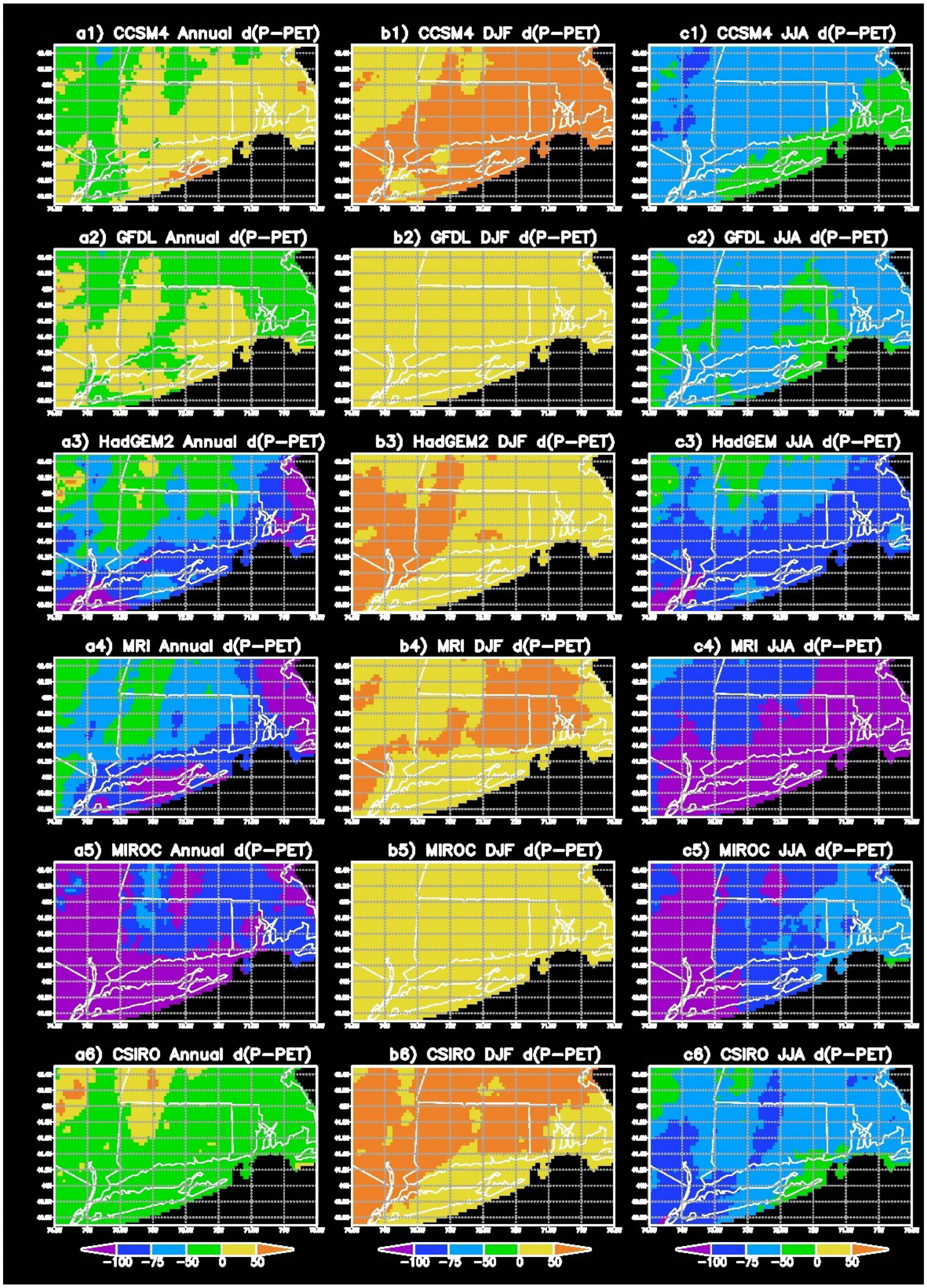


Figure 2-11 Projected future changes in water availability (as defined by P-PET)

Climate Change Impacts on Algal Blooms

In-situ reservoir water quality depth profile data (from 2003 to 2017) from six inland reservoirs in southeastern Connecticut were obtained. Changes in temperature, dissolved oxygen, specific conductivity, chlorophyll-a fluorescence (i.e., indicator of total algal biomass), and phycocyanin fluorescence (i.e., indicator of cyanobacterial biomass) were analyzed. Additionally, historical (i.e., 1980-2017) and statistically downscaled air temperature data (i.e., over land at 4 km resolution) from the MACAv2-METDATA dataset[11] was used in conjunction with water quality data. Models that project past and future surface water temperature and thermal stability using air temperature data alone were developed. Air temperature data was produced through applying the MACA statistical downscaling approach to the daily output from 20 Coupled Model Inter-Comparison Project 5 global climate models for both the RCP 4.5 and 8.5 scenarios during 2005-2099[12]. Analysis of this dataset found that six of these models capture the full range of uncertainties in climate sensitivity for the state of Connecticut. Downscaled data from the same six models were used to derive the past and future daily air temperature (i.e., 1971-2000 and 2041-2070) at the locations corresponding to each reservoir. This data was used to forecast surface water temperature and total relative thermal resistance to mixing (RTRM) under various climate warming scenarios.

Climate warming is changing lake conditions by increasing surface dissolved oxygen percent saturation, surface water temperature, thermal stability, and specific conductivity.

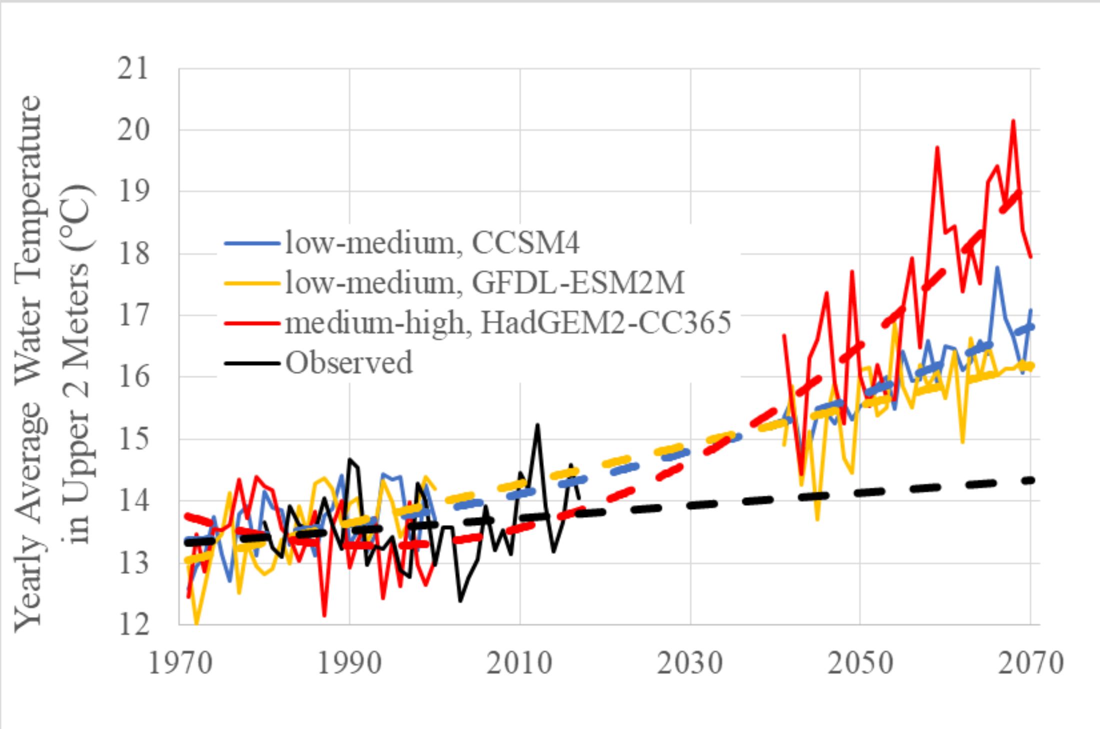


Figure 2-12 Observed and modeled past and future surface water temperature in a small, shallow Connecticut lake show water temperature is increasing.

11 METDATA dataset available at: http://maca.northwestknowledge.net/

12 Abatzoglou and Brown. *Int. J. Climatol.* 32, 772–780 (2011)

Climate projections suggest that surface water temperature (i.e., average of the upper 2 meters) and total RTRM will increase throughout the year (see Figure 2-13, upper and lower panels, respectively). This means lakes are becoming warmer and more thermally stable. The number of days a year with extreme surface water temperatures is also increasing.

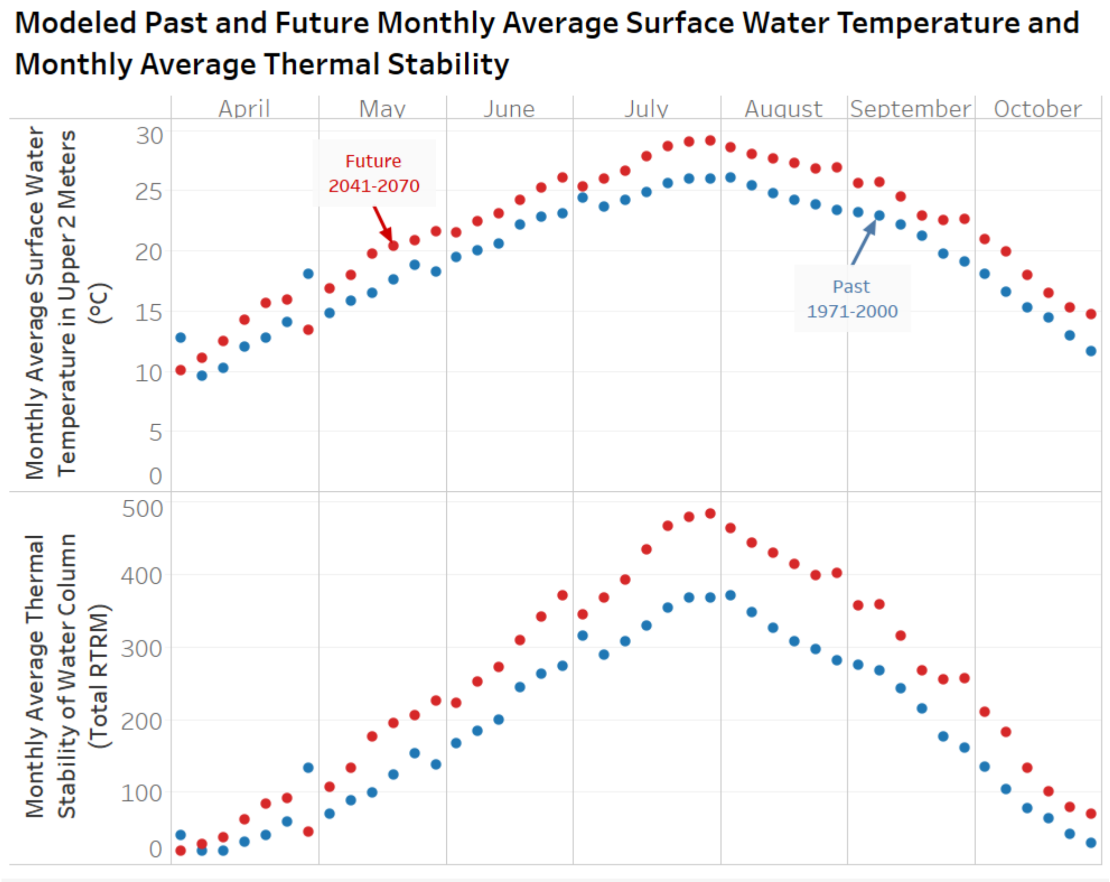
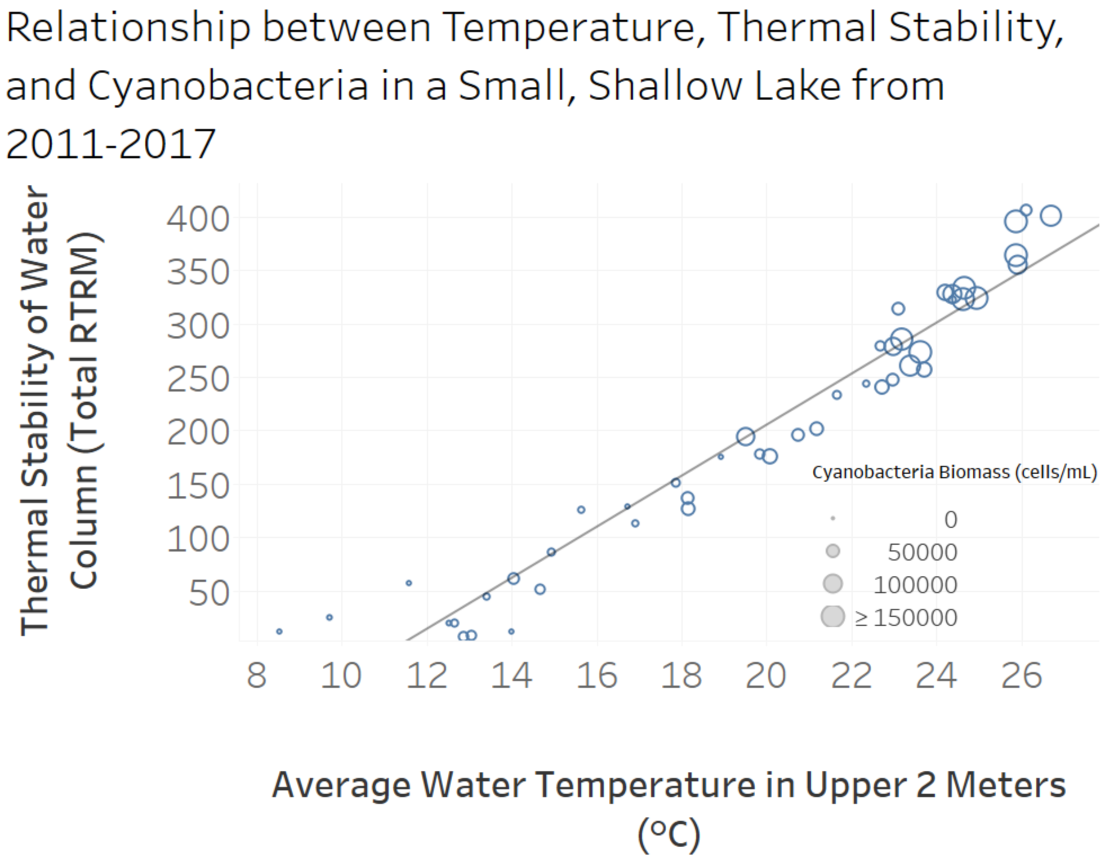


Figure 2-13 Top panel, comparison of past surface water temperature (1971-2000) to future surface water temperature (2041-2070), shows surface water temperatures are projected to be warmer across the year at mid century. Bottom panel, comparison of past RTRM (1971-2000) to future RTRM (2041-2070), shows thermal stability is projected to increase across the year at mid century.

Dissolved oxygen solubility decreases with increasing temperature, so since we are seeing an increase in surface dissolved oxygen percent saturation even though surface water temperature is warming, this means there is increased algal growth in all the reservoirs. Figure 2-14 shows the relationship between temperature, thermal stability, and cyanobacteria biomass. Too much algal productivity can lead to eutrophication and hypoxia, both of which are associated with source water quality and treatment issues. Moreover, warmer, more stable lakes are more vulnerable to harmful or toxic algal blooms, and we anticipate that cyanobacteria blooms will occur more often in the future



as the climate continues to warm, especially in lakes where they are already a concern.

Figure 2-14 Example of relationship between temperature, thermal stability, and cyanobacteria from 2011 – 2017 for a small, shallow lake that currently experiences algal blooms

State Water Plan Analysis

The climate change analysis for the Connecticut SWP was prepared by CDM Smith. This analysis utilized a range of GCMs, with a spatial resolution of 1/8 degree grid, which is approximately 70 square miles.

The climate models generally show a hotter and wetter future, with annual temperature changes for 2080 ranging from approximately +0.5 ˚C to + 6.5 ˚C, as well as mean annual precipitation changes ranging from approximately -5% to +30%, with a majority of the projections showing an increase.

The hybrid delta ensemble (HDe) results compare historical data to a dataset adjusted for 2080. The output includes monthly time series plots of the following:

- Average temperature and total precipitation: raw output and month-to-month variability
- Mean monthly temperature and precipitation bar charts: projected seasonal changes
- Monthly temperature and precipitation percentile plots: full range of projected changes

All ensembles project a consistent increase in temperature for all calendar months. However, precipitation projections are more variable but generally show an increase for all four seasons. Winter and spring changes are projected to be higher than summer and autumn changes. The projections also show minimal changes regarding drier months in terms of frequency and rainfall level.

The projections translate into changes in future water availability. The results imply there is potential for water loss due to rising temperatures and evapotranspiration loss. However, a projected increase in rainfall, which is not consistently distributed throughout the year, could potentially offset this temperature increase. The changes in rainfall frequency could affect both droughts and flooding potential. Climate forecasts do tend to associate the coupled increases with more frequent and intense storms and longer dry periods during the summer months.

The smaller reservoirs found in Connecticut may be sensitive to these changes, and demand could also be impacted. The projected increase in temperatures may result in a rise in demand; however, again, the increase in precipitation could offset this demand. The conclusion is also drawn that water availability and stream flows will be impacted due to less snow pack and an earlier melt. The rapid snowmelt, in conjunction with higher extreme precipitation, could potentially result in increased flooding risk. Also, river water quality could potentially be negatively impacted due to the impacts of increased temperatures such as increased bacteria and algae growth rates or lower dissolved oxygen saturation levels.

The SWP analysis also translated the climate change projections into stream flow projections to provide insight into potential surface water availability. The same methods were used as the climate change projections but with a planning horizon of 2040. The approach applied "gridded runoff" projections, which were developed by incorporating temperature and precipitation projections for the year 2040 into a rainfall-runoff model.

The "hot/wet" climate scenario projects the largest increase in stream flow, with the largest increases projected for the winter months (December through February). Springtime stream flow is projected to either increase slightly or decrease significantly due to the dynamic of greater winter precipitation and reduced snow accumulation.

The "hot/dry" scenario projects a decrease in stream flow for a majority of spring, summer, and fall; however, these significant decreases are offset by the larger projected increases in winter precipitation. A percentile analysis indicates that the larger flow months will experience the largest increase while the lower flow months will experience a significantly smaller increase in flow, if any at all.

2.5 Assessment of Critical Assets of Small Community Water Systems

PWSs are comprised of sources of supply, transmission pipes or mains, storage facilities, pumping facilities, and distribution systems. Some PWSs also utilize treatment. Relative to storage, PWSs typically utilize some combination of atmospheric storage (water stored at ambient pressures) and/or pressurized storage unless storage is elevated and therefore provides pressure through elevation. PWSs that lack redundancy in sources, transmission, storage, or pumping are typically less resilient than PWSs that incorporate redundant critical assets.

PWS interconnections are physical connections between systems and are common in Connecticut. Many interconnections are used for active, daily transfer of water between systems whereas some are used for only emergency supply. Interconnections are useful tools for building redundancy of public water service in a community or region because water can be shared. An interconnection can be beneficial if a PWS lacks redundancy in sources, transmission, storage, or pumping.

There are approximately 160 small CWSs in the four southern Connecticut counties that are not affiliated with a large water utility such as Aquarion Water Company or Connecticut Water Company. While many small CWSs provide adequate or good quality service to their customers, they inherently lack the resources and redundancy of large community systems/water utilities. Small systems that are affiliated with large systems have access to an extensive inventory of parts and expertise, which are often not available to unaffiliated systems.

Small community systems serve as few as 25 individuals and as many as several hundred though most are small enough to operate only one source of supply. This means that nearly all parts of the water system (all assets) are critical in order to maintain consistent service, from the well and the well pump, to the storage tanks and boosters, to the distribution system. A component failure that could easily be replaced with the in-house inventory of a large system could require days of waiting and supply interruptions in a small, unaffiliated system. A failure of any of these components would, at the very least, provide an unacceptable level of service to customers. Failure of critical components would often cause a complete loss of supply. Due to the small size of these systems, there is often a lack of redundancy in sources of supply, infrastructure, power supply, or human resources. System components that may not be considered critical in a large system, like a single booster pump, distribution main, or source of supply, are often critical in a small system.

During the WUCC data collection process, unaffiliated small CWSs in the state were evaluated through the Capacity Assessment Tool (CAT) "scorecard," which considers economic, managerial, and system performance in the areas of technical, managerial, and financial capacity. While a low scorecard rating does not necessarily mean that a water system is in danger of failure, it does mean that there is a greater chance of system disruption in the future. Small systems with low ratings are considered the highest priority for determining the means to increase capacity, including interconnections if appropriate.

Appendix H contains an analysis of small CWS assets. Table H-1 in Appendix H (Small System Checklist) provides a yes/no inventory of the assets of the 157 small systems that were rated through the CAT. The table indicates whether each system has one or more wells, interconnections, booster pumping station, contact tank, atmospheric pressure storage tank, hydropneumatic storage tank, bladder storage, and/or treatment. All small community systems in Fairfield, New Haven, Middlesex, and New London Counties source their water from groundwater supply sources or interconnections with larger utilities.

Table H-2 in Appendix H (Critical Assets List) individually inventories all of these assets. The list indicates the critical assets in each system and provides a more detailed look at the types of critical assets within each system. Critical assets listed include groundwater supply sources, interconnections, booster pumps, contact tanks, atmospheric tanks, hydropneumatic tanks, bladder tanks, and treatment. Since all systems maintain a distribution system, this piece of critical infrastructure was not included in this list. The following are notable findings:

- Overall, just four systems maintained no storage at all. One such system is a consecutive system of Aquarion Water Company, meaning that it receives all of its water through a metered interconnection with a large Aquarion system.

- Just 11 systems maintain no source of active pressurized storage (hydropneumatic or bladder storage). Some of these 11 systems may have elevated atmospheric storage, which can provide some pressure by gravity. In the event of a power failure or loss of a supply source, most systems have at least some reserve water supply. The amount of pressure storage varies considerably, however, from multi-thousand-gallon hydropneumatic tanks to small 30-gallon bladder tanks.

- Approximately 57% of systems operate some type of water treatment system. Water treatment consists of pH adjustment, chlorination, or removal of dissolved materials such as iron or manganese. Although these systems are in place as a protective measure, they also can indicate a vulnerability as the water may not be potable in the event of a failure of the system.

- A few systems have interconnections to larger water utilities. While some are consecutive systems, there are at least two examples of systems that maintain their own source of supply and also have an interconnection with a large system. This arrangement provides significant redundancy and emergency protection for the small community system.

As a result of this assessment, multiple recommendations could be made. For example, those systems with no storage should be required to have some level of storage that is capable of being distributed throughout the service area. Also, it is apparent some systems utilize treatment; however, there are many that do not. Testing requirements should be altered for those systems that have no treatment as they could be at greater risk of water quality issues. In general, this comprehensive inventory of system assets provides a foundation for identifying those systems that are in need of redundancies to ensure minimal service disruptions.

2.6 Assessment of Critical Facilities Served by Community Water Systems

Critical facilities are integral to a community during emergencies and natural disasters; therefore, understanding which facilities are more vulnerable than others based on their relative water system is imperative to better serving a community during an event. For the purposes of the DWVARP, a critical facility may include an ambulance garage, care facility, city hall, community center, emergency medical services (EMS), EOC, fire department, hospital, police department, public works, school, shelter, and town hall. A comprehensive list of critical facilities used in this analysis can be found in Appendix I.

To assess potential vulnerability of critical facilities to a flood event in Connecticut's four coastal counties, a GIS analysis was conducted based on the assumption that if a PWS was potentially vulnerable to a flood event then all facilities served by that system were also potentially vulnerable. Each critical facility was linked to a PWS, and it was assumed that the system nearest to the facility was the water supplier.

It was noted that some critical facilities in fact had their own well, which they are responsible for maintaining and therefore are considered their own CWS and are not served by an outside system. A validation check was conducted to ensure that the critical facility and PWS shared the same name and that the identification of this system was correct. A key word search was conducted on PWS well names, stored as an attribute in the PWS spatial data layer. The following terms were searched for within a PWS well name:

- Academy
- School
- College
- University
- Community Center
- Safety
- Fire
- Police
- Town Hall
- Public Works
- Ambulance
- Health Care
- Hospital
- Nursing
- Rehab
- Elderly
- Manor
- Senior
- Assisted
- Medical

In total, 486 PWS wells were identified as having a well name that contained one of these key word phrases. The names of the 486 PWS wells were then manually compared against the names of the 1,617 priority critical facilities. When a critical facility name was matched to one of the flagged PWS well names, the PWS assignment based on the overlay analysis was checked. If the PWS assigned to the facility did not match the PWS well sharing the same name, the PWS assigned to the facility was edited to the matching PWS well. Thirty critical facilities were edited so that the closest PWS assigned corresponded to the PWS well of the same name.

Also, a CWS WSP priority customer list was used to compare to the GIS overlay analysis. Of the 597 priority customers, 144 appeared on the initial list of critical facilities. The PWS initially identified as a water supplier was compared to the supply plan list, and any discrepancies were manually corrected. A total of five facilities were edited, and 35 were changed as a result of the validation methods (2.2% of critical facilities).

Critical facility proximity was also compared to CWS component location. All facilities were linked to the nearest treatment plan, intake, and pump facility associated with the system determined to serve the critical facility. Without PWS flow network data, the analysis was based off the assumption that a facility was served by the nearest PWS component. If a PWS only had one component, such as only one treatment plant, that component was then associated with the critical facilities within the service area.

Of the 1,617 priority critical facilities, 1,291 were associated with a PWS identified as potentially vulnerable to a flood event (79.8%). Specifically, 1,281 critical facilities were associated with a potentially vulnerable CWS, four were associated with a potentially vulnerable TNC system, and six were associated with a potentially vulnerable NTNC system. When considering facility type, over 85% of the critical facilities classified as town halls (88.9%), care facilities (87.4%), and shelters (86.6%) in the four-county coastal region were associated with a PWS identified as potentially vulnerable to a flood event (Figure 2-15). The lowest percent of potentially vulnerable facilities by system type corresponded to critical facilities classified as city halls (59.6%), public works (71.8%), and community centers (72.2%).

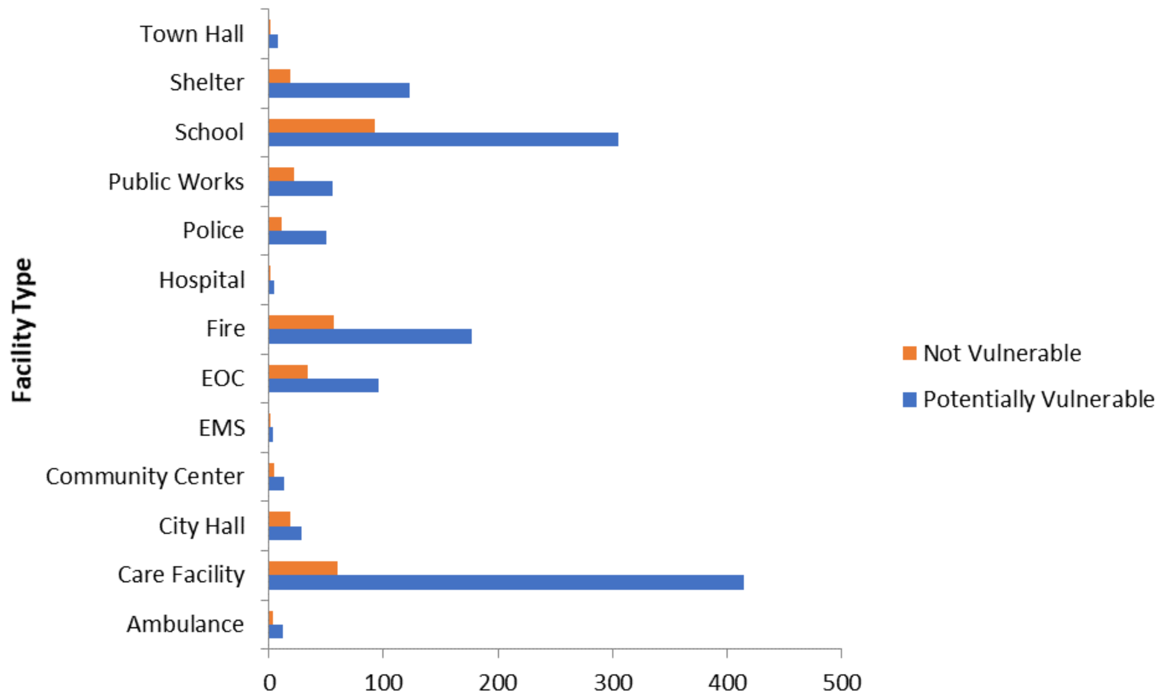


Figure 2-15 Number of Priority Critical Facilities

The 1,281 critical facilities associated with a potentially vulnerable CWS were linked to one of 30 CWSs, with the largest number of associated facilities corresponding to Aquarion Water Company of CT – Main System (490 facilities) and Regional Water Authority (264 facilities). The second-tier overlay analysis conducted for these 30 CWSs reduced the number of potentially vulnerable facilities from 1,291 to 912, a reduction of 29%. For example, 27 were associated with Meriden Water Division and classified as potentially vulnerable because the Meriden Water Division was identified as a potentially vulnerable CWS according to the critical asset assessment. After refining the association to consider the vulnerability classification of the closest treatment plant, intake, and pump facility to each critical facility, the number of potentially vulnerable facilities for the Meriden Water Division was reduced to 16.

Ultimately, given the complexities of the larger CWS regarding multiple sources of supply and pressure zones, more information is needed to further refine the level of risk of these 912 critical facilities served by CWSs. This could potentially be accomplished by larger water utilities by leveraging critical facilities lists as part of the water supply planning process.

2.7 Potential Infrastructure Upgrades to Encourage Regional Resiliency

For many small CWSs, installing additional supply sources or redundant infrastructure is not an option due to economic, environmental, or hydrologic factors. One way that small community systems can increase redundancy is to interconnect with other systems.

GIS mapping was used to identify small CWSs that could feasibly be interconnected. The distance from each small CWS to the nearest water system (small or larger) was analyzed. If the distance was under approximately 1,000 feet, an interconnection was deemed feasible. This distance was somewhat flexible as certain situations made longer distances potentially worthwhile to explore, such as the interconnection of particularly low-scoring systems. This exercise was focused on small systems in Fairfield, New Haven, Middlesex, and New London Counties as these are the primary target counties for the grant. However, the adjacent counties to the north (Litchfield, Hartford, Tolland, and Windham) were checked to verify whether the nearest small water system was located across the county line.

If the nearest water system to each small system was another small system, the distance to the nearest large system was mapped out as well. It is generally more desirable to connect small systems to large systems than to connect small systems to other small systems because large systems have inherent redundancies and greater resources. Again, this exercise was focused on systems in Fairfield, New Haven, Middlesex, and New London Counties as these are the primary target counties for the grant. However, the adjacent counties to the north were checked to verify whether the nearest large water system was located across the county line.

The following interconnection-related tables are provided in Appendix J as supporting documentation:

- Table J-1 is a copy of the tables included in the Water Supply Assessment reports completed for the three WUCC regions and adopted by the WUCCs in December 2016. This table identifies systems within 1,000 feet of one another, which are thereby assumed to be sufficiently close for potential interconnections. The table covers all systems, statewide, including those located in the four coastal counties where the grant focuses as well as the four northern counties. This information is included for the sake of consistency with previously published WUCC-related products. The table does not recommend any particular interconnections.

- Table J-2 lists the 93 small unaffiliated systems that could feasibly be interconnected to another system. The table lists the nearest PWS of any size and the nearest large system if applicable. In all cases, the nearest small or large system was in the same county or an adjacent southern county. This data was generated for this project using ArcGIS mapping.

- Table J-3 lists 78 potential interconnections that could be recommended to improve resiliency based on factors such as the CAT scores. To help draw these conclusions, this table includes key data from Tables J-1 and J-2 (described above), namely whether the system is characterized as having a "Single Well," "No Storage," "Only Bladder Storage," and/or "Hydro-Pneumatic Storage." The 78 interconnections in Table J-3 represent a subset of the 93 small systems listed in Table J-2.

- Table J-4 lists detailed information on the WUCC-derived potential interconnections between systems of any size (not only small systems). This data was originally generated for the WUCC project using ArcGIS mapping. Many of these potential interconnections have been mentioned in WSPs although they may seem excessively long or unnecessary in the context of resiliency. The table contains affiliated small system interconnections, unaffiliated small system interconnections, and large system interconnections. Also included in the table are the starting CWS, ending CWS, distance of interconnection, population served, elevation change throughout interconnection route, and other information. This information is included for the sake of consistency with ongoing draft WUCC-related products.

- Table J-5 lists potential interconnections between systems in the southern counties and systems in the northern counties. Many exceed 1,000 feet and are not likely to occur unless significant needs arise. Many of these potential interconnections have been mentioned in WSPs just like the interconnections in Table J-4.

The following are notable findings:

- Approximately 93 potential interconnections were identified between small unaffiliated systems and other CWSs.
- Approximately 40 potential interconnections were identified between small unaffiliated systems and large CWSs. These may be prioritized for interconnection funding subject to other funding factors.
- Approximately 40 potential interconnections are within 100 feet of the nearest system, with many systems directly adjacent. In areas where more than one interconnection is possible, consolidation of multiple systems may be appropriate.
- For many small CWSs, installing additional supply sources or redundant infrastructure (such as pumping stations, storage tanks, and other system upgrades) is not an option due to lack of available land, lack of space within facilities, and/or lack of funding. In these cases, interconnections are the best option for resilience.

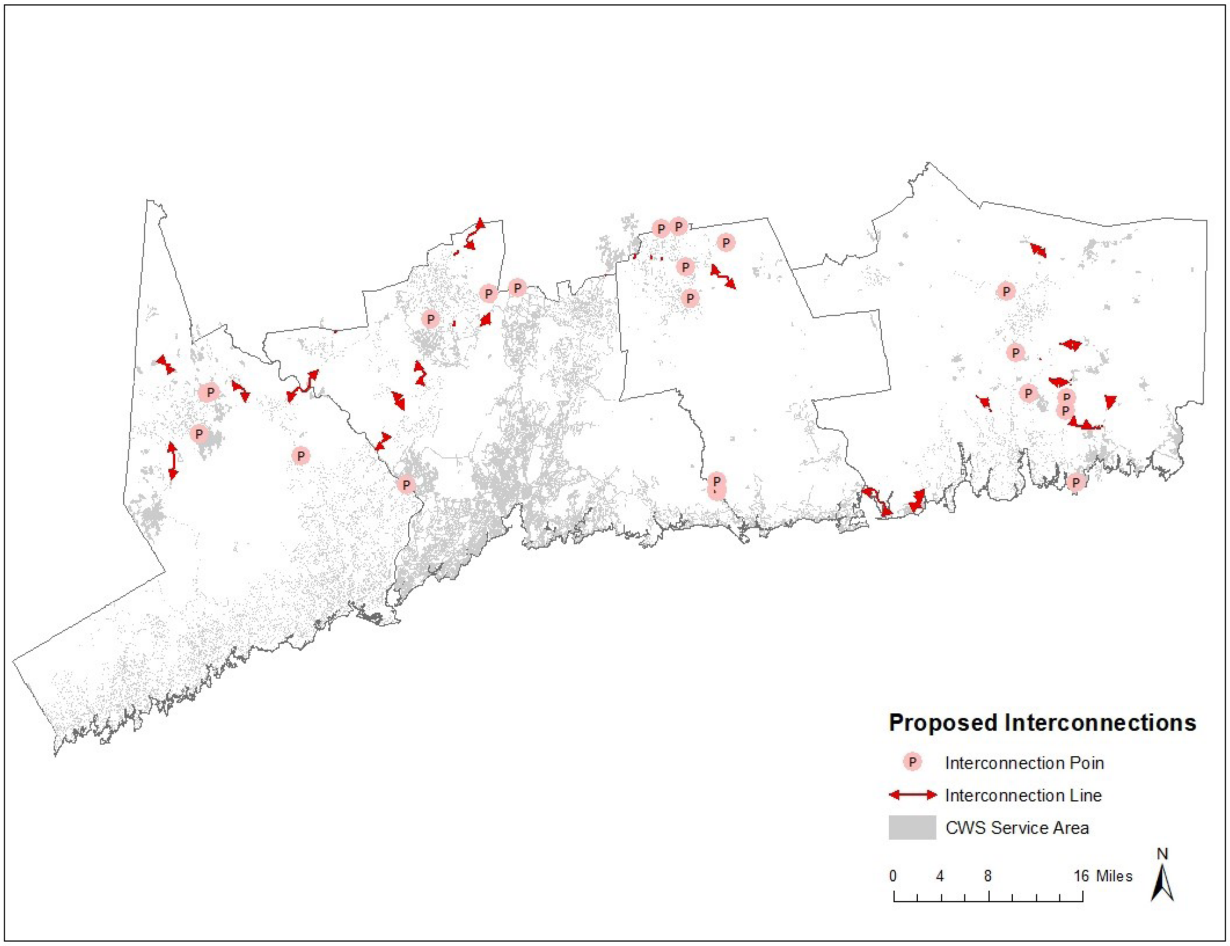


Figure 2-16 Proposed potential interconnections within the four coastal counties

3.0 Private Well Vulnerability And Risk Assessment

3.1 Private Well Vulnerability Assessment

Private well vulnerability across the state is a concern for DPH. Private well water quality is solely the well owner's responsibility and testing may not be done as often as recommended. DPH recommends private wells be tested annually. For example, some wells may only be tested as part of the purchase of a property and not retested until the property is sold such that there may be many years or even decades between water quality tests.

Some private wells have been constructed in flood zones and within proximity to the shoreline, resulting in flooding vulnerability from both coastal and riverine events. There is also the concern of saltwater intrusion to those wells located near Long Island Sound.

To better assess the vulnerability of these private wells throughout the four coastal counties, parcels suspected to be served by private wells were established and compared to FEMA flood zone maps. Larger neighborhoods that were assumed to rely on wells were identified, and specific recommendations were made to improve resiliency in that area. An analysis was also conducted on three coastal towns with a large number of coastal wells with recommendations made for these areas.

3.1.1 Private Well Identification Methodology

To establish the presumed locations of private wells, parcel data was collected for all towns across the four coastal counties of Fairfield, New Haven, Middlesex, and New London. This data was obtained from multiple sources including CT DEEP, COGs, and municipal GIS departments. To identify the parcels not serviced by a PWS, first the small PWS service areas were overlaid with the parcel data. Any parcel that was within the small PWS[13] service area was deleted; it is assumed these parcels are served by a PWS. Next, a 100-foot radius was placed around the large PWS[14] service area boundary, and any parcels that were within this buffer zone were also deleted. Again, this was assuming these parcels rely on public water and do not have a private well. This analysis resulted in 212,881 parcels outside of PWS service areas; however, not all parcels will actually have a well. Many of these parcels are open space.

13 Typically, a small PWS serves less than 1,000 and generally does not file WSPs; however, in this context, a small PWS is defined by the GIS data. A small system is defined by one large polygon representing its service area.

14 A large PWS is typically a system that serves over 1,000 and files WSPs. In this context, a large PWS was defined by the GIS data; a large PWS provided a pipes-in-the-ground layer, which is distinctly different than the small PWS layer.

Open space parcels throughout the four counties were identified to better establish the private well areas. Open space data layers were acquired from CT DEEP to overlay with the private well parcel data. These layers included DEEP property, federal open space, and municipal and private open space. By including these layers into the analysis, those parcels that were thought to have a private well were distinguished from those that are open space and likely have no well. Also, parcels over 100 acres were assessed for well location using satellite imagery. If one of these large parcels contained a residence, then the residence was cut from the remainder of the open space to better identify private well location.

By utilizing the available parcel data, open space data, and satellite imagery, an estimated 192,396 parcels in the four coastal counties contain a private well, 13,979 are open space parcels, 4,515 are municipal space parcels, 1,884 are DEEP property, and 107 parcels likely contain no well per health director comments[15]. Parcel data statistics can be found in Appendix K. These statistics include the parcel types, the total count of that parcel type in that town, the minimum and maximum acreage among that parcel type, the mean acreage of that parcel type, the sum of acreage for that parcel type, and standard deviation and range for acreage of that parcel type.

Local Directors of Health were contacted for their input on the private well task in March 2017. This email included a letter describing the project and asking for their input and knowledge of private wells in their town and vulnerabilities in these areas. Of the 52 towns and districts contacted, 33 did not respond to the invitation, and 11 delivered responses merely stating they had no data on wells, offering their well completion records, or providing reference to another source. The remaining eight districts gave minimal input on well location and available data. However, out of the eight health districts or departments to offer input, Fairfield was the only town to offer a GIS layer representing private well parcels.

All Health Directors were again contacted in September 2017 via email. This email included a letter describing the results of the analysis and maps of their respective town or district. These maps showed the assumed private well parcels, along with an overlay of the FEMA flood zone. This email invited all directors to provide comment on the accuracy of the maps or to give input on any flood areas within their respective towns. Of those contacted, 10 directors replied. Six of these replies were informative and were incorporated in some way into the maps, and four responses were general confirmation of the map or merely indicated interest in the project.

15 The Darien Health Department Director, David Knauf, informed that "private well parcels" south of Interstate 95 were likely served by a PWS and were not relying on a private well.

3.1.2 Flood Mapping Results

Four-County Vulnerability Assessment

A vulnerability assessment was conducted on the four coastal counties' assumed private well locations. Because the FEMA flood hazard maps are the most comprehensive flood risk maps for the state and also provide the regulatory basis for actions within or involving floodplains, these maps were used to identify those areas of concern. The FEMA flood hazard area was compared to the assumed private well map. By analyzing the maps, areas that were both within the FEMA flood zone and had high concentrations of well parcels were identified. These areas were also compared to the repetitive loss (RL) property list available from CT DEEP. The RL list was used simply as a barometer of flood risk and flood damage; the study acknowledges that not all property owners maintain flood insurance or make claims after damage occurs.

After assessing the flood zones and satellite imagery confirmation, 12 clusters of private wells were identified and grouped into 12 corresponding vulnerable areas or neighborhoods (Table 3-1).

Table 3-1
Neighborhoods identified as vulnerable regarding private wells

Vulnerable neighborhood/area	Town
Flood Bridge Road	Southbury
Hopeville Pond	Griswold
Sandy Hook	Newtown
Saugatuck River	Weston
Saugatuck River	Westport
Meadowbrook Manor	Brookfield
West Lake & Clear Lake	Guilford & North Branford
Rogers Lake	Old Lyme
Little Meadow Road	Haddam
Hop Brook & Long Swamp Brook	Middlebury
Housatonic River	Oxford
Downtown West Redding	Redding

Flood Bridge Road Neighborhood

There is a small row of houses off Flood Bridge Road in Southbury that are each likely reliant on a private well that may be vulnerable to flooding. These homes are near the Pomperaug River, northwest of Main Street south. There is also a section of Riverhill Road that is vulnerable to flooding from the river. These homes are located north of the Flood Bridge Road homes. There are six RL properties on Flood Bridge Road. The Heritage Village Water Company has a water line that runs adjacent to this vulnerable area on Main Street South, less than 0.5 miles away.

Hopeville Pond

Mallard Point in Griswold is situated east of Hopeville Pond. Here there are multiple homes located within the FEMA flood zone. There are no known RL properties within the area. The nearest drinking water system is Jewett City Water Company, and it is approximately 0.5 miles southwest of the vulnerable neighborhood.

Sandy Hook

South of the Shepaug Hydro Station along the Housatonic River, there is a neighborhood in Sandy Hook that lies within the flood zone and is assumed to rely on private wells. The vulnerable area extends from Housatonic Drive to Hull Road and includes multiple homes. There are three known RL properties within this vulnerable neighborhood. The nearest PWS is Oakdale Manor Water Association, which is approximately 1.25 miles away. Heritage Village Water Company also has a water main approximately 2 miles away but is unable to serve the Sandy Hook area. Aquarion Water Company's Newtown System is approximately 2 miles away.

Saugatuck River, Weston

A small cluster of houses west of the Saugatuck River off Colony Road, Fern Valley Road, and Lyons Plain Road in Weston lies within the FEMA flood hazard area and is vulnerable to private well flooding. There is at least one known RL property within this area. Weston Water Supply lies approximately 1.25 miles northwest of the neighborhood, and Aquarion Water has a main approximately 1.75 miles southeast of the neighborhood.

Saugatuck River, Westport

East of the Saugatuck River, there are homes vulnerable to well flooding on Riverfield Drive and Tuck Lane. These homes lie just north of the Saugatuck and Aspetuck Rivers' convergence point. With rivers to both the east and west, private wells located here are at risk of flooding. There are at least three known RL properties within this flood hazard area. Aquarion Water has a water main running along Coleytown Road approximately 0.25 miles from this vulnerable neighborhood.

Meadowbrook Manor

This neighborhood is located west of Route 7 and distant from the Still River and is a good example of a flooding issue without the neighborhood being in a mapped FEMA flood zone. A drainage project to alleviate flooding has been implemented in this area. There were no known RL properties found in this neighborhood.

West Lake and Clear Lake

This vulnerable area extends from Clear Lake, which partially lies within North Branford, east toward West Lake, which is in Guilford. The flood zone surrounding Clear Lake extends along the north shore up Clear Lake Road and Clear Lake Manor Road. The FEMA flood zone is contiguous with the West Lake flood zone, which shows a vulnerable residential area along the northwestern shore, including Putzel Avenue and Flat Iron Road, and extending northeast down Williams Drive and Cardinal Drive. This area has a large residential presence within the FEMA flood zone; however, no known RL properties were found here. There is also a smaller area of concern along the southeastern shore of West Lake on Shore Drive, where there is a row of homes located partially within the flood zone. There is one known RL property located in this area. Regional Water Authority appears to have water mains running less than 0.25 miles east of the vulnerable Clear Lake neighborhoods. Connecticut Water Company's Guilford System has a water main approximately 0.5 to 1.5 miles from the vulnerable neighborhoods along the northern coast and roughly 0.25 miles from the neighborhood along the southeast.

Rogers Lake

Cranberry Bottoms neighborhood in Old Lyme is located southwest of Rogers Lake. This neighborhood is also home to the Cranberry Bottoms Stream. This stream runs through a FEMA flood zone, which includes multiple homes that are vulnerable to private well flooding. The roads engulfed in this zone are Beta Avenue, Gamma Avenue, Delta Avenue, and Epsilon Avenue. The nearest PWS is Lymewood Elderly Housing, which is a little over a mile away, and East Lyme Water and Sewer Commission has a line approximately 2.5 miles away from the vulnerable neighborhood.

Little Meadow Road

Little Meadow Road is located on the western bank of the Connecticut River in Haddam. This road has multiple homes that are in close proximity to the river and are within the FEMA flood zone. This neighborhood, located just south of Eagle Landing State Park, likely relies on private wells for its water source and is vulnerable to riverine flooding. There is one known RL property in this vulnerable area and three others within 0.5 miles outside of this road but within the same flood zone. The nearest CWS, Saybrook at Haddam, is approximately 1 mile away from this neighborhood, and the nearest large CWS is Connecticut Water Company Shoreline Region Chester System, which is approximately 2 miles away.

Hop Brook and Long Swamp Brook

There is a row of homes located on Regan Road in Middlebury that lies between Hop Brook and Long Swamp Brook. These homes are in the FEMA flood zone and are vulnerable to private well flooding. There is one known RL property within this area of concern. Connecticut Water Company's Naugatuck Region Central System has a water main less than 0.25 miles along CT Route 188.

Housatonic River

Less than 1 mile south of Lake Zoar along the eastern bank of the Housatonic River is a flooding area of concern. This area stretches roughly 0.5 miles along Route 34. There are three known RL properties that are located within this flood zone and four others located just outside of the flood zone. The Aquarion Water Company – Hawkstone System is located about 0.5 miles from this vulnerable area.

Downtown West Redding

This area of concern was identified by the Redding Health Officer, Douglas Hartline. The downtown west Redding area is surrounded by the Saugatuck River, Bogus Mountain Brook, and Blackmans Pond Brook. The center of this area of concern is at the intersection of Umpawaug Road, Redding Road, and Station Road. The area extends northwest to Sidecut Road, and there is also a small neighborhood on Long Ridge Road that appears to be a combination of residential and commercial but is still located in the flood zone. While this area of concern is widely spread, it has been noted that seasonal flooding is a problem, and there are in fact private wells located throughout the area. There are no known RL properties located in this vulnerable neighborhood. Bethel Water Department is located about 2 miles from the downtown west Redding area, and the Aquarion Water Ridgefield System is about 2.5 miles from the area.

While these neighborhoods have been identified with the utilization of FEMA flood mapping, it does not necessarily mean there are no other areas of concern throughout the four counties. With risks changing due to climate change effects, there may be areas that are vulnerable to future conditions that have not been identified with current spatial data. Due to these changing risks, vulnerability assessments on private wells should be an ongoing venture whether it be at the state or local level or even by the homeowner.

The neighborhoods identified under the DWVARP should address their private well issues and look to remediate any flooding issues that have occurred, or that they may vulnerable to in the future, to ensure a clean source of drinking water. Specific recommendations for these areas are presented in subsequent sections; however, the strategies suggested can be implemented throughout the state.

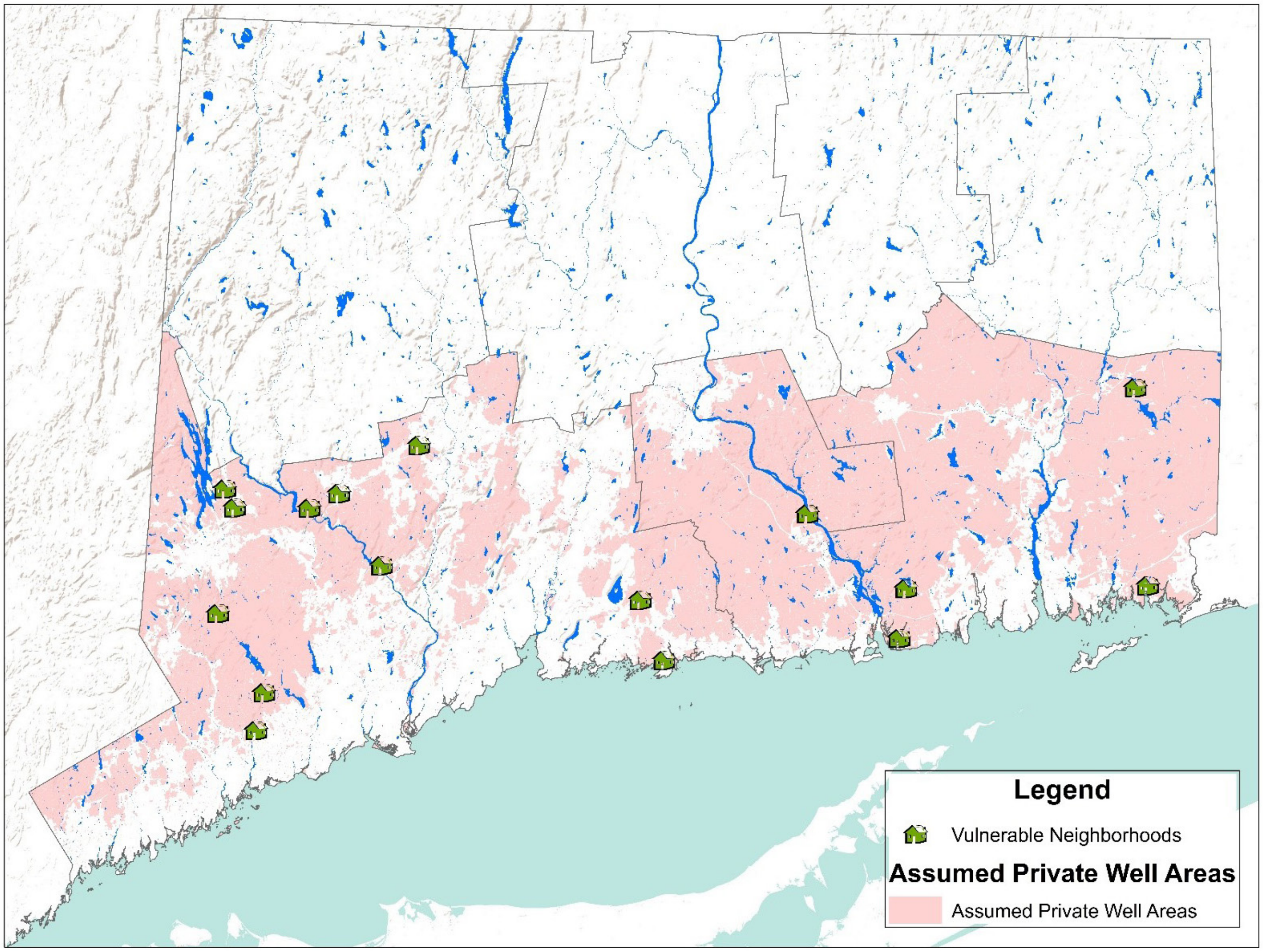


Figure 3-1 Assumed private well areas in the four coastal counties and the vulnerable neighborhoods identified in the vulnerability assessment

Coastal Vulnerability Assessment

In addition to a four-county analysis, a more concentrated vulnerability assessment was conducted on the three coastal towns of Guilford, Old Lyme, and Stonington. Because of the threat of storm surge and sea level rise, a GIS layer depicting a 1% annual chance storm event plus 7 feet of sea level rise was used. This layer was used to account for an event that may include large storm surge. Assumed private well parcels that fell within this flood zone were extracted for further assessment, resulting in 1,468 vulnerable well parcels.

However, rather than conducting this assessment on a parcel level, satellite imagery was used to mark every residence on these vulnerable parcels as a point on the center of the dwelling. These points were then given a 100-foot buffer. This buffer accounts for the location of the well head in proximity to the house. Once all well locations were identified, there were a total of 1,020 wells located within the initial vulnerable parcels.

Not all parcels fell completely within the flood zone; therefore, not all vulnerable well locations actually fell within the flood zone. This brought the vulnerable well count to 857 wells within the 100-year event layer. The progression of this process (Figure 3-2) shows that the total number of assumed vulnerable wells was cut by approximately 58% when going from the parcel level to a more localized well identification using satellite imagery for all three towns.

Figure 3-2 Showing the numerical progression of the coastal vulnerability assessment as the level of analysis went from parcel to point within the flood zone

While Old Lyme had almost twice as many well parcels within the flood zone as Guilford, both towns showed approximately only 77% of these parcels actually having wells and roughly 66% of these identified wells actually being in the flood zone (Table 3-2). Both Guilford and Old Lyme had roughly 85% of the identified wells actually located in the flood zone. Stonington, while having a more relative number of parcels within the flood zone as Guilford, showed to have only 47% of the parcels having a well and 35% of the parcels having a well in the food zone. Stonington was found to have roughly 75% of the wells identified within the flood zone.

This coastal vulnerability analysis has dual purpose in regard to this report. The first purpose represents the vulnerability along the shoreline. These three towns appeared to have the highest concentration of private wells along the coast, therefore making them more vulnerable to storm surge, sea level rise, or saltwater intrusion. The more focused analysis can lead to better recommendations for specific roads or neighborhoods rather than general areas that appear to be inundated by a certain scenario.

Table 3-2
Coastal vulnerability assessment statistics

	Guilford	Old Lyme	Stonington
Parcels within the flood zone	368	709	392
Well locations within the parcels	285	550	185
Wells located within flood zone	241	476	140
% of parcels that have wells	77.4	77.6	47.2
% of parcels with wells in flood zone	65.5	67.1	35.7
% of identified wells that are vulnerable in the flood zone	84.6	86.5	75.7

3.2 Current State of Practice and Best Practices

Currently in Connecticut, a private well homeowner is responsible for their private well maintenance, for which there are no requirements. The well owner is also responsible for testing the quality of their water; these wells are not regulated by the United States EPA. Local health departments and districts do however have authority over private well construction.

The Connecticut Public Health Code provides regulations for private wells, some of which take resiliency into account. The most recent regulations are applicable to wells constructed after January 12, 1971, when the code became effective. There were, however, regulations set in place in 1959 that were then modified in 1966 that applied to wells constructed prior to 1971. The following are the regulations that, in some sense, acknowledge well resiliency.

Sec. 19-13-B51d. Location

(a) Wells with a required withdrawal rate of under ten gallons per minute.

(1) Each such well shall be located at a relatively high point on the premises consistent with the general layout and surroundings; be protected against surface wash; be as far removed from any known or probable source of pollution as the general layout of the premises and the surroundings will permit; and, so far as possible, be in a direction away from ground water flow from any existing or probable source of pollution.

(3) No such well shall be located within twenty-five feet of the high-water mark of any surface water body, nor within twenty-five feet of a drain carrying surface water or of a foundation drain.

(b) Wells with a required withdrawal rate from ten to fifty gallons per minute

(1) Each such well shall be located at a relatively high point on the premises consistent with the general layout and surroundings; be protected against surface wash; be as far removed from any known or probable source of pollution as the general layout of the premises and the surroundings will permit; and, so far as possible, be in a direction away from ground water flow from any existing or probable source of pollution.

(3) No such well shall be located within 50 feet of high water mark or any surface water body, nor within fifty feet of a drain carrying surface water or of a foundation drain.

(c) Wells with a required withdrawal rate of more than fifty gallons per minute.

(1) Location of such well shall be approved by the state department of health in accordance with the provisions of section 25-33 of the 1969 supplement to the general statutes and section 19-13-B39 of the public health code.

(2) Each such well shall be located at a relatively high point on the premises consistent with the general layout and surroundings; be protected against surface wash; be as far removed from any known or probable source of pollution as the general layout of the premises and the surroundings will permit; and, so far as possible, be in a direction away from ground water flow from any existing or probable source of pollution.

(4) No such well shall be located within fifty feet of the high-water mark of any surface water body nor within fifty feet of a drain carrying surface water or of a foundation drain.

Sec. 19-13-B51e. Precautions

While this section of the health code does state precautions that should be taken during well construction to avoid contamination, there are no regulations here that pertain to private well vulnerability during a flooding event.

Sec. 19-13-B51f. Construction

(a) **Materials.** Pipe used for casing a well other than a dug well shall…have watertight connections.

(b) **Dug well.** The casing or side walls of a dug well shall be constructed of watertight concrete at least four inches thick to a depth of at least ten feet below the ground surface…The annular space between the face of the excavation and the watertight section of casing shall be filled with clean clay or other impervious material.

(c) **Gravel well.** The casing of a gravel well shall be surrounded with concrete grout to a depth of at least ten feet below the ground surface. The annular space between the casings of a gravel well with artificially placed gravel shall be protected at the top by a watertight covering to prevent any foreign matter entering the well through the gravel.

(d) **Drilled well.** The construction of a drilled well shall provide for shutting out all water except that from the water bearing formations which are intended to supply water to the well. The casing shall extend at least ten feet below ground surface. Any annular space surrounding the casing pipe needed for drilling shall be filled with concrete grout to a depth of at least ten feet below the ground surface. Below ten feet, any clean fill material can be used. Where the unconsolidated material above consolidated rock is less than twenty feet deep and the casing ends in the consolidated rock, the casing shall be effectively sealed in the rock.

(e) **Upper terminal of casing.** The casing of every well shall project not less than six inches above the established grade at the well or above the pump house floor… Where a pitless adapter is used, it shall be designed to, and made of materials that will, keep soil and water from entering the well during the life of the casing…

Sec. 19-13-B51h. Well pits

(b) A well pit and its juncture with any other structure shall be watertight, or suitably drained to insure dryness as provided in section 19-13-B51i.

(c) Every conduit or similar connection with a well pit shall be made watertight.

Sec. 19-13-B51i. Well pit drains

(a) Where there is no danger of flood or back flow, the water from a pit shall be drained onto the surface of the ground. The pipe used shall be at a grade of not less than one-eighth inch per foot toward the outlet. The junction between the pit floor and the drain pipe shall be made watertight. The drain pipe and joints shall be watertight to a distance of twenty-five feet from the pit. Any drain to the ground surface shall be screened to prevent entrance of animals and insects.

(b) No well pit drain shall be connected directly with any sewer, house drain or storm drain. The drainage of any well pit shall not be dependent on the operation of any pumping system except where gravity drainage at the location cannot be.

(c) When a well pit is constructed in impervious soil, no porous material shall be used as a base under the well pit floor. If fill is required, it shall be clean, impervious earth, well tamped.

Sec. 19-13B51j. Permanent appurtenances

(a) Any equipment, piping or appurtenance, permanently installed in a well, shall be joined watertight to the well casing at the point of entrance to the well by a well top seal or equally effective means.

(b) Every well in which the drawdown is ten feet or more shall be fitted with an adequate air vent. Such vent shall be extended to the height of at least twelve inches above any possible high-water level. The vent shall be shielded and screened in such manner as to permit the entrance of air but keep out foreign matter.

(c) The foundation for a reciprocating pump shall be constructed with sufficient clearance around the well casing and the base of the power head to permit the assembly in place of a watertight well top seal. The well casing shall extend at least six inches above the floor.

(d) The foundation for a turbine type pump may be of concrete upon which the power head may rest directly. It shall be so constructed that the well opening is adequately covered and all openings through the base shall be sealed watertight. The well casing shall be installed at least six inches above the floor.

(e) A hand pump shall be constructed so that a stuffing box or other arrangement prevents entrance of contamination around the pump rod. The pump spout shall be of covered type. The base shall be of the one-piece flange type. Provision shall be made for leading waste water away from the top of the well. A hand pump shall be frostproof and shall not require priming. A hand pump shall be mounted: (1) When a well is cased with iron pipe, upon a base flange which is attached rigid and watertight to the well casing; (2) on a concrete platform or similar structure when a well is not cased with iron pipe. A metal sleeve shall be used through the concrete platform or cover slab and extend above the slab into the pump base; or (3) by other sanitary method approved by the commissioner of health.

The public health code also identifies regulations in regard to well permits in Sec. 19-13-B51m. These regulations reveal under which circumstances a director of health has the authority to either approve or deny a well permit. These circumstances include demonstrating adequate distance from a septic system or the presence of public sewers and assessing the proximity of the private well parcel to a community water supply system for both residential and nonresidential premises. However, the commissioner of health services has the authority to grant an exception if the CWS is unable to provide adequate supply or if construction problems warrant the exception.

Most of these regulations have not been amended since their inception in 1971 and therefore do not consider the current discussion of climate change and flood risk.

3.3 Summary of Brackish Water Intrusion

A growing concern along the Connecticut coastline is the intrusion of salt water into private wells. As these wells pump less dense fresh water and lower the groundwater level, salt water may migrate into these fresh water zones and potentially contaminate wells resulting in poor quality drinking water. Typically, wells located near the Connecticut shoreline are shallow dug wells. This well construction avoids deep drilling, which may result in brackish water; however, the shallow nature of the well also leaves it vulnerable to contamination from storm surge. In the event of saltwater contamination, it is possible that freshwater restoration could take years or may not occur at all. The USGS California Water Science Center has also presented multiple other factors that may contribute to saltwater intrusion[16].

1. Rate of water withdrawal compared to freshwater recharge
2. Distance between pumping location and saltwater source
3. Geology of the aquifer
4. Aquifer hydraulic properties
5. Presence or absence of fine-grained material

Various models are currently available to simulate intrusion into coastal aquifers. The USGS suggests multiple models that can be used for saltwater intrusion simulation including the following:

- MODFLOW is a USGS open source model that is popular among consultants, academics, and government scientists. The model is typically used to simulate three-dimensional groundwater flow but can also be utilized to couple groundwater and freshwater systems. In Connecticut, MODFLOW is appropriate for overburden aquifers such as alluvium and outwash; bedrock aquifers are not typically simulated with MODFLOW.

16 https://ca.water.usgs.gov/sustainable-groundwater-management/seawater-intrusion-california.html

- SHARP is model that assumes a "sharp" interface between freshwater and saltwater zones. This model also assumes that water flow is horizontal, making this a quasi-three-dimensional model.
- SutraSuite includes SUTRA, which is a groundwater model that includes utilities for preprocessomg and postprocessing and can be conducted in either 2D or 3D.
- MOCDENSE is a model specifically for the simulation of solute transport in groundwater. This model addresses 2D, cross-sectional issues and can compute concentration changes over time.
- SEAWAT is a program like MODFLOW and is also openly offered by the USGS. This 3D model is a variable-density groundwater model that has been widely used for a variety of groundwater studies, including saltwater intrusion.
- DHI Technologies offers FEFLOW, which is a broad-spectrum groundwater model that can be used to simulate saltwater intrusion. This model does require a license, which is offered at various levels; however, its applications range from mine water management to groundwater remediation/attenuation.

The USGS California Water Science Center has suggested these models as examples of useful tools for intrusion and for general flow models. While these few examples may not be the full extent of available technology, there appear to be models within these suggestions that are useful for this task.

These models are characteristically different and offer benefits relative to their qualities. While most seem comprehensive, there will likely be data that is necessary for running these simulations. For example, MODFLOW and SHARP require boundary conditions, aquifer properties, and initial conditions. SHARP also requires specific gravities, dynamic viscosities, bathymetry, and base layer elevations. Depending on the model chosen, data specific to the Connecticut coastline will have to be collected for input into the simulation.

3.4 Resiliency Plan for Private Wells

3.4.1 General Methods of Adapting Private Wells

There are certain measures that can be taken both on a smaller scale for individual wells and on a larger scale for neighborhoods. For this report, certain strategies have been identified as optimal situation-specific solutions. Fact sheets have also been created for use by the Private Well Program (Appendix L). These sheets can be distributed to provide further information on mitigation and resiliency solutions. The strategies included in these sheets are well protection, property acquisition, water main extension, drainage project, new PWS, and smart development.

Well Protection

A private well owner is responsible for the maintenance of their well, and because of that, there are certain measures that can be taken, especially on older wells. Extending the well casing above flood levels, in conjunction with mounding the surrounding earth, is a measure typically taken by public system wells; however, the method could be implemented for private residential wells. If there are any exposed portions of the well, these should be sealed to ensure the well is watertight. It is important to note that while a watertight well cap is recommended to prevent contamination it may not completely eliminate contamination due to the screen and shield air vent, which could potentially allow for inundation. Also, FEMA recommends grouting the space between the casing and the bore hole. There is also the FEMA P-348, Protecting Building Utility Systems from Flood Damage, which outlines various methods of flood protection for a multitude of systems. Well protection costs in relation to other remediation projects are relatively economical solutions, with costs ranging from 1 to 10 thousand dollars, typically on the lower end of the spectrum.

Relocate Well on a Property

For those private well parcels with a section of the parcel located out of the flood zone, by relocating a well on the property, the resident can move the well head out of the flood zone to greatly reduce the risk of flooding. While a new well could get costly, having a clean private water source may outweigh the initial investment. Well relocation is also another relatively economical solution with costs ranging from $5,000 and up.

Property Acquisition

There will be certain procedures for acquisition depending on whether it is the state or the town acquiring the property. Acquisition of a property at risk of flooding enables the homeowner to relocate to an area with public water or a more resilient private water supply. Property acquisition also creates more open space and eliminates future property damage. A property acquisition is dependent upon land value, which could potentially cost upwards of $100,000.

Water Main Extension

While this option may not be viable for all vulnerable areas, there may be certain neighborhoods that are within proximity to a PWS, and extending a main could be possible. This could also be said for those homes that may be located within the service area of a PWS but have chosen to not hook up to public water.

Water Main Installation
Photo by DPH.

For example, there is currently a main extension project in Guilford, Connecticut. The project will provide public water to Mulberry Point, Tuttles Point, and Long Cove. These neighborhoods are located along the shoreline and experience issues with their private wells, including saltwater intrusion. By extending this line, those homes that have chosen to connect to the main will receive consistent water supply of good quality. The water provided by a system is subject to more frequent and rigorous testing than that of a private well. These drinking water systems must also adhere to the strict rules of the Safe Drinking Water Act while private wells are not monitored by any agency.

An example of homes located within a service area that have not connected to the system but could at any time is the Point O' Woods neighborhood in Old Lyme. Several homes with private wells are bounded on all sides by properties connected to the PWS.

Ultimately, a water main extension is a higher cost option; however, to some, the benefits could outweigh the cost. An extension project could cost upwards of $500,000 with costs potentially being distributed among the state, municipality, and residents.

Drainage Project

Implementing a drainage project can help to alleviate persistent flooding in vulnerable neighborhoods. A new drainage system may be the best large-scale solution for areas where water main extension is not feasible, and several houses are being affected by flooding. A project of this nature could potentially cost over $100,000 depending on the size.

In Brookfield Connecticut, FEMA awarded a grant for a new stormwater drainage system to solve the flooding problem Meadowbrook Manor has experienced for close to 5 decades. The installation of this system will prevent contaminants from septic systems and other sources from entering drinking water wells, along with protecting property and preventing property value decrease.

New Public Water System

A new public system as a mitigation strategy can both eliminate the risk of flooding to private wells and provide consumers with a reliable, clean water supply. This strategy is ideal where a usable source is available and where there is a significant vulnerable population. A new PWS could also serve businesses, schools, and other facilities, alleviating flooding risk to their sources as well. While a new PWS is a costly option with estimates greater than $100,000, this option, similar to main extension, eliminates well unreliability, and benefits may outweigh costs.

Smart Development

This mitigation strategy should be implemented before a problem occurs. By utilizing flood mapping, areas of concern can be identified, and informed decisions regarding development can be made. Large parcels that are being looked at for residential development should be assessed for flood risk presence. If flood hazard areas are found, steps should be taken to site wells outside of this zone. By using smart development, private well flooding issues can be avoided, and the risk of property damage will be greatly reduced. Smart development has no direct costs; however, education and promotion of this strategy may result in expenses such as educational material, registration fees, and staff time.

3.4.2 Specific Recommendations for Vulnerable Neighborhoods

Each vulnerable neighborhood identified has unique characteristics, making any private well mitigation recommendations specific for that area. Not all vulnerable areas are within proximity to a PWS. Some areas have a few houses while other areas include multiple homes that experience flooding. To be economical and practical, not all vulnerable areas should implement the same mitigation application. Because these vulnerable areas are all unique in their vulnerabilities and locations, there is no one solution for all neighborhoods. Recommendations for resiliency and mitigation efforts were made for each area based on proximity to a CWS (Table 3-3).

Table 3-3
Specific mitigation strategies to be implemented in the identified vulnerable neighborhoods

Vulnerable neighborhood/ area	Town	Resilience Recommendation
Flood Bridge Road	Southbury	Water Main Extension/Property Acquisition
Hopeville Pond	Griswold	Water Main Extension
Sandy Hook	Newtown	Water Main Extension or New PWS
Saugatuck River	Weston	Well Protection
Saugatuck River	Westport	Water Main Extension
Meadowbrook Manor	Brookfield	Drainage – project underway
West Lake and Clear Lake	Guilford and North Branford	Water Main Extension
Rogers Lake	Old Lyme	Well Protection
Little Meadow Road	Haddam	Property Acquisition
Hop Brook and Long Swamp Brook	Middlebury	Water Main Extension
Housatonic River	Oxford	Property Acquisition
Downtown West Redding	Redding	New PWS
Guilford Coastal Wells	Guilford	Water Main Extension
Old Lyme Coastal Wells	Old Lyme	Water Main Extension
Stonington Coastal Wells	Stonington	Water Main Extension

<u>Flood Bridge Road</u>
With the Heritage Water Company within 1 mile of this neighborhood, extending the water main may be the most effective resilience strategy. It is important to note that the Town of Southbury has been interested in property acquisitions in this area, so that may also be a viable option.

<u>Hopeville Pond</u>
Jewett City Water Company is approximately 0.5 miles from this small neighborhood. With no known RL properties in this neighborhood, a water main extension could be the most feasible option.

Sandy Hook

The Aquarion Water Main System is approximately 2 miles away, and with this neighborhood flooding from the Housatonic River, water main extension may be the most appropriate solution. However, there are roughly 50 homes within the neighborhood identified, and roughly 50 more in the adjacent neighborhood, which is also settled along the river. Therefore, a new PWS could also be a viable option.

Saugatuck River – Weston

There are only a small number of homes found in this vulnerable area, and water mains are over 1 mile away. Because of these factors, homeowners should look to upgrade and protect their own wells. This may be the most economical option.

Saugatuck River – Westport

With multiple homes in this area and several RL properties, wells are likely very vulnerable. By extending the Aquarion water main, which is roughly 0.25 miles away, this would be effective for the entire neighborhood and provide reliable and resilient water.

Meadowbrook Manor

This neighborhood has already identified its resilience strategy by applying for and receiving funding for a drainage project.

West Lake and Clear Lake

With both Regional Water Authority and Connecticut Water having mains nearby and the houses being relatively close, a water main extension project would cover the entire area of concern.

Rogers Lake

This area of concern is three individual streets with a few houses on each. The disconnect between streets may increase the cost of a drainage or water main extension project; therefore, well protection by the owner may be the best application for this neighborhood.

Little Meadow Road

This small neighborhood on the Connecticut River is vulnerable to flooding and contains multiple RL properties. Because of the size of the river and the increasing risk of flooding events, property acquisition may be the best option for this area.

Hop Brook and Long Swamp Brook

Connecticut Water has a water main less than 0.25 miles away from this neighborhood. Because of the water main proximity, extending down Regan Road may be the most economical option.

Housatonic River

With only a few houses in this area of concern and large number of RL properties, property acquisition may be the most economical decision.

Downtown West Redding

This area of concern is a combination of residential and commercial properties. By establishing a new PWS, this would ensure clean and resilient water to private homeowners as well as a few local businesses in the area. This PWS will allow continuous service to residents and possibly prevent businesses from closing during a flooding event due to contaminated water supply.

Coastal Guilford, Old Lyme and Stonington

All three of these vulnerable coastal areas are at risk to saltwater intrusion, sea level rise, and storm surge. Water main extension is likely the most effective mitigation option for these private well neighborhoods.

3.4.3 Recommendations from Findings

One of the biggest challenges in assessing private well vulnerability was the data gap. There are thousands of wells across the state for which a location database is lacking. With advanced technology and programs, such as GIS, entering and maintaining private well coordinates is more feasible than 30 years ago. By implementing future reporting regulations, it may be possible to collect the coordinates of both newly constructed wells and older existing wells that apply for a permit to the local Health Department for repair work. A staff person within the Department of Consumer Protection (which presently collects and stores private well permits and logs) or within the DPH Private Well Program could collect spatial data and maintain a database.

Municipalities should also look to create a GIS database like that of Fairfield. Many towns across the state either have in-house GIS capabilities or contract this work out. If a town has these capabilities, then a private well layer at the parcel level should be developed.

It is also important to educate residents on the importance of upgrading older wells. This education program should target areas that are typically older construction and likely have older wells. Aside from education, there is also the potential for incentivization. Many residents do not understand the importance of private well testing. Either the state or municipalities could create a program that incentivizes the annual testing of private wells. By doing so, this would promote care and upkeep of the well while ensuring clean private water sources.

Private well areas are just as vulnerable to extreme weather events and more importantly power outages. If residents lose power and do not have a backup power source, their water supply will be offline until restoration. Municipalities or the state should identify water buffaloes that could be utilized for private well areas during an emergency. This would ensure safe drinking water for those affected until power has been restored or wells have been decontaminated.

The FEMA benefit-cost analysis (BCA) is required for FEMA funding to be utilized in order to ensure that a hazard mitigation project is cost effective. The potential benefits to private wells should be included in the FEMA BCA for mitigation projects that also protect private wells and improve resiliency.

3.4.4 Recommendations for Private Well Program Materials

"Well Siting, Construction and Permitting Requirements"
Drilled well construction should recommend that the top of the well casing should extend above the flood level if the well is in a delineated FEMA flood zone, assuming the recommended 6 inches is potentially inadequate. Dug well construction should also recommend this extension for the flood zone requirements.

"Private Well Water Systems in Connecticut: Best Management Practice Checklist"
While the recommendation to test water quality refers to an additional publication, it should be stated to test water quality at least once a year in the event the well owner does not refer to the well testing publication.

Just like the Well Siting publication, this checklist should also recommend that the well be extended about the flood levels if located in a FEMA flood zone.

4.0 Findings

This study addresses multiple aspects of the current state of PWSs and private water supplies in the context of vulnerability, risk, and resilience. These aspects appear on the surface to be disparate and pointing to numerous incongruent findings. However, the findings of the study can be aggregated into 10 categories:

1. **Lessons Learned from Past Events** – Recent severe storms and droughts have provided important lessons regarding risks and resiliency.
2. **Flood Risk to CWS Infrastructure and Critical Facilities** – CWS infrastructure and sources are currently located within areas of flood risk. Risks can be addressed to make these assets more resilient. This will, in turn, help maintain service to critical facilities served by CWSs.
3. **Water Quality and Quantity Vulnerabilities** – A review of water quality and quantity metrics points to potential trends that indicate vulnerabilities and existing risks to PWSs.
4. **Climate Change Impacts** – Climate change projections demonstrate that drought and flood risks will increase and suggest that source water quality will be threatened.
5. **CWS Vulnerabilities and Emergency Preparedness** – A review of current CWS vulnerability assessments and emergency response plans found opportunities for planning-level improvements.
6. **Drought Planning and Resilience** – Climate change projections and recent drought experiences together point to needed improvements for resilience.
7. I**nterconnections and Infrastructure Upgrades** – Source and storage redundancies along with interconnections can increase resiliency even as risks are changing.
8. **Drinking Water Section Emergency Preparedness** – Interviews with surrounding state and Connecticut drinking water staff provided guidance for emergency response planning that the DWS can undertake to prepare for severe storm and drought events.
9. **State and Local Laws Affecting Drinking Water** – A review of current laws affecting drinking water found a foundation for resilience, but improvements are suggested.
10. **Private Well Vulnerabilities** – Sea level rise and riverine flood risks will affect private wells. Steps can be taken to make private water supplies more resilient.

These categories of findings are briefly described below. Additional details can be found in the appropriate sections of this report.

4.1 Lessons Learned from Past Events

Many CWSs across the state have at one time or another experienced an emergency or felt the impacts of a drought or severe storm. A survey designed to poll CWS managers about past events was helpful in understanding impacts. In addition, interviews covering 24 CWSs were conducted, including five small, seven medium, and nine large systems.

Recent Storm Impacts

Backup generator.
Photo by DPH.

The most prominent storm events of the past 10 years have included October Snowstorm Alfred, Superstorm Sandy, and Tropical Storm Irene. Other events such as the tornadoes of May 2018 show that storms can strike at any time. From the survey responses, it was apparent that backup power sources are crucial for sustaining the system. It is also important for systems to have ERPs that should be learned by multiple staff in the event of implementation. While it was also apparent that systems did not perceive flooding as a risk, climate change data insinuates this may become an increasing challenge for systems. Therefore, systems should assess their vulnerability to flooding, protect their infrastructure where necessary, and prepare for future events. This also includes preparing staff for flooding and other events as the surveys and interviews indicated another challenge experienced by systems was staff being unable to report to work during a storm.

Recent Drought Impacts

CWSs have experienced impacts due to drought, including the very significant drought of 2015 to 2016. However, few systems experienced severe impacts. Over half (57%) of the systems surveyed implemented voluntary water restrictions while nearly a fifth (18%) implemented mandatory water restrictions. Roughly 1/3 of the systems experienced some level of reduced supply, with 61% of large systems reporting they experienced reduced supply. It was also noted that 39% of large systems surveyed experienced misalignment with drought messages from the governor's office.

4.2 Flood Risk to Community Water System Infrastructure and Critical Facilities

Infrastructure within a CWS and critical facilities served by CWSs represent the two ends of a critical system – water produced at one end and then water served to a user that cannot tolerate sustained outages.

Critical PWS Infrastructure

CWSs rely on critical infrastructure components to source, treat, and deliver water to end users. Certain infrastructure components may be more vulnerable than others due to their construction and more at risk depending on their location (such as proximity to a flood zone).

Floods present risks to both riverine and coastal infrastructure. While many CWS source wells have been elevated on mounds to prevent inundation, these levels may no longer be sufficient with the effects of a changing climate. Many reservoirs also have well-designed dams and spillways; however, with climate change projections anticipating an increase in precipitation and heavier future storms, these dams and spillways may be pushed beyond their design limits more frequently leading to damage or failure. Treatment plants and pump stations may also be vulnerable if they are located in flood zones and not properly floodproofed. Fortunately, water storage tanks are typically elevated and therefore have a lower flood risk.

Critical Facilities Served by PWSs

While some systems are more resilient than others, those that lack redundancies are more vulnerable overall, in turn leaving critical facilities served by them similarly more vulnerable. By identifying those critical facilities served by a system, both DPH and the system can be prepared to respond and assist those facilities during an emergency.

4.3 Water Quality and Quantity Vulnerabilities

The review of water quality and quantity metrics points to potential trends that indicate vulnerabilities and existing risks to PWSs.

During the interview and surveys, some PWS managers indicated that recent droughts impacted source water quality and therefore finished water quality, and some also indicated that recent storms impacted source water quality and therefore caused finished water quality problems. Experiencing finished water quality problems during droughts and storms can be associated with the need to issue boil water advisories. While few systems perceive that their source or finished water quality is currently threatened, systems generally perceive that water quality problems will increase in the future.

An analysis was conducted of drinking water quality deficiencies from January 1, 2006, to December 31, 2016, including 4,066 maximum contaminant level (MCL) deficiencies across 2,487 PWSs. The most common MCL deficiencies include exceeding bacterial count limits (i.e., violating the Total Coliform Rule), limits for turbidity, and allowable limits for disinfection byproducts. Turbidity limit exceedances, which are more common after heavy rainfall, have been linked to gastrointestinal illness outbreaks in other regions[17].

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17 De Roos, A. J., Gurian, P. L., Robinson, L. F., Rai, A., Zakeri, I., & Kondo, M. C. (2017). Review of Epidemiological Studies of Drinking-Water Turbidity in Relation to Acute Gastrointestinal Illness. Environmental health perspectives, 125(8), 086003. doi:10.1289/EHP1090
Mann, A. G., Tam, C. C., Higgins, C. D., & Rodrigues, L. C. (2007). The Association Between Drinking Water Turbidity and Gastrointestinal Illness: A Systematic Review. BMC Public Health, 256(7). doi:10.1186/1471-2458-7-256

Among PWSs that use groundwater, NTNC systems experience the most MCL violations (40%) but receive the fewest enforcement actions. Across all PWSs that rely on groundwater, privately owned systems experience the most (90%) MCL violations.

An analysis of sanitary survey reports between 1996 and 2016 found 730 significant deficiencies occurred over the 10-year period and that 15% were deficiencies that a PWS incurred repeatedly during the period of analysis. Over half (55%) of all deficiencies involved source water wells (55%) including wells not being watertight (23%), evidence of flooding (12%), or well not properly screened (9.5%). Approximately one quarter (26%) of all significant deficiencies involved storage tanks not being adequately protected from contamination.

Meanwhile, water quality data from six drinking water reservoirs in south-central Connecticut indicates that surface water dissolved oxygen saturation, surface water temperature, and specific conductivity are increasing. Overall, this means that biological growth (algal productivity) is increasing, and lakes are becoming hotter and less well mixed as the climate warms. Hotter, more thermally stable lakes are more likely to experience harmful algal blooms, especially if blooms are already a problem.

4.4 Climate Change Impacts

This report clearly documents that flood, storm, drought, and water quality risks are already affecting PWSs. While we often think of these risks as stationary, they are believed to be changing as our climate changes. The climate change analysis conducted for this study is considered a "high" emission scenario.

Changes to Flood Risk

The DMP for all modeled return periods (5, 10, 20, 50, and 100 years) is projected to increase, with a larger increase of extreme precipitation for longer return periods. Five of the six models project a DMP relative increase of more than 50% for most of Connecticut for all five return periods. Some portions of the state are projected to experience a doubling in the DMP for a 20-year return event and tripling for a 100-year return event. In evaluations of past climate, roughly 15% of total precipitation in Connecticut was accounted for by heavy rain events. It is projected that future climate changes could result in an additional 2 to 10% of precipitation attributed to heavy rain events that may produce flooding and erosion.

Changes in Drought Risk

While projections anticipate an increase in total precipitation, much of the increase can be accounted for by winter precipitation rather than summer. Also, with temperatures projected to rise, so does the PET. The projected PET that was modeled exceeded the projected precipitation increase as primarily accounted for during warm seasons. The seasonal trends display a clear contrast with slight increases of water budget during winter and a drastic decrease during summer. Overall, the models project a decrease in average summer potential water availability, resulting in the potential for an increase in extreme summer droughts. The models do however differ regarding the severity of longer duration future droughts, leaving a high degree of uncertainty regarding longer-term, sustained droughts.

Source Water Protection

An increase in precipitation may potentially increase flooding events and associated risks to PWS wells while an increase in stormwater runoff and in seasonal droughts poses a risk to surface water sources. There is also potential for a longer algal bloom season (starting earlier and ending later) and for more harmful algal blooms with the rise in temperatures as warmer temperatures favor blue-green algae that may produce toxins as well as compounds that impact taste and odor. Stringent source water protection measures will help maintain resiliency of some sources while new and innovative source water protection methods or plant treatment process changes will achieve resiliency even as climate changes.

4.5 Community Water System Vulnerabilities and Emergency Preparedness

Vulnerability Assessment Review

Many systems maintain a separate assessment with sensitive and confidential system vulnerabilities; these documents are separate from the WSP. However, some systems chose to include an ECP or chapter that included general vulnerabilities such as "power outage." Overall, vulnerabilities were primarily characterized in these plans by focusing on the related emergency response procedures. CWSs consistently do not acknowledge climate change as a factor in their vulnerability assessments. However, it is clear that many of the large systems have redundancies built into their systems to avoid infrastructure going offline during an event and that these redundancies reduce vulnerability.

Emergency Contingency Plan Review

In general, most CWSs are prepared for an event. Many have looped transmission mains to assist in small break isolation and are able to repair small breaks with in-house parts. The systems that are not able to repair breaks typically have contractors available. It was also found that most utilities are capable of functioning normally if one or more primary sources is offline, and if there is total failure, most have at least 24 hours of storage. Surface water dependent systems also have EAPs in the event there is dam failure due to flooding and also have dam monitoring programs in place for during the event. ECPs include lists of "priority facilities" for restoration of water service; however, water utilities have broad latitude in deciding which customers should be listed. Priority facilities are often synonymous with critical facilities but could also include major employers or industry in order to enhance a "return to normalcy" following a major storm.

Drought Response Plans

A large percentage of systems with submitted drought response plans utilize a five-stage drought response; however, Aquarion Water Company and Connecticut Water Company use a four-stage response plan. These two companies operate a large number of individual CWSs. Drought triggers vary and are dependent on factors such as season, depth of water in well, reservoir storage capacity or well output compared to demand, and well run time.

4.6 Drought Planning and Resilience

With severe droughts occurring recently (2015 to 2016) and projected to become more frequent, PWSs need to be prepared for changes that may occur in both surface and groundwater sources.

Drought triggers vary between systems based on demand, source type, and drought response stages. During past droughts, these triggers were adequate for some systems while other systems found their triggers were engaged faster than anticipated. Among respondents to the surveys described in this report, 8% found drought triggers to be inadequate overall while among large systems 26% found drought triggers inadequate. With climate change projections anticipating an increase in severe droughts, drought triggers may need revision. Complicating matters, the review of ECPs (above) noted that a large percentage of large CWSs with drought response plans utilize a five-stage drought response; however, many use the preferred four-stage response plan, and at least one uses a hybrid.

The SWP and the Coordinated Water System Plans address droughts as a central topic beyond their shared emphasis on promoting a water conservation ethic. With droughts a central theme of those two planning processes and this study, the timing is appropriate for making changes in how PWSs address droughts. However, climate change projections need to be incorporated into the thought process, and PWSs need to adopt changes that do not rely on static risk levels based on past events but rather adopt a mindset that involves ongoing learning and adaptation as risks change in order to properly project the risk to future events.

4.7 Interconnections and Infrastructure Upgrades

CWSs are comprised of integral infrastructure that ensures reliable water delivery to customers. Some of these systems, typically the smaller ones, lack internal redundancies. This makes them vulnerable during an extreme weather event. Some PWSs should pursue infrastructure upgrades whereas others should focus on interconnections that can create source redundancy for smaller systems that often rely on limited sources.

Of the systems surveyed, over half (53%) are interested in interconnections. Interconnections provide small systems an option to increase redundancy though for some systems increasing supply or redundancy may not be feasible due to environmental, economic, or hydrologic factors or due to lack of space and land.

A GIS assessment was conducted to identify the potential for interconnections. If the distance between systems was less than 1,000 feet, it was deemed feasible. However, if this potential interconnection was between two small systems, a potential interconnection was mapped to the nearest large system, which offers greater redundancy and resources. By evaluating potential interconnections between small unaffiliated, small affiliated, and large systems from the Coordinated Water System Plans, recommendations were made regarding the most feasible interconnections according to the mapping.

It is beneficial for systems to incorporate more redundancies into their infrastructure by improving internal redundancies, developing adequate storage, or developing interconnections. The DWSRF could be a potential source of funding for future projects; however, small systems have difficulty applying for these funds, and even larger systems feel that applying may not be worth it because funding is not guaranteed. Solutions to this problem identified by drinking water stakeholders include the following:

- Hiring consultants to assist DPH with the development of specifications for common projects as was recently done by DPH for the generator program funded under DWSRF
- Holding DWSRF application workshops where experts or DPH staff assist small systems with preparing applications
- Establishing a grant program with less front-end application requirements which allows, for example, payment for evaluations of necessary system upgrades

While interconnections are important options, there are potential challenges and risks including the following: (1) irregular use of interconnections may create temporary water quality issues when activated because of differences in water chemistry; (2) interconnections that are emergency use only must be properly exercised and maintained so they are ready when needed; and, (3) routine use interconnections may create disincentives for the recipient system to conserve water due to contractual minimums.

4.8 Drinking Water Section Emergency Preparedness

In the event of a statewide emergency, an ICS is established by the Connecticut State Department of Emergency Services & Public Protection, DEMHS, and the OEM. During this emergency, the SEOC is activated, and DPH-DWS has a representative at the SEOC. A water task force is also activated during an emergency, which includes various drinking water stakeholders. If the task force finds an issue, this concern is forwarded by DPH-DWS to the SEOC so it can be addressed by regional coordinators and leaders.

The Public Health Emergency Response Plan (PHERP) was developed in 2011 to identify appropriate department response to public health emergencies. The plan also helps to manage ESF #8 and allow the state to operate and provide services effectively during an emergency. However, several elements of this plan (such as the WEAR Team) are no longer utilized, and therefore, the PHERP should be updated.

Everbridge is utilized by DPH-DWS prior to an emergency to disseminate mass communications to CWSs, including emergency preparedness tasks. DPH-DWS also makes an after-hours phone line available for systems to use for updates or questions; this information is also included in the mass communication. The key recipients of this information are the designated emergency response leads for each large CWS. Typically, small systems are sent multiple notices to ensure receipt. The DWS has also created a contact information form for systems to fill out annually.

Interviews were conducted with state drinking water staff from Maine, Vermont, Rhode Island, Pennsylvania, Massachusetts, New Jersey, New Hampshire, and Ohio. These interviews identified proven actions for before, during, and after an emergency. Some notable findings include the following:

- Establish who needs to be involved during an emergency depending on the nature and extent.
- Identify staff from other state agencies with whom the department typically works and maintain a list of current contact information.
- Maintain Standard Operating Procedures (SOPs) and keep them available in a SharePoint folder for all staff to access.
- Automated communication with water systems such as calls, emails, or online status submission have proven effective.
- Utilize reverse 911 in the event a system is unable to notify consumers of a water advisory (boil water, etc.).
- Assist systems with communicating with FEMA and encourage them to take pictures of all damage to facilitate getting funding.
- SOPs and ERPs are updated annually and built upon based on experiences and lessons learned.

The DPH-DWS has lacked its own unified set of emergency response protocols. A draft ERP was developed for use by DPH-DWS under separate cover. The plan provides guidance to DPH-DWS staff for evaluating the priority of a reported incident and a framework for incident and emergency response.

4.9 State and Local Laws Affecting Drinking Water

Nationwide and in Connecticut, some existing laws include resiliency, and some do not, with some laws affecting the resiliency of PWSs. The RCSA have been amended as needed to incorporate resiliency concepts. For example, the standby power supply regulations were recently incorporated into the RCSA. It is apparent that very few statutes or regulations address both resiliency and PWSs. Public Act 18-82 was one of the most recently passed bills that addressed resiliency, and components of the act will affect PWSs. However, there may be a need for more regulations and/or guidance that directly links PWSs and resiliency. This has happened in the past relative to sanitary sewer systems and water pollution control facilities, demonstrating that it may be possible for PWSs.

4.10 Private Well Vulnerabilities

The DPH estimates that approximately 23% of the state's population relies on private drinking water wells. With minimal data available in digital format, one of the challenges in assessing vulnerability is identifying where these numerous private wells are located and what their respective vulnerability is to existing natural hazards and climate change.

Identifying Private Well Locations

As part of this assessment, local health directors were contacted to take part in the process and provide their comments on where private wells may be located in their respective town or district and were asked if there was any knowledge of private well areas that experience flooding. Most comments received regarding well location were minimally informative, with a majority of those who responded offering a review of paper completion records. Fairfield was the only town that offered a GIS shapefile with private well location at the parcel level.

PWS service areas are mapped by DPH in GIS, with larger systems presented using a buffer of the distribution pipe network beneath roads and smaller systems typically depicted using a general footprint that includes homes/facilities served within the parcel boundaries. By assuming that any residential parcel outside a 100-foot radius of a service area had a private well, and excluding open space parcels, a map was created to depict assumed private well locations. This resulted in 192,396 assumed wells throughout the four coastal counties. Newtown appears to have the highest number of wells, with an assumed count of 8,266, and New London appears to have the fewest with an assumed count of 21 wells. However, New London currently believes that every property in the city is serviced by public water. Based on the city's belief, the assumed 21-well count could be a result of error in the location analysis or reveal areas in the city that are still dependent on private wells.

Assessing Areas of Concern

With the parcels assumed to have private wells identified throughout the area, neighborhoods that typically experienced flooding were next identified. The FEMA flood maps were used to narrow down areas with a number of wells within a flood zone. A total of 12 areas were found, with one of those identified by a local health director (West Redding area). A more concentrated assessment was also conducted on the three coastal towns of Guilford, Old Lyme, and Stonington; these towns appeared to have the highest concentration of private wells along the shoreline.

Mitigation and Resiliency Strategies

There are some general best practices that private well owners can follow to ensure a safe drinking water source: elevate the well head, test their well water frequently, connect to a public water supply if available, and have a backup generator or a plan for storage in the event of an emergency such as well pump failure or extended power outage. By following these standards and others, well owners can create a safer source of water. There are also specific resilience strategies that can be implemented that are more area-specific such as drainage projects.

4.11 Summary of Findings

The vulnerability assessment for Connecticut's four coastal counties and the stakeholder workshop have revealed key findings (Table 4-1) that can be attributed to the main themes of the study. These findings address all aspects of the assessment, the resilience plan, and the DWS ERP. These findings will be used to make recommendations to DPH on ways to improve and strengthen infrastructure, better prepare the agency for an emergency, provide strategies for systems to prepare for climate change, provide ways to address private well flooding concerns, among many others.

Table 4-1
Key Findings by Theme

Task	Key Findings
1. Lessons Learned from Past Storms	Challenges experienced during past storms included difficulty accessing facility, power outages, issues receiving supply deliveries, communication issues, and bottled water delivery coordination.
	Generators have significantly helped during storms.
	Some systems find United States Department of Agriculture funding to be helpful.

Table 4-1
Key Findings by Theme

Task	Key Findings
2. Flood Risk to CWS Infrastructure and Critical Facilities	CWS source wells, including those that have already been elevated, may need to be reassessed and be elevated to levels that address effects of climate change.
	Increased precipitation could pose a threat to the design integrity of dams and spillways.
	A majority of facilities could be identified as vulnerable due to their association with a vulnerable system. However, without the capability of identifying which system component a facility is served by, this vulnerability status is a general assumption.
3 Water Quality and Quantity Vulnerabilities	Informal enforcement appears to work better than formal.
	It is difficult to distinguish between persistent problems and new problems regarding water quality violations.
	Water testing for small systems is too infrequent.
4. Climate Change Impacts	Water systems should also prepare for changes in summer water availability (increased PET).
	Connecticut water systems should prepare for the following: • Increase in storm magnitude and heavier precipitation • An increase in the frequency of extreme events • More frequent droughts with short duration but extreme conditions • An extended algal bloom season
5. CWS Vulnerabilities and Emergency Preparedness	No utilities cite climate change as a hazard in their ECPs or vulnerability assessments.
	Many utilities have redundancies built into their systems to avoid infrastructure going offline during an event.
	Few utilities acknowledge the vulnerability of or mitigation efforts for communication.
	Most utilities have looped transmission mains, which allows for small breaks to be isolated and repaired.
	Most utilities are capable of repairing breaks with in-house parts – systems that are not capable typically have close working relationships with contractors.
	Most utilities have the capability of functioning normally if one or more primary sources are offline.
	In the event of total failure, many systems have at least 24 hours of backup storage available.
	Small systems need assistance to participate in the DWSRF.

Table 4-1
Key Findings by Theme

Task	Key Findings
6. Drought Planning and Resilience	Stream gauge data is an important decision-making tool, with some systems considering installing their own gauges.
	Drought communication is not uniform across systems.
7. Interconnections and Infrastructure Upgrades	One hundred seventy-three (173) potential interconnections were identified within the four coastal counties, with more than half being between small unaffiliated systems and other CWSs.
	For many small CWSs, interconnections are the best option for resilience due to lack of space for facility expansion.
	Almost all small systems assessed have a well and at least one method of storage; a little more than half have a booster station, and a little over half have a treatment plant.
	Only 15 small CWSs have an interconnection.
	The Southeastern Connecticut Council of Governments was highly successful in conducting an interconnections program in southeast Connecticut.
8. Drinking Water Section Emergency Preparedness	Identify staff, both within the DWS and from other state agencies, that may be critical to emergency response.
	The draft ERP developed under the DWVARP should be exercised and updated to improve emergency response.
	Make SOPs and emergency response documents available and easily accessible for all staff.
9. State and Local Laws Affecting Drinking Water	There are areas where regulations could be used to promote PWS resiliency. There are several lessons learned from the programs and procedures used in other states that may be able to be replicated in Connecticut.
	There should be discussions with OPM for Plan of Conservation and Development integrations.
10. Private Well Vulnerabilities	Private well testing, or lack thereof, is a concern among public health officials.
	Only one municipality has a GIS database for private well locations.
	According to the mapping, there does not appear to be one large area of vulnerable private wells. However, this does not mean private wells are not vulnerable.
	There is a gap with dispersing information to private well owners.
	Private well owners continue to be a vulnerable population.

5.0 Recommendations

Table 5-1 at the end of this section presents recommended strategies and specific action items which, when implemented, will reduce the vulnerability and/or risk of drinking water supply sources and systems to the effects of natural hazards and climate change. The related recommended general themes and strategies are presented in the following subsections.

5.1 Recommendations to Increase Resiliency for Community Water Systems

The resiliency of PWSs to emergencies varies widely based on factors such as the size, financial soundness, location, and condition of the system. The recommendations listed below were developed from the research performed in compiling this report.

Operational Resiliency

Operational resiliency can be improved via any method that reduces the risk of a loss of service in the system. Since systems include supply sources, storage, treatment, and distribution systems, there are several opportunities for failure in the system, each of which affects the systems with varying degrees of severity and permanence. Planning for future vulnerabilities is the first step in defense. CWSs should begin to acknowledge climate change and the associated vulnerabilities in their WSPs. Theme 1 from table 5-1 serves as a reminder of the lessons learned during recent severe events. By acknowledging these vulnerabilities, emergency response procedures can also be created. System ECPs/Vulnerability Assessments should consider the climate change results presented in this report in addition to other analyses.

The most effective means for increasing resilience in a PWS is to provide interconnections with neighboring systems, which can provide emergency flow. Interconnections are especially effective because they only require the distribution system of the ailing system to be operational. Most PWSs have distribution systems that can be repaired relatively easily in emergency situations using in-house supplies. Areas of the distribution system that cannot be repaired can often be isolated or bypassed. CWSs should ensure that multiple sources and interconnections are available for conjunctive use of supplies and sharing of water. Regarding interconnections to connect large CWSs, the interconnection recommendation tables in this report and in the West, Central, and East Coordinated Water System Plans (CWSPs) should be used to prioritize future interconnections. For example, the Western CWSP recommends a tiered system of interconnections for resiliency. This should be pursued. Theme 7 in table 5-1 explores the various ways interconnections can safely aid in resiliency.

Regarding interconnections to connect small PWSs to one another or to large CWSs, the interconnection recommendation tables in this report and in the West, Central, and East CWSPs should be used to prioritize future interconnections. For example, the Western CWSP recommends that small systems in New Fairfield center should be connected. Whether or not interconnections are available, small CWSs should incorporate more redundancies into their infrastructure. If possible, the DWSRF should be utilized.

Emergency electrical generation is an important tool in increasing the resiliency of PWSs. The purpose of a generator is to combat a loss of service by providing power to draw water from the source and to pump water to high service zones. In 2015, the DPH required ALL CWSs regardless of size to have an emergency backup generator or have a plan for acquiring an emergency backup generator. The DWVARP takes this a step further. In addition to owning a generator, systems should plan for longer power outages by exploring the possibility of redundant fuel systems or larger fuel capacities. See Table 5-1, Theme 1-A for current recommendations on generator usage. Utilities should also coordinate with local Emergency Management Directors to ensure that PWSs are on the priority electrical service restoration list even if they have standby power.

An additional means of combatting a loss of service is to expand system storage. This can buy time during a power outage. This is especially important for systems that may not have the space or option to increase their fuel capacities for emergency electrical generation.

Drought Resiliency

Drought resiliency was brought to the forefront in Connecticut in 2016 when several large systems struggled with shortages in supply. Communication between water purveyors and state agencies was an issue during this time period. Drought communication is not uniform, which can lead to confusion among the public. Efforts to improve coordination between the state and CWSs about drought messages and to better communicate to the public when messages differ should be made. A reasonable level of drought response uniformity is needed to avoid confusion regarding drought responses. Stronger communication between the state and CWSs is needed to better convey drought responses to the public. Additionally, CWSs should evaluate and reset drought triggers, giving priority to those systems that have experienced serious impacts in the past decade.

CWSs should promote water conservation as well as public education and better communication to manage droughts. While water use restrictions are effective during drought, small systems have difficulty enforcing use restrictions, especially when customer water is not metered. Small systems may require additional technical and financial assistance for addressing droughts.

5.1.1 Resiliency for Public Water Supply Sources

The source of supply is the heart of any PWS. Common threats to water supply sources include aging infrastructure and flooding. These two factors work synergistically to compound each other as older, weaker infrastructure will tend to be less resilient to flooding.

Flooding is a major issue for both small and large CWSs. Since many of the most productive supply wells are situated in alluvial deposits, these areas naturally pose a flood risk. It is important to identify systems with public water supply wells in flood zones and ensure adequate measures are taken to protect wells from flooding. By identifying those wells that are located within a flood zone and ensuring sufficient protective mounding, the risk of flooding will be reduced. If wells are found to be inadequately prepared for a flooding event, improvements should be made so the well head is above the 500-year flood event plus appropriate freeboard.

Reservoirs with aging infrastructure, such as dams and spillways should be assessed for their capacity in dealing with future flooding and heavy precipitation events. While the storm scenarios typically used for spillway and dam design are large events such as a 1,000-year flood, more often than not newer precipitation data is not used for design. Therefore, up-to-date precipitation data should be used for new designs and reevaluations of infrastructure. By assessing the structural integrity and water flow capacity, upgrades and improvements can be made to the components to withstand climate change effects. This ensures that the systems not only function as designed during flood events but also do not cause or exacerbate flooding in their own right.

5.1.2 Resiliency for Community Water System Distribution Systems

The distribution system of a PWS comprises the network of arteries that ensure that public drinking water reaches its destination with the quality and pressure prescribed by law and expected by the consumer. The distribution system is critical to the function of the system in an emergency; a PWS can function with no source of supply if it has a functioning interconnection. A PWS with no source of supply and a nonoperational distribution system cannot function properly even if the system has a functioning interconnection.

To maintain properly functioning distribution systems, vulnerable pump stations and treatment plants should be made more resilient by floodproofing or utility hardening. These mitigation efforts will reduce the flood risk to the system. Additionally, water chemistry/compatibility should be assessed before the utilization of an interconnection. This will ensure that water quality will not be compromised due to interactions between the water and the distribution system.

5.1.3 Resiliency for Critical Facilities Served by Community Water Systems

Critical facilities include institutions such as hospitals, shelters, nursing homes, and other places that would be severely and quickly impacted by a loss of public water service in a way that endangers human life. Identifying where and what each critical facility is that is served by public water systems is an important stepping stone to increasing resilience. A GIS database should be developed to represent critical facilities and which PWS they are served by and identify critical facilities that are their own PWS. Once the GIS database has been developed, refined data could show which portions of CWSs serve specific critical facilities. To better identify these connections, there should be guidelines for CWSs to assess critical facilities that are located far from their sources; this would determine what infrastructure facilities rely on, therefore making service restoration easier. Lastly, critical facilities served by a PWS must inform the PWS of upgrades in order to provide the best possible service.

5.2 Long-Term Implementation Plan

5.2.1 Recommended Modifications to Current Law

Current law provides the provisions for maintaining quality drinking water in the State of Connecticut. Nevertheless, increasing knowledge and changing climactic conditions mean that regulations may need to be updated. On a broad scale, regulations should be developed to specifically link public water systems to resiliency planning and design standards. For example, the Water Supply Planning Regulations should be modified to incorporate climate change and resiliency in several areas. The water planning council should also help promote and advance PWS/CWS resiliency. This could be accomplished by ensuring that resiliency is included in the consideration of new laws, regulations, and policies and by promoting greater education of PWS about the importance of resiliency.

Local regulations should more directly address construction of public water supply wells in flood zones, and requirements should be uniform across the state. Guidance should be provided to the local land use commissions on revising these regulations to make well construction in flood zones more stringent (a similar recommendation for private wells is provided below).

Since small systems tend to have less inherent redundancies than large systems, testing should be increased in frequency for small PWSs (this should be incorporated into regulations but should provide DWS with flexibility to not require increased testing for all PWSs). Additionally, the DPH can incorporate a resiliency metric into the sanitary surveys through the small system CAT ("scorecard"). In order to monitor results over time, create a baseline for water quality and violations and compare future results to baseline. This baseline can prioritize land use decisions based on quality of adjacent watersheds and water bodies. In surface water bodies, DPH should increase source water quality monitoring in reservoirs that experience algal blooms.

Additional structural improvements could improve the resiliency of public water service. All CWSs must have adequate storage or an interconnection. CWSs that completely lack storage should be disallowed. Critical facilities served by a PWS must inform the PWS of upgrades.

5.2.2 Resources to Assist with Implementation

Many resources exist to help implement increases in resiliency. Among the most important resources is funding. Additional funding is especially needed to help small systems address severe events. The state should invest in science to explore the relationship between water quality violations and sanitary survey deficiencies with boil water advisories and waterborne disease outbreaks. The state should also promote and help fund additional source water protection measures and the Drinking Water Quality Management Plan for voluntary collaborative water quality protection. The State Bond Commission is also a potential funding source for future projects; however, recent past attempts at procuring funding have proven difficult. In 2018, the commission decided to not fund a PWS expansion project in New Fairfield for roughly 2 million dollars, however, a grant was provided for tide gate improvements in West Haven for almost 4 million dollars. While both proposals were resiliency projects, only the tide gates were funded. Therefore, future petitions for drinking water projects should be strongly cast as resiliency projects to make certain the commission realizes the importance of both new and improved drinking water infrastructure.

Nonregulatory guidance is also useful to aid in preventative PWS actions. The DPH should provide specific targeted nonregulatory guidance to PWSs regarding how to incorporate changes to flood and drought risks into planning and operations. They should also provide more support to NTNC and private systems to reduce MCL violations. For example, harmful or potentially harmful algal bloom data in Connecticut should be tracked, and DPH should provide technical assistance to CWSs to address these events.

Internal training and preparation on the part of the DPH can help public water systems increase resiliency and respond to emergency situations. The DWS should conduct DWSRF application workshops to assist systems in the application process. They should use source water protection and the Drinking Water Quality Management Plans as a source of resiliency and increase funding and support for investments in watershed protection. Other existing guidance sources should be updated. The PHERP has not been revised since 2011. The response plan should be revised as departmental changes occur, for example, the WEAR team is named in the PHERP; however, this team is no longer operating during an emergency. Utilizing new technology is critical in bolstering communication between PWSs, government agencies, and customers. The DPH should implement WebEOC and provide training for using the program. Internally, DPH should revise and exercise the ERP template developed under this study. They should also train multiple DWS staff in emergency response protocols and foster a culture of preparedness in the DWS by conducting weekly reminders about events that could potentially occur during the specific season or time of year. Externally, the DPH can form a Drinking Water Workgroup with other states.

5.3 Consistency with Other Planning Documents

The DWVARP addresses many important themes through both the analyses that were conducted and the recommendations to improve resilience. These themes and goals can be found within other resources that are available for resiliency projects.

The DWSRF has recently been modified so the priority ranking system utilized can prioritize projects geared toward infrastructure resiliency and sustainability and water conservation, among others. The DWSRF priorities are based in part on EPA's Drinking Water Infrastructure Needs Survey and Assessment (DWINSA), which estimates the 20-year capital investment requirements for PWSs in each state. The DWVARP has recognized that systems should protect vulnerable infrastructure from flooding, drought triggers should be reevaluated, and interconnections should be explored and that systems should plan and prepare for changes in water quality. Found in the appendices of the DWVARP are tables representing systems that may have vulnerable supply wells and other system components. Therefore, if these systems were to pursue state revolving funds, the projects would be and should be prioritized. Also, systems that are looking to increase drought resiliency by investing in infrastructure to reduce water loss should also be prioritized.

The DPH Capacity Development Strategy is a federally mandated strategy to which all primacy states must adhere to, including Connecticut. This strategy is targeted toward improving capacity for new and existing PWSs and includes four main focus areas:

1. Source protection and planning
2. Compliance and enforcement
3. Operation certification
4. DWSRF

The DWVARP has presented multiple recommendations that coincide with this strategy. For example, to improve source water protection, systems could acquire land to minimize pollution to wells or to increase recharge areas or conduct source protection improvements such as stormwater treatment basins. The plan also suggests increasing water quality testing and various ways the DWSRF can be leveraged to execute resilience projects. The overarching goal of the strategy is to provide systems with tools to succeed from a technical, managerial, and financial aspect; the DWVARP recommendations will likely address these aspects as well to improve the systems' capacity.

The WUCC process, as described in section 1.4.1, was also aimed at improving public water system resiliency. While the DWVARP takes a more detailed look at the factors that can exploit systems which lack resiliency, the goal of the plan is similar to one of the goals of the WUCC Process: that is, to ensure that public water systems are as resilient as possible, so that water service is not interrupted during extreme conditions. While the WUCC process focused more on how utilities can coordinate with one another, the DWVARP focuses on the natural phenomenon that will increasingly threaten public water systems. These threats are expected to increase in frequency and severity due to the impacts of climate change.

The Coordinated Water System Plans for the west, central, and east regions suggested that some small systems should be acquired by larger systems, and that interconnections should be pursued for resiliency and/or active daily supply. The Western Coordinated Water System Plan, for example, recommended development of a network of primary and secondary interconnections throughout the west region that would connect groups of CWSs in the Torrington, Waterbury, Southbury, Newtown, Bridgeport, and Stamford areas of the region; with connections to the central region in several locations. The DWVARP recommends further exploration of potential interconnections, and if not feasible, to install other redundancies such as additional wells and tanks, and backup power sources.

Table 5-1: Prioritization and Implementation of Recommendations

Theme	Strategy	Recommended Actions	Implementing Agency and PWS	Target Date	Potential Cost to Implementing Agency	Consistency with WUCC CWSPs	Consistency with DWSRF and DWINSA
I. Lessons Learned from Past Events	A. Generators are widely used and are helpful during power outages, but water systems are increasingly concerned about access to fuel during multi-day outages and the possibility of a generator failure during an event. Additional redundancies and/or additional planning for fuel outages may help many PWSs.	1. Evaluate fuel storage capacity and available runtime hours per tank for each generator, and ability of operators to bring additional fuel. Language should be added to RCSA Section 19-13-B-102(w) as follows: CWS shall be capable of maintaining adequate fuel storage ensuring a minimum of 48 hours of generator runtime in the event of a power outage. The emergency contingency and response plan shall include provisions for how the CWS will obtain and maintain fuel supply for the backup power supply, both prior to and during an event.	DPH	By 2020	Low	X	X
		2. When emergency contingency plans for large CWS and emergency contingency and response plans for small CWS are submitted, evaluate ability of each CWS to clear access roads of minor and major debris that would inhibit fuel delivery. Require CWSs to comment on this and the potential timeframe for restoring roadway access to system components during Sanitary Survey reconnaissance and report.	DPH & CWS	Begin in 2019	Low		
		3. Consider feasibility of alternatives to stretch fuel supplies for critical sites, such as through the installation of solar panels, larger fuel tanks, or installation of a portable generator hookup near the main road connected to the pumphouse/treatment building through an underground conduit. Require CWSs to comment on this during Sanitary Survey reconnaissance and report.	DPH & CWS	Begin in 2019	Low	X	X
	B. Coordinate with local Emergency Management Directors (EMDs) to ensure that PWSs are on the priority electrical service restoration list even if they have standby power.	1. Ensure that each EMD has a current list of community water systems and list of non-community public water systems of post-disaster importance (pharmacies, gas stations, grocery stores etc.) including contact information and addresses : this list should be updated and delivered annually.	DPH	Begin in 2019	Low		
	C. Additional funding is needed to help small systems address their risk to severe natural hazard events.	1. Leverage the DWSRF to provide streamlined access to loans similar to the recent generator program.	DPH	By 2023	Moderate	X	X
		2. Similar to what was done with Public Act 13-15 (SB-1010), develop legislation that will assist DPH in allocating public water system resiliency funding.	DPH	By 2023	Moderate	X	X
		3. Support water supply interconnection and other utility hardening or redundancy projects as "resiliency projects" before the State Bond Commission.	DPH	Begin in 2019	Low	X	
	D. Water use restrictions are effective during drought, but small systems have difficulty enforcing use restrictions, especially when customer water is not metered. Small systems may require additional technical and financial assistance for addressing droughts.	1. Work with industry committees and the Interagency Drought Workgroup to determine suitable pathways forward for enforcement of water use restrictions.	WUCCs & Local Health Departments	By 2023	Low	X	
		2. Encourage large water systems to achieve and maintain 100% customer metering , and allocate funding for small system metering.	DPH	Begin in 2019	High	X	X
		3. Provide pamphlets and flyers to local health departments for annual distribution to small CWS and residents on private wells regarding the need for water conservation. For example, distribute the EPA WaterSense "When in Drought...Use Your WaterSense" fact sheet, or utilize the information found on the WaterSense webpage to create comprehensive conservation documents.	DPH, Local Health Departments	Begin in 2020	Moderate	X	
		4. Review safe yield information for small CWS as part of office preparation for sanitary surveys. The sanitary survey should state whether the safe yield has been approved by DPH, was "grandfathered," or if information is missing which could be requested as part of the sanitary survey response.	DPH	Begin in 2019	Low		
		5. Require new aquifer testing and evaluation of groundwater safe yields every 25 years to account for potentially declining yields.	DPH	By 2023	Low		
	E. Drought communication is not uniform which can lead to confusion among the public. Efforts to improve coordination between the state and CWS about drought messages and to better communicate to the public when messages differ should be made.	1. Work with industry committees and the Interagency Drought Workgroup to determine a suitable communication method to inform CWS customers of requested water conservation and water restrictions, and to consider potential reporting requirements to track implementation .	WUCCs	By 2023	Low	X	

Table 5-1: Prioritization and Implementation of Recommendations

Theme	Strategy	Recommended Actions	Implementing Agency and PWS	Target Date	Potential Cost to Implementing Agency	Consistency with WUCC CWSPs	Consistency with DWSRF and DWINSA
II. Flood Risk to CWS Infrastructure and Critical Facilities	A. Identify systems with public water supply wells in flood zones, and ensure adequate measures are taken to protect wells from flooding in order to reduce the risk of flooding. If wells are found to be inadequately protected from a flooding event, improvements should be made so the well head is above the 0.2% annual chance flood event, plus appropriate freeboard.	1. For those public water supply wells identified as being at risk in Appendix F, require preparation of a FEMA Elevation Certificate, or equivalent elevation survey, and other supporting information be prepared to demonstrate that the wellhead is compliant with the elevation requirement of the Public Health Code.	DPH	By 2021	Low		
		2. Include flood elevation information and wellhead elevation information (in the same vertical datum such as NAVD88) as part of the System Description section of the sanitary survey report to track compliance.	DPH	Begin in 2019	Low		
		3. As part of the sanitary survey, require improvements for those wells not meeting the Public Health Code.	DPH	Begin in 2019	Low		X
		4. Add "public water supply wells and other above grade infrastructure used to provide public water supply" to the definition of "Critical Activity" under CGS 25-68b and update the Public Health Code to require new wells to be elevated to the 0.2% annual chance flood elevation or higher, plus appropriate freeboard.	DPH	By 2023	Low		
		5. Consider a sunset clause for wells installed prior to 1970 that pre-date current flood management laws. This would require that PWSs improve these wells to reduce flood risk, despite their age.	DPH	Begin in 2019	Low		
	B. Reservoirs with aging infrastructure, such as dams and spillways, should be assessed for their capacity to deal with future flooding and heavy precipitation events. By assessing the structural integrity and water flow capacity, upgrades and improvements can be made to the components to withstand climate change affects.	1. Summarize information regarding dams utilized for providing public water supply, including owner, age, condition, hazard class, spillway capacity, and design storm. Make this information available prior to sanitary surveys.	DPH, DEEP, and CWS	By 2023	Low	X	
		2. For dams that may be undersized or at risk (in the opinion of any State agency or the CWS), require reevaluation of the design storm based on updated precipitation data compiled by the Northeast Regional Climate Center, which may in turn drive infrastructure improvements.	DPH	By 2030	Low		
	C. Vulnerable pump stations and treatment plants should be made more resilient by floodproofing or utility hardening. These mitigation efforts will reduce the flood risk to the system.	1. For the infrastructure identified as being at risk in Appendix E require preparation of a FEMA Elevation Certificate, or equivalent elevation survey, and other supporting information be prepared to demonstrate the elevation of flooding that may occur, the degree of floodproofing afforded by the structure, and that the building is compliant with the Public Health Code.	DPH	By 2021	Low		
		2. Include flood elevation and infrastructure elevation information (in the same datum such as NAVD88) as part of the sanitary survey report to track compliance.	DPH	Begin in 2019	Low		
	D. All CWSs must have adequate storage or be serviced through an interconnection where the source utility has adequate storage.	1. Change the Public Health Code to require each CWS to have, at a minimum, an atmospheric storage volume equal to the average day demand as required by the CPCN regulations, and to demonstrate that this storage is capable of being distributed throughout the entire system. For those systems with interconnections, the interconnected system must demonstrate that sufficient storage is available in the source system to meet the average day demand of the combined system in consideration of any other interconnected systems.	DPH, CWS	By 2023	Low	X	X
	E. A GIS database should be developed to represent critical facilities and which PWS they are served by, and to also identify critical facilities that are also a PWS.	1. Annually request that Connecticut COGs and municipalities ensure critical facilities are listed in Hazard Mitigation Plans (in Table format, with addresses) and not just spatially presented in general terms on a map. The South Central Regional Hazard Mitigation Plan Update (2018) and Capitol Region Natural Hazard Mitigation Plan Update (2019) may be used as examples.	DPH	Begin in 2019	Low		
		2. Using information from Water Supply Plans, local Hazard Mitigation Plans, priority power restoration lists, and information from local EMDs, prepare a list of critical facilities referenced to their water source (private well, self-owned or operated C, NTNC, or TNC public water system, or customer of another public water system). A starting point for this information for the four coastal counties can be found in Appendix I. Use the addresses of each critical facility to geocode the spatial location in ArcGIS and correct locations as necessary. Provide this list and mapping to local health districts, EMDs, and regional COGs. This list should be updated a minimum of every two years.	DPH	Begin in 2019	Low		
	F. Once the GIS database in Strategy E. has been developed, refined data could show which portions of CWSs serve specific critical facilities. There should be guidelines for CWSs to assess critical facilities that are located far from their sources; this would determine what infrastructure facilities rely on, therefore allowing for prioritization of repairs.	1. Update the water supply planning regulations to require this assessment (Strategy F) as part of regular Emergency Contingency Plan updates. To facilitate this assessment, provide large CWSs a list and spatial data for the critical facilities in and near their service area when the request for a water supply plan update is sent.	DPH	Begin in 2019	Low		
		2. Update the emergency contingency and response plan regulations for small CWS to require this assessment (Strategy F) for small CWS who serve other critical facilities as customers.	DPH	Begin in 2019	Low		

Table 5-1: Prioritization and Implementation of Recommendations

Theme	Strategy	Recommended Actions	Implementing Agency and PWS	Target Date	Potential Cost to Implementing Agency	Consistency with WUCC CWSPs	Consistency with DWSRF and DWINSA
II. Flood Risk to CWS Infrastructure and Critical Facilities	G. Critical facilities served by a PWS should advise that PWS of any changes of use which may affect the priority of service restoration.	1. Require CWS to survey served critical facilities every three years (as part of the sanitary survey) to identify changes in use which may affect the priority of response. This may require a regulation change to ensure that this aspect of managerial capacity is implemented.	DPH, CWS	Begin in 2019	Low		
III. Water Quality and Quantity Vulnerabilities	A. Increase testing frequency for small PWSs for certain constituents of concern (this regulatory change should provide DWS with flexibility to not require increased testing for all PWSs).	1. Compile a list of small PWS that do not have treatment systems and who therefore may be at greater risk of being affected by raw water quality changes. Review the list prior to sanitary surveys.	DPH	By 2023	Low	X	
		2. Develop a regulation allowing for increased testing frequency for constituents of concern based on the types of treatment system components which are in place.	DPH	By 2023	Low		
	B. Incorporate resiliency information into sanitary surveys.	1. Include information regarding backup power, fuel source, tank capacity, and runtime as part of the System Description section of the sanitary survey.	DPH	Begin in 2019	Low		
	C. Incorporate resiliency metrics into the small system Capacity Assessment Tool ("Scorecard").	1. Include failure to comply with Public Health Code requirements for flood elevation as a minor deficiency under question T2.	DPH	Begin in 2019	Low	X	
		2. The system sufficiency plan under M5 must include provisions for restoring access to critical infrastructure following hurricane events in order to receive full points.	DPH	Begin in 2019	Low	X	
		3. To receive full points under M7, the list of emergency crews and vendors must include tree removal crews and associated capabilities.	DPH	Begin in 2019	Low	X	
		4. Update question M10 regarding emergency power capability to provide full points only if two days of generator runtime are provided.	DPH	Begin in 2019	Low	X	
		5. In order to get full points under F1 and F5, the related plans must include the need to addressing potential future water quality changes.	DPH	Begin in 2019	Low	X	
	D. Create a baseline for water quality and violations and compare future results to baseline. This baseline can prioritize land use decisions based on quality of adjacent watersheds and water bodies. Explore the relationship between water quality violations and sanitary survey deficiencies with boil water advisories and waterborne disease outbreaks.	1. Update the water supply plan regulations to require large CWS to conduct trend analysis of source (raw) water quality results as part of their water supply plan updates. To ensure that this is not too burdensome, provide guidance to CWSs such as a written series of questions to answer in the water supply plan, which would accomplish the analysis.	DPH	By 2023	Low		
		2. Hire staff trained in GIS, geodatabases, and Microsoft Access to track water quality trends for small CWS, TNC, and NTNC systems and provide a copy to these systems during sanitary surveys.	DPH	Begin in 2019	Moderate		
		3. Provide DPH management an annual report summarizing outbreaks, violations, and other related trends.	DPH	Begin in 2020	Moderate		
	E. Use source water protection and the Drinking Water Quality Management Plans to encourage resiliency and increase funding and support for investments in watershed protection	1. Leverage the Local Assistance and Other State Programs Set-Aside within DWSRF to acquire land in watersheds where high percentages of land are not controlled by the utility or otherwise protected from development. This will be done for the purpose of wellhead protection or to protect recharge areas. Development of a priority setting process may be necessary for EPA approval.	DPH	By 2023	Low	X	X
		2. Prioritize the use of DWSRF to conduct source protection improvements such as installation of stormwater treatment basins.	DPH	Begin in 2019	Moderate	X	X
		3. Annually encourage PWS to apply to the Open Space and Watershed Land Acquisitions Grant Program managed by DEEP and authorized by CGS Section 7-131d(b), such as via Circular letter (subject to the availability of the grant program).	DPH, DEEP, PWS	Begin in 2019	Low	X	X
		4. Secure funding to develop Drinking Water Quality Management Plans for reservoir watersheds spanning multiple communities. Begin with watersheds where percent of water company land is relatively low.	DPH	By 2023	High	X	X

Table 5-1: Prioritization and Implementation of Recommendations

Theme	Strategy	Recommended Actions	Implementing Agency and PWS	Target Date	Potential Cost to Implementing Agency	Consistency with WUCC CWSPs	Consistency with DWSRF and DWINSA
III. Water Quality and Quantity Vulnerabilities	F. Increase the frequency of required source water quality monitoring in public water supply reservoirs that experience algal blooms.	1. When an algal bloom occurs, encourage the CWS to sample the reservoir for Secchi disk transparency, chlorophyll-a, total nitrogen, total phosphorus, temperature, dissolved oxygen, specific conductivity, pH, copper sulfate, the residuals of any applied algaecides, and alkalinity at various locations and depths and provide the results to DPH.	DPH, CWS	Begin in 2019	Low		
		2. Request that CWSs track the timing of occurrence and the length of algal blooms each year and provide this information to DPH. To ensure that this is not too burdensome, provide guidance to the CWSs such as a written series of questions to answer.	DPH, CWS	Begin in 2019	Low		
		3. Compile algal bloom and sampling information into a spatial trend analysis to determine if reservoirs are changing from oligotrophic or mesotrophic to eutrophic conditions.	DPH	Begin in 2019	Moderate		
		4. If raw water quality appears to be significantly affecting treated water quality (in the opinion of DPH or the CWS), DPH should request the system to conduct a formal limnological assessment and runoff monitoring to determine potential point and nonpoint sources driving the algal bloom in order to potentially rectify the situation.	DPH, CWS	As needed	Low		
	G. Provide more support to NTNC and TNC water systems to reduce MCL violations.	1. Annually provide pictures, information, and pamphlets to Local Health Directors for distribution to NTNC and TNC public water systems that they may use to evaluate source water protection, the sanitary nature of their well caps, and if treatment is necessary. This should be accompanied by information on the DWSRF to promote a funding source for any necessary upgrades.	DPH, Local Health Departments	Begin in 2019	Moderate	X	
IV. Climate Change Impacts	A. Provide specific targeted non-regulatory guidance to PWSs regarding how to incorporate changes to flood risks into planning and operations.	1. Conduct regional workshops every five years to educate utilities and small systems on flood risk planning.	DPH & WUCCs	Begin by 2023	Low	X	
		2. Develop and provide pamphlets, flyers, or fact sheets based on the flood workshops to those systems and provide copies to local health departments for distribution to small CWS, NTNC, and TNC systems every five years.	DPH, Local Health Departments	Begin by 2023	Moderate	X	
	B. Provide specific targeted non-regulatory guidance to PWSs regarding how to incorporate changes to drought risks into planning and operations.	1. Conduct regional workshops every five years to educate utilities and small systems on drought risk planning.	DPH & WUCCs	Begin by 2023	Low	X	
		2. Develop and provide pamphlets, flyers, or fact sheets based on the drought workshops to those systems and provide copies to local health departments for distribution to small CWS, NTNC, and TNC systems every five years.	DPH, Local Health Departments	Begin by 2023	Moderate	X	
	C. Track harmful or potentially harmful algal bloom data in Connecticut and provide technical assistance to CWSs to address these events.	1. Conduct workshops to discuss limnological trends and potential methods to improve water quality based on the data collected under Strategy III.F. above. The outcome from these workshops should be information and resources which CWS may use to prevent, mitigate, and treat algal blooms with information on the potential effectiveness of various strategies.	DPH	By 2030	Moderate	X	
		2. Determine potential funding sources for potential projects to improve water quality.	DPH	By 2023	Low	X	X
V. CWS Vulnerabilities and Emergency Preparedness	A. CWSs should begin to acknowledge climate change and the associated vulnerabilities in their water supply plans. By acknowledging these vulnerabilities, emergency response procedures can also be created. System ECP's/VA's should consider the climate change vulnerability assessment results.	1. Update the water supply planning regulations to require assessment of the potential impacts of climate change (changing rainfall patterns, flooding, sea level rise, drought management) on the water system as part of Water Supply Plan updates.	DPH	By 2023	Low	X	
		2. Assist small community systems in how to evaluate drought information as part of their emergency response and contingency plans, and direct them to useful resources.	DPH	Begin in 2019	Moderate	X	
		3. Advise systems of potential vulnerabilities using the system component vulnerability data found in Appendix E.	DPH	By 2020	Low	X	

Table 5-1: Prioritization and Implementation of Recommendations

Theme	Strategy	Recommended Actions	Implementing Agency and PWS	Target Date	Potential Cost to Implementing Agency	Consistency with WUCC CWSPs	Consistency with DWSRF and DWINSA
V. CWS Vulnerabilities and Emergency Preparedness	B. Emergency contingency plan priority facility lists should include all critical facilities in communities served by the CWS. Local hazard mitigation plans should be consulted to compile these lists. [The definition of "critical facility" is "structures and institutions necessary for a community's response to and recovery from emergencies. Critical facilities must continue to operate during and following a disaster to reduce the severity of impacts and accelerate recovery]	1. Implement the recommendations under Strategies II.E. and II.F. above.	DPH	Begin in 2019	Low		
VI. Drought Planning and Resilience	A. CWSs should evaluate and reset drought triggers, with priority for those systems that have experienced serious impacts in the past decade.	1. Work with industry committees and the Interagency Drought Workgroup to determine a reasonable method to establish and reset drought triggers.	CWS, WUCCs	By 2023	Low	X	
		2. For systems largely reliant on reservoirs, consider the use of drought forecasting techniques to manage reservoir storage and water restrictions. These techniques should consider risk based on both past events and the potential for changing conditions in the future. Reliance on past trends alone should be disallowed.	CWS	By 2030	Moderate	X	
		3. For systems with mostly groundwater sources, ensure that drought triggers include provisions for when some groundwater sources are offline.	CWS	By 2030	Moderate	X	
	B. Given that drought risks are changing due to climate change, CWSs should re-evaluate drought triggers and drought response protocols at least once per decade.	1. Update reservoir safe yield calculations to include provisions to ensure compliance with the Connecticut Streamflow Standards and Regulations.	CWS	By 2023	Moderate	X	
		2. Large CWS should modify their drought response to the preferred four-stage response to ensure continuity across the state, although stages within each of the four stages should be allowed if the CWS finds that this is beneficial for reducing the onset of emergencies.	CWS	By 2030	Low	X	
		3. Reevaluate drought triggers and update the drought response plan during each water supply plan update. This need not take the form of a new rigorous study during each plan update; however, events over the interceding period of time must be considered.	CWS	By 2030	Low	X	
	C. CWSs should invest in drought forecast modeling that includes not only consideration of recent climate but also future climate changes. This is a different approach than the reservoir forecasting currently being conducted by several large water utilities.	1. Evaluate the value and pros and cons of different types of drought forecasting and modeling.	CWS, WUCCs	By 2030	Low	X	
		2. Determine the appropriate level of drought forecasting based on system demand, system storage, percentage of demand met by surface water supplies, and other inputs. These techniques should consider risk based on both past events and the potential for changing conditions in the future.	CWS, WUCCs	By 2030	Low	X	
		3. For small CWSs that do not file water supply plans, update the drought portion of emergency response and contingency plans at least once per decade to keep track of changing climatic conditions.	Small CWS	By 2030	Low	X	
	D. CWSs should ensure that multiple sources and interconnections are available for conjunctive use of supplies and sharing of water.	1. Install redundant supply sources for systems with only one source of supply.	CWS	By 2030	Low	X	X
		2. Consider written agreements with neighboring utilities to allocate water in an emergency.	CWS	By 2030	Low	X	
		3. Small CWS should maintain a supply of bottled emergency water to distribute during emergencies, or maintain an agreement with local emergency responders to ensure that water can be provided.	CWS	By 2030	Moderate		
	E. CWSs should promote water conservation as well as public education and better communication to manage droughts.	1. Distribute information regarding water conservation techniques to system consumers on an annual basis, such as concurrent with Consumer Confidence Reports.	CWS	Begin in 2019	Low	X	
		2. Clearly communicate water conservation goals and water use restrictions to consumers when such restrictions are necessary.	CWS	Begin in 2019	Low	X	

Table 5-1: Prioritization and Implementation of Recommendations

Theme	Strategy	Recommended Actions	Implementing Agency and PWS	Target Date	Potential Cost to Implementing Agency	Consistency with WUCC CWSPs	Consistency with DWSRF and DWINSA
VII. Interconnections and Infrastructure Upgrades	A. Regarding interconnections to connect large CWSs: The interconnection recommendation tables in this report and in the West, Central, and East CWSPs should be used to prioritize future interconnections. For example, the Western CSWP recommends a tiered system of interconnections for resiliency. These should be pursued.	1. Work with the utilities to be interconnected to develop plans and specifications for the interconnection and secure permits.	DPH, CWS	Begin in 2019	Low	X	
		2. Seek DWSRF funding or other funding to construct and implement the project.	CWS	Begin in 2019	High	X	X
	B. Regarding interconnections to connect small PWSs to one another or to large CWSs: The interconnection recommendation tables in this report and in the West, Central, and East CWSPs should be used to prioritize future interconnections. For example, the Western CSWP recommends that small systems in New Fairfield center should be connected.	1. Use the CAT to help prioritize DWSRF funding distributions.	DPH	Begin in 2019	Low	X	X
		2. Leverage the WUCCs to identify potential areas where system interconnection and/or consolidation may be pursued and host meetings with affected systems and/or ESA holders to determine project feasibility. Projects will likely need to be funded by grants or loans from the DWSRF.	DPH, WUCCs	By 2023	High	X	X
	C. Water chemistry/compatibility should be assessed before the utilization of an interconnection.	1. As part of the Sale of Excess Water Permit, require submission of water samples taken and appropriately mixed with different hold times to estimate potential water quality following the interconnection. Analyses may include pH, corrosivity, and disinfection byproducts along with other DPH constituents of concern. Pipe composition in both systems should be disclosed and taken into consideration when reviewing the permit application. A regulation change may be necessary to require sampling.	DPH, CWS	Begin by 2020	Low	X	
	D. Small CWSs should incorporate more redundancies into their infrastructure. If possible, DWSRF funds should be utilized.	1. Utilize DWSRF funding to install redundant wells and tanks, and backup generators.	CWS	By 2030	Moderate	X	X
		2. Utilize DWSRF funding to install interconnections between small CWSs and with large CWSs.	CWS	By 2030	High	X	X
	E. Conduct DWSRF application workshops and provide other assistance to small systems in the application process.	1. Conduct regional workshops each year to assist with preparation of DWSRF applications.	DPH, WUCCs	Begin in 2019	Low	X	
		2. Appropriate funding for a consultant to prepare plans and specifications to support DWSRF applications for small systems, similar to the recent generator effort.	DPH	Begin in 2019	Moderate	X	
VIII. Drinking Water Section Emergency Preparedness	A. The Public Health Emergency Response Plan (PHERP) has not been revised since 2011. The Response Plan should be revised as departmental changes occur, for example, the WEAR team is named in the PHERP, however, this team is no longer operating during an emergency.	1. Perform a 10-year update to the PHERP to incorporate information in the DWS Emergency Response Plan template developed and submitted under separate cover.	DPH	By 2021	Moderate		
	B. Implement WebEOC and provide training to CWSs to use the program.	1. Conduct annual workshops and tabletop drills, before each hurricane season, to simulate emergency events with utilities where WebEOC is used to track response.	DPH, CWS	Begin in 2019	Moderate		
	C. Finalize, maintain, and exercise the Drinking Water Section Emergency Response Plan template developed under this study.	1. Develop and add security-sensitive information to the appropriate appendices.	DPH	Begin in 2019	Low		
		2. Add additional appendices as additional classifications of information are identified that need to be part of the plan .	DPH	Begin in 2019	Low		
		3. Ensure the plan is updated annually (at a minimum) to reflect changes in policy and personnel.	DPH	Begin in 2019	Low		
		4. Perform a training exercise annually to ensure all aspects of the plan are appropriate and are up to date.	DPH	Begin in 2019	Low		
	D. Form a Drinking Water Workgroup with other states.	1. Coordinate on contact information and procedures to conduct emergency response for incidents crossing state lines.	DPH	Begin in 2019	Low		
		2. Share success stories and lessons learned to provide additional education on emergency response.	DPH	Begin in 2019	Low		
		3. Invite neighboring states to participate in tabletop training exercises when appropriate.	DPH	Begin in 2019	Low		
	E. Ensure redundancy is available to ensure essential emergency functions can be carried out even if all staff are not in the office	1. Train multiple DWS staff in emergency response protocols.	DPH	Begin in 2019	Low		

Table 5-1: Prioritization and Implementation of Recommendations

Theme	Strategy	Recommended Actions	Implementing Agency and PWS	Target Date	Potential Cost to Implementing Agency	Consistency with WUCC CWSPs	Consistency with DWSRF and DWINSA
VIII. Drinking Water Section Emergency Preparedness	F. Foster a culture of preparedness in the DWS by conducting weekly reminders about events that could potentially occur during the specific season or time of year.	1. Assign a staff person to prepare a newsletter or email to this effect.	DPH	Begin in 2019	Low		
		2. Include case studies of specific events that could potentially occur as an appendix to the DWS Emergency Response Plan.	DPH	Begin in 2019	Low		
IX. State and Local Laws Affecting Drinking Water *[numerous statute and regulation changes are recommended in the above Themes and Strategies. This Theme addresses additional Strategies].*	A. The Water Planning Council should help promote and advance PWS/CWS resiliency. This could be accomplished by ensuring that resiliency is included in the consideration of new laws, regulations, and policies and by promoting greater education of PWS about the importance of resiliency.	1. Utilize the WPC as a platform for interagency and public discussion of potential laws, regulations, and policies related to public water system resiliency.	DPH	Begin in 2019	Low	X	
	B. Local regulations should more directly address construction of public water supply wells in flood zones, and requirements should be uniform across the State. Guidance should be provided to the local land use commissions when revising flood regulations to make well construction in flood zones more stringent [a similar recommendation for private wells is provided below].	1. Request DEEP's NFIP Coordinator to keep DPH advised when local flood regulations are being updated. An annual message to this effect should be sent to DEEP.	DPH, DEEP	Begin in 2019	Low		
		2. When local flood regulations are being updated, request that the local flood regulations are at least as stringent as any flood management regulations in the Public Health Code.	DPH, Local Health Districts	Begin in 2019	Low		
		3. Work with DEEP's NFIP coordinator to incorporate additional text into the model flood regulations.	DPH, DEEP	Begin in 2019	Low		
	C. The CWSPs are required by regulation to be updated every 10 years, whereas the DWVARP is a one-off plan. The CWSPs should be leveraged to provide future assessment of regional public water system resiliency.	1. Require an updated resiliency assessment similar to the DWVARP as part of Coordinated Water System Plan updates. Update the CWSP regulations if necessary to ensure that adequate funding can be obtained.	DPH	By 2030	High	X	
X. Private Well Vulnerabilities	A. Conduct workshops to educate towns and local health departments on identification of private well issues, and how to identify potential neighborhood scale resiliency projects.	1. Promote "smart development" by encouraging new construction and private wells outside flood zones to avoid risk to wells. This will require consideration of building lot configurations.	Municipalities, Local Health Districts	Begin in 2019	Low		
		2. Provide direct guidance to the local land use commissions when revising Subdivision Regulations to make private well construction in flood zones more stringent. Local planning and zoning committees currently utilize generic regulations regarding construction of wells in flood zones. These generic regulations are insufficient for reducing the number of at-risk wells.	DPH, Municipalities, Local Health Districts	Begin in 2019	Low		
		3. Distribute fact sheets in Appendix L to augment local education regarding private well remediation methods.	DPH	Begin in 2019	Low		
	B. Make funding available to remediate private well issues.	1. Determine potential funding sources and allocate funding for remediation projects.	DPH	Begin in 2019	High		
		2. Determine potential funding sources and allocate funding for incentivization programs.	DPH	Begin in 2019	High		

Table 5-1: Prioritization and Implementation of Recommendations

Theme	Strategy	Recommended Actions	Implementing Agency and PWS	Target Date	Potential Cost to Implementing Agency	Consistency with WUCC CWSPs	Consistency with DWSRF and DWINSA
X. Private Well Vulnerabilities	C. Towns and Local Health Departments should conduct public outreach to identify their local private well issues, evaluate potential projects that will address the neighborhood scale issues, and apply for funding to remediate.	1. Educate residents on the importance of upgrading private wells and educate developers on the importance of siting well locations outside flood zones.	Municipalities, Local Health Districts	Begin in 2019	Low		
		2. Identify drainage and flood control projects to alleviate flooding of private wells (i.e. projects similar to Meadowbrook Manor in Brookfield).	Municipalities, Local Health Districts	Begin in 2019	Low		
		3. Identify property acquisitions to eliminate private well and property damage (i.e. remaining at-risk properties/ wells along River Trail and Flood Bridge Road in Southbury).	Municipalities, Local Health Districts	Begin in 2019	Low		
		4. Identify potential water main extension projects Statewide to replace private water supplies and ensure reliable and consistent public water supply (i.e. Guilford and Stonington).	Municipalities, Local Health Districts	Begin in 2019	Low	X	X
		5. Extend public water systems to coastal areas that are at risk of coastal flooding, sea level rise, and salt water intrusion (i.e. Indian Cove in Guilford).	Municipalities, Local Health Districts	Begin in 2019	High	X	X
		6. Identify well protection projects such as retrofitting a well to provide flood protection.	Municipalities, Local Health Districts	Begin in 2019	Low		
		7. Identify well relocation projects such as moving a well out of a flood zone within a specific property or parcel.	Municipalities, Local Health Districts	Begin in 2019	Low		
		8. Identify potential new PWSs to create small reliable systems that replace private wells of the new customers.	Municipalities, Local Health Districts, WUCCs	Begin in 2019	Low	X	X
	D. A dedicated list of bulk water haulers is necessary to alleviate private well impacts	1. Identify and maintain an up to date list of "water buffaloes" and other small water hauling vehicles to dispatch to areas of private wells during and after severe weather events and power outages. Encourage such haulers to be certified by DPH and added to the Bulk Water Hauler List.	DPH	Begin in 2019	Low		
	E. State private well regulations should be reviewed periodically to reflect standards necessary to avoid flooding of wells	1. As private well construction standards change, or at least every ten years, review regulatory standards to ensure these standards reflect climate change effects and the most up to date sanitary requirements.	DPH	Begin in 2019	Low		
	F. Private well information is limited and the existing database managed by the Department of Consumer Protection only allows searching by town and installation year. Location reporting requirements should be enacted and well logs spatially digitized to allow for easier use and study.	1. Update the Well Completion Report Form to require the latitude and longitude of new wells (and for existing wells when the Well Completion Report is utilized) to be reported.	DCP	By 2023	Low		
		2. Digitize new well logs into a spatial geodatabase as they are submitted upon completion. Digitize the existing logs to the extent possible based on the available information. Develop an online database to allow public access to this information similar to The Water Well Inventory Program in New Hampshire (https://www.des.nh.gov/organization/commissioner/gsu/wwip/index.htm).	DCP	By 2030	High		

Potential Costs:

Low = <$10,000

Moderate = Between $10,000 and $100,000

High = > $100,000

APPENDIX A

Summary of Applicable Laws
and Policies

A summary of state laws and state policies and practices follows. In general, the existing laws, statutes, and regulations provide a strong foundation for resiliency. The various statewide planning efforts authorized by laws and regulations provide additional tools which may be used to further encourage resiliency in public water systems. Finally, the State Water Plan, the Coordinated Water System Plans, and the Water Utility Coordinating Committees can provide the means to implement resiliency planning and projects for community public water systems.

Summary of State Laws Enacted Prior to 2010

Prior to 1974, the responsibility for regulation of public drinking water supplies was left to state government. The Federal Safe Drinking Water Act (SDWA) was passed in 1974 which authorized the federal government to set national drinking water standards, conduct special studies, and to generally oversee the implementation of the Act. However, primary responsibility of implementation and enforcement essentially remained in the hands of state government.

Subsequent to the passage of the SDWA, interim primary drinking water regulations were promulgated. These regulations and subsequent revisions set standards for a variety of contaminants. In June 1986, amendments to the SDWA were adopted. The amendments converted interim and revised primary drinking water standards to national primary drinking water regulations and converted recommended maximum contaminant levels (RMCLs) to maximum contaminant level (MCL) goals.

The SDWA was reauthorized in 1996. The law focuses water program spending on the contaminants that pose the greatest risk to human health and that are most likely to occur in a given water system. It also requires water systems to notify the public of water safety violations within 24 hours. It maintains requirements that EPA set both a maximum contaminant level and a maximum contaminant level goal for regulated contaminants based on health risk reduction analysis that includes a cost/benefit consideration. The revised act also requires EPA to establish a database to monitor the presence of unregulated contaminants in water.

At the state level, the authority for regulation of public drinking water is established under Section 25-32 of the Connecticut General Statutes and implemented through the Public Health Code by DPH. These requirements are consistent with federal regulations and have additional requirements such as annual watershed surveys, annual cross connection surveys, monitoring of raw and finished water, and public notification requirements. DPH has statutory authority (CGS 22a-471) to establish drinking water action levels for contaminants in groundwater, above which pose an unacceptable risk to persons who use the groundwater as a drinking water source or for other domestic uses. DPH sets action levels that are protective of public health and also feasible based upon analytical detection and treatment technology. If well contamination exceeds an Action Level, DEEP is authorized to take further action in addressing the groundwater contamination.

For the interests of this project, pertinent laws can be categorized into four categories: laws regarding Critical Public Infrastructure, laws regarding Infrastructure Vulnerabilities and Resiliency, laws affecting Planning, and laws regarding Emergency Preparedness. Table 1 summarizes the various state laws as to their applicability to the four categories.

Table 1.
Summary of State Laws Enacted Prior to 2010

Law	Critical Public Infrastructure	Infrastructure Vulnerabilities and Resiliency	Planning	Emergency Preparedness
CGS Section 16-262m (RCSA 16-262m)	X	X		
CGS Sections 22a-401 to 411 (RCSA 22a-409-1 &2)	X			X
CGS Section 25-32d		X		
CGS Section 25-32d-1 (RCSA 25-32d)	X	X	X	X
CGS Section 25-68b to 68h	X	X		
Public Act 85-535			X	
Public Act 01-177			X	
Public Act 03-236				X
Public Act 04-144			X	
Public Health Code Section 19-13-B51	X			
Public Health Code Section 19-13-B101	X			
Public Health Code Section 19-13-102	X			

Section 16-262m of the Connecticut General Statutes and Section 16-262m of the Regulations of Connecticut State Agencies: Certificate of Public Convenience and Necessity

The Certificate of Public Convenience and Necessity (CPCN) is a process for establishing new public water systems. Although the individual water supply planning and coordinated water system planning (described below) are somewhat unique to Connecticut, the CPCN is similar to other states' staged or stepped processes for approving new water systems. DPH manages the process in three phases, and may involve PURA as needed. Phase IA is commonly known as the new source site approval, but it includes an overall review of the project's location and general characteristics such as the technical, managerial, and financial capacity of the proposed water system owner. Phase IB includes a review of new source quantity and quality. Phase II is the review and approval of detailed plans for the new water system.

By statute, the CPCN is designed to work with the coordinated water system planning process. DPH may request that a convened WUCC provide a recommendation for how the development of a new public water system should proceed in a PWSMA. Specifically, the WUCC may recommend the creation of a new satellite system, the extension of a water main to serve the site, or recommend against the development of public water supply. However, WUCC approval is not necessary for the creation of a new public water system.

The regulations are presently devoted to specifying requirements for the development of new CWSs, and include a variety of requirements to promote redundancy (such as requiring installation of backup wells) Furthermore, the requirements are designed in part to ensure well-constructed, resilient systems which will last for many years. Regulations devoted to the development of new non-community systems are a recommendation of each Water Utility Coordinating Committee (WUCC) in their draft Integrated Reports dated March 2018.

Section 19-13-B51 of the Public Health Code: Water Supply Wells and Springs & Section 19-13-B101 and Section 19-13-B102 of the Public Health Code: Testing of Water Quality in Private Water Supply Systems

Sections 19-13-B51a through m, inclusive of the Public Health Code governs the construction of both public wells and private wells, as well as interconnections. For example, wells must be constructed at a relatively high point on the premises consistent with the general layout and surroundings, be above the location of the 100-year (0.1% annual chance) flood (per RCSA Section 19-13-B102(d)(1)(A)), and be protected from surface wash. These requirements impact a base level of resilience to new groundwater supplies.

According to the DPH, approximately 322,578 private residential wells in Connecticut serve approximately 23% of the state's population.

Private wells that supply residential properties for domestic use and many small non-residential properties are not regulated by the EPA, and likewise are not regulated by the DPH's Drinking Water Section. Private well owners are responsible for testing the quality of their own drinking water and maintaining their own wells. Private wells are initially tested when a well is first constructed for basic parameters and may not be tested for several years thereafter. Private wells are typically tested during the home inspection of a real estate transaction or when required by a mortgage company. Testing of private wells since 2013 for metals such as arsenic and uranium, that were not likely included in the basic testing of a private well prior to this timeframe, has resulted in the identification of areas of the state with very high levels of these naturally occurring contaminants.

Well yield and well construction data is not available in a single spatial data set. Scanned drilling permits and well drilling logs for wells installed since 1970 are available online through the Connecticut Department of Consumer Protection website, or may be reviewed in person at the Connecticut Department of Consumer Protection or Department of Energy and Environmental Protection (DEEP). The logs are organized by town and year. Well drilling logs prior to 1970 are on file at the USGS East Hartford Office by appointment, and CT DEEP maintains well records back to the 1050's.

The State's 73 local health departments and districts have the authority over all private wells in the towns where they have jurisdiction, and all municipalities are served by a health department of district. Private wells must be properly sited, tested, and the water quality results approved by the local director of health before a certificate of occupancy is granted. DPH has a regulatory requirement to approve separating distance exceptions for septic system repairs within the sanitary radius of a water supply well; reportedly, almost all well separating distance exceptions issued by DPH affect private wells.

DPH maintains a Private Well Program that provides outreach and education to the public, technical guidance, and training to local health departments and districts. DPH has the statutory authority to develop regulations for private residential wells.

Section 22a-401 through 22a-409 of the Connecticut General Statutes and Section 22a-409-1 & 2 of the Regulations of Connecticut State Agencies:
Dam Safety

The State's dam safety program is closely aligned with its flood management program. Due to the relationship between dams and water supply (described above), streamflow regulations (described above), and fish passage (described below), a detailed description of the dam safety program is provided herein.

The dam safety statutes are codified in Sections 22a-401 through 22a-411 inclusive of the Connecticut General Statutes. Sections 22a-409-1 and 22a-409-2 of the Regulations of Connecticut State Agencies have been enacted, which govern the registration, classification, and inspection of dams. The DEEP administers the statewide Dam Safety Program and designates a classification to each state-registered dam based on its potential hazard.

- Class AA dams are negligible hazard potential dams that upon failure would result in no measurable damage to roadways and structures and negligible economic loss.

- Class A dams are low hazard potential dams that upon failure would result in damage to agricultural land and unimproved roadways, with minimal economic loss.

- Class BB dams are moderate hazard potential dams that upon failure would result in damage to normally unoccupied storage structures, damage to low volume roadways, and moderate economic loss.

- Class B dams are significant hazard potential dams that upon failure would result in possible loss of life; minor damage to habitable structures, residences, hospitals, convalescent homes, schools, and the like; damage or interruption of service of utilities; damage to primary roadways; and significant economic loss.

- Class C dams are high potential hazard dams that upon failure would result in loss of life and major damage to habitable structures, residences, hospitals, convalescent homes, schools, and main highways, with great economic loss.

Dam inspection regulations require that nearly 700 dams in Connecticut be inspected annually. The DEEP currently prioritizes inspections of those dams that pose the greatest potential threat to downstream persons and properties. Dams found to be unsafe under the inspection program must be repaired by the owner. Depending on the severity of the identified deficiency, an owner is allowed reasonable time to make the required repairs or remove the dam. If a dam owner fails to make necessary repairs to the subject structure, the DEEP may issue an administrative order requiring the owner to restore the structure to a safe condition and may refer noncompliance with such an order to the Attorney General's Office for enforcement.

Owners of Class C dams have traditionally been required to maintain Emergency Operation Plans (EOPs). Guidelines for dam EOPs were published by DEEP in 2012, creating a uniform approach for development of EOPs. Important dam safety program changes are underway in Connecticut. Public Act No. 13-197, An Act Concerning the Dam Safety Program and Mosquito Control, passed in June 2013 and describes new requirements for dams related to registration, maintenance, and EOPs, which will be called emergency action plans (EAPs) moving forward. This Act requires owners of certain unregistered dams or similar structures to register them by October 1, 2015. The Act generally shifts regularly scheduled inspection and reporting requirements from the DEEP to the owners of dams. At the present time, the owner of any high or significant hazard dam (Class B and C) must develop and implement an EAP pursuant to regulations for EAPs adopted in 2015. The EAP shall be updated every two years, and copies shall be filed with DEEP and the chief executive officer of any municipality that would potentially be affected in the event of an emergency.

Section 25- 32d of the Connecticut General Statutes: Public Water Supply Watershed Protection

At the state level, DPH has been responsible for public drinking water regulation and oversight since the early 1900s, significantly preceding the SDWA.

The authority for regulation of drinking water is established under Section 25-32 of the Connecticut General Statutes and implemented through the Regulations of the Connecticut State Agencies (RCSA) and the Public Health Code (PHC). These requirements are consistent with the federal regulations that oftentimes came later, but have additional requirements such as annual watershed surveys, annual cross connection surveys, monitoring of raw and finished water, and public notification requirements.

These source protection measures encourage resilience of public water systems against the effects of severe storms and climate change, ensuring that watershed lands continue to provide the critical initial barrier to pollution (Attachment A).

Section 25- 32d-1 of the Connecticut General Statutes and Section 25- 32d of the Regulations of Connecticut State Agencies: Individual Water Supply Planning

Connecticut's public water supply planning process was prompted by the state's extended drought in the early 1980s and was an outcome of a water resources task force.

In the state of Connecticut, all water companies serving greater than 1,000 people are required to develop and maintain a WSP. Plans are developed in accordance with Section 25- 32d-1 of the Connecticut General Statutes and Section 25- 32d of the Regulations of Connecticut State Agencies, and are typically updated every six to nine years. These regulations and the supporting statutes recognize that planning is a critical management activity of all water utilities. The principal goals of water system planning as defined by the Connecticut DPH are to: (1) ensure an adequate quantity of pure drinking water, now and in the future; (2) ensure orderly growth of the system; and (3) make efficient use of available resources. PURA, OPM, and DEEP all provide review comment to DPH in the agency's review of WSPs.

All WSPs begin with a description of the water utility's structure and assets. This section normally includes information on company structure, employee certifications, company finances, and assets. The next sections typically provide a description of water supply sources, supply capacity, system performance, and water quality. These sections often provide source safe yield and available water, as well as distribution system specifications, and water quality records.

After describing company infrastructure and available output, the WSPs generally focus on present and future water demands, service area land use, and source protection. These sections often observe trends within current demographics and attempt to extrapolate them into the future, to anticipate any improvements and changes that will need to be made to company infrastructure. WSPs help ensure that water utilities are able to adjust to changing human populations and environmental conditions within the supply area and are planning to meet projected demand over a 50-year period.

The regulations further require the development of companion documents to address water conservation and emergency contingency planning. Water conservation plans discuss supply-side and demand-side water conservation methods which have or can be enacted by the utility. ECPs provide policies and general response procedures for responding to water supply emergencies, including loss of supply, power outage, and water main breaks. Lists of emergency contacts and supplies are included. The ECP also includes the utility's drought response plan. Drought preparedness and response is further described in this appendix.

Section 25-68b through 25-68h of the Connecticut General Statues: Flood Management Act

The Flood Management Act outlines the flood management responsibilities of DEEP and lays out the rules and regulations to be used by all state agencies when undertaking or funding activities within or affecting floodplain areas, which are normally coincident with Special Flood Hazard Areas defined by FEMA. This law requires Flood Management Certifications for certain projects and the requirement that DWSRF-funded projects for critical facilities are built to be resilient to storms greater than the 100-year (0.1% annual chance) flood such as the 500-year event (0.2% annual chance). Public water system projects funded by the federal government and passed through the State of Connecticut, or funded by the State, must be compliant with the more stringent standards of the Flood Management Certification.

PA 85-535: An Act Concerning a Connecticut Plan for Public Water Supply Coordination

Connecticut's public water supply planning process was prompted by the state's extended drought in the early 1980s. During the 1985 Legislative Session, the Connecticut General Assembly passed Public Act 85-535, "An Act Concerning a Connecticut Plan for Public Water Supply Coordination," initiating the first statewide water supply planning program. The Connecticut DPH in consultation with the former DPUC (now PURA), DEEP, and OPM was given the charge of developing a coordinated approach to long-range water supply planning to assure adequate future supplies. The legislative finding, as reflected in Section 25-33c of the CGS, states the following: "In order to maximize efficient and effective development of the state's public water supply systems and to promote public health, safety, and welfare, the DPH shall administer a procedure to coordinate the planning of public water supply systems."

Pursuant to Public Act 85-535 and Section 25-33e of the CGS, the boundaries of public water supply management areas (PWSMAs) were delineated based upon the similarity of water supply issues, population density and distribution, existing sources of public water supply, service areas or franchise areas, existing interconnections between public water systems, municipal and regional planning agency boundaries, natural drainage basins, and similar topographic and geologic characteristics. The CGS required that the Commissioner of DPH convene a Water Utility Coordinating Committee (WUCC) for each PWSMA to implement the area wide water supply planning process. Each current PWSMA boundary is consistent with the recently realigned regional planning agency boundaries completed by OPM in 2014.

A "Coordinated Water System Plan" is comprised of the individual WSPs of the public water systems within the PWSMA which serve over 1,000 people or have 250 or more service connections, and an "area wide supplement" which includes a water supply assessment, delineation of exclusive service area boundaries, an integrated report, and an executive summary. The WUCC representing each PWSMA convened in June 2016 with the goal of developing new coordinated water system plans over the two-year process from June 2016 through June 2018. The individual components of the area wide supplement (listed above) will be subject to State agency consultation and public review and comment, as required.

Resilience is addressed in the updated Coordinated Water System Plan in the following sections:

- Water Supply Assessment, Section 7.0, "Issues, Needs, and Deficiencies": Impacts of Climate Change – The resiliency of water systems to climate change and natural hazards is a significant concern, particularly given the extensive power outages that occurred throughout the state during Tropical Storm Irene, Winter Storm Alfred, and Hurricane Sandy. Many smaller systems do not have standby power facilities. Future planning will be necessary to prepare for and respond to climate change. Interconnections may become more important as part of these efforts;
- Integrated Report, Section 2.4, "Climate Change and Resiliency", specifically, the impacts of climate change on safe yield, the importance of resiliency in planning, and the importance of resiliency to long-term viability of recommendations of the plan.
- Integrated Report, Section 5.4, "Potential Interconnections Recommended to Increase Resiliency", such as large water systems to groups of smaller interconnected systems, groups of smaller interconnected systems to make larger resilient blocks, and providing options for small community systems to improve capacity;
- Executive Summary and Table of Recommendations (nine recommendations regarding resiliency):
    - Review safe yield regulations every 10 years to determine if data inputs (e.g. evaporation rate) and assumptions continue to be valid in light of the effects of climate change on rainfall and runoff patterns, and revise regulations if necessary
    - Encourage DEEP/USGS to monitor regional groundwater levels to detect trends that may impact safe yield
    - Update the public health code to require new wells to be elevated to the 0.2% annual chance flood elevation
    - Develop redundant infrastructure, backup power, increase system storage, and conduct more comprehensive emergency response planning to improve resiliency
    - Encourage small systems with the potential to develop emergency interconnections to do so
    - Initiate planning for development of interconnections to regionally interconnect groups of systems
    - Develop regional water supply response plans for regionally interconnected systems (e.g. Intra-Regional Water Supply Response Plan for Southeastern Connecticut)
    - Assist systems in conducting asset management planning and developing formal infrastructure replacement programs
    - Re-evaluate reservoir release requirements in light of changing rainfall and runoff patterns as USGS StreamStats is updated

PA 01-177 of 2002 and PA 097-4 Section 2(c) of 2007: Connecticut's Water Planning Council

The Connecticut Water Planning Council was created by the Energy and Technology Committee of the Connecticut General Assembly in 2001 with representation from the four state agencies described above (DPH, OPM, and the predecessors of DEEP and PURA [DEP and DPUC]). The charge of the WPC is to "identify issues and strategies which bridge the gap between the water supply planning process and water resources management in order that water can be appropriately allocated to balance competing needs while protecting the health, safety and welfare of the people of Connecticut and minimizing adverse economic and environmental effects."[18] Therefore, the WPC inherently has a directive to consider practices and protocols regarding critical public infrastructure, infrastructure vulnerabilities and resiliency, planning, and emergency preparedness. The WPC does not receive regular, dedicated funding from the State.

The WPC initially established three Committees to investigate specific issues identified in PA 01-177 and submitted an Issues Work Plan to the Legislature on January 28, 2002. The three committees were the Water Resource Management Committee, the Water Utility Committee, and the Technical Management Committee. Each committee supervised the work of two subcommittees that, together, evaluated 11 issues ranging from review of water rates to streamlining the diversion permit process. A full description of this process can be found in other reports. Since that time, the WPC has overseen progress in promoting policy and regulations for management of the State's water resources. The recent focus of the WPC has been on the State Water Plan (statewide water planning), water conservation, drought management, and watershed land management, topics which encourage the resilience of public water systems in reference to drought and water quality.

The WPC established the Water Planning Council Advisory Group (WPCAG) pursuant to PA 07-4, Section 2(c) in 2007 to assist in researching and analyzing water resources issues. The WPCAG has formed a number of work groups over the years. The WPCAG typically oversees the work completed by its work groups and reports back to the WPC about specific issues.

PA 03-236: Public Health Emergency Response Act

The DPH is the lead administrative and planning agency in Connecticut for public health initiatives including public health emergency preparedness. DPH works with federal, state, regional, and local partners to improve the State's ability to respond to public health emergencies. The Connecticut Public Health Emergency Response Plan (PHERP), last revised in 2011, identifies the appropriate DPH response activities during a public health emergency. This plan supports the public health and medical care component in existing state disaster and emergency plans.

PA 04-144: An Act Concerning Floodplain Management and Hazard Mitigation

This legislation covers many different aspects of floodplain management. It requires municipalities to revise their current floodplain zoning regulations or ordinances to include new standards for compensatory storage and equal conveyance of floodwater. The DEEP was required to develop model regulation language and allowed for municipalities to use local capital improvement (LoCIP) funds from the state to conduct floodplain management and hazard mitigation activities, and requires disclosure of flood hazard information to prospective buyers of residential real estate. Furthermore, the legislation established a new state hazard mitigation and floodplain management grant program.

The Office of Policy and Management (OPM) is required to continuously incorporate consideration of natural hazards into the revision of the Conservation & Development Policies Plan State POCD as part of the compliance with the Floodplain Management and Hazard Mitigation Act. The update of the Conservation & Development Policies Plan 2013-2018 State POCD incorporated this requirement and was adopted in June 2013. The revised natural hazards policy in the 2013-2018 State POCD was entitled "Minimize the potential risks and impacts from natural hazards, such as flooding, high winds and wildfires, when siting infrastructure and developing property. Consider potential impacts of climate change on existing and future development."

[18] DEEP, http://www.ct.gov/deep/cwp/view.asp?a=2720&q=325644&depNav_GID=1654

Summary of Recent State Laws

Each year, the Connecticut Water Works Association (CWWA) publishes a summary of the new laws and regulations affecting the water industry. For the interests of this project, pertinent laws can be categorized into four categories: laws regarding Critical Public Infrastructure, laws regarding Infrastructure Vulnerabilities and Resiliency, laws affecting Planning, and laws regarding Emergency Preparedness. The CWWA reports were analyzed from 2010 until 2017 for relevant laws in these categories. Table 2 summarizes the various recent public acts as to their applicability to the four categories.

Table 2. Summary of Recent Laws

Law	Critical Public Infrastructure	Infrastructure Vulnerabilities and Resiliency	Planning	Emergency Preparedness
Public Act 10-158 (HB-5208)			X	
Public Act 11-242 (HB-6618)	X		X	
Public Act 12-101 (SB-376)			X	
Public Act 12-148 (SB-23)				X
Public Act 13-15 (SB-1010)			X	
Public Act 13-78 (SB-807)		X	X	
Public Act 13-197 (HB-6441)	X	X		
Public Act 14-94 (SB-357)	X			
Public Act 14-163 (HB-5424)			X	
Public Act 15-1 (SB-1501)		X		
Public Act 15-89 (SB-569)	X	X		
Public Act 16-197 (SB-288)	X	X		
Public Act 16-199 (SB-301)		X		
Public Act 17-211 (HB-7221)			X	
Regulation 2015-21	X	X		X
Special Act 13-9 (SB 1013)			X	

The various recent laws are summarized below:

PA 10-158 (HB-5208): AN ACT CONCERNING THE PERMIT AND REGULATORY AUTHORITY OF THE DEPARTMENT OF ENVIRONMENTAL PROTECTION AND ESTABLISHING AN OFFICE OF THE PERMIT OMBUDSMAN WITHIN THE DEPARTMENT OF ECONOMIC AND COMMUNITY DEVELOPMENT

This act is intended to address concerns regarding delays in DEEP's processing of permit applications. The act:

- Requires that all proposed changes to water quality standards undergo the rulemaking procedures and notice and comment requirements effective March 1, 2011
- Establishes strict timeframes for completing the review of permit applications
- Creates a new program for expediting permits for projects of economic significance
- Creates a statewide permit ombudsman (Maya Loewenberg, formerly of the state Department of Economic and Community Development, was named to this position)
- Reviews procedures for adopting general permits and assessing the impact of the Connecticut Environmental Protection Act on economic development and environmental protection (with recommendations for improvement due by Sept. 30, 2010)
- Reduces permit application requirements for certain categories of facilities

- Establishes a new "consulting services program" within the DEP, modeled after the Connecticut OSHA program for non-adversarial on-site compliance assistance
- Allows the DEP to extend the effective date of any general permit up to 12 months in a streamlined manner, (and to not hold a hearing on tentative determination to issue or deny a permit if the petition requesting the hearing is withdrawn);
- Requires the use of various methods to reduce the impact of proposed regulations on small businesses; and
- Creates a task force to make recommendations for expanding disclosure requirements regarding federal consistency with proposed regulations.

This public act encourages resiliency through streamlining of the permit process such that resiliency projects which may affect the environment can receive on-site compliance assistance and a more certain regulatory timeframe.

Public Act 11-242 (HB-6618): AN ACT CONCERNING VARIOUS REVISIONS TO PUBLIC HEALTH RELATED STATUTES

Small Water, Treatment, Distribution and Systems Certification: Section 71 of the act requires DPH to certify small water systems that (1) treat or supply water for public use, (2) test backflow prevention devices, or (3) perform cross-connection surveys. DPH must already do this for water treatment plants and water distribution systems that perform these functions. The act requires DPH to adopt regulations on standards and procedures for issuing and renewing certificates for small water systems as it must already do for water treatment plants and water distribution systems. Under the act, a "small water system" serves fewer than 1,000 people and has either (1) no treatment or (2) treatment that does not require any chemical treatment, process adjustment, backwashing, or media regeneration by an operator. This action allows DPH greater oversight of the condition of small water systems which will encourage improvements to critical public infrastructure.

Private Residential Wells - Testing & Reporting

Section 72 of the act requires a laboratory or firm testing a private residential well to report the results to DPH, instead of only the local health authority, in a format the department specifies. Results must be reported within 30 days, if the test is performed within six months of the property's sale. Otherwise no report is required. The act requires a property owner, before selling, exchanging, purchasing, transferring, or renting property with a residential well, to notify the buyer or tenant that educational material concerning residential well testing is available on the DPH website. It specifies that failure to provide the notice does not invalidate the property transaction. If the seller or landlord provides written notification, he or she and any real estate licensee are deemed to have satisfied the notification requirement. The act specifies that a laboratory or firm is a DPH-registered environmental laboratory.

Prior law prohibited DPH from adopting certain regulations affecting the testing of private residential wells. This act eliminates provisions barring the testing of a private residential well for:

1) Alachlor, atrazine, dicamba, ethylene dibromide, metolachlor, simazine or 2.4-d, or any other herbicide or insecticide unless (a) a prior test showed a nitrate concentration of at least 10 milligrams per liter and (b) the local health director had reasonable grounds to suspect the presence of such chemicals, and

2) Organic chemicals unless a local health director had reasonable grounds to suspect their presence.

It instead allows a local health director to require private residential well testing for (1) radionuclides and (2) pesticides, herbicides, or organic chemicals when there are reasonable grounds to suspect the presence of such contaminants in the groundwater. The act defines "reasonable grounds" as:

1) for radionuclides, (a) the existence of a geological area known to have naturally occurring radionuclide deposits in the bedrock or (b) when the well is located in an area known to have radionuclides in the groundwater, and

2) for pesticides, herbicides, or organic chemicals, (a) the presence of a nitrate-nitrogen groundwater concentration of at least 10 milligrams per liter or (b) when the well is located on or in proximity to land associated with past or present production, storage, use, or disposal of organic chemicals as identified in any public record.

Sample Collections

The act allows private residential well samples to determine water quality to be collected only by (1) employees of a DPH-certified or -approved laboratory who are trained in sample collection techniques, (2) certified water operators, (3) local health departments and state employees trained in sample collection techniques, or (4) individuals with training and experience DPH deems as sufficient. The act creates an exception to this requirement for qualified homeowners or general contractors. Prior law allowed homeowners and general contractors of new residential construction, where private residential wells are located, to collect water samples for testing by a laboratory or firm, if the laboratory or firm found that the owner or contractor was qualified to collect the sample. The act continues to allow such sample collection if the (1) laboratory or firm provides instructions to the owner or general contractor on how to collect the samples and (2) owner or general contractor is identified to the subsequent owner on a DPH-prescribed form.

The private well sampling data improves the resiliency of public water systems through planning requirements that allow for centralized tracking of water quality trends.

Public Act 12-101 (SB-376): AN ACT CONCERNING THE COASTAL MANAGEMENT ACT AND SHORELINE FLOOD AND EROSION CONTROL STRUCTURES

The act makes several changes in the Coastal Management Act (CMA) and laws regulating certain activities in the state's tidal, coastal, or navigable waters. Among other things, it:

1) Modifies CMA's general goals and policies to consider (a) private property owners' rights when developing, preserving, or using coastal resources and (b) the potential impact of a rise in sea level when planning coastal development to minimize certain needs or effects (§ 1);

2) Expands the list of land uses that can be protected by structural solutions under certain circumstances to include cemetery and burial grounds and inhabited structures built by January 1, 1995 (§ 1);

3) Requires a municipal zoning commission to approve a coastal site plan for a shoreline flood and erosion control structure under certain circumstances (§ 3);

4) Requires a municipal zoning commission or the Department of Energy and Environmental Protection (DEEP) commissioner to propose structure alternatives or mitigation measures and

techniques if they deny a shoreline flood and erosion control structure application for certain reasons (§ 1); and

5) Replaces the statutory definition of "high tide line" with one for "coastal jurisdiction line" (§§ 4-8). The act also requires the Office of Policy and Management (OPM) to consider coastal erosion when revising the state Plan of Conservation and Development after October 1, 2012, as well as a requirement for communities to consider sea level rise in their Plans of Conservation and Development.

This public act improves the coastal management regulatory process, encourages resilient shoreline communities, and expands the types of land uses eligible for funding.

Public Act 12-148 (SB-23): AN ACT ENHANCING EMERGENCY PREPAREDNESS AND RESPONSE
In response to concerns following Connecticut's two major storm events in 2011, this act requires the Public Utilities Regulatory Authority (PURA) to conduct public proceedings to establish industry-specific standards for acceptable emergency preparedness and response efforts by public service companies and other utilities. The act is primarily aimed at addressing concerns with the performance of electric and gas companies, however, there are some implications for water utilities.

Emergency Service Restoration Plans
Prior law required private and municipal utility companies, including water companies, to file emergency service restoration plans with PURA, DESPP, and local municipalities every five years. The act instead requires these plans to be filed every two years, with the next plan due July 1, 2012, and adds VOIP providers to the utilities subject to the mandate. In addition to the items prior law required in the plans, the act requires them to include (1) communication and coordination measures with state officials, municipalities, and other private utilities and telecommunications companies during a major disaster or emergency; (2) participation in training exercises as directed by the DESPP commissioner; and (3) responses for service outages affecting more than 10%, 30%, 50%, and 70% of customers. Under the act, any information provided in the plans is considered confidential, not subject to the Freedom of Information Act (FOIA), and cannot be transmitted to anyone unless it is needed to comply with the act. The act requires PURA, by September 1, 2012, and biannually thereafter, to summarize the plans in a report to the Energy and Technology Committee.

Microgrids
Microgrids are discussed in Docket 12-01-07 and Public Act 12-148. PURA is actively planning for redundant and hardened energy infrastructure such as microgrids and to harden transmission lines. DEEP is conducting the Microgrid Grant and Loan Pilot Program which seeks projects that support local distributed energy generation for critical facilities during times of electric grid outages. To date, DEEP has issued three rounds of requests for proposals, and a fourth round of funding is expected as a result of PA 13-239 which committed the State to $30 million in bonding revenue to support microgrids after the pilot round in 2013.

Special Act 13-9 (SB-1013): AN ACT CONCERNING CLIMATE CHANGE ADAPTATION AND DATA COLLECTION
This Special Act established the Connecticut Institute for Resilience and Climate Adaptation (CIRCA) to conduct research, analysis, design, outreach, and education projects to guide the development and implementation of technologies, methods, and policies that increase the protection of ecosystems, coastal properties, and other lands and attributes of the state that are subject to the effects of rising sea levels and natural hazards.

Public Act 13-15 (SB-1010): AN ACT CONCERNING SEA LEVEL RISE AND THE FUNDING OF PROJECTS BY THE CLEAN WATER FUND

This Act expands the factors that the DEEP commissioner must consider when establishing the priority list and ranking system for making Clean Water Fund grants and loans for eligible water quality projects. Specifically, it requires him to consider the necessity and feasibility of implementing measures designed to mitigate sea level rise impact over a project's life span. Under existing law, he must consider, among other things, public health and safety, protecting environmental resources, and attaining state water quality goals and standards. This law essentially incorporates climate change planning into funding of wastewater projects. By law, the commissioner makes the grants and loans to municipalities based on the priority list order.

Public Act 13-78 (SB-807): AN ACT CONCERNING WATER INFRASTRUCTURE AND CONSERVATION, MUNICIPAL REPORTING REQUIREMENTS AND UNPAID UTILITY ACCOUNTS AT MULTI-FAMILY DWELLINGS

The Act requires PURA, and municipal legislative bodies setting water rates, to consider: 1) demand projections that recognize conservation's effects; 2) implementing metering and measures to provide timely price signals to consumers; 3) multi-year rate plans; 4) measures to reduce system water losses, and 5) alternative rate designs that promote conservation. The act also allows companies to recover general rate case costs if it can be proven that the costs were used to cover water conservation measures such as water meters, leak detection systems, and water audits. These measures help to improve the resiliency of public water systems.

Public Act 13-197 (HB-6441): AN ACT CONCERNING THE DAM SAFETY PROGRAM AND MOSQUITO CONTROL

This Act was described on Page 6 in the context of the dam safety laws, which have been in place for decades. The Act updated the dam safety laws by requiring owners of certain unregistered dams or similar structures to register them by October 1, 2015. It generally shifts, from the commissioner to the owners of dams or similar structures, regularly scheduled inspection and reporting requirements. The Act also makes owners generally responsible for supervising and inspecting construction work and establishes new reporting requirements for owners when the work is completed. The law also authorizes up to $6 million in FY 14 and $5 million in FY 15 for DEEP for dam repairs, including state-owned dams. It also authorizes up to $4.5 million in FY 14 and $6.9 million in FY 15 for DEEP for flood control improvements, flood repair, erosion damage repairs, and municipal dam repairs.

Public Act 14-94 (SB-357): AN ACT CONCERNING CONNECTICUT'S RECYCLING AND MATERIALS MANAGEMENT STRATEGY, THE UNDERGROUND DAMAGE PREVENTION PROGRAM AND REVISIONS TO ENERGY AND ENVIRONMENTAL STATUTES

Sections 50 and 53 of the act expand the jurisdiction of the Public Utilities Regulatory Authority (PURA) over troubled water providers to include deficient well systems, under certain circumstances. It allows PURA to order an investor-owned water company to extend its system to supply water to properties that PURA determines are served by a deficient well system. But it must do so only (1) in consultation with DPH, (2) at an investor-owned water company's request, and (3) if the costs are reasonable. This public act thereby improves the resiliency of public water systems by providing additional options for connection to a larger system.

Public Act 14-163 (HB-5424): AN ACT CONCERNING THE RESPONSIBILITIES OF THE WATER PLANNING COUNCIL.

Section 1 of this act requires the state's Water Planning Council (WPC; described on Page 9) to prepare, within available appropriations, a State Water Plan by July 1, 2017. The act specifies the State Water Plan must:

1. Identify water amounts and qualities (specifically, surface and groundwater resources available for public water supply, health, economic, recreation, and environmental benefits for regional basins, rather than those, under prior law, that could be feasibly distributed to specific areas);

2. Identify current and future water demand for statewide and regional basins instead of for specific areas, as prior law required;

3. Recommend using the state's water resources to, instead of maximizing benefits, balance public water supply, economic development, recreation, and ecological health;

4. Recommend major engineering works or special districts, as well as technology and infrastructure upgrades and interconnections;

5. Recommend land use and other measures, that include assessing land acquisition or land protection needs, to ensure the desired water quality and quantity, as well as promoting development based on available water resources;

6. Consider desired recreational, agricultural, industrial, and commercial uses, as well as ecological uses; and

7. Try to incorporate regional and local water use and management plans and programs and water and sewerage facilities plans.

Resiliency is addressed in the climate change assessment, policy recommendations, pathway forward recommendations, "Top Ten Consensus-Based Policy Priorities", and "Five Most Important Messages in the Plan" sections. The policy recommendations related to the water quality impacts of land use; water conservation; outreach, education, and public engagement; and regionalization are most pertinent to resiliency, as are the pathway forward recommendations related to water conservation, regionalization and interconnections, aging infrastructure, statewide drought planning, and overcoming future challenges.

Out of the "Top Ten" priorities, the following recommendations are most pertinent to encouraging resiliency:

- Encourage regional water solutions where they are practical and beneficial; and
- Reaffirm support for the protection of Class I and II land contributing to water supply. Expand protections to other watershed lands and land that feed aquifers used for public water supply or by private wells.

Out of the "Five Most Important Messages", the most important message for encouraging resiliency regards conservation: While Connecticut leads the nation in protections of drinking water quality, the State lags in its water conservation ethic. Outreach that builds on utility initiatives is one of the most important recommendations in this Plan.

Public Act 15-1 (SB-1501, Sec. 63-64): CLEAN WATER FUND

The Bond Package includes Clean Water Fund grants-in-aid of $47.5 million in FY 16 and $92.5 million in FY 17 and Clean Water Fund loans (Revenue Bonds of $58 million in FY 16 and $180 million in FY 17. This funding may be used for resiliency-related infrastructure projects.

Public Act 15-89 (SB-569): COMMUNITY WATER SYSTEMS

To address ongoing concerns with CWSs, this act allows PURA, on its own initiative or at the Department of Public Health (DPH) commissioner's request, to investigate whether a small CWS's rates are sufficient for the system to maintain its economic viability and provide adequate service to its customers. The act defines "small CWSs" as those that do not have to submit a WSP (i.e., generally water companies that serve fewer than 1,000 people or 250 service connections). This public act provides a process to ensure that proper asset management and capital improvement planning is being conducted for small CWSs, which is expected to result in more resilient small water systems.

Regulation 2015-21: Regulations Concerning Public Drinking Water Quality Standards

This regulation amended CGS Section 19a-36 and CGS Section 25-32 and Section 19-13-B102 of the Public Health Code to ensure that every CWS is supported by an emergency generator or an alternative source of backup power. The amendment also requires CWSs to develop emergency contingency and response plans to guide CWSs before, during, and following power outages. These requirements are designed to help systems prevent loss of water pressure or water outages, thereby protecting the system from exposure to bacterial contamination and associated waterborne diseases.

Public Act 16-197 (SB-288): AN ACT CONCERNING THE DEPARTMENT OF PUBLIC HEALTH'S RECOMMENDATIONS ON THE EXPANSION AND CONSTRUCTION OF WATER SYSTEMS

This act revises the process for issuing certificates of public convenience and necessity for water companies seeking to expand or construct their systems. Among other things, it: 1) requires certain water companies to obtain the certificate from the Department of Public Health (DPH), instead of both DPH and the Public Utilities Regulatory Authority (PURA); 2) exempts state agencies from the $100 certification fee for residential water systems; 3) under certain conditions, requires PURA to determine if a water system owner has sufficient financial resources to provide adequate service and operate reliably and efficiently; and 4) correspondingly eliminates the requirement that PURA adopt regulations on the certificate process and allows, rather than requires, DPH to adopt them. This public act has led DPH to begin developing CPCN regulations for the development of new non-CWSs, which is expected to increase the resiliency of newly constructed systems.

Public Act 16-199 (SB-301): AN ACT MODIFYING THE THRESHOLDS FOR MANDATORY REPORTING OF ENVIRONMENTAL SPILLS

The act requires the Department of Energy and Environmental Protection (DEEP) commissioner to adopt regulations specifying numerical thresholds for reporting to DEEP discharges, spills, or other releases of specified substances, materials, and waste. A person responsible for a release must report it under the act if it exceeds the applicable threshold. Current law requires anyone responsible for these events to report them to DEEP if the released substance, material, or waste may threaten human health or the environment, regardless of the amount. They must continue to do so under the act until the effective date of the regulations setting the thresholds. This public act relates to resiliency as it improves the level of protection of public water supply source water areas.

Public Act 17-211 (HB-7221): AN ACT CONCERNING ACCESS TO WATER PLANNING INFORMATION

Public Act 17-211 became effective on July 1, 2017 and encourages public access to water supply planning information. To accomplish this goal, any WSP submitted after July 1, 2017 is required to be accompanied by a redacted version of such plan that omits any information related to the following topics that are considered confidential and not subject to disclosure under the FOIA. Such confidential information includes:

- Security-related documentation and training procedures;
- ECPs and preparedness plans; incident management, mitigation, and recovery plans, and the like, except for drought management and response plans which must be disclosed;
- Design drawings and maps showing the specific location of infrastructure, provided the general location of water mains, wells, and interconnections is disclosed;
- Dam specifications, construction details, and emergency action plans related to dam failure response;
- Building floor or structural plans;
- Network topology maps;
- Specific locations of or specifications regarding electrical power, standby generators, and fuel systems, except that general information regarding such may be disclosed;
- Operational specifications, schematics and procedures related to water and sewage treatment plant processes and the use of chemicals, except that a general description of such treatment plant may be disclosed;

- Logs detailing movement or assignment of personnel;
- Distribution system hydraulic models; and
- Any other record if there are reasonable grounds to believe that the disclosure of such record may result in a safety risk, as determined by the Connecticut Department of Administrative Services.

As noted above, Public Act 17-211 requires that drought planning and response procedures developed by public water systems be available to the public, which is expected to help further understanding of the need for drought management.

Connecticut Conservation and Development Policies Plan

CtWARN is a Water/Wastewater Agency Response Network (WARN) comprised of utilities providing voluntarily assistance to one other in the form of personnel and resources during emergencies by means of pre-arranged mutual aid agreements. The mission of CtWARN is to support and promote statewide emergency preparedness, disaster response, and mutual assistance matters for public and private water and wastewater utilities. CtWARN accomplishes this mission by providing increased planning, coordination and enhanced access to specialized resources to enable rapid, short-term deployment of emergency services to restore critical operations of the affected water or wastewater utility. A total of 22 water and wastewater utilities and departments are members of CtWARN, covering more than half of Connecticut's geographic area.

Connecticut Conservation and Development Policies Plan

The Connecticut Conservation and Development Policies Plan 2018-2023 was issued in 2017 and will be adopted in 2018. Revised policies include:

- Minimize the siting of new infrastructure and development in coastal areas prone to erosion and inundation from sea level rise or storms, as anticipated in sea level change scenarios published by the National Oceanic and Atmospheric Administration, ensure that coastal hazards are accounted for when considering options for the replacement, expansion, or reduction of existing infrastructure under Policy 1.1, and otherwise limit development activities within coastal areas to those consistent with statutory goals and policies set forth in the Connecticut Coastal Management Act.

- Discourage new development activities within areas prone to flooding and coastal erosion, manage any unavoidable activities in such areas in an environmentally sensitive manner and in compliance with applicable laws, and seek to prevent the loss of life and property by maintaining existing dikes, channels, dams, and other barriers, or removing such structures where removal would be a more cost- effective option for reducing threats to downstream property.

- Proactively address climate change adaptation strategies to manage the public health and safety risks associated with the potential increased frequency and/or severity of flooding and drought conditions, including impacts to public water supplies, air quality, and agriculture/aquaculture production.

Drought Preparedness and Response

Large public water systems that are required to undertake water supply planning have developed drought planning and response plans as part of their ECPs, which will need to be decoupled from those plans moving forward. Currently, the drought planning and response plans developed by public water systems are either based on the WSP regulations (RCSA Section 25-32d-3) or the parameters identified in the 2003 *Connecticut Drought Preparedness and Response Plan* (adopted November 2018) prepared by the

Interagency Drought Work Group, although some drought response plans appear to rely on parameters and the five-stage response protocols that predate the 2003 document and the current edition of the WSP regulations.

For public water systems primarily reliant on reservoir sources, the volume of storage in the reservoir is typically utilized to define the criteria for each drought stage. Public water systems primarily reliant on groundwater sources typically use the amount of storage in a primary storage tank over a period of days, or a combination of precipitation and groundwater levels, to define the criteria for each drought stage.

The four drought stages in the water supply planning regulations with water conservation goals from the 2003 *Connecticut Drought Preparedness and Response Plan* (adopted November 2018) include:

- "Advisory" with a voluntary 10% reduction goal for residents and organizations;
- "Watch" with a voluntary 15% reduction goal for residents and organizations;
- "Warning" with a voluntary 20% reduction goal for residents, organizations, and state agencies; and
- "Emergency" with a Governor-mandated 25% reduction in water use by residents, businesses, and state agencies.

Utilities have strengthened these goals where appropriate. For example, many utilities identify the 20% reduction goal under Drought Warning to be mandatory, as utilities have found that a better reduction in demand is realized when mandatory conservation measures are enacted. In addition, some utilities also define and utilize an "Alert" cautionary stage to prepare internally for implementation of voluntary and mandatory water conservation measures. The Interagency Drought Work Group has been working on an update to the 2003 Plan. The current draft of the update is dated June 29, 2016, and includes the following drought stages (in increasing severity): "Heightened Awareness"; "Below Normal Conditions"; "Moderate Drought"; "Severe Drought"; and "Extreme Drought". These proposed classifications are intended to align more closely with US Drought Monitor terminology and limit confusion with any individual utility drought statuses.

As noted above, some water utilities still utilize the older five-stage method with the following water conservation criteria:

- "Alert" which does not include a reduction goal;
- "Advisory" with a voluntary 10% reduction goal;
- "Emergency Phase I" with a voluntary 15% reduction goal;
- "Emergency Phase II" with a voluntary 20% reduction goal; and
- "Emergency Phase III" with water rationing.

The drought of 2015-2016 raised public awareness of voluntary and mandatory water conservation measures, which are enacted by many utilities to reduce demands during a drought. Typically, such reductions are requested on a percentage basis for each customer. One issue raised by the public as part of the recent widely reported and protested commercial bottling plant in Bloomfield was whether commercial/industrial users should be completely shut off prior to limiting water for residential customers. Utilities typically request reductions from all users concurrently. Many utilities have ECPs which focus water conservation enforcement on high-volume users by recommending more frequent (weekly) meter readings of high-volume customers when conservation measures are requested or mandated, and requiring large customers to file a water conservation "plan of action" with the utility to demonstrate how that customer will reduce its water usage to the requested percentage.

It has long been recognized that water utilities, particularly non-municipal (regional and investor-owned) utilities, have limited methods to enforce voluntary and mandatory conservation measures. Several utilities have noted that high volume accounts sometimes have no interest in conserving water; some residential accounts are simply willing to pay for irrigation water regardless of water conservation surcharges and voluntary or mandatory conservation requests. In some cases, residential developments have requirements to maintain green lawns as part of the ownership contract, and homeowners feel that compliance with the local requirement is more important than the restrictions put in place by a utility.

As noted in the 2003 *Connecticut Drought Preparedness and Response Plan* (adopted November 2018), municipal authority may be necessary to locally enforce any measures, but many municipalities do not have local ordinances in place to ensure proper implementation of water conservation measures during droughts and other emergencies. To that end, a model ordinance was developed to encourage adoption of these policies at the local level, but few municipalities have adopted the model ordinance. The model ordinance includes examples of banned uses, the procedures for announcing the need for conservation measures, and procedures for issuing fines or even curtailment of service. Because of concerns over the administrative procedures needed to enact such ordinances and potential inconsistency between local ordinances when served by a single utility, legislative authority for water utilities to enforce restrictions may be warranted. In addition, specific language prohibiting enforcement of "green lawn" requirements during declared droughts may be necessary.

> In the Western part of the state, municipal drought ordinances have been successful. This occurred through municipal interest prior to the drought of 2015-2016 (e.g., in Greenwich), as well as during reaction to the drought of 2015-2016 (in Stamford, Darien, and New Canaan).

Summary of State and Federal Practices and Protocols

A variety of practices and protocols have been developed at the state and federal levels to address critical public infrastructure, infrastructure vulnerabilities and resiliency, planning, and emergency preparedness.

<u>State Practices and Protocols</u>

Several statewide committees and task forces have met recently regarding critical public infrastructure, infrastructure vulnerabilities and resiliency, planning, and emergency preparedness. Many of these efforts have informed later legislation and planning efforts. A few examples include the following, with additional detail provided in the following subsections:

- The Adaptation Subcommittee of the Governor's Steering Committee on Climate Change (formed in 2008);
- The Connecticut GIS Council's Storm Response and Recovery Assessment Group (formed in 2011);
- The Connecticut Department of Public Health (DPH) last revised its Public Health Emergency Response Plan in 2011.
- The Shoreline Preservation Task Force (formed in 2012);
- The State's Long-Term Recovery Committee (formed in 2012);

The Govenor's Two Storm Panel (2012)

Governor Dannel P. Malloy announced the formation of The State Team Organized for the Review of Management ("STORM") of Tropical Storm Irene on September 13, 2011.

The eight member Panel was charged with the following mission, "a broad, objective evaluation reviewing how Irene was handled in the state both in preparation and recovery, identify areas that can be improved upon and, most importantly, make recommendations for future disaster preparedness and response." Following the October snow storm Alfred, the Governor expanded the work of the Panel, renamed it "The Two Storm Panel," and directed it to report its findings to him by the first week of January, 2012.

The Two Storm Panel first reviewed the State Emergency Framework as well as several representative municipal emergency plans in order to benchmark state and local emergency planning. In addition, the Panel conducted eight days of hearings with over 100 witnesses providing written and/or oral testimony to the Panel. Panel hearings were also carried on CT-N so that they could be viewed by the public. In addition to the public hearings, many members of the public provided written comments to the Panel that were also considered in the preparation of the panel's report.

PURA docket 11-09-09 is the Report of the Two Storm Panel. The report acknowledged that "Tropical Storm Irene and the 'October Nor'easter' (Winter Storm Alfred) had tested Connecticut's emergency resources in ways that they had not been tested in more than 25 years. In that intervening 25 years, Connecticut's infrastructure had increased significantly, while the manpower associated with the maintenance and repair of that infrastructure had decreased significantly."

The Report of the Two Storm Panel included 82 individual recommendations that have been shaping legislative initiatives and inter-agency policies since 2012, helping to increase capabilities in Connecticut. Some of these policies have already helped, as noted during Hurricane Sandy in October 2012. Although not all of the 82 recommendations can be listed here, those listed in the Executive Summary include:

- The need to develop reasonable performance standards for utility recovery and restoration after storms, and link recoverable costs to these standards;
- Revisions to State engineering standards to accommodate predicted increases in storm surge along coastal areas;
- The need for improved worst-case planning and staffing by the State's utilities;
- Connecticut's infrastructure needs to be better hardened to withstand natural disasters, and such work should begin as quickly as possible;
- The use of microgrids and other emerging technologies should be considered as potential methods for mitigation of impacts to infrastructure;
- Increased collaboration between municipalities, State resources, and electric utilities and telecommunications service providers with respect to tree trimming;
- Increased communication and planning between municipalities and utilities before a storm or disaster is imminent;
- Increased communication between labor and management in all utilities is strongly recommended;

- Additional emergency response training and exercises for municipalities, utilities and the State;
- A review of sheltering needs to ensure that at-risk populations can be served if sheltering is required for a significant length of time;
- The use of geographical information systems (GIS) should be better leveraged for both emergency planning and response purposes;
- The Public Utilities Regulatory Authority and the Connecticut Siting Council should be provided with additional enforcement resources;
- A Center for Research should be developed to study and make recommendations on storm hazard mitigation and power system resiliency; and
- Standards should be more clearly developed for backup power requirements and communication infrastructure hardening for wireless telecommunications.

The State Vegetation Management Task Force (2012)
On April 24, 2012, the State Vegetation Management Task Force held its inaugural meeting. The Mission of the Task Force is to develop standards for road side tree care in Connecticut, vegetation management practices and schedules for utility rights of way, tree/right place standards, and standards for tree wardens, municipal tree inventories and pruning schedules. This Task Force has been formed by the Commissioner of DEEP, as called for in the report of the Governor's Two Storm Panel. The goal is to develop consensus recommendations to DEEP within the stated mission. The final report of the task force dated August 2012 included numerous recommendations, but those listed in the Executive Summary include:

- Developing a certification program for local tree wardens;
- Requiring municipalities to develop a 5-year roadside forest management plans based on a model ordinance;
- Requiring all new trees planted within the public right-of-way and on municipal property to be reviewed and approved by the tree warden;
- Developing a centralized state location for information related to tree and forest management, including to inform property owners on how to properly maintain trees and reduce potential community hazards;
- Utilizing Right Tree, Right Place guidelines;
- Actively managing roadside forests;
- Establishing standards for tree removals;
- Developing state or federal funding sources to incentivize municipal investments in tree maintenance;

- Utilize 1.5% of all funds approved for utility vegetation management by PURA to fund removal of hazard trees on private property for five years;

- Encourage municipalities to develop annual budgets for roadside forest management; and

- Reducing non-vegetation management costs as utility vegetation management costs are increased.

Connecticut Natural Hazard Mitigation Plan (2014)
Connecticut adopted a Natural Hazards Mitigation Plan Update (CT 2014 NHMP Update) in January 2014 to meet Federal Emergency Management Agency (FEMA) guidelines set forth in the Disaster Mitigation Act of 2000. This Plan represents the State of Connecticut's efforts to approach mitigating the effects of natural disasters on a multi-hazard basis, and shifts from a disaster-response driven system to one based on effective hazard mitigation planning.

The implementation of effective mitigation of natural hazards requires on-going planning and dedicated persistence both on a state and local level to maintain what has been done in the past and to improve upon past efforts to strive for implementing the most protection possible from natural hazards. To that end, the plan is updated every five years.

Regarding climate change, the plan states that summer and winter temperatures are expected to increase, hurricanes may become more intense, thunderstorms may become more frequent and intense, and that precipitation intensities and amounts may increase. The plan reports that climate models have indiciated that fewer but more intense precipitation events will occur during the winter with more precipitation falling as rain rather than snow. The change in winter precipitation could result in less frequent but more intense snow storms with heavier snow. The plan further predicts that forests will shift northward and vegetation will change, which may change wildfire risks.

The related strategies and activities outlined in this Plan provide a guide to assist Connecticut in working towards achieving these goals that will be implemented or initiated during the time period encompassing this Natural Hazards Mitigation Plan update. The goals themselves are achievable, yet they require adequate resources such as financial and staff resources to achieve significant results. The State of Connecticut believes in the importance of natural hazards mitigation planning and implementation of hazard mitigation activities both on a state and local level in order to reduce/eliminate lives lost and property damaged as a result of natural hazards. The State also believes that climate change and adaptation techniques are an area of continued concern for which new policies and strategies will need to be developed. Some recommendations of the plan included encouraging municipalities to adopt local water restriction measures, and coordinating with water utilities to more actively promote water conservation measures with their customers.

The adoption of this Plan allows Connecticut to be eligible for Federal funding equal to 15% of the total disaster damages from a presidentially declared disaster under the FEMA Hazard Mitigation Grant Program (HMGP).

Executive Order 50 (2015)
Executive Order 50 establishes the State Agencies Fostering Resilience (SAFR) Council, which is responsible for strengthening the state's resiliency from extreme weather events including tropical storms, hurricanes, storm surges, flooding, ice storms, extreme high winds, extreme heat, and slow onset events

such as sea level rise. The "SAFR Council" is responsible for working to create a Statewide Resilience Roadmap based on the best climate impact research and data and assisting OPM in the creation of a State policy on disaster resilience. SAFR interacts with CIRCA and will be involved with the NDRC-funded planning in the coming years.

Other Relevant State Policies and Practices

Other relevant state policies and practices include:

- Minimize the siting of new infrastructure and development in coastal areas prone to erosion and inundation from sea level rise or storms, encourage the preservation of undeveloped areas into which coastal wetlands can migrate, and undertake any development activities within coastal areas in an environmentally sensitive manner consistent with statutory goals and policies set forth in the Connecticut Coastal Management Act.

- Allow redevelopment and rebuilding of coastal areas consistent with coastal area management principles and regulations and prevailing federal rules and requirements.

- Discourage new development activities within floodway and floodplain areas, manage any unavoidable activities in such areas in an environmentally sensitive manner and in compliance with applicable laws, and seek to prevent the loss of life and property by maintaining existing dikes, channels, dams, and other barriers, or removing such structures where removal would be a more cost-effective option for reducing threats to downstream property.

- Proactively address climate change adaptation strategies to manage the public health and safety risks associated with the potential increased frequency and/or severity of flooding and drought conditions, including impacts to public water supplies, air quality and agriculture/aquaculture production.

Relative to floods, the State of Connecticut adopted a set of standards several decades ago that was forward-thinking and has helped make many state-funded projects resilient. Critical facilities must be designed according to the elevation of the 0.2% annual chance flood (500-year flood) rather than the 1% annual chance (100-year flood) the elevations of which are typically developed for regulatory purposes by the Federal Emergency Management Agency (FEMA). The Connecticut Public Health Code does not require that water system components or water supply wells be resistant to flooding from the 0.2% event, but water supply wells must be elevated above the 1% annual chance flood elevation. This creates a disparity among State laws because many public water system projects are partly funded by the State (or by federal funds passed through the State, which are subject to State requirements) and would therefore be subject to the more conservative standards.

Federal Practices and Protocols

- Executive Order 11988 – Floodplain Management – This Executive Order requires Federal agencies to evaluate the potential effects of any Federal action that may affect floodplains and to eliminate or reduce any negative effects of that action.
- PL-566, Section 205 – This Public Law authorizes the USDA, NRCS and the USACE to undertake flood and erosion control projects in cooperation with the DEEP.
- Executive Order 11990 – Protection of Wetlands.
- Executive Order 13632 – Establishing the Hurricane Sandy Rebuilding Task Force

- Executive Order 13653 – Preparing the United States for the Impacts of Climate Change

Executive Order 13690 – Establishing a Federal Flood Risk Management Standard and a Process for Further Soliciting and Considering Stakeholder Input.
On January 30, 2015, President Obama issued Executive Order (EO) 13690. It modified an earlier Executive Order in place since 1977 (EO11988, Floodplain Management) to establish a new Federal Flood Risk Management Standard (FFRMS) for federal taxpayer-funded projects and actions. The new standard requires a climate-informed forward look to ensure that federal investments in or near floodplains are protected in the future. Aimed at increasing resilience against flooding and helping to preserve the natural values of floodplains, the FFRMS directs approaches that will take into account both current and future flood risk to ensure that projects last as long as intended. Appendix I contains an undated summary report prepared by federal agencies to assist with understanding the standard.

The FFRMS offers options for determining the vertical and horizontal extent of a floodplain in planning. The preferred option is an approach that incorporates the use of climate-informed science ("climate informed science approach" or CISA) when providing estimates of future flooding. The other approaches are using freeboard ("freeboard value approach" or FVA) or using the 0.2% annual chance flood elevation, often called the 500-year floodplain (0.2 Percent Floodplain Approach [PFA]). The Association of State Floodplain Managers (ASFPM) Foundation provides the following handy graphic to remind agencies and communities of the three methods:

Federal agencies have developed somewhat different draft procedures for implementation of the FFRMS. These procedures are not enumerated in Appendix I. Instead, individual agency guidance (much of it in draft form as of 2016-2017) must be consulted. Consider the following:

- The USACE allows use of CISA, FVA, and 0.2PFA to characterize risk and delineate the floodplain. However, additional statements in the guidance state that "all Corps actions subject to the FFRMS will utilize the CISA approach"[19] and "for critical actions that are not subject to the FFRMS, the vertical elevation and horizontal floodplain extent for critical actions will be based on the 0.2 percent annual

[19] Implementation of EO 11988, Floodplain Management, and EO 13690, Establishing a Federal Flood Risk Management Standard and a Process for Further Soliciting and Considering Stakeholder Input, line 320-321

chance flood."[20] Interestingly, the USACE guidance defines the 1% annual chance flood as "equivalent to the 1 percent flood in the North Atlantic Coast Comprehensive Study (NACCS)."[21]

- Regarding the use of the FFRMS as a design standard, the USACE guidance states that "... this vertical elevation will not be used as a design standard or to provide a minimum vertical elevation for use in the planning or design of Corps projects that involve horizontal infrastructure including but not limited to riverine, harbor, and coastal facilities; seawalls; jetties; revetments; engineered beaches and dunes; levees; and interior drainage facilities."[22] However, the guidance further states that "though not intended to be used as an explicit design standard, the identified vertical flood elevation and corresponding horizontal extent of the floodplain must be considered when implementing the eight-step decision making process."[23]

- FEMA proposes to "use the FFRMS-FVA as the baseline approach for both critical and non-critical FEMA federally-funded projects."[24] FEMA reasons that this will help standardize its procedures in both non-disaster and post-disaster conditions, and the use of freeboard tends to compensate for unknown factors. Furthermore, the CISA is not as well established for noncoastal flood risks. FEMA is "not proposing to use the FFRMS-0.2PFA because of the limited national availability of information on the 0.2 percent annual chance flood elevation."[25]

- FEMA states that the FVA is the 100-year BFE plus 3 feet for critical actions and the 100-year BFE plus 2 feet for noncritical actions.

- In its conclusion, FEMA explains that "FEMA proposes to combine approaches and use the FFRMS-FVA to establish the floodplain for non-critical actions and allow the use of the FFRMS-FVA floodplain or the FFRMS-CISA for critical actions, but only if the elevation established under FFRMS-CISA is higher than the elevation established under FFRMS-FVA. This proposal balances flexibility with standardization...."[26]

On August 15, 2017, President Trump repealed Executive Order 13690, the Federal Flood Risk Management Standard (FFRMS). The repeal is part of Trump Administration's efforts to eliminate

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[20] Implementation of EO 11988, Floodplain Management, and EO 13690, Establishing a Federal Flood Risk Management Standard and a Process for Further Soliciting and Considering Stakeholder Input, line 340-343

[21] Implementation of EO 11988, Floodplain Management, and EO 13690, Establishing a Federal Flood Risk Management Standard and a Process for Further Soliciting and Considering Stakeholder Input, line 602-603

[22] Implementation of EO 11988, Floodplain Management, and EO 13690, Establishing a Federal Flood Risk Management Standard and a Process for Further Soliciting and Considering Stakeholder Input, line 256-263

[23] Implementation of EO 11988, Floodplain Management, and EO 13690, Establishing a Federal Flood Risk Management Standard and a Process for Further Soliciting and Considering Stakeholder Input, line 345-348

[24] Federal Register Vol. 81, No. 162, 8/22/16 Proposed Rules p. 57411

[25] Federal Register Vol. 81, No. 162, 8/22/16 Proposed Rules p. 57412

[26] Federal Register Vol. 81, No. 162, 8/22/16 Proposed Rules p. 57412

regulations and/or streamline permitting regulations for infrastructure projects. However, the Department of Housing and Urban Development continues to require the FFRMS for its projects.

Section 14 of the Flood Control Act of 1946 (as amended)

Section 14 provides for the U.S. Army Corps of Engineers to participate in the planning and construction of economically justified stream-bank erosion control projects in situations where public facilities are threatened. Due to the emergency nature of this erosion problem, there is a streamlined implementation process allowing the project study and design to be concurrently completed. The intent is to abbreviate the time required for the completion of the project. Section 14 requires a complete and comprehensive solution that solves the immediate erosion problem in a manner that does not obligate or imply future Federal participation. Once Section 14 projects are completed, they are relinquished to the local non-federal sponsor for operation and maintenance. The goal of the process is the protection of public infrastructure from present and future erosion with minimal ecological consequences. A recent successful Section 14 project was completed at the City of Middletown Roth Wellfield.

Attachment A
Public Water Supply Watershed Protection

Several very early public health laws in Connecticut recognized the link between disease outbreaks, water use, and land use. For example, CGS 25-38 through 25-43, CGS 25-32, and CGS 34-36 enacted a series of laws in 1902 and 1915, respectively, to "prevent outbreaks of water related disease…, protect and preserve for future generations, . . ." Relative to source protection, Section 19-13-B32 of the CT PHC sets forth the standards for sanitation of watersheds as follows that have persisted to the present time:

> *"Unless specifically limited, the following regulations apply to land and watercourses tributary to a public water supply including both surface and ground water[27] sources:*

a) As used in this section, "sewage" shall have the meaning found in section 19-13-B20 (a) of the public health code[28]; "Toxic metals" shall be arsenic, barium, cadmium, chromium, lead, mercury and silver and the salts thereof; "high water mark" shall be the upper limit of any land area which water may cover, either standing or flowing, at any time during the year and "watershed" shall mean land which drains by natural or man-made causes to a public drinking water supply intake.

b) No sewage disposal system, cesspool, privy or other place for the deposit or storage of sewage shall be located within one hundred feet of the high water mark of any reservoir or within fifty feet of the high water mark of any stream, brook, or watercourse, flowing into any reservoir used for drinking purposes.

c) No sewage disposal system, cesspool, privy or other place for the deposit or storage of sewage shall be located on any watershed, unless such facility is so constructed that no portion of the contents can escape or be washed into the stream or reservoir.

d) No sewage shall be discharged on the surface of the ground on any watershed.

e) No stable, pigpen, chicken house or other structure where the excrement of animals or fowls is allowed to accumulate shall be located within one hundred feet of the high water mark of a reservoir or within fifty feet of the high water mark of any watercourse as above mentioned, and no such structure shall be located on any watershed unless provision is made in a manner acceptable to the commissioner of health for preventing manure or other polluting materials from flowing or being washed into such waters.

f) No toxic metals, gasoline, oil or any pesticide shall be disposed of as a waste into any watercourse tributary to a public drinking water supply or to any ground water identified as supplying a public water supply well.

[27] "Ground water" is two words in this reference

[28] Section 19-13-B20 B20 was repealed and replaced with PHC Section 19-13-B103 and the associated Technical Standards in 1982 following DPH's receiving additional concurring water pollution control authority from DEEP via CGS Section 22a-430 (g).

g) Where fertilizer is identified as a significant contributing factor to nitrate nitrogen occurring in excess of 8 mg/l in a public water supply, fertilizer application shall be made only under current guidelines established by the commissioner of health in cooperation with the state commissioner of agriculture, the college of agriculture of the University of Connecticut and the Connecticut agricultural experiment station in order to prevent exceeding the maximum allowable limit in public drinking water of 10.0 mg/l for nitrite plus nitrate nitrogen.

h) Where sodium occurs in excess of 15 mg/l in a public drinking water supply, no sodium chlorine shall be used for maintenance of roads, driveways, or parking areas draining to that water supply except under application rates approved by the commissioner of health, designed to prevent the sodium content of the public drinking water from exceeding 20 mg/l.

i) The design of storm water drainage facilities shall be such as to minimize soil erosion and maximize absorption of pollutants by the soil. Storm water drain pipes, except for crossing culverts, shall terminate at least one hundred feet from the established watercourse unless such termination is impractical, the discharge arrangement is so constructed as to dissipate the flow energy in a way that will minimize the possibility of soil erosion, and the commissioner of health finds that a discharge at a lesser distance is advantageous to stream quality. Special protections shall be taken to protect stream quality during construction."

In addition to the above requirements, stormwater discharges within 100 feet of a tributary to a public water supply reservoir must be reviewed and approved by the DPH. State statutes and regulations do not require watershed management per se, but they do require water utilities to conduct annual watershed surveys.

Regulation of water company land is an important component of source protection in Connecticut. In Connecticut, the sale and/or change of use of water company owned lands is regulated. A change in water company land associated with either a groundwater supply or a public water supply reservoir is reviewed and approved through a permit process.

As explained Task 1B-2 Conservation and Economic Development Trends, source protection has a key component in local land use application review processes. Developers and land use applicants in aquifer protection areas and public water supply watershed must notify water utilities and DPH of their application, and DPH may provide comments to local land use commissions and agencies.

The following table provides a list of statutes and regulations that address drinking watershed sanitation.

Regulations and Statutes Affecting Watershed Sanitation

Name and Citation	Description
Water Company Lands: P.H.C. Sections 25-37c-1 et esq. and 25-37d-1 et seq.	Regulates the sale and/or change of use of water company owned lands, along with defining watershed land classifications, and through Connecticut General Statute 25-32(b) controls the sale of watershed lands and changes in its present use through permit processes.

Name and Citation	Description
Source Abandonment: C.G.S. Sections 25-33k, 25-33l, & 25-33m	Regulates the sale and abandonment of public water supply sources.
Location of Cemeteries: C.G.S. Section 25-41	Prohibits the location of cemeteries within one-half mile of a public water supply reservoir.
Prohibition of Sewage Discharge: C.G.S Section 22a-417	Prohibits sewage discharge within a public water supply watershed area.
Sanitation of Watersheds: P.H.C. Section 19-13-B32 et. seq.	Mandates various separating distances from potential sources of pollution to the edge of an established watercourse within a public water supply watershed area or aquifer recharge area and requires that special protections be taken during construction to protect stream quality.
Watershed Survey: P.H.C. Section 19-13-B102(b)	Requires a water company having an active water source of supply under its control to conduct a sanitary survey of the watershed at least annually and report the results of this survey to the Department of Public Health by March 1st each year.
Sanitary Survey Of A System Using Groundwater	In conducting a sanitary survey of a system using groundwater pursuant to P.H.C. Section 19-13-B102(e)(7)(E)(iii), information on sources of contamination within the delineated wellhead protection area shall be considered.
Watershed Prohibitions, Fishing, Passive Recreation & Penalties For Polluting A Reservoir: C.G.S. Sections 25-43, 25-43c and 43(a)	Prohibits (i.e., bathing, aircraft, and general pollution) and regulates specific activities (i.e., fishing from boats with electric motors, fishing from shoreline) on public water supply reservoirs and associated watershed. Allows passive recreation for both surface and groundwater source areas through a permitting process. Any person who causes or allows any pollutant or harmful substance to enter any public water supply reservoir is subject to a fine of not less than one hundred dollars or imprisonment for not more than thirty days, or both.
Threat of Pollution: C.G.S. Section 25-34 (a)	The Department of Public Health may make orders as it deems necessary to protect public drinking water sources or ice supplies for any pollution or threatened pollution, which, in its judgment is prejudicial to public health.
Orders To Correct Pollution: C.G.S. Section 25-32g	Allows, after investigation, the issuance of orders in writing to any person to discontinue, abate, alleviate or correct conditions or activities that constitute an immediate threat to public water supplies.
Monitoring Waivers	The department may grant a public water system a waiver from the monitoring requirement for certain chemicals pursuant to P.H.C. Section 19-13-B102(e)(7)(C)(xii) – (xvi) if the watershed or zone of influence is not subject to certain types of land uses, and for certain chemicals, where previous analytical results showed no detectable limit of the contaminant to be waived.
Review of Projects In A Watershed By The Department of Public Health: C.G.S Section 25-32f	Allows the State Department of Public Health to review and comment on proposed development projects and zoning changes within public water supply source water areas.

Name and Citation	Description
Water Company Review of Projects In A Source Water Area: C.G.S. Sections 8-3i and 22a-42f	Requires an applicant to either the municipal planning and zoning commission, zoning board of appeals or the inland wetlands commission to notify the water company of the proposed development if this proposal is within the water company's public water supply watershed area (8-3i also includes aquifer protection areas). The water company therefore has the opportunity to provide comments to the municipality concerning the development proposal.
Individual Water Supply Plans: C.G.S. Sections 25-32d and 25-32d-1 et seq.	Requires water companies which serve over 1,000 people to produce long-term water supply plans in which the water company must plan for adequate supply to meet projected demand for the next 50 years, which includes an evaluation of source water protection measures.
Regional Water Supply Plans: C.G.S. Section 25-33d through 25-33j	Mandates water supply planning on a regional basis. Regulations detail the creation of the regional water supply plan. Individual water supply plans are a part of this regional process.
Local Governmental Consideration of Public Drinking Water Sources: C.G.S. Section 8-2 & 8-23	Requires that a municipal plan of conservation & development and zoning regulations shall be made with consideration for the protection of existing and potential public surface and ground drinking water supplies.

APPENDIX B

CWS Vulnerability Assessment
Plan Review Documentation

APPENDIX C

CWS Survey Results Statistics

Tables:

1 – Survey sample

Table 1.1 – Systems

Water source		Customers		Size		Region		Ownership	
Surface	22%	Residential	79%	Large 10,000+	29%	Western	37%	Local	41%
Ground	71%	Commercial	9%	Medium 500-9999	30%	Central	33%	Private	56%
Purchased	7%	Institutional	12%	Small <500	40%	Eastern	30%	State	2%

Table 1.2 - Participants

Role in system		Time with systems	
Elected official	9%	Less than 1 year	5%
Independent certified operator	4%	1 - 3 years	12%
Private water company employee	14%	4 - 6 years	16%
Public utility employee	32%	7 - 10 years	9%
System owner	16%	11 - 15 years	8%
Other (volunteer/property manager/director/etc.)	25%	More than 15 years	50%

2 - Impacts

2.1 Drought Impacts

Has your system been impacted by recent severe droughts?	% Yes All	Large	Medium	Small
Communicated with customers about drought	65%	87%	52%	64%
Implemented voluntary water restrictions	57%	65%	52%	61%
Increased monitoring of supply	55%	87%	60%	34%
Provided status updates to DPH	51%	83%	64%	24%
Used a drought response plan	33%	52%	40%	18%
Reduced supply	29%	61%	28%	9%
Changed source water operations	18%	30%	28%	3%
Implemented mandatory water restrictions	18%	13%	24%	18%
System's drought message did not align with the governor's drought messages	16%	39%	8%	3%
Used an interconnection	11%	13%	16%	6%
Found drought triggers inadequate	8%	26%	0%	3%
Used a water hauler or bottled water	7%	4%	0%	15%
Had a boil water advisory	6%	0%	4%	9%
Experienced finished water quality problems	6%	4%	4%	6%
Experienced source water quality problems	4%	9%	0%	3%
Used a temporary pipe	2%	9%	0%	0%

2.2 Storm Impacts

Has your system been impacted by recent severe storms?	% Yes All	Large	Medium	Small
Used a generator	72%	91%	58%	70%
Lost power	72%	91%	61%	64%
Provided status updated to DPH	55%	83%	58%	36%
Used an emergency response plan	54%	74%	52%	42%
Increased monitoring of water supply	45%	70%	42%	31%
Communicated with customers about storms	42%	48%	42%	42%
Staff had difficulty getting to work	23%	52%	17%	9%
Experienced flooding	12%	22%	17%	3%
Used an interconnection	8%	13%	13%	3%
Changed source water	8%	17%	13%	0%
System's message did not align with the governor's storm response messages	6%	5%	8%	3%
Shared equipment with a neighboring system	6%	13%	8%	0%
Issued a boil water advisory	5%	0%	4%	9%
Experienced finished water quality problems	5%	0%	4%	9%
Experienced source water quality problems	0%	0%	0%	0%

3 – Response

3.1 Drought response plan sufficiency by the size of the system

Did you find your emergency drought response plan sufficient for managing drought impacts?	*All*	Large	Medium	Small
Yes	*70%*	68%	79%	67%
Somewhat	*18%*	32%	13%	15%
No	*12%*	0%	8%	18%

3.2 Emergency response plan sufficiency by size of the system

Did you find your emergency response plan sufficient for managing storm impacts? (% yes)	*All*	Large	Medium	Small
Yes	*82%*	82%	79%	85%
Somewhat	*13%*	18%	21%	6%
No	*5%*	0%	0%	9%

3.3 Post-drought and post-storm analysis

Did you conduct a post-event analysis? (% yes)	*All*	Large	Medium	Small
Drought	*20%*	48%	8%	12%
Storm	*48%*	65%	38%	48%

3.4 Generator operation for systems with generators

Does your generator start automatically or manually?	*All*	Large	Medium	Small
Automatically	*67%*	58%	75%	70%
Manually	*15%*	0%	8%	30%
Combination of both	*19%*	42%	17%	0%

3.5 Items that help the systems respond to threats now (ranked most to least)

How much do the following items enable your system(s) to respond to threats now?	Not at all	Not much	Some	A lot	% Some or A lot
Backup generators	10	5	21	42	81%
Adequate funding	14	14	28	21	64%
Remote sensing/SCADA	19	11	19	25	62%
Multiple sources of supply	17	13	31	17	61%
Improved emergency response plans	9	22	38	10	59%
Special project funding including state or federal grants	17	15	30	15	58%
Regulatory requirements	15	21	32	10	54%
Interconnections	23	12	30	12	55%
Better drought models	19	23	28	8	46%
Revised drought triggers	15	33	24	6	38%
Flood proofing	28	27	16	6	29%
Salinity barriers	59	11	3	3	8%

3.6 Items that help systems respond in the future (ranked most to least increase from now)

How much do the following items enable your system(s) to respond to threats in the future?	Relative Change (-2 to 2 scale)
Multiple sources of supply	0.29
Interconnections	0.26
Adequate funding	0.18
Special project funding including state or federal grants	0.16
Better drought models	0.15
Revised drought triggers	0.13
Flood proofing	0.08
Backup generators	0.07
Remote sensing/SCADA	0.05
Improved emergency response plans	0.04
Regulatory requirements	0.04
Salinity barriers	0.01

3.7 Actions that help systems respond to threats now (ranked most to least)

How much do the following actions enable your system(s) to respond to threats now?	Not at all	Not much	Some	A lot	% Some or A lot
Good operations and maintenance	1	4	16	54	93%
Good communication with customers	2	9	35	29	85%
Investment in skilled workforce	5	10	23	37	80%
Maintaining a healthy watershed	12	6	16	40	79%
Investment in technology	3	13	35	24	76%
Investment in conservation	5	26	32	11	58%
Becoming more aware of climate change impacts to my system (adaptation step 1)	15	17	37	6	57%
Collaboration with other systems	18	18	25	14	52%
Identifying options to prepare for and manage climate change (adaptation step 3)	18	18	33	4	51%
Gathering information about climate change (adaptation step 2)	16	23	31	5	48%
Beginning to implement options for responding to climate change (adaptation step 4)	20	24	27	4	41%

3.8 Actions that help systems respond in the future (ranked most to least increase from now)

How much do the following actions enable your system(s) to respond to threats in the future?	Relative Change (-2 to 2 scale)
Becoming more aware of climate change impacts to my system (adaptation step 1)	0.28
Identifying options to prepare for and manage climate change (adaptation step 3)	0.28
Beginning to implement options for responding to climate change (adapt step 4)	0.26
Gathering information about climate change (adaptation step 2)	0.26
Investment in conservation	0.25
Maintaining a healthy watershed	0.14
Investment in technology	0.13
Collaboration with other systems	0.08
Investment in skilled workforce	0.07
Good operations and maintenance	0.07
Good communication with customers	0.06

3.9 Actions to increase reliability

Would the system you manage pursue any of the following options to increase service reliability?	Definitely not	Probably not	Probably yes	Definitely yes
Invest in internal improvements	4%	6%	35%	55%
Interconnect with a neighboring system	18%	29%	36%	17%
Interconnect and consolidate with a neighboring system	24%	47%	18%	10%
Acquisition by a larger water system	38%	37%	13%	12%

3.10 Changes made to increase resilience (ranked most to least)

Has your system made any of the following changes in response to droughts, storms, or for other reasons?	Number of systems
Purchased a generator	39
Revised emergency response plans	26
Implemented recommendations from DPH	24
Increased education and training of staff	23
Raised water rates	22
Revised drought triggers	18
Updated or conducted a vulnerability assessment	18
Established an interconnection	17
Passed or supported passage of a voluntary or mandatory water use restriction ordinance	17
Changed customer communication strategy	16
Raised well heads	16
Applied for additional funding	14
Gathered information about changing droughts and storms	14
Invested in modeling to prepare for droughts and storms	14
Revised safe yield calculations	13

4 - Threats

4.1 Threats now (ranked most to least)

How likely is this threat to negatively impact your system now?	Very Unlikely	Somewhat Unlikely	Somewhat Likely	Very Likely	% Somewhat or Very Likely
Regulations	11	23	29	18	58%
Storms	17	21	38	5	53%
Power failures	20	22	30	9	48%
Infrastructure failure	13	32	31	6	45%
Insufficient funding	24	20	25	12	46%
More frequent or intense storms (climate change related)	19	25	34	3	46%
More frequent and severe high temperatures (climate change related)	18	33	28	3	38%
More frequent or intense droughts (climate change related)	15	39	24	4	34%
Access to a skilled workforce	24	27	26	5	38%
Drought	22	32	25	3	34%
Changes in demand	34	25	22	1	28%
Source water quality	46	23	9	2	14%
Finished water quality	48	28	3	1	5%
Sea level rise (climate change related)	65	10	5	2	9%

4.2 Threats in the future (ranked most to least increase from now, negative means decreased threat)

How likely is this threat to negatively impact your system in the future (20+ years)?	Relative Change (-2 to 2 scale)
Drought	0.29
Access to a skilled workforce	0.26
Changes in demand	0.23
Regulations	0.23
More frequent or intense droughts (climate change)	0.18
Source water quality	0.13
Insufficient funding	0.13
More frequent or intense storms (climate change)	0.11
More frequent and severe high temperatures (climate change)	0.11
Infrastructure failure	0.10
Finished water quality	0.10
Storms	0.07
Sea level rise (climate change)	-0.03
Power failures	-0.12

APPENDIX D

Drinking Water Vulnerability and Resilience
Plan Workshop

C.1 Workshop Agenda

8:15am Breakfast and Check-in – Student Center

9am Welcome and Overview* - Academic Building 308

James O'Donnell, CIRCA Executive Director and UConn Professor of Marine Sciences
Rebecca French, CIRCA Director of Community Engagement

9:10am Presentation: *The Importance of Resilience* - ACD 308

Lori Mathieu, Public Health Section Chief, Drinking Water Section, Department of Public Health

9:25am Part I Oral Presentations – ACD 308

Future Challenges of Climate Change for Community Water Systems: Drought, Precipitation and Coastal Flooding

James O'Donnell, CIRCA Executive Director and UConn Professor of Marine Sciences
Guiling Wang, CIRCA Affiliated Faculty Member and UConn Professor of Civil & Environmental Engineering

Resilience Lessons from Community Water Systems Experience with Past Storms

Christine Kirchhoff, CIRCA Affiliated Faculty Member and UConn Assistant Professor of Civil & Environmental Engineering

Keeping the Water on for Critical Facilities: Mapping Flood Risk

Amy Burnicki, CIRCA Affiliated Faculty Member and UConn Assistant Professor in Residence of Civil & Environmental Engineering

Private Wells: Identifying Neighborhoods at Risk and Options to Improve Resilience

Victoria Brudz, CIRCA Project Specialist

Panel Discussion with Speakers (Live Q&A with webinar and in-person participants)

10:40am Morning Break – Student Center

11:00am Part 2 Oral Presentations - ACD 308

How Well Are We Already Prepared: Reviewing the Current State of Practice for Community Water Systems

David Murphy, Manager of Water Resources Planning, Milone & MacBroom

Resilience Laws and Policy – Tools to Maintain and Enhance Safe Drinking Water Compliance

David Murphy, Manager of Water Resources Planning, Milone & MacBroom

A Resilience Plan for Community Water Systems

Christine Kirchhoff, CIRCA Affiliated Faculty Member and UConn Professor of Civil & Environmental Engineering
David Murphy, Manager of Water Resources Planning, Milone & MacBroom

Funding Opportunities for Resilience Strategies

Cam Walden, Supervising Sanitary Engineer, Drinking Water State Revolving Fund, Department of Public Health

12:15pm Lunch Provided – Branford House

1:15pm Breakout Sessions – small group facilitated discussions on:

- *It's An Emergency! Keep the Water Supply Running - Branford House Oak Room*
- *Redundancy = Resilience: Options and Alternatives for CWSs & Drinking Water Policy - ACD 206*
- *Using Climate Data to Inform CWS Decisions - ACD 207*
- *What Do We Do About Private Well Resilience? - ACD 311*

2:45pm Report Out on Breakout Sessions and Wrap-up – ACD 2nd Floor Auditorium

3:15pm End Workshop

C.2 Workshop Participants

In Person Participants

Karl	Acimovic	Engineer	acimovick@grotonutilities.com	Groton Utilities
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C.3 Workshop Presentation Summaries

In addition to the summaries provided here, copies of all the oral presentations are posted on CIRCA's website, along with a recording of the webinar for viewing by the public.

The Importance of Resilience

Lori Mathieu, Public Health Section Chief, Drinking Water Section, Department of Public Health

Ms. Mathieu reviewed the lessons learned from the prior storms of Irene, Sandy and Alfred, including a lack of capacity, planning and preparedness especially for small public water systems. In response, the Three Storm Strategy made recommendations to assure a sustained water supply for all community public water systems through better during storm status updates in WebEOC, restoration of street power, and more proactive management and oversight of small systems. Preparedness was also emphasized with requirements for emergency plans and power capacity, a subsidized loan program for generators and asset and resiliency planning, which led to the partnership with CIRCA to undertake the vulnerability assessment and resiliency plan for drinking water systems.

Future Challenges of Climate Change for Community Water Systems: Drought, Precipitation and Coastal Flooding

James O'Donnell, CIRCA Executive Director and UConn Professor of Marine Sciences

Professor O'Donnell reviewed changes in temperature, frost onset, discharge of rivers into Long Island Sound and CIRCA's updated sea level rise projections for Connecticut. Based on four projections updated from a NOAA 2012 report, CIRCA recommends that Connecticut plan for up to 20 inches of sea level rise by 2050. This level of sea level rise is being used in the drinking water vulnerability assessment to look at changes in 1% annual chance floodplain area with additional sea level rise.

Guiling Wang, CIRCA Affiliated Faculty Member and UConn Professor of Civil & Environmental Engineering

Precipitation information is needed at the scale where decisions are being made for drinking water systems and existing resources, such as the National Climate Assessment, are not sufficient. The approach taken by Professor Wang includes a spatially distributed assessment for Connecticut with fine temporal and spatial resolutions, assuming a worst case scenario for carbon dioxide emissions with multiple climate models compared to account for differences between model outputs. Conclusions about flood risks are that there will be substantial increases in flood risk, including today's 5% annual chance flood is at least a 20% annual chance flood in the future and the number of days per year with more than 1 inch of precipitation would increase by 1-3 days by mid-century. There was not as much agreement between climate models on drought risk. For example, some models showed generally more frequent 1-year and 2-year droughts, but some models showed they could be less frequent. However, models agreed on a more frequent occurrence of extreme June/July/August droughts.

Resilience Lessons from Community Water Systems Experience with Past Storms

Christine Kirchhoff, CIRCA Affiliated Faculty Member and UConn Assistant Professor of Civil & Environmental Engineering

Professor Kirchhoff is using social science methods of interview and surveys to understand how systems have been impacted by storms and droughts, what they are doing to improve resilience and gathering lessons learned to build resilience. Preliminary results from the interviews and surveys showed that good staff, a high quality water source and a continuous and reliable water supply matter for resilience. Generators are often cited as a resilience strategy that works while multiple water sources and interconnections were much less frequently cited as a resilience strategy. Operations and maintenance with forward thinking investments also improved resilience. The study found that regulations can drive investments to build resilience and that small and large systems' experiences highly differ. Finally the majority of those individuals surveyed do not think that climate change will impact them, which represents a resiliency gap.

Keeping the Water on for Critical Facilities: Mapping Flood Risk

Amy Burnicki, CIRCA Affiliated Faculty Member and UConn Assistant Professor in Residence of Civil & Environmental Engineering

The goal of this study is to assess critical facilities (commerce centers, hospitals, nursing homes, and emergency shelters) in four counties impacted by super storm Sandy for vulnerability to future flood risk. To date 1617 critical priority facilities were identified. Public water system service area footprints were assessed and overlaid with FEMA 1% annual chance flood zones for coastal and upland areas. Dr. Burnicki shared data from the results from the 475 care facilities in the four county region to understand which of them could be vulnerable to future flooding based on an association with a public water system. The study identified that for large public water systems, 71 care facilities are vulnerable due to the water source and of those 71, 42 facilities were vulnerable due to treatment plant vulnerability. For small public water systems, 14 care facilities were identified as vulnerable.

Private Wells: Identifying Neighborhoods at Risk and Options to Improve Resilience

Victoria Brudz, CIRCA Project Specialist

Ms. Brudz reviewed the objectives for assessing the vulnerability of private well systems, including determining where wells are located in the four coastal counties, identifying neighborhoods vulnerable to flooding that rely primarily on wells and recommending strategies to improve private well resilience. The study identified 13 at risk neighborhoods at risk due to coastal and riverine flooding. The resilience strategies reviewed included a drainage project, property acquisition, water main extension, well protection, relocating a well on site, forming or joining a public water system and pursing smart development strategies. The presentation shared best practices for private well owners of elevating wellheads, testing wells, connecting to a public water supply, having a backup general or planning for water storage and using steel casing for new wells.

How Well Are We Already Prepared: Reviewing the Current State of Practice for Community Water Systems

David Murphy, Manager of Water Resources Planning, Milone & MacBroom

This project required a review of current water system vulnerability assessment (per the Bioterrorism Act or other assessments), ECPs, small CWS vulnerabilities and potential interconnections to reduce risks. The review of ECPs found there is a need for specific mitigation measures for emergency issues, climate change is not addressed since plans focus only on short-term challenges, groundwater sources are not vulnerable to flooding and there are potential issues with inconsistency between plans on how to deal with drought. Small systems were consistently highly vulnerable due to few sources of supply, low storage capacity and no ability to disinfect at all or only with power. Many small systems do not have any interconnections, despite the finding that interconnections are feasible for the majority of small CWSs with low Capacity Assessment Tool (CAT) scores.

Resilience Laws and Policy – Tools to Maintain and Enhance Safe Drinking Water Compliance

David Murphy, Manager of Water Resources Planning, Milone & MacBroom

This presentation reviewed state and federal statutes and policy that impact both drinking water and resiliency. Although climate change and resiliency are not explicitly mentioned in the Public Health Code, interconnections and mitigating flood risk are there. There were six pieces of legislation passed since 2012 that promote or address resiliency for drinking water systems. Flood management stands out as the most explicit look at resiliency with requirements that drinking water state revolving funded-projects for critical facilities go higher and stronger than the 100-year flood. Sea level rise has been incorporated into wastewater system-related statutes and it was suggested this process might be mirrored for drinking water systems. The Connecticut Hazard Mitigation Plan encouraged municipalities to adopt local water use restriction ordinances and to coordinate with water utilities to more actively promote water conservation measures. The State Plan of Conservation and Development calls on the state and municipalities to proactively address climate change adaptation strategies in the face of flooding and drought conditions including "impacts to public water supplies." Both the Connecticut State Water Plan and the Coordinated Water System Plan include explicit science and recommendations on climate change impacts and resiliency.

A Resilience Plan for Community Water Systems

Christine Kirchhoff, CIRCA Affiliated Faculty Member and UConn Professor of Civil & Environmental Engineering

David Murphy, Manager of Water Resources Planning, Milone & MacBroom

The Resilience Plan was in the early stages of development at the time this workshop was held and therefore the presentation focused on the elements of the plan as called for in the contract with the Department of Public Health. The implementation plan will cover uninterrupted supply to customers and critical facilities; redundant, resilient sources and infrastructure; modification to current laws; extreme weather, drought and climate change; engagement of partners; and linkages to the Drinking Water State Revolving Fund and Capacity Assessment Tool.

Funding Opportunities for Resilience Strategies

Cam Walden, Supervising Sanitary Engineer, Drinking Water State Revolving Fund, Department of Public Health

The Department of Public Health provided an overview of the Drinking Water State Revolving Fund (DWSRF) highlighting how it could be used for resilience projects. As of 2017, under the priority ranking system, the loan program includes a Category 6 Resiliency/Security area to increase public water systems' ability to withstand and recover from natural or man-made disaster including drought. Eligible projects under this category include asset management and climate change planning, redundancy or relocation of critical drinking water facilities if identified as vulnerable by climate change studies, regional interconnections for rapid transfer of water during emergencies and security enhancements. It also includes a Category 3 for Conservation/ Water Loss Reduction. Interconnections are further being incentivized through the Public Water System Improvement Program that provides state grant funding as part of the DWSRF with a 50% subsidy for small systems and 30% subsidy for large systems.

APPENDIX E

PWS Component Vulnerability
Analysis Results

APPENDIX F

CWS Well Vulnerability and Mitigation Efforts

CWS with 100-year flood resilient wells

PWS ID	PWS Name	City	Flood Response Status	Well Cap	WSP Year	WSF Name	Well Status	Treatment	Pump Type	FEMA Flood Zone
CT0150011	AQUARION WATER CO OF CT-MAIN SYSTEM	BRIDGEPORT	Pump well seal	Pump well seal		WESTPORT WELL #5	A	T	VT	AE
CT0150011	AQUARION WATER CO OF CT-MAIN SYSTEM	BRIDGEPORT	Pump well seal	Pump well seal		WESTPORT WELL #7	A	T	VT	AE
CT0150011	AQUARION WATER CO OF CT-MAIN SYSTEM	BRIDGEPORT	Pump well seal	Pump well seal		COLEYTOWN WELL #2	A	T	VT	AE
CT0150011	AQUARION WATER CO OF CT-MAIN SYSTEM	BRIDGEPORT	Pump well seal	Pump well seal		WESTPORT WELL #4	A	T	VT	AE
CT0150011	AQUARION WATER CO OF CT-MAIN SYSTEM	BRIDGEPORT	Pump well seal	Pump well seal		COLEYTOWN WELL #1	A	T	VT	AE
CT1350011	AQUARION WATER CO OF CT-STAMFORD	STAMFORD	Watertight pump base	Watertight pump base		WIRE MILL WELL	A	T	VT	AE
CT0090011	BETHEL WATER DEPT	BETHEL	Well is completely sealed to preclude surface water infiltration		2007	MAPLE AVE WELL 2	A	T	VT	AE
CT0330011	CROMWELL FIRE DISTRICT WATER DEPARTMENT	CROMWELL	Located in watertight structure		2005	GARDINER WELL 2	A	T	VT	AE
CT0330011	CROMWELL FIRE DISTRICT WATER DEPARTMENT	CROMWELL				GARDINER WELL 1	A	T	VT	AE
CT0330011	CROMWELL FIRE DISTRICT WATER DEPARTMENT	CROMWELL				GARDINER WELL 3	A	T	VT	AE
CT0608011	CTWC - SHORELINE REGION-	GUILFORD	Watertight well cap	Watertight well cap		HOLBROOK WELL	A	T	SU	A

PWS ID	PWS Name	City	Flood Response Status	Well Cap	WSP Year	WSF Name	Well Status	Treatment	Pump Type	FEMA Flood Zone
	GUILFORD SYSTEM									
CT0608011	CTWC - SHORELINE REGION-GUILFORD SYSTEM	GUILFORD	Watertight pump bloc	Watertight pump bloc		FIVE FIELDS WELL 2A	A	T	VT	AE
CT0608011	CTWC - SHORELINE REGION-GUILFORD SYSTEM	GUILFORD	Watertight well cap	Watertight well cap		PINEWOOD WELL 2	A	T	SU	AE
CT0608011	CTWC - SHORELINE REGION-GUILFORD SYSTEM	GUILFORD	Watertight pump bloc	Watertight pump bloc		WEISS WELL	A	T	VT	AE
CT0608011	CTWC - SHORELINE REGION-GUILFORD SYSTEM	GUILFORD	Watertight pump bloc	Watertight pump bloc		CLINTON WELL	A	T	VT	AE
CT1050752	CTWC - SHORELINE REGION-POINT O WOODS	OLD LYME	Watertight well cap	Watertight well cap		WELL 2	A	T	SU	AE
CT0380021	DURHAM CENTER DIVISION	DURHAM	Well casing extended above 1% annual chance flood elevation			DURHAM FAIR WELL 1	A	T	SU	AE
CT0380021	DURHAM CENTER DIVISION	DURHAM				DURHAM FAIR WELL 2	A	T	SU	AE
CT0450011	EAST LYME WATER & SEWER COMMISSION	EAST LYME	Watertight seal	Watertight seal		WELL 6	A	T	VT	AE

PWS ID	PWS Name	City	Flood Response Status	Well Cap	WSP Year	WSF Name	Well Status	Treatment	Pump Type	FEMA Flood Zone
CT0970021	FAIRFIELD HILLS	NEWTOWN	Pitless adaptor casing installed in 2006 and is now above floodplain		2012	WELL #3	A	T		AE
CT1300021	HERITAGE WATER COMPANY	SOUTHBURY	Turbine pump seal	Turbine pump seal		WELL 5A	A	T	VT	AE
CT1300021	HERITAGE WATER COMPANY	SOUTHBURY				WELL M 4	A	T	VT	AE
CT1300021	HERITAGE WATER COMPANY	SOUTHBURY				WELL HV 2A	A	T	VT	AE
CT1300021	HERITAGE WATER COMPANY	SOUTHBURY				WELL HV 3	A	T	VT	AE
CT1300021	HERITAGE WATER COMPANY	SOUTHBURY				WELL 1A	A	T	VT	AE
CT0861021	MEADOWS APARTMENTS	MONTVILLE	Watertight well cap	Watertight well cap		WELL 1	A	T	SU	AE
CT1030011	NORWALK FIRST TAXING DISTRICT	NORWALK	All well pump structures are installed above the 1% annual chance flood elevation		2012	WELL D-1	A	N	VT	AE
CT1030011	NORWALK FIRST TAXING DISTRICT	NORWALK				WELL L-1R	A	N	VT	AE
CT1030011	NORWALK FIRST TAXING DISTRICT	NORWALK				WELL D-2	A	N	SU	AE
CT1030011	NORWALK FIRST TAXING DISTRICT	NORWALK				WELL L-2	A	N	VT	AE
CT1040011	NORWICH PUBLIC UTILITIES	NORWICH	Pump seal	Pump seal		NORWICHTOWN WELL - WELL #1	A	T	VT	AE
CT0600041	QUONNIPAUG HILLS - MAIN SYSTEM	GUILFORD	Merril watertight cap	Merril watertight cap		WELL 2	A	N	SU	A
CT1020021	SCWA, NORTH STONINGTON DIVISION (NST)	NORTH STONINGTON	Watertight cap	Watertight cap		WELL 2	A	T		A
CT1300011	SOUTHBURY TRAINING SCHOOL	SOUTHBURY	Welded steel cover	Welded steel cover		WELL 1	A	T	SU	A

PWS ID	PWS Name	City	Flood Response Status	Well Cap	WSP Year	WSF Name	Well Status	Treatment	Pump Type	FEMA Flood Zone
CT1330021	SPRAGUE WATER & SEWER AUTHORITY	SPRAGUE	Watertight well cap	Watertight well cap		WELL #1	A	T	SU	AE
CT1330021	SPRAGUE WATER & SEWER AUTHORITY	SPRAGUE	Top elevation of the wells have been raised above the 1% annual chance flood elevation		2012	WELL #2	A	T	SU	AE
CT1330021	SPRAGUE WATER & SEWER AUTHORITY	SPRAGUE				WELL #3	A	T	SU	AE
CT1480011	WALLINGFORD WATER DEPARTMENT	WALLINGFORD	Watertight pump seal	Watertight pump seal		OAK STREET WELL #3	A	T	VT	AE

CWS with 100-year flood vulnerable well response plans

PWS ID	PWS Name	City	Flood Response Status	Well Cap	WSP Year	WSF Name	Well Status	Treatment	Pump Type	FEMA Flood Zone
CT0150011	AQUARION WATER CO OF CT-MAIN SYSTEM	BRIDGEPORT	Pump well seal	Pump well seal		WESTPORT WELL #5	A	T	VT	AE
CT0150011	AQUARION WATER CO OF CT-MAIN SYSTEM	BRIDGEPORT	Pump well seal	Pump well seal		WESTPORT WELL #7	A	T	VT	AE
CT0150011	AQUARION WATER CO OF CT-MAIN SYSTEM	BRIDGEPORT	Pump well seal	Pump well seal		COLEYTOWN WELL #2	A	T	VT	AE
CT0150011	AQUARION WATER CO OF CT-MAIN SYSTEM	BRIDGEPORT	Pump well seal	Pump well seal		WESTPORT WELL #4	A	T	VT	AE
CT0150011	AQUARION WATER CO OF CT-MAIN SYSTEM	BRIDGEPORT	Pump well seal	Pump well seal		COLEYTOWN WELL #1	A	T	VT	AE
CT1350011	AQUARION WATER CO OF CT-STAMFORD	STAMFORD	Watertight pump base	Watertight pump base		WIRE MILL WELL	A	T	VT	AE
CT0090011	BETHEL WATER DEPT	BETHEL	Well is completely sealed to preclude surface water infiltration		2007	MAPLE AVE WELL 2	A	T	VT	AE
CT0330011	CROMWELL FIRE DISTRICT WATER DEPARTMENT	CROMWELL	Located in watertight structure		2005	GARDINER WELL 2	A	T	VT	AE
CT0330011	CROMWELL FIRE DISTRICT WATER DEPARTMENT	CROMWELL				GARDINER WELL 1	A	T	VT	AE
CT0330011	CROMWELL FIRE DISTRICT WATER DEPARTMENT	CROMWELL				GARDINER WELL 3	A	T	VT	AE
CT0608011	CTWC - SHORELINE REGION-GUILFORD SYSTEM	GUILFORD	Watertight well cap	Watertight well cap		HOLBROOK WELL	A	T	SU	A

PWS ID	PWS Name	City	Flood Response Status	Well Cap	WSP Year	WSF Name	Well Status	Treatment	Pump Type	FEMA Flood Zone
CT0608011	CTWC - SHORELINE REGION-GUILFORD SYSTEM	GUILFORD	Watertight pump bloc	Watertight pump bloc		FIVE FIELDS WELL 2A	A	T	VT	AE
CT0608011	CTWC - SHORELINE REGION-GUILFORD SYSTEM	GUILFORD	Watertight well cap	Watertight well cap		PINEWOOD WELL 2	A	T	SU	AE
CT0608011	CTWC - SHORELINE REGION-GUILFORD SYSTEM	GUILFORD	Watertight pump bloc	Watertight pump bloc		WEISS WELL	A	T	VT	AE
CT0608011	CTWC - SHORELINE REGION-GUILFORD SYSTEM	GUILFORD	Watertight pump bloc	Watertight pump bloc		CLINTON WELL	A	T	VT	AE
CT1050752	CTWC - SHORELINE REGION-POINT O WOODS	OLD LYME	Watertight well cap	Watertight well cap		WELL 2	A	T	SU	AE
CT0380021	DURHAM CENTER DIVISION	DURHAM	Well casing extended above 1% annual chance flood elevation			DURHAM FAIR WELL 1	A	T	SU	AE
CT0380021	DURHAM CENTER DIVISION	DURHAM	Well casing extended above 1% annual chance flood elevation			DURHAM FAIR WELL 2	A	T	SU	AE
CT0450011	EAST LYME WATER & SEWER COMMISSION	EAST LYME	Watertight seal	Watertight seal		WELL 6	A	T	VT	AE
CT0970021	FAIRFIELD HILLS	NEWTOWN	Pitless adaptor casing installed in 2006 and is now above floodplain		2012	WELL #3	A	T		AE
CT1300021	HERITAGE WATER COMPANY	SOUTHBURY	Turbine pump seal	Turbine pump seal		WELL 5A	A	T	VT	AE
CT1300021	HERITAGE WATER COMPANY	SOUTHBURY	Turbine pump seal	Turbine pump seal		WELL M 4	A	T	VT	AE
CT1300021	HERITAGE WATER COMPANY	SOUTHBURY	Turbine pump seal	Turbine pump seal		WELL HV 2A	A	T	VT	AE

PWS ID	PWS Name	City	Flood Response Status	Well Cap	WSP Year	WSF Name	Well Status	Treatment	Pump Type	FEMA Flood Zone
CT1300021	HERITAGE WATER COMPANY	SOUTHBURY				WELL HV 3	A	T	VT	AE
CT1300021	HERITAGE WATER COMPANY	SOUTHBURY				WELL 1A	A	T	VT	AE
CT0861021	MEADOWS APARTMENTS	MONTVILLE	Watertight well cap	Watertight well cap		WELL 1	A	T	SU	AE
CT1030011	NORWALK FIRST TAXING DISTRICT	NORWALK	All well pump structures are installed above the 1% annual chance flood elevation		2012	WELL D-1	A	N	VT	AE
CT1030011	NORWALK FIRST TAXING DISTRICT	NORWALK				WELL L-1R	A	N	VT	AE
CT1030011	NORWALK FIRST TAXING DISTRICT	NORWALK				WELL D-2	A	N	SU	AE
CT1030011	NORWALK FIRST TAXING DISTRICT	NORWALK				WELL L-2	A	N	VT	AE
CT1040011	NORWICH PUBLIC UTILITIES	NORWICH	Pump seal	Pump seal		NORWICHTOWN WELL - WELL #1	A	T	VT	AE
CT0600041	QUONNIPAUG HILLS - MAIN SYSTEM	GUILFORD	Merril watertight cap	Merril watertight cap		WELL 2	A	N	SU	A
CT1020021	SCWA, NORTH STONINGTON DIVISION (NST)	NORTH STONINGTON	Watertight cap	Watertight cap		WELL 2	A	T		A
CT1300011	SOUTHBURY TRAINING SCHOOL	SOUTHBURY	Welded steel cover	Welded steel cover		WELL 1	A	T	SU	A
CT1330021	SPRAGUE WATER & SEWER AUTHORITY	SPRAGUE	Watertight well cap	Watertight well cap		WELL #1	A	T	SU	AE
CT1330021	SPRAGUE WATER & SEWER AUTHORITY	SPRAGUE	Top elevation of the wells have been raised above the 1% annual chance flood elevation		2012	WELL #2	A	T	SU	AE
CT1330021	SPRAGUE WATER & SEWER AUTHORITY	SPRAGUE				WELL #3	A	T	SU	AE
CT1480011	WALLINGFORD WATER DEPARTMENT	WALLINGFORD	Watertight pump seal	Watertight pump seal		OAK STREET WELL #3	A	T	VT	AE

CWS with 100-year flood vulnerable wells or no data on mitigation was found

PWS ID	PWS Name	City	Flood Response Status	Well Cap	WSP Year	WSF Name	Well Status	Treatment	Pump Type	FEMA Flood Zone
CT0189791	AQUARION WATER CO OF CT-BROOKFIELD SYS	BROOKFIELD	No data			MEADOWBROOK WELL #3	A		SU	AE
CT0189791	AQUARION WATER CO OF CT-BROOKFIELD SYS	BROOKFIELD	No data	Baker/monitor-10WPSM		MEADOWBROOK WELL #4	A		SU	AE
CT0189791	AQUARION WATER CO OF CT-BROOKFIELD SYS	BROOKFIELD	No data	Baker/monitor-10WPSM		MEADOWBROOK WELL #5	A		SU	AE
CT0189791	AQUARION WATER CO OF CT-BROOKFIELD SYS	BROOKFIELD	No data			MEADOWBROOK WELL #1	A	T	SU	AE
CT0189791	AQUARION WATER CO OF CT-BROOKFIELD SYS	BROOKFIELD	No data			MEADOWBROOK WELL #2	A	T	SU	AE
CT1180011	AQUARION WATER CO OF CT-RIDGEFIELD SYS	RIDGEFIELD	No data			OSCALETA WELL #2	A	T	SU	A
CT1180011	AQUARION WATER CO OF CT-RIDGEFIELD SYS	RIDGEFIELD	No data			NORTH STREET WELL #3	A	T	SU	AE
CT1180011	AQUARION WATER CO OF CT-RIDGEFIELD SYS	RIDGEFIELD	No data			NORTH STREET WELL #1	A	T	SU	AE
CT1180011	AQUARION WATER CO OF CT-RIDGEFIELD SYS	RIDGEFIELD	No data			NORTH STREET WELL #2	A	T	SU	AE
CT1240011	AQUARION WATER CO OF CT-VALLEY SYSTEM	SEYMOUR	No data			OXFORD WELL #6	A	T		AE
CT1240011	AQUARION WATER CO OF CT-VALLEY SYSTEM	SEYMOUR	No data			OXFORD WELL #7	A	T		AE
CT1240011	AQUARION WATER CO OF CT-VALLEY SYSTEM	SEYMOUR	No data			OXFORD WELL #5	A	T		AE

PWS ID	PWS Name	City	Flood Response Status	Well Cap	WSP Year	WSF Name	Well Status	Treatment	Pump Type	FEMA Flood Zone
CT0184011	BROOKFIELD ELDERLY HOUSING	BROOKFIELD	No data			WELL 1	A	N	SU	AE
CT1180091	BROOKVIEW WATER COMPANY	RIDGEFIELD	No data			WELL 1	A	N		AE
CT0420071	CHATHAM APARTMENTS	EAST HAMPTON	No data			WELL 1	A	T		A
CT0880011	CTWC - NAUGATUCK REGION-CENTRAL SYSTEM	NAUGATUCK	Wells listed in ECP as facilities "potentially subject to flooding"		2010	INDIAN FIELDS WELL #2	A	T		A
CT0880011	CTWC - NAUGATUCK REGION-CENTRAL SYSTEM	NAUGATUCK				INDIAN FIELDS WELL #1	A	T		A
CT0880011	CTWC - NAUGATUCK REGION-CENTRAL SYSTEM	NAUGATUCK	Casing flush with ground level. No additional data			MARKS BROOK WELL #1	A	T		AE
CT0261031	CTWC - SHORELINE REGION-CHESTER SYSTEM	CHESTER	Wells listed in ECP as facilities "potentially subject to flooding"			DENNISON WELL	A	N		AE
CT0800011	MERIDEN WATER DIVISION	MERIDEN	No data			MULE WELL	A	T	SU	AE
CT0800011	MERIDEN WATER DIVISION	MERIDEN	No data			PLATT WELL	A	T	SU	AE
CT1051021	MIAMI BEACH WATER COMPANY	OLD LYME	no data			DRILLED WELL 1	A	N		AE
CT1051021	MIAMI BEACH WATER COMPANY	OLD LYME	The well suction pipes for the Columbus Wells needed re-grouting to provide a watertight condition as of 2014			WELL 3 CORSINO AVE	A	N		AE
CT1051021	MIAMI BEACH WATER COMPANY	OLD LYME				WELL 1 COLUMBUS AVE	A	T		AE
CT1051021	MIAMI BEACH WATER COMPANY	OLD LYME				WELL 2 COLUMBUS AVE	A	T		AE

PWS ID	PWS Name	City	Flood Response Status	Well Cap	WSP Year	WSF Name	Well Status	Treatment	Pump Type	FEMA Flood Zone
CT0830011	MIDDLETOWN WATER DEPARTMENT	MIDDLETOWN	No data			JOHN S ROTH WELL #8	A	T		AE
CT0830011	MIDDLETOWN WATER DEPARTMENT	MIDDLETOWN	No data			JOHN S ROTH WELL #10	A	T		AE
CT0830011	MIDDLETOWN WATER DEPARTMENT	MIDDLETOWN	No data			JOHN S ROTH WELL #9	A	T		AE
CT0830011	MIDDLETOWN WATER DEPARTMENT	MIDDLETOWN	No data			JOHN S ROTH WELL #4A	A	T		AE
CT0830011	MIDDLETOWN WATER DEPARTMENT	MIDDLETOWN	No data			JOHN S ROTH WELL #6	A	T		AE
CT0830011	MIDDLETOWN WATER DEPARTMENT	MIDDLETOWN	No data			JOHN S ROTH WELL #7	A	T		AE
CT0830011	MIDDLETOWN WATER DEPARTMENT	MIDDLETOWN	No data			JOHN S ROTH WELL #3	A	T		AE
CT0830011	MIDDLETOWN WATER DEPARTMENT	MIDDLETOWN	No data			JOHN S ROTH WELL #2A	A	T		AE
CT0830011	MIDDLETOWN WATER DEPARTMENT	MIDDLETOWN	No data			JOHN S ROTH WELL #5	A	T		AE
CT0830011	MIDDLETOWN WATER DEPARTMENT	MIDDLETOWN	No data			JOHN S ROTH WELL #1	A	T		AE
CT0930011	REGIONAL WATER AUTHORITY	NEW HAVEN	No data			SEYMOUR WELL 5	A	T	VT	AE
CT0930011	REGIONAL WATER AUTHORITY	NEW HAVEN	No data			SEYMOUR WELL 4R	A	T		AE
CT0930011	REGIONAL WATER AUTHORITY	NEW HAVEN	No data			SEYMOUR WELL 6	A	T	VT	AE
CT0930011	REGIONAL WATER AUTHORITY	NEW HAVEN	No data			SEYMOUR WELL 7	A	T	VT	AE

PWS ID	PWS Name	City	Flood Response Status	Well Cap	WSP Year	WSF Name	Well Status	Treatment	Pump Type	FEMA Flood Zone
CT0930011	REGIONAL WATER AUTHORITY	NEW HAVEN	No data			NORTH CHESHIRE WELL #5	A	T		AE
CT1020021	SCWA, NORTH STONINGTON DIVISION (NST)	NORTH STONINGTON	No data			WELL 1	A	T		A
CT0720041	SCWA, TOWER-FERRY VIEW DIVISION	LEDYARD	No data			WELL 1 - FVH	A	T		A
CT0720041	SCWA, TOWER-FERRY VIEW DIVISION	LEDYARD	No data			WELL 2A - FVH	A	T		A
CT0720041	SCWA, TOWER-FERRY VIEW DIVISION	LEDYARD	No data			WELL 2B - FVH	A	T		A
CT0720041	SCWA, TOWER-FERRY VIEW DIVISION	LEDYARD	No data			WELL 3 - FVH	A	T		A
CT0720041	SCWA, TOWER-FERRY VIEW DIVISION	LEDYARD	No data			WELL 4 - FVH	A	T		A

CWS with 500-year flood resilient wells

PWS ID	PWS Name	City	Flood Response Status	Well Cap	WSP Year	WSF Name	Well Status	Treatment	Pump Type	FEMA Flood Zone
CT1189201	AQUARION WATER CO OF CT-SCODON - WELL #4	RIDGEFIELD	No data	Campbell well cap		WELL #4	A	N	SU	X
CT0608011	CTWC - SHORELINE REGION-GUILFORD SYSTEM	GUILFORD	WSP notes that access road may be inaccesible due to flooding	Watertight pump bloc	2009	GUILFORD WELL	A	T	VT	X
CT1050752	CTWC - SHORELINE REGION-POINT O WOODS	OLD LYME	No data	Watertight well cap		WELL 4	A	T	SU	X
CT1050752	CTWC - SHORELINE REGION-POINT O WOODS	OLD LYME	No data	Watertight well cap		WELL 6	A	T	SU	X
CT1050752	CTWC - SHORELINE REGION-POINT O WOODS	OLD LYME	No data	Watertight well cap		WELL 7	A	T	SU	X
CT1050752	CTWC - SHORELINE REGION-POINT O WOODS	OLD LYME	No data	Watertight well cap		WELL 5	A	T	SU	X
CT1050732	CTWC - SHORELINE REGION-SOUND VIEW	OLD LYME	WSP notes that access road may be inaccesible due to flooding	Watertight well cap	2009	WILLIAM HARTUNG WELL #11	A	T	SU	X
CT1050732	CTWC - SHORELINE REGION-SOUND VIEW	OLD LYME				WILLIAM HARTUNG WELL #12	A	T	SU	X
CT1050732	CTWC - SHORELINE REGION-SOUND VIEW	OLD LYME				WILLIAM HARTUNG WELL #13	A	T	SU	X
CT1050732	CTWC - SHORELINE REGION-SOUND VIEW	OLD LYME				WILLIAM HARTUNG WELL #14	A	T	SU	X
CT0420021	EDGEMERE CONDOMINIUM ASSN., INC.	EAST HAMPTON	No data	Watertight well cap		WELL 2	A	N	SU	X
CT0760021	GREEN SPRINGS SUBDIVISION	MADISON	No data	Watertight well cap		WELL 3	A	T	SU	X

PWS ID	PWS Name	City	Flood Response Status	Well Cap	WSP Year	WSF Name	Well Status	Treatment	Pump Type	FEMA Flood Zone
CT0760021	GREEN SPRINGS SUBDIVISION	MADISON	No data	Watertight well cap		WELL 1	A	T	SU	X
CT0760021	GREEN SPRINGS SUBDIVISION	MADISON	No data	Watertight well cap		WELL 2	A	T	SU	X
CT0614021	HIGH MEADOW	HADDAM	Above grade and fitted with watertight well caps	Campbell well cap	2014	WELL #1	A	T	SU	X
CT1480011	WALLINGFORD WATER DEPARTMENT	WALLINGFORD	WSP notes that this well is significantly above the 100-year elevation. No mention on 500 year elevation.	Watertight pump seal	2017	WELL #1	A	T	VT	X

CWS with 500-year flood vulnerable wells or no mitigation was found

PWS ID	PWS Name	City	Flood Response Status	Well Cap	WSP Year	WSF Name	Well Status	Treatment	Pump Type	FEMA Flood Zone
CT0180051	AQUARION WATER CO OF CT-BROOK ACRES	BROOKFIELD	No data			WELL 3	A	N	GW	X
CT1180021	AQUARION WATER CO OF CT-RIDGEFIELD KNOLL	RIDGEFIELD	Well has cap and pitless adaptor		2013	WELL 7	A	T	GW	X
CT0420031	BELLWOOD COURT	EAST HAMPTON	No data			WELL 1	A	T	GW	X
CT1051011	BOXWOOD CONDOMINIUM ASSOCIATION	OLD LYME	Deficiency in cap or seal		2014	WELL 1	A	T	GW	X
CT0420021	EDGEMERE CONDOMINIUM ASSN., INC.	EAST HAMPTON	The 2014 sanitary survey found concerns regarding the potential for flooding in Well 1.	Split top seal	2014	WELL 1	A	T	GW	X
CT0590011	GROTON UTILITIES	GROTON	No data listed, however this well pumps water into an untreated surface supply reservoir, so effects of contamination from flooding would be minimal.		2012	PUMPING WELL 3	A	T	GW	X
CT1050141	LYME REGIS, INC.	OLD LYME	Sanitary survey indicates well has concrete casing above grade, however no indication well has a cap that with a watertight seal to the casing.		2015	WELL 1	A	T	GW	X

PWS ID	PWS Name	City	Flood Response Status	Well Cap	WSP Year	WSF Name	Well Status	Treatment	Pump Type	FEMA Flood Zone
CT1050131	MILE CREEK APARTMENTS	OLD LYME	No data			WELL 2	A	N	GW	X
CT1050131	MILE CREEK APARTMENTS	OLD LYME	No data			WELL 1	A	N	GW	X
CT0860011	SCWA, MONTVILLE DIVISION (MTV)	MONTVILLE	No data			WELL 12	A	T	GW	X
CT0720041	SCWA, TOWER-FERRY VIEW DIVISION	LEDYARD	No data			WELL 2	A	T	GW	X

PWS ID	PWS Name	City	Flood Response Status	Well Cap	WSP Year	WSF Name	Well Status	Treatment	Pump Type	FEMA Flood Zone
CT1050131	MILE CREEK APARTMENTS	OLD LYME	No data			WELL 2	A	N	GW	X
CT1050131	MILE CREEK APARTMENTS	OLD LYME	No data			WELL 1	A	N	GW	X
CT0860011	SCWA, MONTVILLE DIVISION (MTV)	MONTVILLE	No data			WELL 12	A	T	GW	X
CT0720041	SCWA, TOWER-FERRY VIEW DIVISION	LEDYARD	No data			WELL 2	A	T	GW	X

APPENDIX G

UCONN Climate Change Analysis

Preliminary Report on Climate Change Projections

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1. Introduction

The warming of the climate system is unequivocal and it is virtually certain that this change will continue into the future (IPCC, 2013). To ensure resiliency and sustainability of the state's vulnerable communities, development of long-term planning and policy for climate adaptation has to be informed of the potential impacts of the changing climate at a suitable spatial scale. However, in the latest U.S. national assessment, quantitative climate information in each region was treated with a lumped approach (Easterling et al., 2017). For each climate change quantity of interest, Connecticut and all other states of the Northeast (from West Virginia to Maine) share the same value. It is not clear whether strong spatial heterogeneity exists within Northeast and how representative the region-lumped changes might be for Connecticut. The national assessment report therefore cannot support the development of local and state-level adaptation strategies. To bridge this gap, this sub-task assesses future changes of *local* and *regional* climate that pose risks to the state's drinking water infrastructure based on the most up-to-date future climate projections, with a focus on precipitation extremes, drought, and water availability. Consistent with the typical time frame for planning and infrastructure design, this assessment focuses on the mid-century.

Future climate projections are typically conducted using global climate models under various assumptions of future greenhouse gas (GHG) emissions. The latest projections were from the Coupled Model Intercomparison Project phase 5 (CMIP5) (Taylor et al., 2012) that included the participation of 20 climate modeling groups worldwide and was the primary source of information for the Intergovernmental Panel for Climate Change's 5th Assessment Report (IPCC, 2013). The GHGs scenarios used in CMIP5 are designated as representative concentration pathways (RCPs) that are numbered according to the change in radiative forcing (from +2.6 to +8.5 watts per square meter) that results by 2100. For the timeframe of focus in this project (mid-century), the differences between different RCP scenarios are still relatively small. CMIP5 includes model projections for all four RCP scenarios (RCP2.6, RCP4.5, RCP6, and RCP8.5) to represent the span of the radiative forcing literature at the time of their selection (~2010) when RCP8.5 was considered a high emission scenario within the space of uncertainty. However, since then the RCP2.6 has been considered unfeasible; GHGs emission in recent years has closely tracked the RCP8.5 scenario (Sanford et al., 2014), and the observed CO2 concentration also closely tracks the concentration used to drive the CMIP5 RCP8.5 future climate projections (Figure 1). This, together with the climate security recommendation to build for a higher magnitude of warming than the target of international climate policy in case mitigation policies fail (Mabey et al., 2011; Sanford et al., 2014), our assessment in this project focuses on the RCP8.5 scenario.

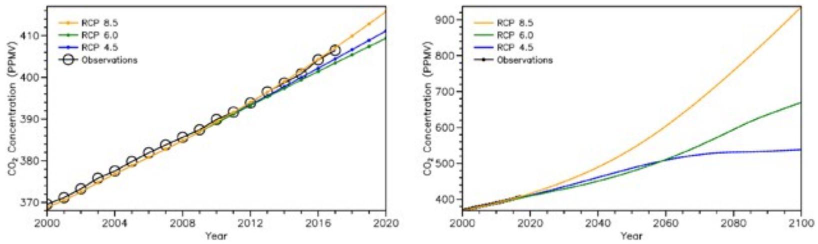

Figure 1: RCP scenarios for mid- year CO2 concentration; and historical annually averaged CO2 concentration

2. Downscaled Future Climate Data

Climate projections (including the latest version from CMIP5) are typically conducted using global climate models (GCMs) with a spatial resolution of 1-3° (~100-300 km), while local and regional adaptation requires actionable information at the spatial scale of several kilometers. Climate downscaling is routinely utilized to address this scale mismatch, including both dynamical downscaling using regional climate models and statistical downscaling. Due to the high computational cost, most dynamical downscaling has been conducted at the resolution of several tens of kilometers (e.g., 50km for the North American Regional Climate Change Assessment Program, NARCCAP, Mearns et al., 2014), which still requires statistical downscaling for adaptation applications. However, the two-step dynamical-then-statistical approach does not provide clear advantage over statistical downscaling from GCMs resolution directly to the local scale of several kilometers (Ahmed et al., 2013). The computational efficiency of the latter makes it feasible to downscale a large number of GCMs directly to the local spatial scale, and was used to produce the two major statistical downscaling databases for the United States, the Multivariate Adaptive Constructed Analogs (MACA, Abatzoglou, Brown, 2011) database at 4km resolution and the Localized Constructed Analogs (LOCA, Pierce et al., 2014, 2015) database at 6km resolution.

The MACA and LOCA databases each includes past climate simulations and future projections from 20 GCMs downscaled using the MACA (Abatzoglou and Brown, 2012) and LOCA (Piece et al., 2014, 2015) approaches, respectively. Both MACA and LOCA are among the most sophisticated statistical downscaling methods, involving bias correction utilizing a training dataset (i.e. a meteorological observation dataset) and spatial downscaling utilizing constructed analogs. The two datasets differ in the number of analogs used to determine the climate variable (especially precipitation) at each grid cell, the stages at which bias corrections are applied, and the training meteorological dataset. The U.S. National Assessment was based on the LOCA database for which the training data was from Livneh et al. (2015). In this project we chose MACAv2-METDATA, which is version 2 of the MACA database that used METDATA (Abatzoglou, 2011) as the training data. MACAv2-METDATA was chosen for its more realistic training data. In a project funded by CIRCA and the Southwest Regional Water Authority, we found that the daily precipitation in METDATA agrees remarkably well with observations from meteorological stations in Connecticut (and other states of the Northeast), much better than the Livneh et al. (2015) data used by LOCA (e.g., Figure 2 for daily the precipitation over the Southwest Connecticut during several extreme events). This disparity significantly influences the downscaled precipitation daily statistics especially precipitation extremes (therefore flood risks), but the impact on precipitation statistics at longer time scales (e.g., 5 days, monthly, annual) should be minimal.

The MACA method used to derive the MACAv2-METDATA includes *epoch removal and replacement* at the beginning and end of the procedure, q*uantile mapping approach* to bias correction (before and after constructed analog downscaling), and c*onstructed analogs* for downscaling (which also partially corrects bias especially in the spatial pattern). The downscaling process involves averaging across multiple chosen analogs. More details can be found at Abatzoglou and Brown (2012).

3. Model Uncertainties

Global Climate Models (GCMs) are known to produce a large spread in their future projections, due to model dependence of both the climate sensitivity (often defined based on the global average temperature response) and the spatial pattern of such response (e.g. Knutti et al., 2010; Tebaldi et al., 2011; Miao et al., 2014). While multi-model ensemble averages are considered more reliable than projections from any individual model, for developing climate adaptation strategies it is important that policy makers are aware of the model-related uncertainty in future projections and consider a range of plausible future climate changes. The MACA database includes downscaled data from 20 GCMs. In this project, six models were chosen to represent the full range of uncertainties in future projections, including MIROC-ESM, HadGEM2-CC365, CSIRO-Mk3.6.0, CCSM4, GFDL-ESM2M, and MRI-CGCM3. These models were chosen based on genealogy (Knutti et al., 2013), global climate sensitivity (Miao et al, 2013), climate sensitivity for the Connecticut area, and overall performance in simulating present-day climate based on assessment for multiple regions of the world (Sheffield et al., 2013; Miao et al., 2013; McSweeney et al., 2015).

Continuous development and improvement of climate models have led to multiple versions of models in any major modeling group, and in some cases multiple versions from a same group participate in CMIP5. Despite often major changes in the parameterization of important processes, most models are still closely tied to their predecessors in both their control climate for preset day and future projections; moreover, some model development groups exchange ideas and code with other groups, leading to interdependence (therefore climate similarity) between some models of different origin (Masson and Knutti, 2011; Knutti et al., 2013). To better represent the full range of uncertainties in future projections, model geneaology should be considered to avoid including interdepdendent models.

Global climate sensitivity is often represented by the time when the average global temperature increase reaches 2.0 ℃ based on a given RCP scenario (e.g., based on RCP8.5 scenario in Table 1). For climate assessment supporting adaptation, sensitivity of a model's climate response at local and regional scales is more relevant, and the sensitivity of precipitation or of temperature and precipitation combined might be of greater concern than sensitivity of temperature alone. Table 1 lists the six models chosen in the order of temperature sensitivity in Connecticut (from high to low), which is similar to (but slightly different from) their ranking based on global temperature. Their precipitation sensitivity ranking is also similar. Of the six models chosen, based on performance assessment over the conterminous United States (CONUS) (Sheffield et al., 2013) and multiple other regions (McSweeny et al., 2015), the performance of the CCSM4, GFDL, and HadGEM2 is generally satisfactory; while MIROC, CSIRO, and MRI produce larger biases in certain aspects, they are included to populate the full range of the model uncertainties in future projections.

Table 1: Model climate sensitivity and performance for temperature (T) and precipitation (P). Spatial scales include the globe, the conterminous United States (CONUS), and the Connecticut State (CT). The model sensitivity categorization of high, medium (Med), and low is relative to the range of the 20 GCMs included in the MACA database.

Model Name	Development Group	Time to Global 2.0 °C	CT T Sensitivity	CT P Sensitivity	Model Biases over CONUS (DJF, JJA) for P (%) & T(K)
MIROC-ESM	Japan	2033 – High	High	Med	(8.7, 4.4) (3.3, 2.8)
HadGEM2-CC365	UK Met. Office	2032 – High	Med/High	High	(4.3, -15.9) (-3.8, 1.2)
CSIRO-Mk3.6.0	Australia	2045 – Med	Med	Med	(5.4, -29.1) (-1.6, 1.3)
CCSM4	U.S. NCAR	2043 – Med	Low/Med	Med/High	(10.2, 3.5) (0.01, 1.1)
GFDL-ESM2M	U.S. GFDL	2049 – Low	Low/Med	Med	(14.7, 12.3) (1.7, -0.4)
MRI-CGCM3	Japan MRI	2045 – Med	Low	Low	(34.4, 16.9) (-0.4, -0.4)

4. Methodology for Data Analysis

In this sub-task, for each of the six downscaled GCMs identified in section 3, the projected future climate changes were derived based on the differences between the historical simulation of 1971-2000 (Control) and the corresponding RCP8.5 scenario simulation of 2041-2070 (Future). The analysis focused on two climate aspects that significantly influence water supply: changes in flood and drought risks. All analyses were done based on spatially distributed data at 4km resolution. Spatial averages for the state of Connecticut were conducted over the area [73.5W, 71.75W] [41.3N, 42N].

Flood risk was assessed based primarily on changes in the severity and frequency of extreme precipitation events, which includes both the daily maximum precipitation (DMP) that is highly relevant for flooding in small watersheds and 5-day maximum precipitation (5DMP) that is highly relevant for flooding in large watersheds. Severity and frequency analyses were conducted for DMP and 5DMP events with return periods of 5 years, 10 years, 20 years, 50 years, and 100 years, by fitting a generalized extreme value (GEV) distribution to each of the past and future 30-year periods from each GCM. The severity of events for any one return period (e.g., 20 years) were determined using the L-moments methods to estimate the location, scale and shape parameters (Hosking 1990; Kharin et al., 2013); these parameters were also used to estimate the future return periods of the present-day extremes.

Other flooding-related quantities analyzed include changes in the number of days (per year) with more than 2 inch of precipitation, and the amount and fraction of annual precipitation accounted for by the top 1% of strong precipitation events (i.e., daily events exceeding the 99th percentile of daily precipitation defined based on the Control time period).

Drought risk was assessed based on precipitation amount (P) and the differences between precipitation (P) and potential evapotranspiration (PET); the amounts were aggregated over monthly, seasonal, annual, and two-year time durations. Droughts are defined as low seasonal, annual, or two-year precipitation with a certain return period (e.g., 5, 10, 15, and 20 years). PET was estimated using the Thorthwaite (1948) approach based on temperature, sunshine hours, and latitude.

5. Results

5.1 Changes Related to Flood Risks

Located in the northeast coast, most of the extreme precipitation events in Connecticut are related to tropical storms/hurricanes in the fall season (and occasionally in summer) and Northeasters during winter, both of which influence the whole Northeast U.S.. Not surprisingly, the extreme precipitation statistics (e.g., Figure 2) features a distinct large-scale spatial pattern, with a northeast-southwest oriented heavy precipitation band slightly off the coast and lighter rain further inland. The projected increase of extreme precipitation follows a similar large-scale spatial pattern with a high degree of consensus among the six models (e.g., Figures 3). When zoomed in on Connecticut and its surrounding areas, part of this spatial pattern is still visible (albeit less pronounced) for both the absolute and relative changes of the extreme precipitation (Figure 4-5).

For extreme precipitation with all return periods examined (5, 10, 20, 50, 100 years), all models project a significant increase across the whole state; in each model, the spatial patterns of the changes and the magnitude of relative changes are similar between results for DMP and 5DMP. So the description here focuses on DMP. The models differ substantially in the magnitude of projected changes; within each model, the projected increase of extreme precipitation is larger for longer return periods, and this statement hold for both the absolute ad relative changes (e.g., Figures 4-5 for the return period of 20 years and Figures 6-7 for the return period of 100 years). MRI is the least sensitive among the six models. For extreme DMP, MRI projected a future increase of less than 50% over most of Connecticut for all return periods; according to the other five models, the projected relative increase was larger than 50% for most of Connecticut for all return periods, and over a portion of the state, the DMP was projected to double in size for the return period of 20 years and triple for the return period of 100 years (Figures 4-7). Engineering design for storm water drainage and other infrastructures has to account for this increase in the severity of precipitation events.

Without significant infrastructure upgrade, major flooding events are expected to become more frequent. For example, DMP events with a return period of 20 years in past climate was projected to occur every 5-10 years in future climate according to MRI and to occur more frequent than every five years over most of the state in the future accordingly to the other five models, doubling to quadrupling in frequency (Figure 8). The projected relative increase in frequency was even more substantial for rarer past events. For DMP events with a return period of 100 years in the past, the projected future return period ranges from less than 10 years to 50 years over most of the state, a factor of 2-10 difference in frequency (Figure 9).

The general change towards more severe and more frequent extreme precipitation events is consistent with other flood-relevant indices. Of the annual total precipitation in the past climate, approximately 15% (12.5-17.5%) was accounted for by heavy precipitation events (defined as days with precipitation exceeding P_{99}, the 99^{th} percentile of daily precipitation); an additional 2-10% was projected for future climate (Figures 10-11). Over most of Connecticut in a typical year, there were approximately 8-15 days with more than 1 inch of precipitation in the past climate, and an increase of 1-3 days was projected for the future climate by all models (Figure 12-13).

In summary, despite a certain degree of model uncertainties in projecting the exact magnitude of future changes, our analysis revealed a remarkable model consensus in projecting an increase of flood risks in the state of Connecticut. The increased flood risks derive from more severe and more frequent extreme precipitation events, the disproportional increase of precipitation amount falling in the form of extremes, and the number of days with more than one inch of precipitation.

5.2 Changes Related to Drought Risks

All six models projected a robust increase of annual total precipitation across the whole Connecticut. A larger fraction of this increase was accounted for by winter precipitation than by summer, and the least sensitive model MRI even projected a slight decrease of summer precipitation (which was dominated by more substantial increase of precipitation in other seasons) (Figure 14). However, this increase of annual precipitation may not be directly translated to increased water supply, as it was accompanied by significant warming that enhances potential evapotranspiration. Accumulated throughout the year, the increase of potential evapotranspiration (PET) exceeded the magnitude of precipitation increase (P) for a majority of the models; most of the PET increase was accounted for by warm season PET, and the contribution during winter was minimal (Figure 15). As a reflection of potential water yield, the projected changes of the water budget term (P – PET) featured a clear seasonal contrast, with a slight increase during winter and strong decrease during summer. The changes of the annual P – ET were dominated by changes during the warm season, with strong decreases projected by four of the six models while little change projected by the other two (CCSM4 and GFDL) (Figure 16). These seasonal contrasts in precipitation changes and P – ET changes are clearly evident from Figure 17 that shows the past and future climates averaged over the entire state.

Consistent with the climatological changes of precipitation, the 1-in-20-years drought (defined as the magnitude of dry anomalies exceeded with an annual occurrence probability of 5%) featured more precipitation in future climate than in the past. This statement holds for droughts of one summer, one year, and two years in duration. When drought was defined based on P – ET instead of based on precipitation alone, the 1-in-20-years summer droughts were projected to become more severe with a remarkable model consensus (Figure 18). There was little model consensus in projecting the future changes of the severity of 1-in-20-years droughts of one year and two years in duration (Figures 19-20), with two of the models projecting increased severity while the other four projecting mixed changes with increase in some areas and decrease in others.

Severe summer droughts were projected to become more frequent. For example, past 1-in-20-years summer droughts were projected to occur once every 3-10 years (Figure 21). Projected changes in the frequency of longer-duration droughts (one year and two years) were subject to a higher degree of model uncertainty. Two of the models projected a return period of 5-10 years or even more frequent, but results from the other four models are mixed – more frequent in some models/areas and less in others (Figures 22-23).

Another commonly used drought-related index is the maximum continuous dry days (CDD) during a year. In Connecticut, maximum CDD occurred during winter for most years, and little future changes were projected by the models. However, as the season of the highest water demand, summer CDD is of more relevance. When limited to the summer season, the CDD projected changes showed no consistency, with increase in some models/areas and decrease in others. This indicates that for Connecticut and most of the Northeast in general, changes in precipitation frequency in general does not contribute to drought perspectives.

In summary, there is a remarkable model consensus in projecting an increase of precipitation in winter and spring. The increases during summer are much smaller in magnitude, and one of the six models even projected a decrease of summer precipitation. There is also a projected increase in the frequency of extreme summer droughts. Models disagree on how the severity and frequency of extreme droughts of longer duration (one year and two years) will change. No clear change was projected for the general rain frequency.

6. Conclusions

Based on downscaled future projections from six GCMs, Connecticut would be subject to increased risks of both floods and droughts. The following changes were projected with model consensus:

1) Increase in the number of days with heavy precipitation (exceeding one inch) by 1-3 days (from 8-15 days in the past);
2) Increase in the fraction of annual precipitation accounted for by extreme events, by 2-10% (from approximately 15% in the past);
3) Increase in the magnitude of extreme daily maximum precipitation and 5-day maximum precipitation, with the magnitude of relative increase ranging from 50% to 300% in most models with larger increase for the more extreme events.
4) Increase (doubling to quadrupling) in the frequency of extremes, again with larger increase in frequency for the more extreme events.
5) Increase of mean precipitation, with the most significant increase projected for winter and spring and inconclusive changes in the other two seasons.
6) Increase of precipitation in extreme years of low precipitation
7) Decrease of the average summer potential water availability (as defined by P – ET)
8) More severe summer droughts (defined as rare summers with extremely low amount of P – ET)
9) More frequent occurrence of past summer droughts

The models diverge on how extreme droughts of longer duration (e.g., one year or two years) might change in the future, indicating a high degree of uncertainty in the perspective of long-term droughts. Results reported here were based the MACAv2-METDATA database. Although the choice of this database was supported with more realistic training data of the algorithm used to downscale and bias-correct the GCMs, it is still desirable to compare how results based on the other database (e.g., LOCA) may differ from results presented here. Follow-up work will repeat the analyses conducted in this study with additional data.

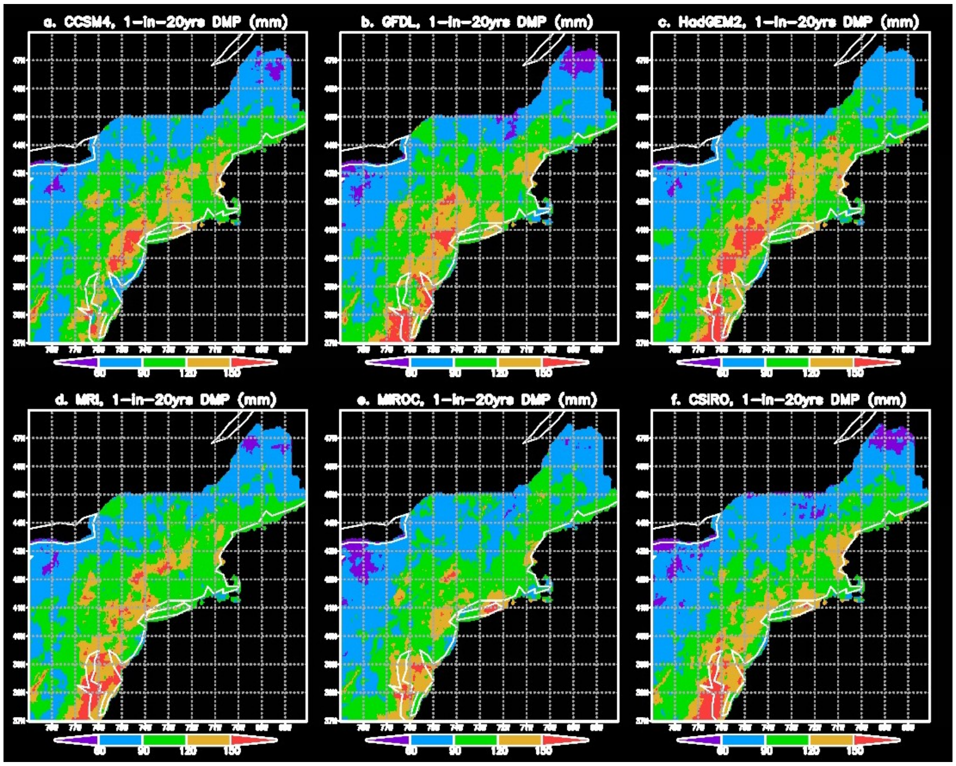

Figure 2. The 1-in-20years daily maximum precipitation from the six downscaled GCMs, for the period 1971-2000.

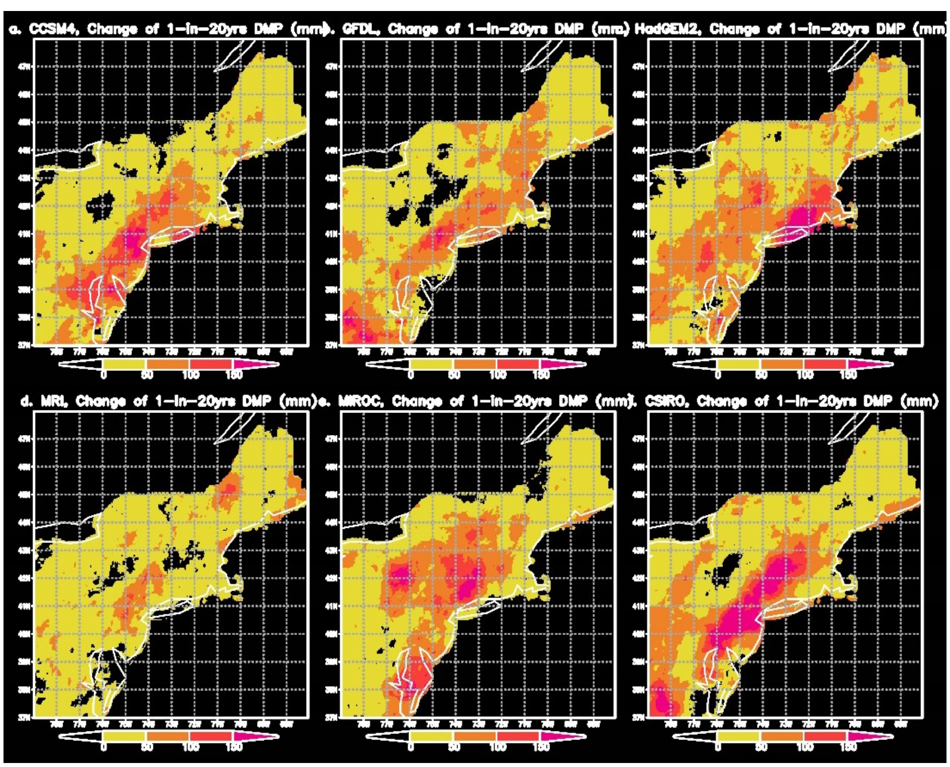

Figure 3. Changes of the 1-in-20years daily maximum precipitation projected by the six GCMs, for the period 2041-2070 relative to 1971-2000.

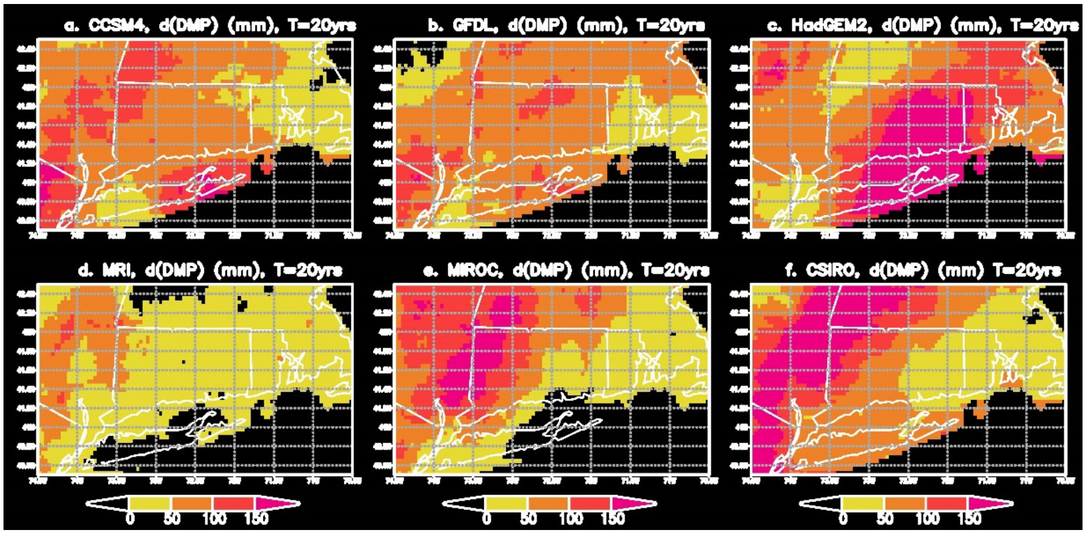

Figure 4. Future changes of 1-in-20years daily maximum precipitation projected by the six GCMs (same as Figure 3), for Connecticut and surrounding areas.

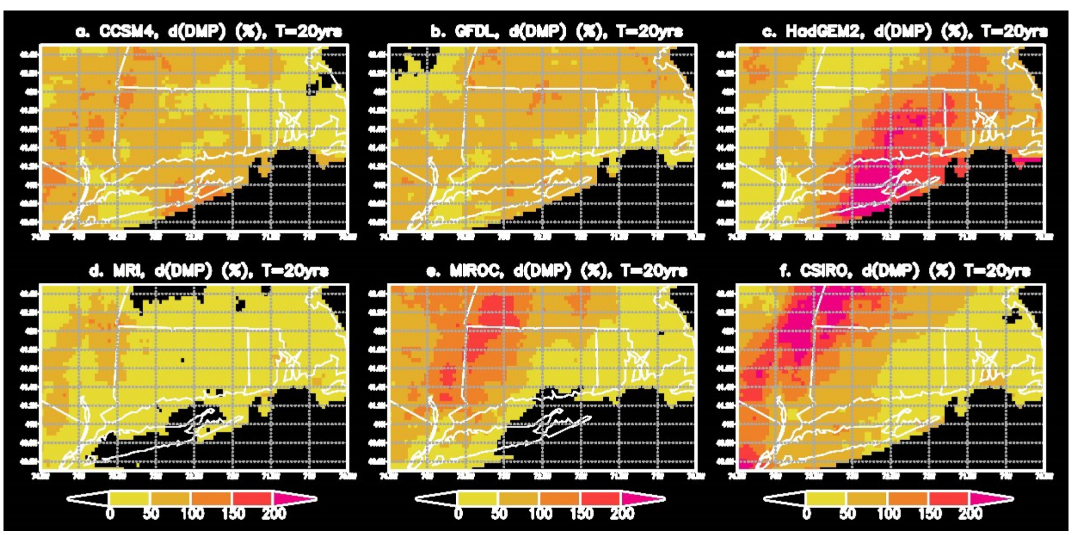

Figure 5. Same as Figure 4, but for relative changes.

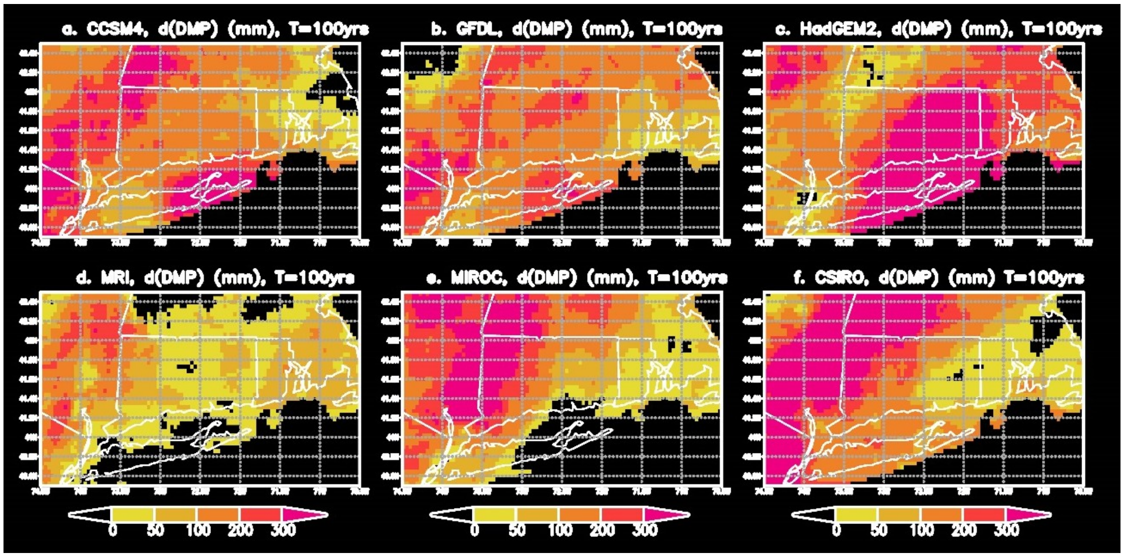

Figure 6. Projected future changes of 1-in-100-years daily maximum precipitation.

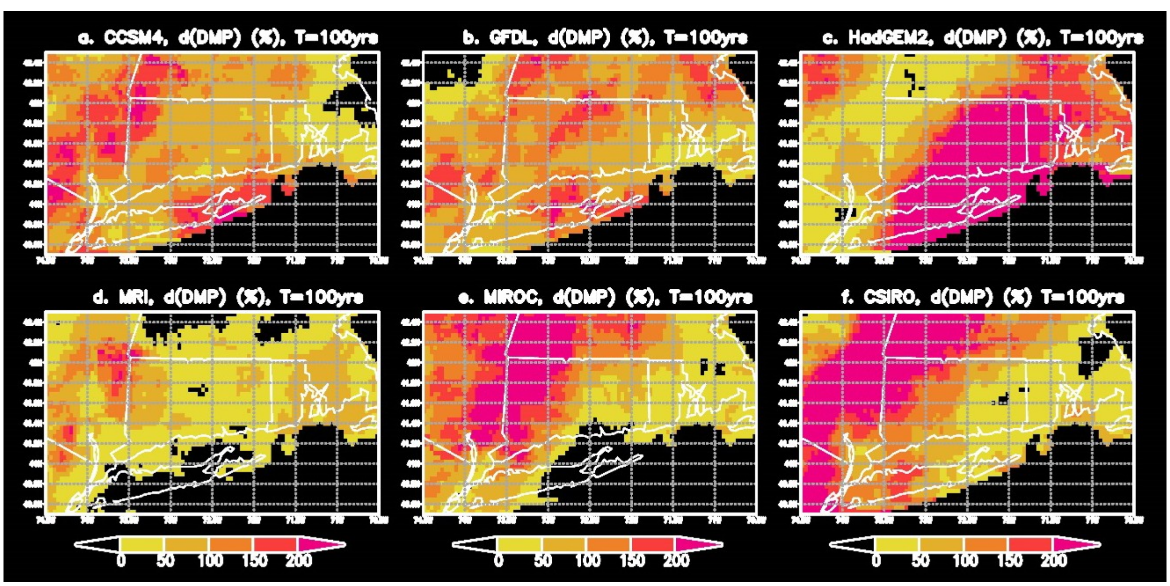

Figure 7. Same as Figure 6, but for relative changes.

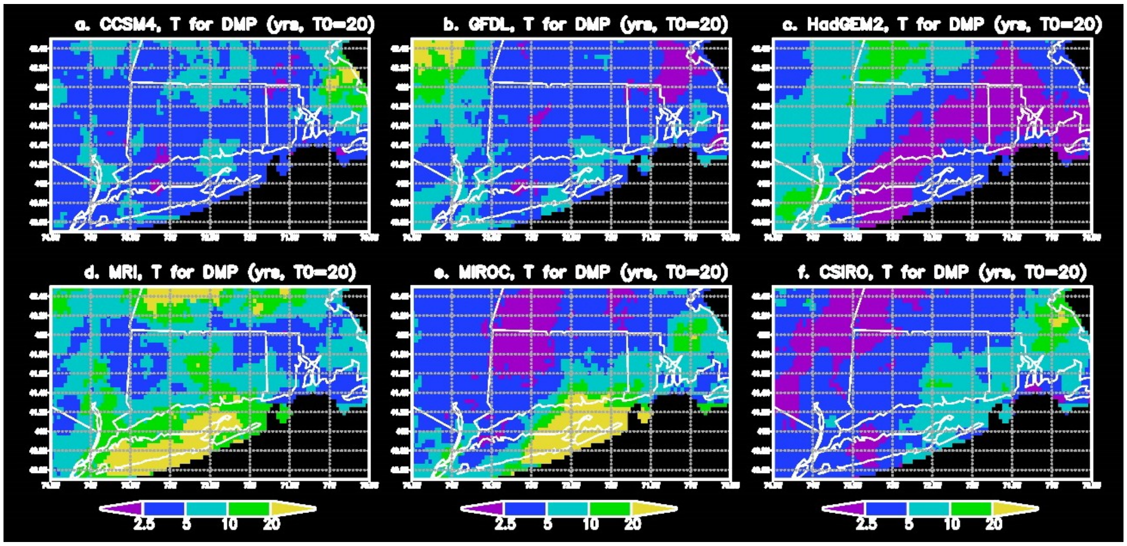

Figure 8. The future return period of the past 1-in-20-years daily maximum precipitation.

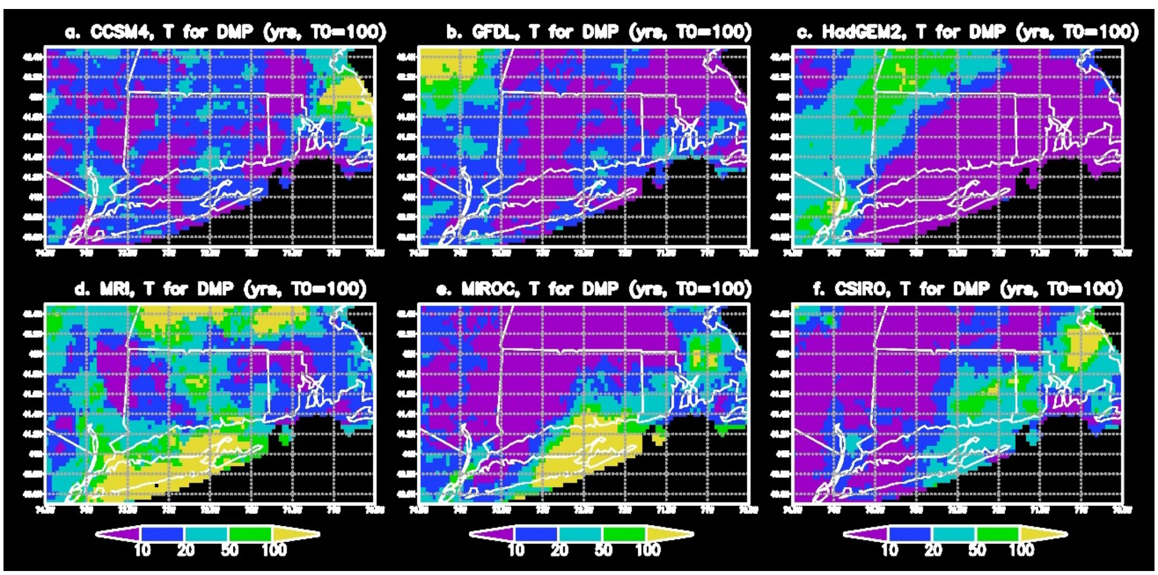

Figure 9. Future return period of the past 1-in-100-years daily maximum precipitation.

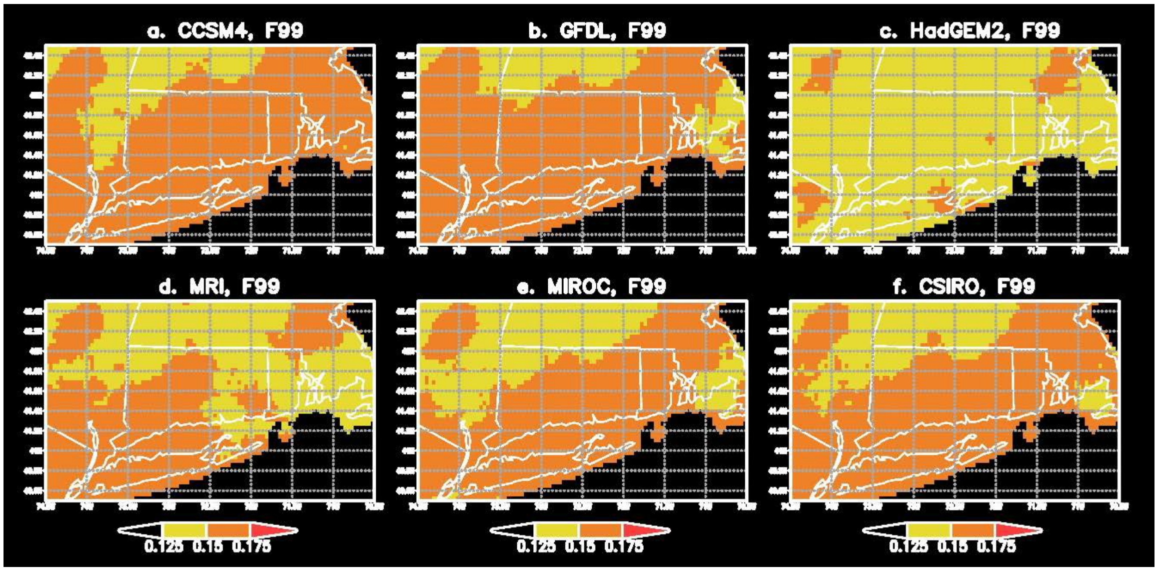

Figure 10. Fraction of annual precipitation accounted for by the top 1% of heavy precipitation days (F99).

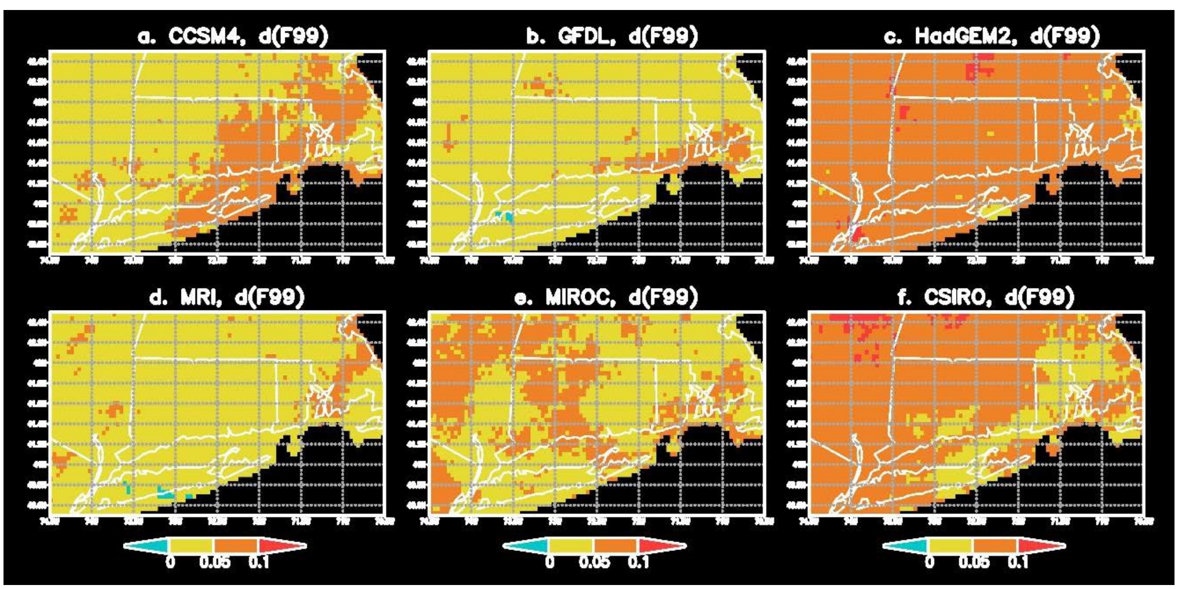

Figure 11: Projected future increase of F99 (with the 99th percentile of daily precipitation defined based on past climate).

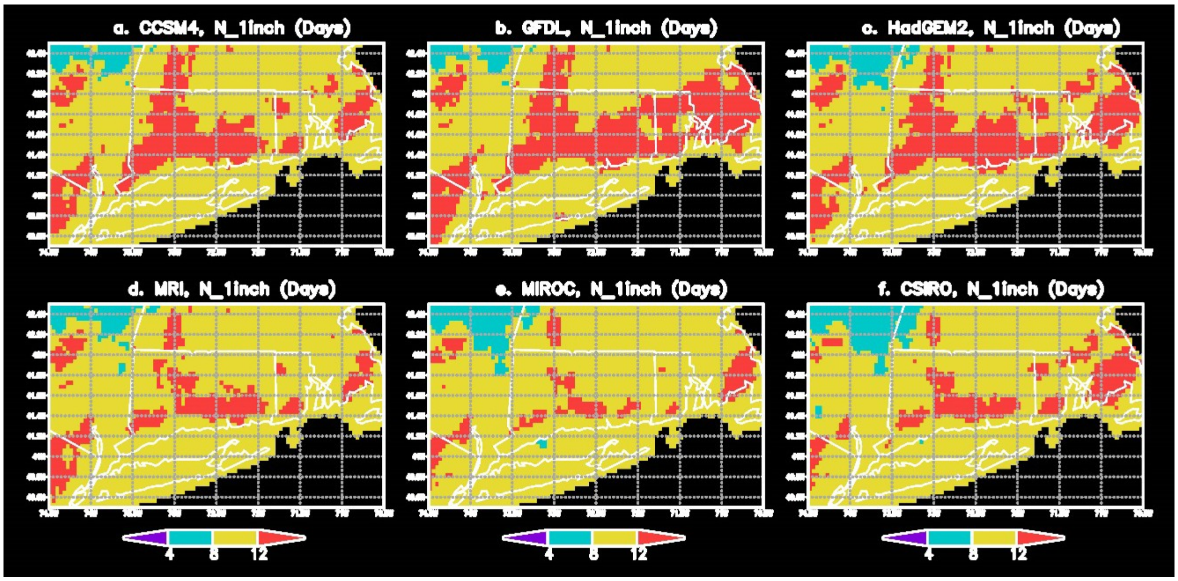

Figure 12. Number of days (per year) with more than 1 inch of precipitation in past climate.

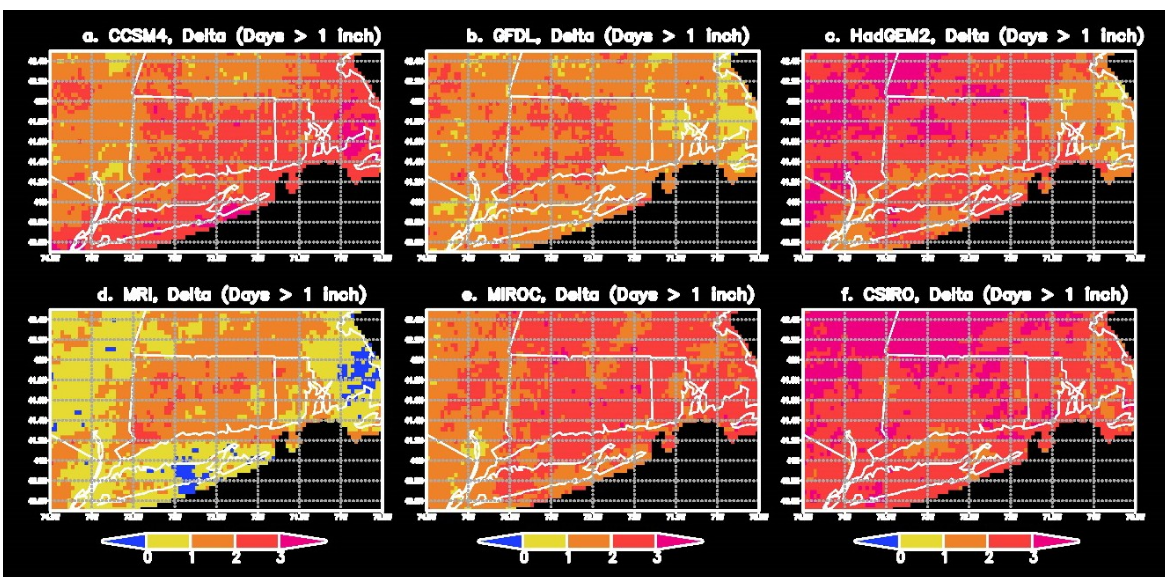

Figure 13. Projected future change of the number of days per year with more than 1 inch of precipitation.

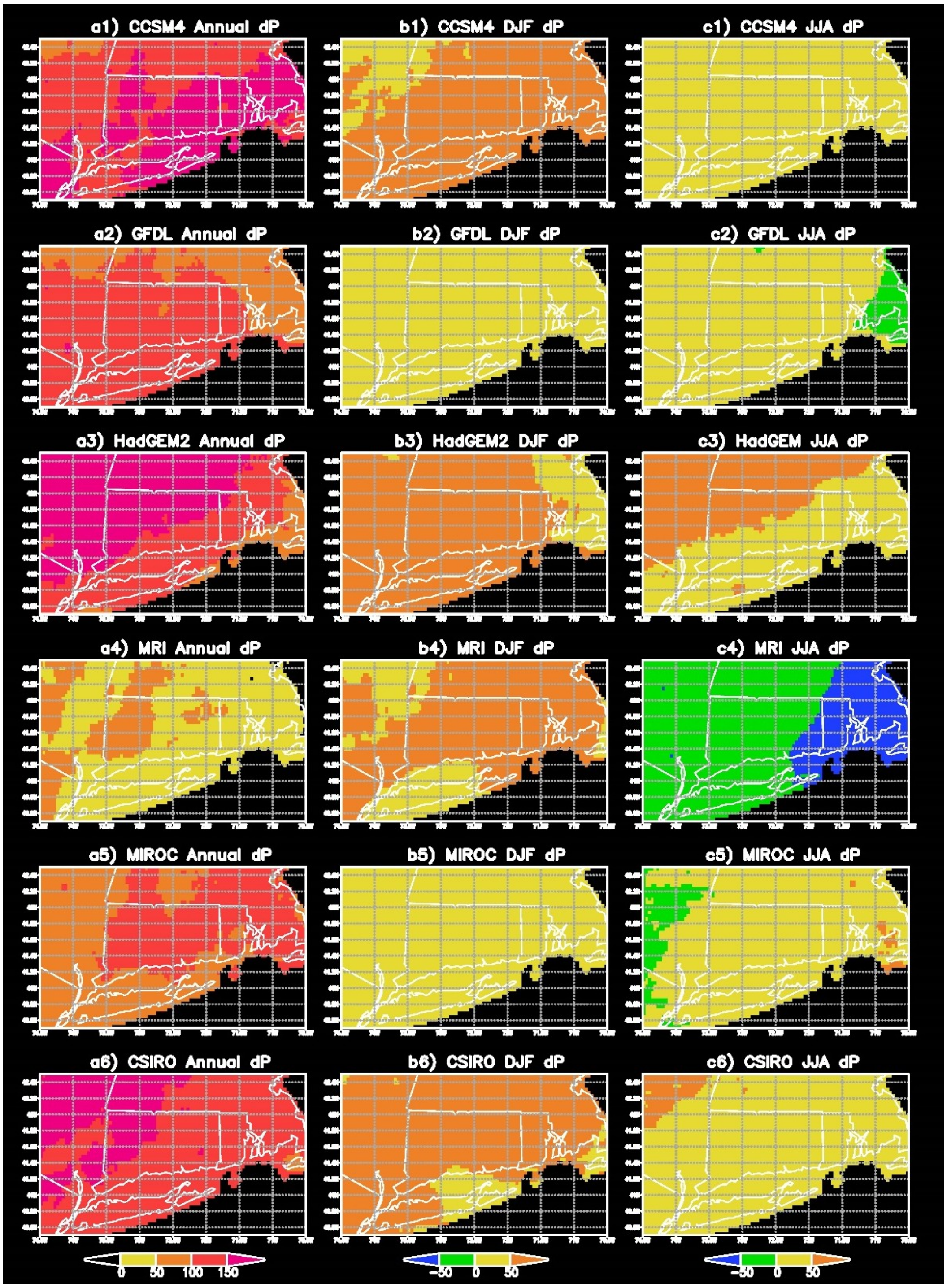

Figure 14. Projected future changes of precipitation (mm) accumulated throughout the year, for DJF and JJA seasons respectively.

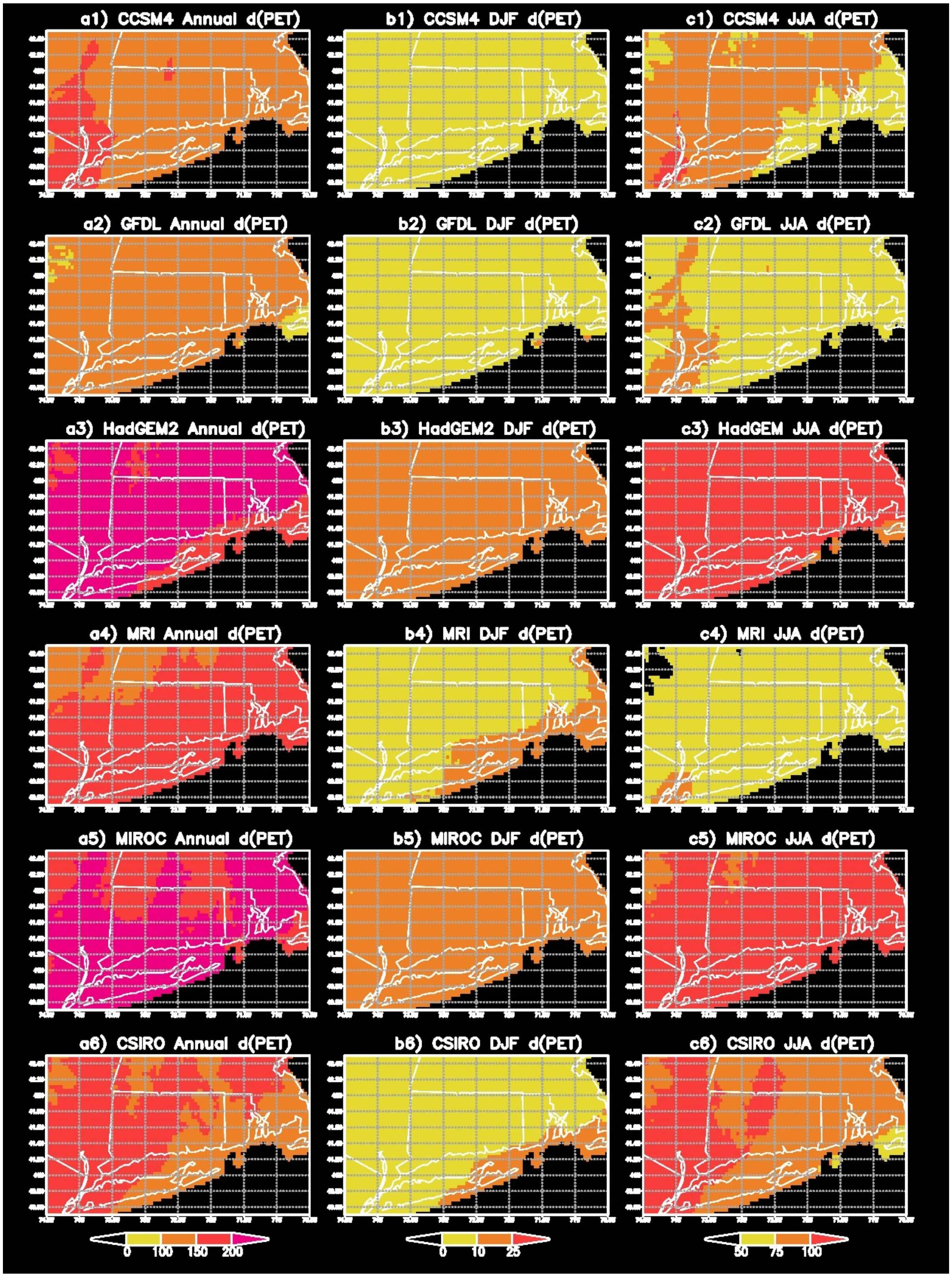

Figure 15. Projected future changes of potential evapotranspiration (PET).

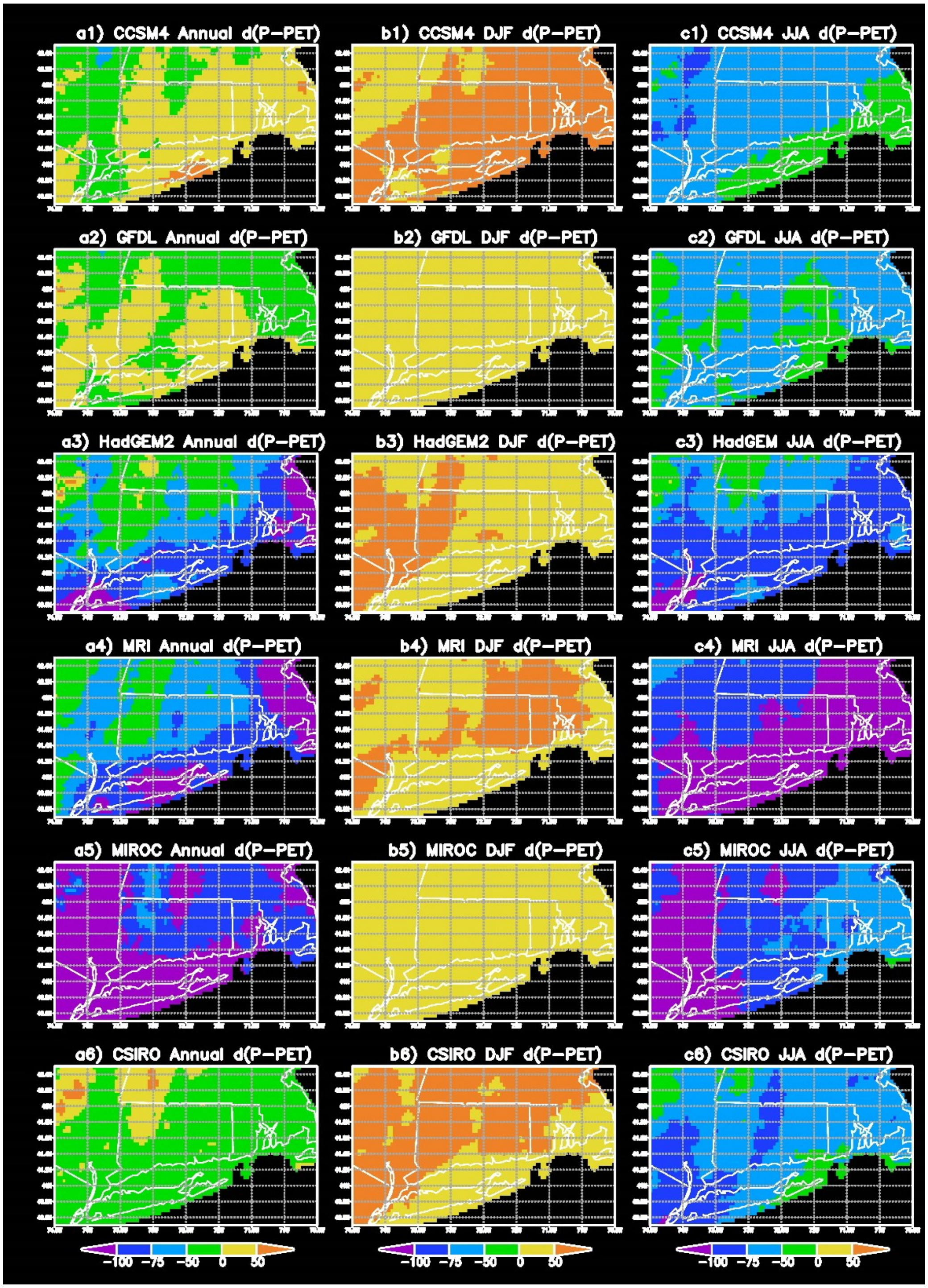

Figure 16. Projected future changes in water availability (as defined by P-PET).

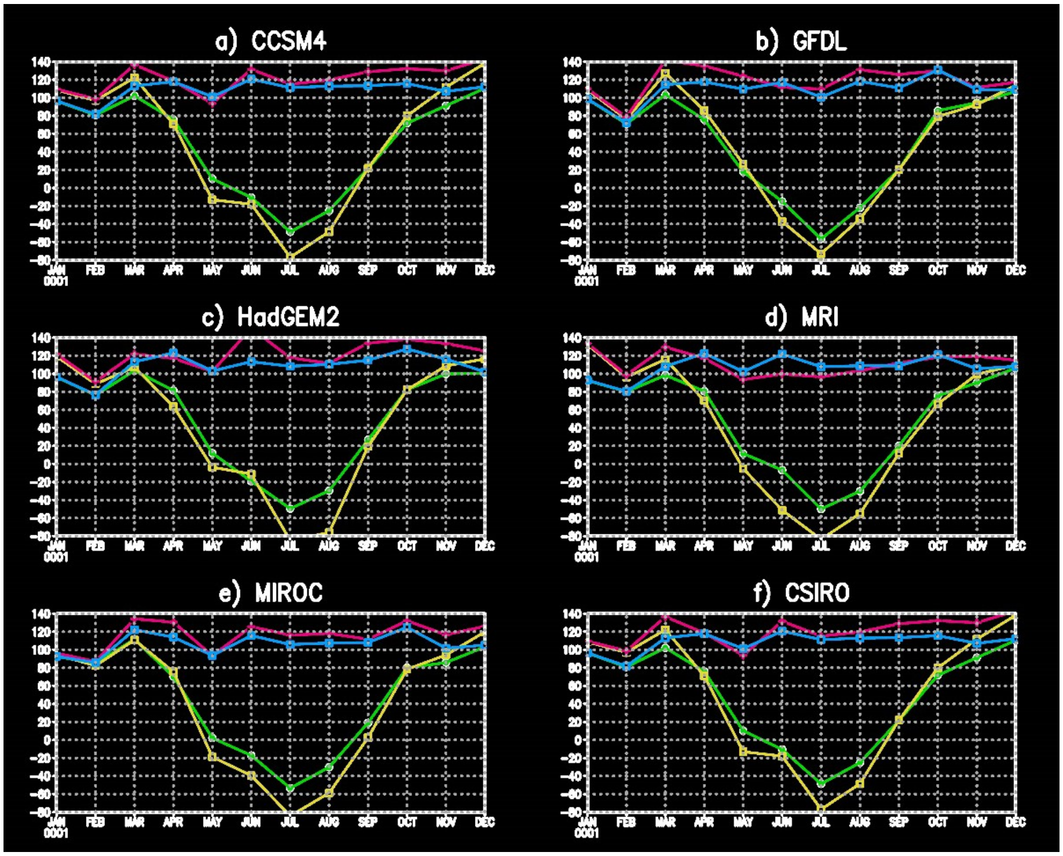

Figure 17. Seasonal cycle of precipitation and water budget averaged over the State of Connecticut: Past precipitation (blue) and past P – PET (green); Future precipitation (green) and future P – PET (yellow).

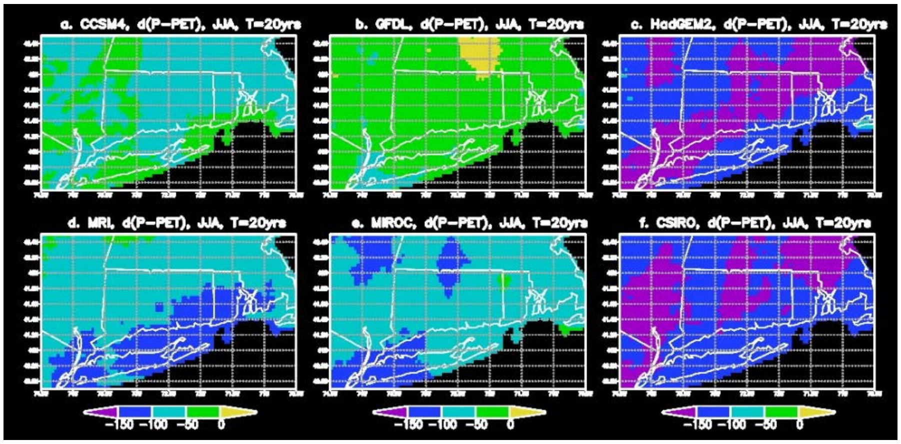

Figure 18. Changes in the 1-in-20-years summer drought as defined based on P – ET during JJA.

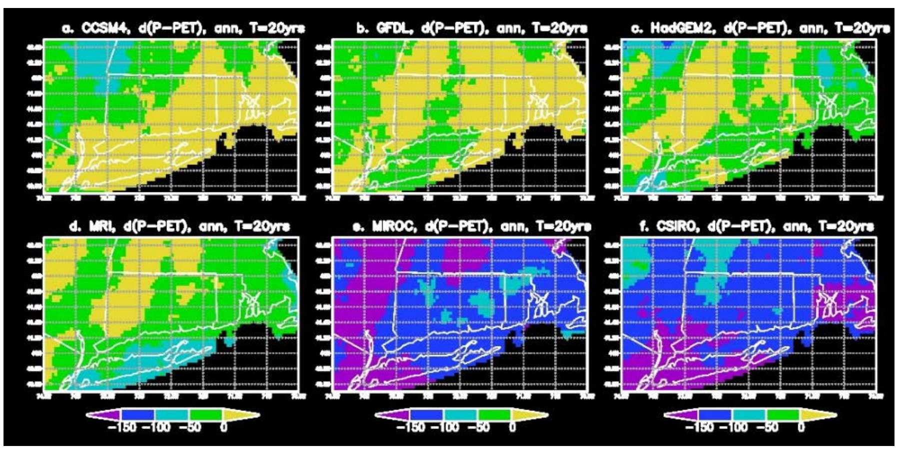

Figure 19. Same as Figure 18 but for 1-in-20-years drought based on annual P – ET.

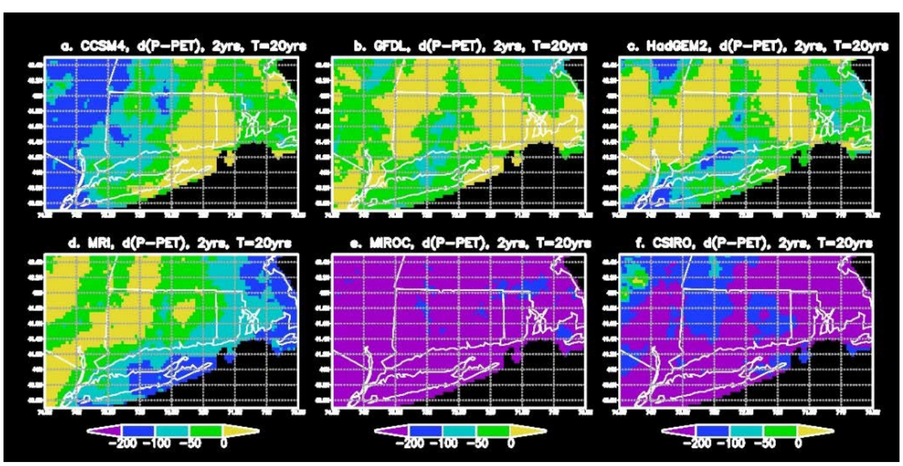

Figure 20. Same as Figure 18 but for 1-in-20-years drought based on 2-year P – PET.

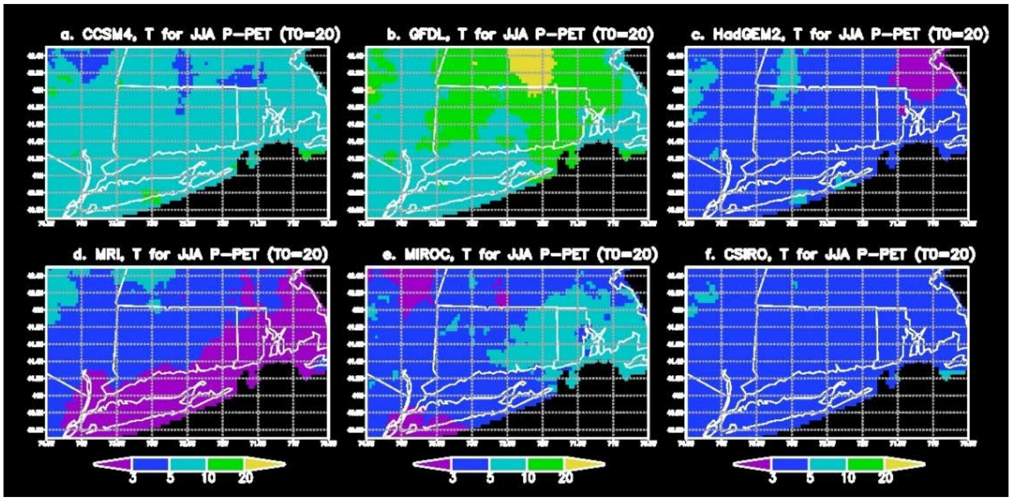

Figure 21. Future return period of the past 1-in-20-years summer drought.

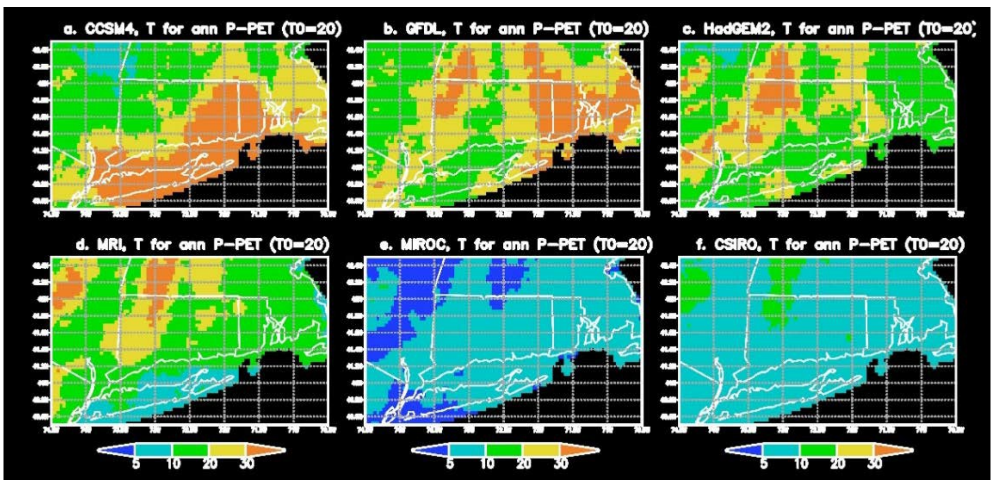

Figure 22. Same as Figure 21 but for one-year droughts.

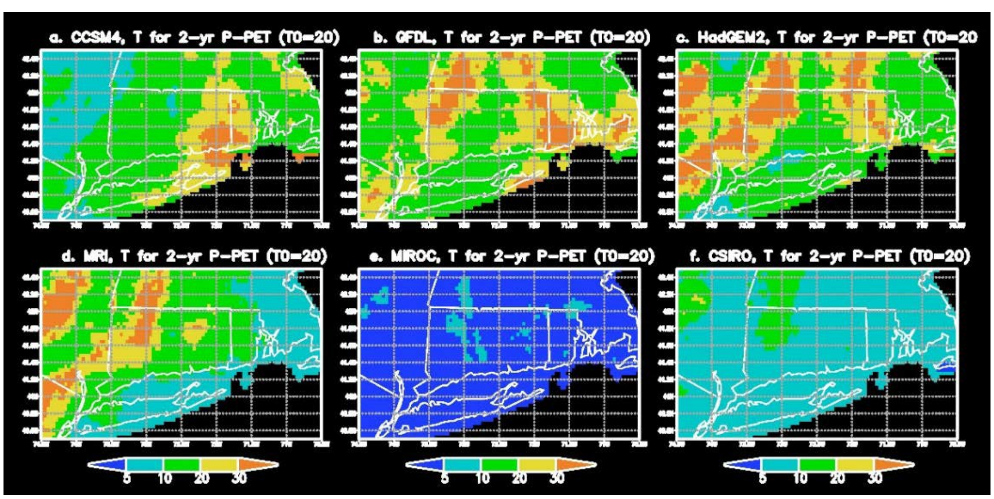

Figure 23. Same as Figure 21 but for two-year droughts.

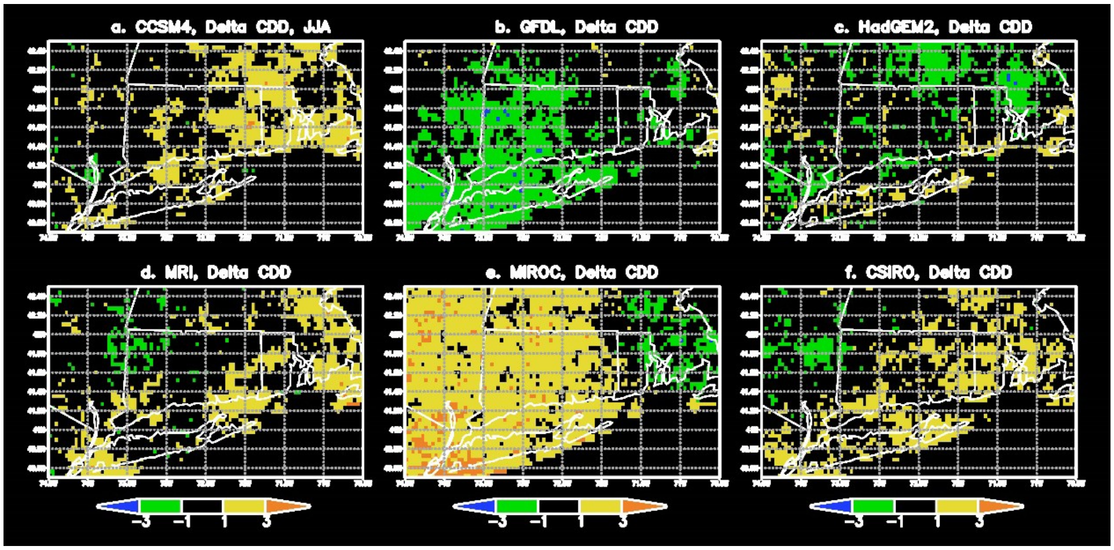

Figure 24. Changes in the average number of continuous dry days during summer (June-July- August).

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APPENDIX H
Small CWS Assets

APPENDIX I

Critical Facilities

Table I-3 Hazard Mitigation Plans Critical Facilities

Beacon Falls		
Beacon Falls Town Hall	10 Maple Avenue	Town Hall, Backup Shelter
Police Department	119 North Main Street	Police Station
Beacon Hose Company No. 1	35 North Main Street	Fire Department
Beacon Hose Company No. 1	35 North Main Street	EMT - Ambulance
Public Works Garage	411 Lopus Road	Public Works
Wastewater Treatment Plant	411 Lopus Road	Utility - Sewer
Sewage Pump Station	West Road	Utility - Sewer
Sewage Pump Station	111 Lopus Road	Utility – Sewer
Sewage Pump Station	123 Railroad Avenue	Utility – Sewer
Aquarion Water Company, Connecticut Water Company	(Infrastructure)	Utility-Water
Eversource	Cold Spring Road	Utility – Electric
Beacon Falls Senior Center	57 North Main Street	Backup Shelter
Laurel Ledge Elementary	30 Highland Avenue	Tertiary shelter
Woodland Regional High	135 Back Rimmon Road	Primary Shelter
Auxiliary Building	52 Railroad Avenue	Emergency Support
Radio Tower	61 Rice Lane	Communications
Radio Tower	Rimmon Hill Road	Communications

Bethany	
Town Hall	40 Peck Road
Old Airport	Amity Road
Elementary School	44 Peck Road
Middle School	190 Luke Hill Road
Hinman Fire Station	300 Bear Hill Rd
Fire Headquarters	460 Amity Road

Bethel	
Police Department	49 Plumtrees Road
Stony Hill Fire Department	59 Stony Hill Road
Bethel Fire Department	36-38 South Street
Municipal Center	1 School Street
Public Works Garage	Sympaug Park Road
Radio Tower	38 Spring Hill Lane
R.M.T. Johnson School	500 Whittlesey Drive
Anna H. Rockwell School	Judd Avenue
Saint Mary School	24 Dodgingtown Road
Frank A. Berry School	200 Whittlesey Drive

Middle School	600 Whittlesey Drive
Bethel High School	300 Whittlesey Drive
Bethel Healthcare	13 Park Lawn Drive
Augustana Congretate	101 Simeon Road
Reynolds Ridge	14 Reynolds Ridge
Bishop Curtis Homes	1-42 Simeon Road
Eureka Water Plant	Long Ridge Road, Danbury
Chestnut Hill Plant	07U Webb Road
Maple Avenue Wells	17U Ballfield Road
Chimney Heights Well	Pondview Drive

Bozrah	
Bozrah Volunteer Fire Company*	239 Fitchville Road
Fields Memorial School (ARC shelter)	8 Bozrah Street
Highway Department Garage	231 Fitchville Road
Bozrah Moose Lodge 950 (alternate shelter)	115 Fitchville Road
Fitchville Residential Care Home	187 Fitchville Road
Reliance House Substance Abuse Rehabilitation Home	36 Haughton Road
Home for people with disabilities	Caroline Road
Chicken Farms	Townwide
Norwich Public Utilities Potable Water Facilities	Townwide

Branford	
Police Department	33 Laurel Street
Fire Headquarters	45 North Main St.
Fire House	84 Thimble Isl Rd
Fire House	6 Linden Ave
Fire House	341 Main St
Fire House	64 Shore Drive
Town Hall	1019 Main St
Counseling Center	342 Harbor St
Public Works	137 No Branford Rd
Willoughby Wallace Library	146 Thimble Island Road
Tisko School	118 Damascus Rd
Sliney School	23 Eades Street
Walsh Middle Schoold	185 Damascus Rd
Community House	46 Church St
Branford High School	185 East Main St
Murphy School	8 Brushy Plain Rd
Pumping Stations	51 pump stations
Treatment Plant	75 Block Isl. Rd

Connecticut Hospice	100 Double Beach Road
Branford Hills Health Center	189 Alps Road
Hearth at Gardenside	173 Alps Road
Cedar Woods	80 Cedar Street
Green View Apts	Hillside Avenue
Rose Street Apts	Rose Street
Rice Terrace Apts	Rice Terrace
Artis Memory Care	814 East Main St
Housing Authority	115 South Montowese St
Housing Authority	3 Block Island Rd
Substation	272 East Main
Army Reserve Center	777 East Main St
State Armory	83 Montowese St

Brookfield	
Brookfield Volunteer Fire Company	92 Pocono Road
Brookfield Volunteer Fire Department, Candlewood Company	18 Bay View Drive
Brookfield Ambulance Facility	4 Obtuse Hill Road (Route 133)
Brookfield Town Hall and Brookfield Senior Center	100 Pocono Road
Brookfield Police Department	63 Silvermine Road
Brookfield High School	45 Longmeadow Hill Road
Huckleberry Hill Elementary School	100 Candlewood Lake Road
Brookfield YMCA	2 Huckleberry Hill Road
Brookfield Public Works Garage	81 Gray's Bridge Road
Sewer Pump Stations	Various Locations
Water Pump Stations	Various Locations
Water tank	
Elderly Housing "Brooks Quarry"	3 Brooks Quarry Road
Assisted Living	246 Federal Road
Brookfield School Age Program	100 Candlewood Lake Road
Christian Life Academy	133 Junction Road
Country Kid's Club	94 Old State Road
Country Kids Play Farm	107 Old State Road
Greenknoll Children's Center	60 Old New Milford Road
Greenknoll Children's Center	2 Huckleberry Hill Road
The Goddard School	1 Production Drive
Kid's Castle Learning Center	777 Federal Road
Montessori Community Center	21 West Whisconier

Prince of Peace	179 Junction Road
Brookfield Hills Condominium	Vail Road
Cederbrook Condominium	Whisconier Road
High Meadows Condominium	Route 133
Lake Lillinonah Shores	Hearthstone Drive
Ledgewood Condominium	Route 133
Mill River Condominium	Federal Road
Newbury Crossing	Silvermine Road
Newbury Village	Federal Road
Oak Meadows	Federal Road
Orchard Place Apartments	Orchard Street
Riverview Condominium	Federal Road
Rollingwood Condominium	Federal Road
Sandy Lane Village	Sandy lane
Silvermine Manor	Silvermine Road
Stony Hill Village	Stony Hill Road
Town Brooke Commons	Nabby Road
Whisconier Village	Whisconier Road
Woodcreek Village	Prange Road

Cheshire		
Elim Park Baptist Home	140 Cook Hill Road	Assisted Living
Marbridge Retirement Center/Fairwinds	665 West Main Street	Assisted Living
Highlands Health Care	745 Highland Avenue	Assisted Living
Cheshire Correctional Institution	900 Highland Avenue	Correctional Facility
Manson Youth Institution	42 Jarvis Road	Correctional Facility
Webster Correctional Institution	111 Jarvis Road	Correctional Facility
Chesprocott Health District	1247 Highland Avenue	Emergency Ops.
Cheshire Fire Dept Company 2	1511 Byam Rd	Fire Department
Cheshire Fire Dept Headquarters	250 Maple Ave	Fire Department
Cheshire Fire Dept Station 3	1125 South Main St	Fire Department
Cheshire Public Library	104 Main Street	Library
Cheshire Police Dept Headquarters	500 Highland Ave	Police Station
Chapman School	38 Country Club Road	School
Cheshire Academy	10 Main St.	School
Cheshire High School (Shelter)	525 South Main Street	School
Darcey School	1686 Waterbury Road	School
Dodd Junior High School	100 Park Place	School
Doolittle School	735 Cornwall Avenue	School
Highland School	490 Highland Avenue	School
Humiston School	30 Spring Street	School

Legionaries of Christ Seminary	475 Oak Avenue	School
Norton School	414 North Brooksvale Rd	School
St. Bridget Elementary School	171 Main Street	School
Cheshire Youth Center (Shelter)	559 South Main Street	Youth Center
Cheshire Town Offices	84 South Main St	Town Office
Sewage Treatment Plant	Cheshire Street	Waste Treatment
Public Works Garage	1286 Waterbury Rd	Public Works

Colchester		
Colchester Hayward Fire Dept. Co. 1 & 2	52 Old Hartford Rd. / 424 Westchester Rd.	
Colchester Police Department	127 Norwich Avenue	
Town Hall	127 Norwich Avenue	
Jack Jackter Elementary School*	362 Halls Hill Road	
Bacon Academy	611 Norwich Avenue	
Public Works Garage	300 Old Hartford Road	
Cabin Road Wellfield WTP	140 Taintor Hill Road	
Cabin Road Wellfield (Wells 3 and 5)	140 Taintor Hill Road	
Judd Brook Wellfield (Well 4)	183 Lebanon Avenue	
Elmwood water pump station	550 Elmwood Heights	
Highland Farm water tank	36 Highland Circle	
Prospect Hill Sewer P.S.	31 Prospect Hill Road	
Apple Rehab Center	36 Broadway Street	
Colchester Commons Mobile Home Park	Lebanon Avenue	
Dublin Village	300 Lebanon Avenue	
Gan Aden	385 South Main Street	
Gan Aden Chestnut	28 Chestnut Hill Road	
Gan Aden Field	564 Norwich Avenue	
Gan Aden Too	564 Norwich Avenue	
Genesis Elder Care	59 Harrington Court	
Ponemah Village	283 Westchester Road	
Westchester Village Mobile Home Park	Shailor Hill Road	
State Communication Tower	95 O'Connell Rd	
State Communication Tower	11 Munn Rd. (Windham Ave.)	
Backus Health Care	151 Broadway Street	

Danbury		
Fire Engine Company 6	65 Jefferson Avenue	
Pope John Paul Health Care	33 Lincoln Avenue	
Fire Headquarters	19 New Street	
Fire Engine Company 3	17 North Street	

Danbury Fire Training Facility	23 Plumtrees Road
Danbury Municipal Airport	Wibling Road
Fire Engine Company 26	75 Kenosia Avenue
Danbury Fair Mall	7 Backus Avenue
Fire Engine Company 24	36 Eagle Road
Fire Engine Company 6	65 Jefferson Avenue
Pope John Paul Health Care	33 Lincoln Avenue
Fire Headquarters	19 New Street
Fire Engine Company 3	17 North Street
Danbury Fire Training Facility	23 Plumtrees Road
Danbury Municipal Airport	Wibling Road
Fire Engine Company 26	75 Kenosia Avenue
Danbury Fair Mall	7 Backus Avenue
Fire Engine Company 24	36 Eagle Road

East Haven	
Police Station	471 North High Street
Fire Headquarters	200 Main Street
Foxon Fire Station	1420 North High Street
Bradford Manor Station	85 George Street
Riverside Fire Station	82 Short Beach Road
Emergency Radio Infrastructure	111 South Shore Road
Emergency Radio Infrastructure	Saltonstall Mountain
Telecommunications station	471 North High Street
Town Hall	250 Main Street
DPW Facility	461 North High Street
Shelter: East Haven Senior Center	91 Taylor Ave
Shelter: East Haven High School	35 Wheelbarrow Lane
The Village at Mariner's Point (senior living)	111 South Shore Drive
Woodview Elderly Housing (senior living)	1270 North High Street
Talmadge Park Health Care (nursing home)	38 Talmadge Avenue
Laurel Woods Convalescent Home	451 N High S
Stewart Rest Home (nursing home)	93 High Street
Caroline Manor (nursing home)	37 Clark Avenue
Lake Saltonstall Water Treatment Plant	Main Street
Tweed-New Haven Regional Airport	155 Burr St. (New Haven)
North High Street underpass at I-95	North High Street
Laurel Street underpass at I-95	Lauren Street
Frontage Road underpass at I-95	Frontage Road

East Lyme	

Flanders Fire Department	151 Boston Post Road
Niantic Fire Headquarters	8 Grand Street
Niantic Fire Station	227 West Main Street
Police Department	278 Main Street, Niantic
Public Safety Building / Emergency Operations Center	171 Boston Post Road
Public Works Garage	Colton Road
Town Hall	108 Pennsylvania Avenue
Community Center	41 Society Road
East Lyme High School	30 Chesterfield Road
East Lyme Middle School	31 Society Road
Bride Brook Rehab Center	23 Liberty Way, Niantic
Charter Oak (Medical Clinic)	324 Flanders Road
Crescent Point	417 Main Street

Franklin	
Volunteer Fire Department	5 Tyler Drive
Town Hall	7 Meetinghouse Hill
Public Works Town Garage	171 Pond Road
Shelter: Franklin Elem. School	206 Pond Road
Elisha Brook (elderly housing)	56 New Park Ave
Private Group Home	Route 32
State Group Home	Old Route 87
Holton Road Group Home (State)	86 Holton Road
Norwich Orthopedic Group	82 New Park Avenue
A B C's & 123's LLC	79 Connecticut 32

Griswold	
Griswold Volunteer Fire Co.	883 Voluntown Road
A.A. Young Jr. Hose & Ladder Co. #1	105 Hill St, Jewett City
Griswold Youth & Family Services	68 Ashland St, Jewett City
Town Hall	28 Main Street
Public Works Garage	1148 Voluntown Rd (Rte.138)
Senior Center	28 Main Street
Griswold Elementary School	303 Slater Ave, Jewett City
Griswold Middle School	211 Slater Avenue
Griswold High School	267 Slater Avenue
Ashland Manor (Housing Authority)	Ashland Street
McCluggage Manor (Housing Auth.)	Taylor Hill Road
Ledgewood Apartments	Pleasant View Drive
United Community & Family Services	76 Main Street
Wastewater Treatment Plant	Wedgewood Drive

Little Log School House (daycare)	242 Bitgood Rd, Jewett City
Headstart (daycare)	129 E. Main St, Jewett City

Groton	
Emergency Operations Center/Public Safety/Emergency Call Center (ECC)	68 Groton Long Point Rd
Groton Ambulance	217 Newtown Road
Mystic River Ambulance	237 Sandy Hollow Rd, Mystic
Center Groton Fire District	163 Candlewood Road, Groton
Groton Long Point Association	5 Atlantic Avenue,
(Police & Fire)	Groton Long Point
Mystic Fire District	34 Broadway, Mystic
Noank Fire District	Ward Avenue, Noank
Old Mystic Fire District	295 Cow Hill Road, Mystic
Poquonnock Bridge Fire District	13 Fort Hill Road, Groton
West Pleasant Valley Fire District	140 Broad Street, Groton City
Town Hall	45 Fort Hill Road, Groton
Town Garage	134 Groton Long Point Road
Shelter: Groton Senior Center	102 Newtown Road
Shelter: Fitch High School	101 Groton Long Point Road
Fairview (nursing home)	235 Lestertown Road
Mystic River Healthcare (nursing home)	475 High Street
Groton Regency (nursing home)	1145 Poquonnock Road
Academy Point (senior living)	20 Academy Lane
Grasso Gardens (senior living)	217 Newtown Road
Pequot Village (senior living)	11 Village Lane
AHEPA (senior living)	251 Drozdyk Drive
Windham Falls (senior living)	425 Drozdyk Drive
Haley Brook (senior living)	2590 Gold Star Highway
Mystic River Homes (senior living)	201 Elm Street
Groton-New London Airport	155 Tower Avenue
Sewer pumping stations	Various
Groton Utilities Water Treatment Plant	170 Gary Court
U.S. Navy Base	Northwest Groton

Groton City	
Fire Station	Broad Street
Fire Station	Benham Road

City Hall (EOC, Police, Groton Utilities, Public Works, Shelter,)	295 Meridian Street
Water Pollution Control Authority	Thames Street
Fitch High School (Shelter)	Groton Long Point Road, Town of Groton
Avery Heights (Elderly Housing)	300 Brandegee Avenue
Pfizer	Eastern Point Road
Electric Boat	Thames Street
University of Connecticut at Avery Point	Shennecossett Road
Guilford	
Police Station	390 Church Street
Fire Headquarters	390 Church Street
Fire Station	10 Graves Avenue
Fire Station	120 Whitfield Street
Fire Station	51 Water Street
Fire Station	3087 Durham Road
Town Hall	31 Park Street
DPW Facility/Town Garage	47 Driveway
Shelter: Community Center	32 Church Street
Shelter: Guilford High School	605 New England Road
Transfer Station	Boston Post Road
Library	67 Park Street
Guilford House (former West Lake Lodge)	109 West Lake Avenue
Apple Rehab. (former Fowler Convalescent)	10 Boston Post Road
The Gables	201 Granite Road
Yale-New Haven Shoreline Medical Center	111 Goose Lane
Boston Terrace (senior living)	41 Boston Terrace
Sachem Hollow (senior living)	310 State Street
Guilford Court (senior living)	32 Guilford Court
CWC Tank	Sachem Head
Guilford Marina	Old Whitfield Street
East River State Boat Lunch	Neck Road
Brown's Boat Yard	348 Chaffinch Island Road
Guilford Boat Yard	230 Water Street
Sachems Head Yacht Club	Chimmney Corner Circle
Guilford Yacht Club	379 New Whitfield St
Brooks and Whittle	20 Carter Drive

Hamden	
Police Department	2900 Dixwell Ave.
Fire Station 2	71 Circular Ave.

Fire Station 3	441 Hartford Turnpike
Fire Station 4	2372 Whitney Ave.
Fire Station 5	2993 Whitney Ave.
Fire Station 9	245 Johnson Rd.
Emergency Operations Center at Government Center	2750 Dixwell Ave
Keefe Community Center	11 Pine St.
Hamden High School	2040 Dixwell Ave.
Middle School	2623 Dixswell Ave.
Government Center	2750 Dixwell Ave
Memorial Town Hall	2750 Dixwell Ave
Public Works	1125 Shephard Ave
Public Works Vehicle Repair	1255 Shephard Street
Hamden High School	2040 Dixwell Ave.
Hamden Middle School	2623 Dixswell Ave.
Keefe Community Center	11 Pine St.
Stormwater Flood Control System	Centerbrook Road
South Central Regional Water Authority Water Treatment Plant	940 Whitney Ave.
Lake Whitney Dam	955 Whitney Ave
South Central Regional Water Authority Wellfield	0 Willow St.

Lebanon	
Volunteer fire department/ Fire Safety Complex*	23 Goshen Hill Road
Police department	Goshen Hill Road
Elementary school	Exeter Road
Middle school	Exeter Road
Lyman Memorial High School	917 Exeter Road
Industrial park off Route 207	Route 207
Hist Dist (Jon. Trumbull home, Jon. Trumbull Jr. home, town green, War Office, etc.)	
Elderly housing facility	Dr. Manning Drive
Senior Center	West Town Street
Norwich Public Utilities (NPU) Water treatment Plant	Reservoir Road
Two transformer stations	
Girl Scout camp off Clubhouse Road	Clubhouse Road
Pumping Stations	Throughout town
Warnings/Emergency Communication (CT Alert)	Volunteer Fire Department Buildings
Department of Public Works	87 Goshen Hill Rd

Ledyard	

Police Department**	737 Colonel Ledyard Highway	
Ledyard Fire Company	11 Fairway Drive	
Gales Ferry Volunteer Fire Company	1772 Route 12	
Town Hall and Annex	741 Colonel Ledyard Highway	
Public Works Garage	889 Colonel Ledyard Highway	
High School*	24 Gallup Hill Road	
Middle School	1860 Route 12	
Highlands Wastewater Treatment Facility	80 Town Farm Road	
Lisbon		
Lisbon Central Elementary School	15 Newent Rd	
Public Works Garage	486 River Road	
Town Hall	1 Newent Rd	
Resident State Trooper	23 Newent Rd	
Volunteer Fire Department*	7 Newent Rd	
Middlebury		
Middlebury Edge	Straits Turnpike/Park Road Intersection	Mixed-Use (Childcare Facility)
The Nest Day Care	984 Southford Road	Day Care Facility
Middlebury Convalescent Home	Middlebury Road	Convalescent Home
New Horizons Handicap Assistantship Home	Nutmeg Road	Handicap Assistantship Facility
Benson Woods	North Benson Road	Age-Restricted Housing
Home for the Blind	George Street near Yale Avenue	Home for the Blind
Middlebury Police Department	Middlebury Road	Police Department
Middlebury Fire Department	65 Tucker Hill Road	Fire Department & Backup Shelter
Middlebury Public Works	1 Service Road	Public Works Department
Shepardson Community Center	1172 Whittemore Road	Municipal & Backup Shelter
Middlebury Town Hall Offices	1212 Whittemore Road	Municipal
Middlebury Public Library	65 Crest Road	Municipal
Pomperaug High School	234 Judd Road, Southbury	School, Primary Shelter
Westover School	1237 Whittemore Road	School, Backup Shelter (Private)
Region 15 Board of Education	286 Whittemore Road	School Offices
Middlebury Elementary School	550 Whittemore Road	School
Memorial Middle School	Memorial Drive	School, Backup Shelter (No Generator)

Chemtura Corporation HQ	Off of Benson Road	Industry - Hazardous Chemicals
Sewage Pump Station 1	Shadduck Rd near Hop Br	Utility – Sewer
Sewage Pump Station 2	Long Meadow Road	Utility – Sewer
Sewage Pump Station 3	270 North Benson Road	Utility – Sewer
Sewage Pump Station 4	Southford Road	Utility – Sewer
Sewage Pump Station 5	Straits Turnpike	Utility – Sewer
Sewage Pump Station 6	Christian Lane – Triangle Hill Subdivision	Utility – Sewer
Sewage Pump Station 7	West end of Gleneagle Rd	Utility – Sewer
Sewage Pump Station 8	Somerset Drive	Utility – Sewer
Sewage Pump Station	1 Service Road	Utility – Sewer
Sewage Pump Station	1 Service Road	Utility – Sewer
Pumping Station	285 Kelly Road	Utility – Water

Milford	
Fire HQ	72 New Haven Ave
Fire Station 5	980 New Haven Ave
Fire Station 7	55 Wheelers Farms Rd
Fire Station 8	349 Naugatuck Ave
Police Station/EOC	430 Boston Post Rd
Milford Health Department	82 New Haven Ave
City Hall	110 River St
Parsons Government Center	70 West River St
Jonathan Law High School	20 Lansdale Ave
Milford Hospital	300 Seaside Ave
Public Works Building	83 Ford St
Milford Senior Center	9 Jepson Dr
West River Healthcare Center	245 Orange Ave
Golden Hill Rehab	2028 Bridgeport Ave
Milford Health and Rehabilitation	195 Platt St
Carriage Green	77 Plains Rd
Four Corner's Rest Home	306 Naugatuck Ave
Guardian Angels Homecare	232 Boston Post Rd
Acord Inc	300 Third Ave

Montville	
Montville Fire Company	77 Route 163
Mohegan Fire Company	2029 Norwich-New London Tpke (Route 32)
Oakdale Fire Company	444 Chapel Hill Road

Chesterfield Fire Company	1606 Hartford-New London Tpke (Rt. 85)
Public Safety Building*	911 Norwich-New London Tpke (Rt. 32)
Town Hall**	310 Norwich-New London Tpke
Montville High School	800 Old Colchester Road
Leonard J. Tyl Middle School	166 Chesterfield Road
Public Works Building	225 Maple Avenue
Cook Drive Water Tank	Cook Drive
Montville (Pink Row) WPCF	83 Pink Row
Killeen Road Substation	Killeen Road
Orchard Grove Specialty Care Center	5 Richard Brown Drive
Haughton Cove Manor	841 Norwich-New London Tpke
Independence Village Elderly Housing	Milefski Drive
Freedom Village Elderly Housing	Liberty Road
Jensen's Hillcrest Mini Estates (age 40+)	Old Colchester Road

Naugatuck		
Borough of Naugatuck Offices	229 Church Street	Municipal Offices
Borough of Naugatuck Police Department	211 Spring Street	Police Station
Naugatuck Fire Headquarters	41 Maple Street	Fire Department
Eastside Fire Station	Intersection of May Street & Osborn Road	Fire Department
Borough of Naugatuck Ambulance Services	246 Rubber Avenue	EMT - Ambulance
Borough of Naugatuck Public Works Department	246 Rubber Avenue	Public Works
Wastewater Treatment Plant	500 Cherry Street	Utility - Sewer
Connecticut Water Company	(Infrastructure)	Utility - Water
Southern New England Telephone	(Infrastructure)	Utility – Phone
Connecticut Light & Power	Cherry Street	Utility – Electric
South Naugatuck Substation	Utility – Electric	
Algonquin Gas Pipeline	Northern Naugatuck	Utility – Gas
Naugatuck Senior Center	300 Meadow Street	Senior Center
Ecumenical Food Bank	75 Spring Street	Food Bank
Borough of Naugatuck High School	543 Rubber Avenue	School
City Hill Middle School	441 City Hill Street	School
Hillside Middle School	51 Hillside Avenue	School
Cross Street Intermediate School	120 Cross Street	School
Hop Brook Intermediate School	75 Crown Street	School
Andrew Avenue Elementary School	140 Andrew Avenue	School
Central Avenue Elementary School	28 Central Avenue	School

Maple Hill Elementary School	641 Maple Hill Road	School
Prospect Elementary School	100 Prospect Street	School
Salem Elementary School	124 Meadow Street	School
Western Elementary School	100 Pine Street	School

New Fairfield	
New Fairfield High School and Middle School	54 Gillotti Road
New Fairfield Senior Center	33 Route 37 North
New Life Community Church	1 Beaver Bog Road
Town Hall and Annex	4 Brush Hill Road
Public Safety Complex (Police Department, Fire Station, and Emergency Operation Center)	302 Ball Pond Road
Ball Pond Volunteer Fire Department	7 Fairfield Drive
Squantz Engine Company Volunteer Fire Department	255 Route 39

New Haven	
Emergency Operations Center	200 Orange Street
City Hall/Government Center	165 Church Street, 200 Orange Street
New Haven Health Department	54 Meadow Street
New Haven School Department	54 Meadow Street
New Haven Fire Training Academy	230 Ella T. Grasso Boulevard
Hill South Police	410 Howard Avenue
Department of Police Services	1 Union Avenue
Dwight-Chapel/West River	150 Edgewood Avenue
Hill North	90 Hallock Street
Dixwell	26 Charles Street
Newhallville/East Rock	596 Winchester Avenue
Fair Haven	295 Blatchley Avenue
East Shore/Fair Haven Heights/Quinnipiac East	830 Woodward Avenue
Beaver Hills/Whalley Avenue	386 Whalley Avenue
Fire Department Headquarters	952 Grand Avenue
Dixwell Fire Station	125 Goffe Street
East Grand Fire Station	73 East Grand Avenue
Fountain Street Fire Station	105 Fountain Street
Hill Fire Station	525 Howard Avenue
Lighthouse Fire Station	510 Lighthouse Road
Whitney Avenue Fire Station	350 Whitney Avenue
Woodward Avenue Fire Station	826 Woodward Avenue
Westside Battalion Chief Fire Station	120 Ellsworth Avenue
Eastside Battalion Chief Fire Station	412 Lombard Street

Yale-New Haven Hospital	20 York Street
St. Raphael Hospital	1450 Chapel Street
Department of Public Works	34 Middletown Avenue
Department of Parks and Recreation	720 Edgewood Avenue
Kathryn Brennan High School Gymnasium	200 Wilmot Road
Hill Career High School	140 Legion Avenue
James Hillhouse High School	480 Sherman Parkway
Wilbur Cross High School	181 Mitchell Drive
Nathan Hale School	480 Townsend Avenue
Tweed New Haven Airport	155 Burr Street
Southern CT State University	501 Crescent Street
East Shore Park	250 Woodward Avenue
Sports Haven	600 Long Wharf Drive
Yale University Athletic Fields	76 Yale Avenue
New Haven Main Library	133 Elm Street
Regional Water Authority	90 Sargent Drive
Union Station (rail, bus)	170 Union Avenue

New London	
Fire Headquarters (EOC)	289 Bank Street
North Fire Station	Broad Street
South Fire Station	Lower Boulevard
Police Department Headquarters	5 Gov. Winthrop Blvd.
City Hall	181 State Street
Stanton Building	111 Union Street
Public Works Complex	189 Crystal Avenye
Water Pollution Control Facility	Trumbull Street
Martin Center/Senior Center	120 Broad Street
New London High School	490 Jefferson Avenue
Bernie Dover Jackson Middle School	36 Waller Street
Jennings Elementary School	
Nathan Hale Elementary School	
Harbor Elementary School	
Lawrence and Memorial Hospital	365 Montauk Avenue
Community Health Center	1 Shaws Cove
Beechwood Manor	31 Vauxhall Street
Harbor Village Rehabilitation & Nursing Center South	89 Viets Street
Harbor Village Rehabilitation & Nursing Center South	78 Viets Street
Bacon and Hinkley Home	581 Pequot Avenue
Briarcliff Manor	179 Colman Street
Sunny Lodge (Cedar Grove Manor)	47 Cedar Grove Avenue

Newtown	
Newtown Municipal Center / Emergency Operations Center (EOC)	3 Primrose Street
Police Department	3 Main Street
New Ambulance Facility	Primrose Street
Newtown Middle School	11 Queen Street
Reed Intermediate School	3 Trades Lane
Fraser Woods Montessori School	173 S Main Street
St. Rose School	40 Church Hill Road
Housatonic Valley Waldorf School	40 Dodgingtown Road
Hawley School	29 Church Hill Road
Head O'Meadow School	94 Boggs Hill Road
Middle Gate School	7 Cold Spring Road
Sandy Hook School	375 Fan Hill Road
Newtown High School	12 Berkshire Road
Wastewater Treatment Plant	Commerce Road
Electrical substations	Various Locations
Sandy Hook Volunteer Fire and Rescue Company	18-20 Riverside Road
Hawleyville Fire Company	34 Hawleyville Road
Botsford Fire Rescue	315 South Main Street
Newtown Hook and Ladder	45 Main Street
Dodgingtown Fire Company	55 Dodgingtown Road

North Haven	
Montowese Fire Station	282 Quinnipiac Ave
Fire Station	11 Broadway
Fire Station	1339 Ridge Road
Fire Station	366 Washington Ave
Police Station	8 Linsley St
Town Hall	18 Church St.
Public Works	110 Elm St.
Middle School	55 Bailey Road
High School	221 Elm St.
Senior Center	189 Pool Road

North Stonington	
New Town Hall*	40 Main Street
North Stonington Ambulance	10 Mains Crossing Road
North Stonington Elementary School	311 Norwich-Westerly Road

North Stonington Medical Clinic	183A Providence – New London Turnpike
Old Town Hall	40 Main Street
Public Works Garage	11 Wyassup Road
Volunteer Fire Department	267 Norwich-Westerly Road

Norwich	
Fire Department Headquarters - Station 1	10 North Thames Street
Greeneville Fire Department - Station 2	446 North Main Street
East Great Plain Volunteer Fire Department	488 New London Turnpike
Laurel Hill Volunteer Fire Company	509 Laurel Hill Road
Occum Volunteer Fire Department	44 Taftville-Occum Road
Taftville Fire Company No. 2 (Volunteer)	134 Providence Street
Yantic Fire Engine Company No. 1 (Volunteer)	151 Yantic Road
Police Department	70 Thames Street
City Hall / backup EOC / Public Works*	100 Broadway
Norwich Public Utilities / EOC	173 North Main Street
Rose City Senior Center	8 Mahan Drive
Public Works Headquarters	50 Clinton Avenue
Public Works - Fleet Management	Asylum Street
Water Pollution Control Facility	Falls Avenue
Backus Hospital	326 Washington Street
Samuel Huntington Elementary	80 West Town Street
Thomas W. Mahan Elementary	94 Salem Turnpike
John M. Moriarty Elementary	20 Lawler Lane
John B. Stanton Elementary	386 New London Turnpike
Uncas Elementary	280 Elizabeth Street Extension
Veterans Memorial Elementary	80 Crouch Avenue
Wequonnoc Elementary	155 Providence Street
Kelly Middle	25 Mahan Drive
Teachers' Memorial Middle	15 Teachers Drive
Deborah Tennant-Zinewich - Special Education	30 Case Street
Hickory Street (Special Education)	201 Hickory Street
Integrated Day Charter School	68 Thermos Avenue
Norwich Technical High School	7 Mahan Drive
Wildwood Christian School	35 Wawecus Hill Road
Montessori Day	218 Dudley Street
Norwich Free Academy	305 Broadway

Preston	

Lincoln Park Elderly Housing	Lincoln Park Road Extension	
Poquetanuck Fire House	87 Route 2A	
Preston City Fire Station*	412 Route 165	
Preston Plains School	1 Route 164	
Preston Veterans Memorial School	325 Shetucket Turnpike	
Public Works Garage	423 Route 2	
Town Hall	389 Route 2	
Prospect		
Prospect Fire Dept	26 New Haven Rd	Fire Dept
(designated shelter)		
Prospect Library	17 Center St	Library
Harmony Acres	Cook Road	Mobile Home Park
Marathon Health Center	25 Royal Crest Drive	Nursing Home
Prospect Police Dept	8 Center St	Police Station
Algonquin School	30 Coer Road	School
Long River Middle School	38 Columbia Ave	School
Prospect Community Elementary School	12 Center St	School
Prospect Town Offices	36 Center St	Town Office
Prospect Senior Center (designated shelter)	6 Center Street	Town Office
Town Garage	221 Cheshire Road	Public Works
Redding		
Redding Community Center	37 Lonetown Road	
Joel Barlow High School	100 Black Rock Turnpike	
John Read Middle School	486 Redding Road	
Police Department and EOC	96 Hill Road	
Town Hall	100 Hill Road	
Sewage Facility / Wastewater Treatment Plant	19 North Main Street	
Highway Garage	28 Great Oak Lane	
Georgetown Fire Department	6 Portland Avenue	
Redding Ridge Fire Department and EMS Company – Fire District #1	186 Black Rock Turnpike	
West Redding Fire Department – Fire District #2	306 Umpawaug Road	
Ridgefield		
Emergency Operations Center	Yanity Gymnasium	
	60 Prospect Street	
Police Department	76 East Ridge Road	
Fire Headquarters	6 Catoonah Street	
Ridgebury Fire Station	169 Old Stagecoach Road	

Town Hall	400 Main Street
Town Hall Annex	66 Prospect Street
Highway Garage	60 South Street
Ridgefield Recreation Center	195 Danbury Road
Barlow Mountain Elementary School	115 Barlow Mountain Road
East Ridge Middle School	10 East Ridge Road
Scotts Ridge Middle School	750 North Salem Road
Prospect Ridge Congregate Care	51 Prospect Ridge
Ballard Green	25 Gilbert Street
Laurel Ridge	642 Danbury Road
Ridgefield Crossing	640 Danbury Road
Wastewater Treatment Plants (2)	Various Locations
Water Pumping Stations	Various Locations
Railroad Station	50 Ethan Allen Highway
Major Roads	Various
Boehringer Campus	900 Ridgebury Road
Commercial Town Center	Vicinity of Main Street and Danbury Road

Salem	
Gardner Lake Volunteer Fire Company	429 Old Colchester Rd
Salem Volunteer Fire Company	424 Hartford Road
Town Hall*	270 Hartford Road
Public Works Garage	270 Hartford Road
Elementary School	200 Hartford Road

Sherman	
Emergency Services Facility	Route 39 North
Mallory Town Hall	9 Route 39 North
Highway Department Garage	43 Route 39 North
Sherman Consolidated School	2 Route 37 East
Sherman Renaissance Senior Center	8 Route 37 Center
Holy Trinity Church	15 Route 37 Center
Sherman Congregational Church	6 Church Road
Jewish Community Center	9 Route 39 South

Southbury		
Heritage Village	Heritage Village	Active Adult Condominiums
Traditions	Route 172	Clustered Housing
Southbury Training School	1461 S Britain Road	Sewer
Kensington Green	655 Main St. South	Assisted Living Community
Grace Meadows	Route 67	Disabled / Low Income Housing

The Watermark	611 East Hill Road	Life Care Community
Pomperaug Woods	80 Heritage Road	Life Care Community
Southbury Training School sewer pumping station	Whale Pass/S. Britain Road	Sewer
Heritage Village STP	Heritage Village	Sewer
IBM (Southbury) STP	150 Kettletown Road	Sewer
Heritage Village Water Co.	Heritage Village	Water Supply Wells
Southbury Fire Dept.	461 Main Street South	Fire Department
Southbury Police Dept.	421 Main Street South	Police Department
Vizada Americas Satellite Services Facility	2120 River Road	National Defense and Communications
Southbury Senior Center	561 Main Street South	Senior Center/Primary Shelter
Pomperaug High School	234 Judd Road	School/Regional Shelter
Southbury Ambulance Association	68 George Hill Road	Ambulance Service
Purchase Firehouse	100 Stillson Road	Backup Dispatch Center
River Glen Health Care Center	162 South Britain Road	Health Care

Sprague	
Baltic Fire Department (Backup EOC)	22 Bushnell Hollow Rd
Town Hall (EOC)	1 Main Street, Baltic
Public Works Garage	1 Main Street, Baltic
Shelter: Sayles Elementary School	25 Scotland Road
Shetucket Village (senior living)	8 Wall Street
Hanover Nursery School	40 Potash Hill Road
Daycare (private home)	Parkwood Road
Hanover Rd sewer pumping station	Hanover Rd, Baltic
Water filtration plant	
Sewer Treatment Plant	45 Bushnell Hollow Rd
Sewer pumping stations	Various
Water supply wells	River Rd, Hanover Versailles Rd

Stonington	
Police Department / EOC	173 South Broad Street
Town Hall / Backup EOC	152 Elm Street
Mystic Fire Department	34 Broadway Avenue
Old Mystic Fire Department	21 North Stonington Road
Pawcatuck Fire Department	33 Liberty Street
Quiambaug Fire Department	50 Old Stonington Road
Stonington Borough Fire Department	100 Main Street
Wequetequock Fire Department	6 Farmholme Road
Stonington Ambulance	86 Alpha Avenue

Public Works Garage	86 Alpha Avenue
Stonington High School	176 South Broad Street
Mystic Middle School	204 Mistuxet Avenue
Deans Mill Water Treatment Plant (Aquarion)	Mistuxet Avenue
Pawcatuck Water Pollution Control Facility	38 Mary Hall Road
Mystic Water Pollution Control Facility	Edgemont Street
Borough Water Pollution Control Facility	High Street
Stone Ridge	186 Jerry Browne Road
Brookside Village	Brookside Lane
Stonington Arms	133 South Broad Street
Edythe K. Richmond Elderly Housing (Town)	45 Sisk Drive
Avalon Health Center	186 Jerry Browne Road
Pendleton Health & Rehabilitation	44 Maritime Drive
Apple Rehabilitation	28 Broadway Avenue

Stonington Borough	
Fire Station	100 Main Street
Borough Hall & Public Works	26 Church Street
Water Pollution Control Facility	High Street

Wallingford	
Emergency Operations Center	135 North Main Street
Police Headquarters	135 North Main Street
Town Hall	45 South Main Street
Central Fire HQ	75 Masonic Ave
Fire Station #1	95 North Main Street
Old Fire Station #4	37 Hall Road
Emergency Management Building	143 Hope Hill Road
Fire Station #7	864 North Farms Road
Fire Station # 8	2 Kondracki Lane
Shelter 1 – Sheehan H.S.	142 Hope Hill Road
Shelter 2 – Lyman Hall H.S	70 Pond Hill Road
Shelter 3 – Dag Hammerskjold	106 Pond Hill Road
Shelter 4 - Moran	141 Hope Hill Road
Public Works Facility	29 Town Farm Road
Gaylord Hospital	Gaylord Farm Road
Masonic Hospital	Masonic Avenue
Regency House	East Main Street
Skyview Nursing Home	Marc Drive
Genesis Health Care	55 Kondracki Lane
Silver Pond Apartments	Center Street

Wallingford Public Housing	Ulbrich Heights and Extension	
Wallingford Public Housing	East Side Terrace	
Wallingford Public Housing	South Side Terrace	
Wallingford Public Housing	McGuire Court	
Wallingford Public Housing	John Savage Commons	
Wallingford Public Housing	McKenna Court	
Water Treatment Plant	Whirlwind Hill Road	
Waste Water Treatment	John Street	
Electric Generation	East Street	

Waterbury		
Abbott Terrace	44 Abbott Terrace	Assisted Living
Health Center of Greater Waterbury	177 Whitewood Road	Assisted Living
Mattatuck Health Care Facility	9 Cliff Street	Assisted Living
Office of Emergency Management	236 Grand Street	Emer. Ops.
Engine 1, Engine 9 and Truck 2	1979 North Main Street	Fire Dept
Engine 10, Truck 1	26 Field Street	Fire Dept
Engine 11	740 Highland Avenue	Fire Dept
Engine 2, Truck 3	519 East Main Street	Fire Dept
Engine 4	823 Baldwin Street	Fire Dept
Engine 5	1956 East Main Street	Fire Dept
Engine 6	431 Willow Street	Fire Dept
Engine 7	315 Walnut Street	Fire Dept
Engine 8	197 Bunker Hill Avenue	Fire Dept
Waterbury Fire Dept. Headquarters	235 Grand Street	Fire Dept
Saint Mary's Hospital	56 Franklin Street	Hospital
Waterbury Hospital	64 Robbins Street	Hospital
Silas Bronson Library	267 Grand Street	Library
Waterbury Police Dept	255 E Main Street	Police Station
Waterbury Police Dept Annex	240 Bank Street	Police Station
5th Floor Jefferson Square	185 South Main Street	Public Works
Highway	51 East Aurora Street	Public Works
Central vehicle maintenance	500 Captain Neville Drive	Public Works
Refuse Transfer facility	Mark Lane	Public Works
B. W. Tinker Elementary School	809 Highland Avenue	School
Barnard School	11 Draher Street	School
Brooklyn School	29 John Street	School
Bucks Hill Elementary School	330 Bucks Hill Road	School
Bunker Hill School	170 Bunker Hill Avenue	School
Carrington Elementary School	24 Kenmore Avenue	School
Crosby High School	300 Pierpont Rd	School

Driggs Elementary School	77 Woodlawn Terrace	School
F J Kingsbury School	220 Columbia Boulevard	School
Gilmartin Elementary School	107 Wyoming Avenue	School
H S Chase School	40 Woodtick Road	School
Hopeville Elementary School	2 Cypress Street	School
Kaynor Technical School	43 Tompkins Street	School
Kennedy High School	422 Highland Ave.	School
Maloney Magnet School	233 South Elm Street	School
Margaret M. Generali School	3196 East Main Street	School
Michael F Wallace Middle School	3465 East Main Street	School
Naugatuck Valley Community College	750 Chase Parkway	School
North End Middle School	534 Bucks Hill Rd.	School
Post University	800 Country Club Road	School
Regan Elementary School	2780 North Main Street	School
Rotella School	380 Pierpont Road	School
Sprague Elementary School	1443 Thomaston Avenue	School
State Street School	35 State Street	School
UConn Waterbury Campus	99 East Main Street	School
Walsh Elementary School	55 Dikeman Street	School
Washington Elementary School	685 Baldwin Street	School
Waterbury Arts Magnet School	16 South Elm Street	School
Wendell L Cross Elementary School	1255 Hamilton Avenue	School
West Side Middle School	483 Chase Pkwy.	School
Wilby High School	568 Bucks Hill Rd.	School
Woodrow Wilson Elementary School	235 Birch Street	School
City Hall	235 Grand Street	City Office
City Offices ("Chase Building")	236 Grand Street	City Office
Jefferson Square	185 South Main Street	City Office

Waterford	
Police Station	41 Avery Lane
Public Safety Complex	204 Boston Post Rd
Cohanzie Fire Company	53 Dayton Road
Goshen Fire Department	63 Goshen Road
Jordan Fire Company	89 Rope Ferry Road
Oswegatchie Fire Company	441 Boston Post Road
Quaker Hill Fire Company	17 Old Colchester Road
Town Hall	15 Rope Ferry Road
Public Works	1000 Route 85
Regional Distribution Center	1000 Route 85
Community Center	24 Rope Ferry Road

Clark Lane School	105 Clark Lane
Quaker Hill School	285 Bloomingdale Road
Oswegatchie Elem. School	470 Boston Post Road
Waterford High School	20 Rope Ferry Road
Ahepa Sr. Housing	95 Clark Lane
Twin Havens Sr. Housing	36 Mary Street
Yorkshire Sr. Housing	55 Yorkshire Drive
Camp Harkness	301 Great Neck Road
Seaside Sanatorium group home (Closed)	Woodsea Place
Bridges at Crossroads	1 Beechwood Drive
New London Convalescent	88 Clark Lane
Greentree nursing home	4 Greentree Drive
Bayview nursing home	301 Rope Ferry Road
Lake Konomoc WTP	Route 85
Water pumping stations (3)	Various
Water tanks (3 owned by town)	Various
Water tanks (3 owned by New London)	Various
Sewer pumping stations (27)	Various
Communication towers (5)	Various

West Haven	
Police Department	200 Sawmill Road
Fire Station #1	366 Elm St
Fire Station #2	860 Ocean Av
Fire Station #3	20 Admiral St
High School	1 Circle St
City Hall	355 Main St
Carrigan Middle School	2 Tetlow St
WWTP	Beach Street
Main Pump Station	Blohm & Anderson
East Ave PS	Beach &East Ave
Dawson Av PS	1 Dawson Av
Trumbull PS	4 Trumbull St
Woodmont Road PS	160 Woodmont Road
Oyster River PS	171 Beatrice Dr.
Cove River PS	350 Painter Dr
Savin Av PS	423 Captain Thomas Blvd. PS
Front Av PS	157 Front Av
Jones St PS	172 Jones St
Morrisey Ln PS	69 Morrisey Ln
Woodycrest PS	525 Ocean Av

Baybrook PS	1 Bayshore Dr	
Morrissey Manor Senior Housing	Bayshore Dr	
Surfside	200 Oak St	
Prete Housing	1187 Campbell Av	
VA Medical Center	950 Campbell Av	
Paradigm Health Care	310 Terrace Av	
Apple Rehab Center	308 Savin Av	
Wolcott		
Wolcott View Manor	50 Beach Rd	Convalescent Home
Public Works, Water Dept.	48 Todd Road	Public Works
Fire Department Company #1	395 Central Ave	Fire Dept
Fire Department Company #2	North St	Fire Dept
Fire Department Company #3	Lyman Rd	Fire Dept
Wolcott Fire Dept	225 Nichols Rd	Fire Dept
Wolcott Police Dept	225 Nichols Rd	Police Sta.
Alcott School	1490 Woodtick Rd	School
Frisbie School (tertiary shelter)	24 Todd Rd	School
Tyrrell School (primary shelter)	500 Todd Rd	School
Wakelee School (secondary shelter)	12 Hemple Dr	School
Wolcott High School	457 Bound Line Rd	School
Wolcott Town Offices	10 Kenea Ave	Town Office
Woodbridge		
Fire Department	100 Center Road	
Police Station	4 Meetinghouse Lane	
Town Hall	11 Meetinghouse Lane	
DPW	15 Meetinghouse Lane	
Library	10 Newton Road	
Senior Center	4 Meetinghouse Lane	
High School	25 Newton Road	
Brookdale Extended Care Facility	330 Amity Road	
RWA Water Treatment Plant	2035 Ltichfield Turnpike	
Fire Department	100 Center Road	
Police Station	4 Meetinghouse Lane	
Town Hall	11 Meetinghouse Lane	
DPW	15 Meetinghouse Lane	
Library	10 Newtown Road	
Senior Center	4 Meetinghouse Lane	
High School	25 Newton Road	
Brookdale Extended Care Facility	330 Amity Road	
RWA Water Treatment Plant	2035 Litchfield Turnpike	

APPENDIX J

Interconnection Related Tables

TABLE J-1

Water Systems within 1000 feet of each other

WESTERN REGION	
Aquarion Water Company of CT - Salisbury Sys.	Chatfield Hill Assn, Inc.
Aquarion Water Company of CT – Kent Sys.	Kent School Corp. (Valley Campus)
Aquarion Water Company of CT – Kent Sys.	Kent School Maintenance Well
Kent School Corp. (Valley Campus)	Kent School Maintenance Well
Aquarion Water Company of CT – New Milford	Litchfield Hill Condos
Aquarion Water Company of CT – New Milford	Sunny Valley Tax District
Aquarion Water Company of CT – New Milford	Candlewood Trails Association Inc.
Candlewood Trails Association Inc.	Birch Groves Association Inc.
Aquarion Water Company of CT – Forest Hills Sys.	Candlewood Springs Property Owners Assn.
Candle Hill MHP (North)	Candle Hill MHP (South)
Interlaken Water Company	Knollcrest Tax District
Candlewood Shores Tax District	Hickory Hills
Candlewood Shores Tax District	Candlewood Orchards Property Owners Corp
Candlewood Shores Tax District	Arrowhead Point Homeowners Assn. Inc.
Candlewood Orchards Property Owners Corp	Arrowhead Point Homeowners Assn. Inc.
Candlewood Shores Tax District	Aquarion Water Company of CT – Western Brookfield
Candlewood Orchards Property Owners Corp	Aquarion Water Company of CT – Western Brookfield
Aquarion Water Company of CT – New Milford	Brookfield Elderly Housing
Aquarion Water Company of CT – New Milford	Aquarion Water Company of CT – Brook Acres
Aquarion Water Company of CT – New Milford	Whisconier Village Association Inc.
Aquarion Water Company of CT – New Milford	Cedarbrook Owners, Inc.
Aquarion Water Company of CT – Berkshire Corp	Brookfield Hills Condominium Unit Owners
Aquarion Water Company of CT – Berkshire Corp	Stony Hill Village
Stony Hill Village	Brookfield Hills Condominium Unit Owners
Woodcrest Association, Inc.	CTWC-Unionville System
Aquarion Water Company of CT – Litchfield Sys.	Aquarion Water Company of CT – Circle Drive
Aquarion Water Company of CT – Circle Drive	Bantam Village
Aquarion Water Company of CT – Judea Main	Gunnery School
Bristol Water Department	Southington Water Department
Bristol Water Department	Chippanydale Association
Bristol Water Department	CTWC-Unionville System
Waterbury Water Department	Arrowhead by the Lake Association, Inc.
Waterbury Water Department	Regional Water Authority
Regional Water Authority	Southington Water Department
Regional Water Authority	Meriden Water Division
Regional Water Authority	Crestview Condominium Association
CTWC – Naugatuck Region-Central System	Bethany Mobile Home Park
CTWC – Naugatuck Region-Central System	Idleview Mobile Home Park
CTWC – Naugatuck Region-Central System	Middlebury Commons
CTWC – Naugatuck Region-Central System	Westover Water Co
Town in Country Condominiums – Upper System	Town in Country Condominiums –Lower System
Town in Country Condominiums –Lower System	Heritage Hill Condominium Assn, Inc.

Aquarion Water Company of CT – Woodbury System	Holly House Apartments
Aquarion Water Company of CT – Woodbury System	Woodbury Place Condominium Association
Heritage Water Company	Southbury Training School
Aquarion Water Company of CT – Lakeside System	Cedarhurst Association
Regional Water Authority	Aquarion Water Co of CT – Main System
Aquarion Water Co of CT – Main System	Aquarion Water Co of CT – Hawkstone System
Aquarion Water Co of CT – Chestnut Tree	Masonicare of Newtown
Aquarion Water Co of CT – Main System	Meadowbrook Terrace Mobile Home Park
Danbury Water Department	Bethel Water Department
Aquarion Water Co of CT – Chimney Heights	Aquarion Water Co of CT – Berkshire Corp
Danbury Water Department	Candlewood Park Inc.
Candlewood Park Inc.	Aquarion Water Co of CT – Cedar Heights
Aquarion Water Co of CT – Cedar Heights	Cedar Terrace Prop Owners Association
Danbury Water Department – Ridgeview Gardens	Aqua Vista Association Inc.
Snug Harbor Development Corp	Aqua Vista Association Inc.
Snug Harbor Development Corp	Danbury Water Department – Ridgeview Gardens
Danbury Water Department	Aquarion Water CO of CT – Pearce Manor
Danbury Water Department	Shady Acres Mobile Home Park
Aquarion Water CO of CT – Ridgefield System	Brookview Water Company
CENTRAL REGION	
MDC	Old Newgate Ridge Water Company Inc.
Chelsea Common Condominium Association	GQC Well Commission
Aquarion Water CO of CT – Simsbury System	Avon Water Company
CTWC – Unionville System	Avon Water Company
MDC	Manchester Water Department
Manchester Water Department	CTWC – Redwood Farms Division
MDC	Sharon Heights Water Association
MDC	Grant Hill Associates Inc.
MDC	Orchard Hill Association
MDC	Juniper Club Inc.
Orchard Hill Association	Juniper Club Inc.
CTWC – Northern Region-Western System	Hazardville Water Company
CTWC – Northern Region-Western System	Shaker Heights Water Company
CTWC – Northern Region-Western System	Connecticut Correctional Institute
CTWC – Northern Region-Western System	East Windsor Housing Authority
CTWC – Northern Region-Western System	School Hill Association, Inc.
East Windsor Housing Authority	School Hill Association, Inc.
CTWC – Northern Region-Western System	Vernon Village Inc.
Coventry Housing Authority – Upper System	Coventry Housing Authority – Lower System
CTWC – Northern Region-Lakewood	CTWC – Northern Region-Lakeview Terrace
University of Connecticut – Main Campus	Orchard Acres Association
University of Connecticut – Main Campus	Knollwood Acres Apartments
Knollwood Acres Apartments	CTWC – Birchwood Heights
Jensens, Inc. Rolling Hills Residential	Club House Apartments

Jensens, Inc. Rolling Hills Residential	Hunting Lodge Apartments
Club House Apartments	Hunting Lodge Apartments
Willington Ridge Condos – System #2	Cedar Ridge Apartments
Tolland Water Department	Stone Pond Condominiums
Whispering Hills LLC, - Well D System	Whispering Hills LLC, - Well A System
CTWC – Hebron Center Division	Hebron Arms Apartments
CTWC – Hebron Center Division	CTWC – Country Manor Apartments
CTWC – Hebron Center Division	CTWC – Mill at Stonecroft Division
CTWC- Wellswood Village Division	Wellswood Estates Foundation, Inc
CTWC- Wellswood Village Division	Hillside Condominiums
Hillside Condominiums	Wellswood Estates Foundation, Inc
Aquarion Water CO of CT – Birchwood Estate	Hillside Corporation
CTWC – West Chester East	Edgemere Condominium Assn, Inc.
Valley Water Systems, inc.	Southington Water Department
Southington Water Department	Apple Valley Village
Meriden Water Division	Berlin Water Control Commission
Middletown Water Department	Sylvan Ridge Condominiums
Middletown Water Department	Connecticut Valley Hospital
Wallingford Water Department	Regional Water Authority
Quonnipaug Hills – Main System	Quonnipaug Hills – Section 1
Lyme Regis, Inc.	Boxwood Condominium Association
Lymewood Elderly Housing	Rye Field Manor Elderly Housing
CTWC – Shoreline Region-Sound View	Miami Beach Water Company
CTWC – Shoreline Region-Sound View	Chadwick Homeowners Assn, Inc.
EASTERN REGION	
Putnam Water Pollution Control Authority	Pinecrest Condominiums
Marianapolis Prep School – St. Johns	Marianapolis Prep School – St. Alberts
CTWC – Crystal Water Company	Gorman Road Apartments
Ashford Hills Apartments	Mar-Lea Park Apartments
Pomfret School	The Rectory School
CTWC – Gallup Water Service, Inc.	Westview Terrace Mobile Home Park
Moosup Pond Terrace, LLC	Arnio Drive LLC
CTWC – Crystal Water Co, Plainfield Div.	Moosup Garden Apartments
CTWC – Crystal Water Co, Plainfield Div.	Jumbo Apartments
CTWC – Gallup Water Service, Inc.	Westview Terrace Mobile Home Park
Westchester Hills Condominium Assn.	Knob Hill Condominiums
Salem Manor Condominiums System #1	Salem Manor Condominiums System #2
Norwich Public Utilities	Sunny Waters Mobile Home Park
Norwich Public Utilities	Country Side Drive Association
Norwich Public Utilities	Lisbon Mobile Homes
Jewett City Water Company	Connollys Trailer Park
SCWA, Cedar Ridge Division	Northstone Gardens
Aquarion Water CO of CT - Mystic	SCWA, Lantern Hill Division
Aquarion Water CO of CT - Mystic	Whipples Mobile Home Park
Aquarion Water CO of CT - Mystic	Colonial Efficiency Apartments
Waterford WPCA	New London Water Division

SCWA, Tower Ferry View Division	Ledyard WPCA, Gales Ferry System
SCWA, Ledyard Center Division	SCWA, Gray Farms Division
SCWA, Hillcrest Division	Independence Village Elderly Housing
Montville Water Supply	Independence Village Elderly Housing
Kitemaug Orchard Association, Inc.	Jensens, Inc. Marina Cover Residential
Montville Water Supply	SCWA, Birchwood Division
Montville Water Supply	SCWA, Mohegan Division
SCWA, Mohegan Division	SCWA, Birchwood Division
Montville Water Supply	Thompson Hill Water CO – Beechwood Acres
Norwich Public Utilities	Thompson Hill Water CO – Beechwood Acres
Thompson Hill Water CO – Beechwood Acres	Meadows Apartments
SCWA, Montville Division	SCWA, Seven Oaks
SCWA, Montville Division	Freedom Village Elderly Housing
St. Thomas More School – Main System	St. Thomas More School – The Cove
Round Hill LLC Well #1	Round Hill LLC Well #2

Table J-2							
PWS ID	System Name	Total Score	Feasible Interconnection	Closest PWS	Feet	Closest Large PWS	Feet
CT0869131	261 & 263-271 ROUTE 163	36.67	YES	MONTVILLE WATER SUPPLY	0		
CT0859071	27 MAPLE DRIVE	36.67	YES	AQUARION WATER COMPANY OF CT MAIN SYSTEM	1000		
CT0347051	AQUA VISTA ASSOC, INC - LOWER SYSTEM	78.67	YES	AQUA VISTA ASSOC, INC - UPPER SYSTEM	0	DANBURY WATER DEPARTMENT	4500
CT0340111	AQUA VISTA ASSOC, INC - UPPER SYSTEM	80.33	YES	AQUA VISTA ASSOC, INC - LOWER SYSTEM	0	DANBURY WATER DEPARTMENT	4500
CT1669011	ARROWHEAD BY THE LAKE ASSOCIATION, INC.	60.00	YES	WATERBURY WATER DEPARTMENT	450		
CT0180091	ARROWHEAD POINT HOMEOWNERS ASSN INC.	85.67	YES	CANDLEWOOD SHORES TAX DISTRICT	0		
CT0720101	ASH WATER COMPANY, LLC	90.67	YES	SCWA TOWER FERRY DIVISION	5300		
CT0081011	BETHANY MOBILE HOME PARK	34.33	YES	CTWC NAUGATUCK REGION CENTRAL SYSTEM	250		
CT0184011	BROOKFIELD ELDERLY HOUSING	72.00	YES	AQUARION WATER CO OF CT BROOKFIELD	600		
CT0180171	BROOKFIELD HILLS CONDOMINIUM UNIT OWNERS	67.33	YES	STONY HILL VILLAGE	0	AQUARION WATER CO OF CT BERKSHIRE CORP	500
CT0579143	BRUNSWICK MIDDLE SCHOOL	82.33	YES	AQUARION SOUTHWESTERN FAIRFIELD COUNTY SYSTEMS	1000		
CT0180181	CANDLEWOOD ORCHARDS PROPERTY OWNERS CORP	89.00	YES	CANDLEWOOD SHORES TAX DISTRICT	500		
CT0347021	CANDLEWOOD PARK INC	54.00	YES	AQUARION WATER CO OF CT-CEDAR HEIGHTS	250	AQUARION WATER CO OF CT-BROOKFIELD	4200
CT0340141	CEDAR TERRACE PROP OWNERS ASSN	50.33	YES	AQUARION WATER CO OF CT CEDAR HEIGHTS	1100	AQUARION WATER CO OF CT BROOKFIELD	10000
CT0180121	CEDARBROOK OWNERS, INC.	40.33	YES	AQUARION WATER CO OF CT-BROOKFIELD	0		
CT1050011	CHADWICK HOMEOWNERS ASSN., INC.	87.00	YES	CTWC SHORELINE REGION SOUND VIEW	50		
CT0420071	CHATHAM APARTMENTS	89.00	YES	MALLARD COVE CONDOMINIUM ASSOCIATION	1200	PORTLAND WATER DEPARTMENT	39000
CT1378011	CLASSEE WATER SYSTEM - LATIMER POINT	60.33	YES	AQUARION WATER COMPANY OF CT- MYSTIC	0		
CT0590071	COLONIAL EFFICIENCY APARTMENTS	55.33	YES	AQAURION WATER CO OF CT MYSTIC	300		
CT0580061	CONNOLLYS TRAILER PARK	70.33	YES	JEWETT CITY WATER COPANY	350		

Table J-2							
PWS ID	System Name	Total Score	Feasible Interconnection	Closest PWS	Feet	Closest Large PWS	Feet
CT0340181	CORNELL HILLS ASSOC, INC	84.67	YES	DANBURY WATER DEPARTMENT	500		
CT1662051	COUNTRYSIDE APARTMENTS	69.00	YES	AQUARION WATER CO OF CT TLWC CLEARVIEW	0	WOLCOTT WATER DEPARTMENT	2100
CT1040061	COUNTRYSIDE DRIVE ASSOCIATION	77.00	YES	NORWICH PUBLIC UTILITIES	100		
CT0251021	CRESTVIEW CONDOMINIUM ASSOCIATION	36.67	YES	REGIONAL WATER AUTHORITY	250		
CT0860051	DEER RUN SUPPLY	45.00	YES	EAST LYME WATER AND SEWER COMMISSION	1800		
CT0420021	EDGEMERE CONDOMINIUM ASSN., INC.	68.33	YES	CTWC WESTCHESTER EAST	50		
CT0270041	EVERGREEN TRAILER PARK - SYSTEM #1	82.33	YES	EVERGREEN TRAILER PARK - SYSTEM #2	0	CTWC SHORELINE REGION GUILFORD SYSTEM	5600
CT0270091	EVERGREEN TRAILER PARK - SYSTEM #2	82.33	YES	EVERGREEN TRAILER PARK - SYSTEM #1	0	CTWC SHORELINE REGION GUILFORD SYSTEM	4400
CT0270101	EVERGREEN TRAILER PARK - SYSTEM #3	85.67	YES	EVERGREEN TRAILER PARK SYSTEMS #1, #2, #4	0	CTWC SHORELINE REGION GUILFORD SYSTEM	4400
CT0270111	EVERGREEN TRAILER PARK - SYSTEM #4	90.67	YES	EVERGREEN TRAILER PARK SYSTEMS #1, #2, #3	0	CTWC SHORELINE REGION GUILFORD SYSTEM	4400
CT0418011	FRANKLIN ACADEMY	70.33	YES	CTWC SHORELINE REGION CHESTER SYSTEM	12500		
CT0866301	FREEDOM VILLAGE ELDERLY HOUSING	86.67	YES	SCWA MONTVILLE DIVISION	50	SCWA NORTH STONINGTON DIVISION	8500
CT0180101	HICKORY HILLS	69.00	YES	CANDLEWOOD SHORES TAX DISTRICT	0		
CT0880031	IDLEVIEW MOBILE HOME PARK	77.33	YES	CTWC NAUGATUCK REGION CENTRAL SYSTEM	1000		
CT0860191	INDEPENDENCE VILLAGE ELDERLY HOUSING	96.33	YES	MONTVILLE WATER SUPPLY	500		
CT0180131	INDIAN FIELDS HOMEOWNERS ASSOCIATION	88.00	YES	AQUARION WATER COMPANY OF CT BROOKFIELD	8000		
CT0911061	INTERLAKEN WATER COMPANY	55.33	YES	KNOLLCREST TAX DISTRICT	0	DANBURY WATER DEPARTMENT	25000
CT0860141	JENSENS, INC. MARINA COVE RESIDENTIAL	82.33	YES	KITEMAUG ORCHARD ASSOCIATION	250	MONTVILLE WATER SUPPLY	4700
CT0860041	KITEMAUG ORCHARD ASSOCIATION, INC.	52.33	YES	JENSENS, INC. MARINA RESIDENTIAL	250	MONTVILLE WATER SUPPLY	2500

Table J-2

PWS ID	System Name	Total Score	Feasible Interconnection	Closest PWS	Feet	Closest Large PWS	Feet
CT0280051	KNOB HILL CONDOMINIUMS	75.67	YES	KNOB HILL CONDOMINIUMS, WELL #5	0	COLCHESTER WATER AND SEWER	19000
CT0280061	KNOB HILL CONDOMINIUMS, WELL #5	78.67	YES	KNOB HILL CONDOMINIUMS	0	COLCHESTER WATER AND SEWER	19000
CT0910081	KNOLLCREST TAX DISTRICT	96.67	YES	INTERLAKEN WATER COMPANY	0	DANBURY WATER DEPARTMENT	25000
CT1660011	LAKE HILLS VILLAGE CONDOMINIUMS	38.67	YES	WOLCOTT WATER DEPARTMENT	3000		
CT0971011	MASONICARE OF NEWTOWN	63.67	YES	AQUARION WATER COMPANY OF CT CHESTNUT TREE	450	AQUARION WATER CO OF CT NEWTOWN SYSTEM	7400
CT0501001	MEADOWBROOK MANOR LLC	79.00	YES	CTWC SHORELINE REGION CHESTER SYSTEM	1200		
CT0970071	MEADOWBROOK TERRACE MOBILE HOME PARK	70.33	YES	AQUARION WATER CO OF CT NEWTOWN SYSTEM	1100		
CT1051021	MIAMI BEACH WATER COMPANY	69.67	YES	CTWC SHORELINE REGION SOUND VIEW	0		
CT0815051	MIDDLEBURY COMMONS	62.00	YES	CTWC NAUGATUCK REGION CENTRAL SYSTEM	1200		
CT0363011	MOUNT SAINT JOHN SCHOOL	85.67	YES	CTWC SHORELINE REGION CHESTER SYSTEM	0		
CT0861051	MOUNTVIEW APARTMENTS	54.00	YES	MONTVILLE WATER SUPPLY	1000		
CT0270051	NOD HILL APARTMENTS	63.67	YES	CTWC SHORELINE REGION GUILFORD SYSTEM	750		
CT1021001	NORTHSTONE GARDENS	43.67	YES	SCWA CEDAR RIDGE DIVISION	500	WESTERLY WATER DEPARTMENT	11500
CT0860171	OAKRIDGE GARDENS, LLC	60.00	YES	SCWA-MONTVILLE DIVISION	1700		
CT0820501	OLD INDIAN TRAIL	90.67	YES	MIDDLETOWN WATER DEPARTMENT	6700		
CT1041001	PLEASURE VALLEY M.H.P. - SYSTEM #1	73.67	YES	PLEASURE VALLEY M.H.P. - SYSTEM #2, #3	0	NORWICH PUBLIC UTILITIES	5400
CT1041021	PLEASURE VALLEY M.H.P. - SYSTEM #2	73.67	YES	PLEASURE VALLEY M.H.P. - SYSTEM #1, #3	0	NORWICH PUBLIC UTILITIES	5400
CT1041031	PLEASURE VALLEY M.H.P. - SYSTEM #3	72.00	YES	PLEASURE VALLEY M.H.P. - SYSTEM #2, #1	0	NORWICH PUBLIC UTILITIES	5400
CT1140011	PRESTON PLAINS WATER COMPANY	80.67	YES	MASHANTUCKET PEQUOT TRIBAL NATION	0	LEDYARD WPCA HIGHLANDS SYSTEM	23000
CT0600041	QUONNIPAUG HILLS - MAIN SYSTEM	60.67	YES	QUONNIPAUG HILLS - SECTION I	800	CTWC SHORELINE REGION GUILFORD SYSTEM	40000

Table J-2							
PWS ID	System Name	Total Score	Feasible Interconnection	Closest PWS	Feet	Closest Large PWS	Feet
CT0606011	QUONNIPAUG HILLS - SECTION I	52.33	YES	QUONNIPAUG HILLS- MAIN SYSTEN	734	CTWC SHORELINE REGION GUILFORD SYSTEM	40000
CT0361011	RIDGEWOOD HILLS ASSOCIATION, SYSTEM #1	68.67	YES	RIDGEWOOD HILLS ASSOCIATION, SYSTEMS #2, #3, #4	0	CTWC SHORELINE REGION CHESTER SYSTEM	6000
CT0363031	RIDGEWOOD HILLS ASSOCIATION, SYSTEM #2	67.00	YES	RIDGEWOOD HILLS ASSOCIATION, SYSTEMS #1, #3, #4	0	CTWC SHORELINE REGION CHESTER SYSTEM	6000
CT0363041	RIDGEWOOD HILLS ASSOCIATION, SYSTEM #3	60.33	YES	RIDGEWOOD HILLS ASSOCIATION, SYSTEMS #1, #2, #4	0	CTWC SHORELINE REGION CHESTER SYSTEM	6000
CT0363051	RIDGEWOOD HILLS ASSOCIATION, SYSTEM #4	72.00	YES	RIDGEWOOD HILLS ASSOCIATION, SYSTEMS #1, #2, #3	0	CTWC SHORELINE REGION CHESTER SYSTEM	6000
CT0597021	ROGERS MOBILE HOME PARK - GROTON	53.67	YES	GROTON UTILITIES	2000		
CT0731031	ROUND HILL LLC - WELL# 2	61.67	YES	ROUND HILL WELL #1	0	JEWETT CITY WATER COMPANY	5500
CT1210011	SALEM MANOR CONDOMINIUMS, SYSTEM #1	54.00	YES	SALEM MANOR CONDOMINIUMS, SYSTEM #2	0	COLCHESTER WATER AND SEWER	22000
CT1219111	SALEM MANOR CONDOMINIUMS, SYSTEM #2	57.33	YES	SALEM MANOR CONDOMINIUMS, SYSTEM #1	0	COLCHESTER WATER AND SEWER	22000
CT0720011	SCWA, BARRETT DIVISION (BAR)	64.67	YES	LEDYARD WPCA HIGHLANDS SYSTEM	0		
CT0869011	SCWA, BIRCHWOOD DIVISION (BWD)	64.67	YES	MONTVILLE WATER SUPPLY	300		
CT1020011	SCWA, CEDAR RIDGE DIVISION	86.33	YES	NORTHSTONE GARDENS	500		
CT0860081	SCWA, CHESTERFIELD DIVISION	88.00	YES	SCWA ROBIN HILL DIVISION	7500	MONTVILLE WATER SUPPLY	10500
CT0727031	SCWA, CHRISWOOD DIVISION (CWD)	64.67	YES	LEDYARD WPCA HIGHLANDS SYSTEM	0		
CT0720081	SCWA, GRAY FARMS DIVISION (GRF)	88.00	YES	SCWA LEDYARD CENTER DIVISION	1100	LEDYARD WPCA HIGHLANDS SYSTEM	3500
CT0860131	SCWA, HILLCREST DIVISION (HLC)	89.67	YES	MONTVILLE WATER SUPPLY	0		
CT1370021	SCWA, LANTERN HILL DIVISION (LNH)	64.67	YES	AQUARIO WATER CO OF CT MYSTIC	0		
CT0720313	SCWA, LEDYARD CENTER DIVISION	91.33	YES	LEDYARD WPCA HIGHLANDS SYSTEM	0		
CT0867101	SCWA, ROBIN HILL DIVISION (RBN)	68.00	YES	SCWA MONTVILLE DIVISION	4000		
CT0869121	SCWA, SEVEN OAKS (OAK)	88.00	YES	SCWA MONTVILLE DIVISION	1700		
CT0347031	SHADY ACRES MOBILE HOME PARK	72.33	YES	DANBURY WATER DEPARTMENT	0		

Table J-2							
PWS ID	System Name	Total Score	Feasible Interconnection	Closest PWS	Feet	Closest Large PWS	Feet
CT0340231	SNUG HARBOR DEVELOPMENT CORP	70.67	YES	AQUA VISTA ASSOC, INC- UPPER SYSTEM	50	DANBURY WATER DEPARTMENT	4300
CT0861251	ST. THOMAS MORE SCHOOL-MAIN SYSTEM	72.00	YES	ST. THOMAS MORE SCHOOL-THE COVE	500	SCWA-MONTVILLE DIVISION	18000
CT0868011	ST. THOMAS MORE SCHOOL-THE COVE	68.67	YES	ST. THOMAS MORE SCHOOL-MAIN SYSTEM	500	SCWA-MONTVILLE DIVISION	18000
CT0180251	STONY HILL VILLAGE	88.67	YES	BROOKFIELD HILLS CONDOMINIUM UNIT OWNERS	0	AQUARION WATER CO OF CT BERKSHIRE CORP	550
CT1040091	SUNNY WATERS MOBILE HOME PARK	72.33	YES	NORWICH PUBLIC UTILITIES	800		
CT0826061	SYLVAN RIDGE CONDOMINIUMS	72.00	YES	MIDDLETOWN WATER DEPARTMENT	1200		
CT1440021	TASHUA VILLAGE ASSOCIATION, INC.	57.00	YES	AQAURION WATER CO OF CT MAIN SYSTEM	50		
CT0867071	THOMPSON HILL WATER CO - BEECHWOOD ACRES	65.67	YES	MONTVILLE WATER SUPPLY	750		
CT0280031	WESTCHESTER HILLS CONDOMINIUM ASSN.	57.33	YES	KNOB HILL CONDOMINIUMS	400	COLCHESTER WATER AND SEWER	20000
CT0810011	WESTOVER WATER CO	60.67	YES	CTWC NAUGATUCK REGION CENTRAL SYSTEM	0		
CT0421001	WESTSIDE MANOR	67.00	YES	CHATHAM ACRES ELDERLY HOUSING	1700	PORTLAND WATER DEPARTMENT	31000
CT0180161	WHISCONIER VILLAGE ASSOCIATION, INC.	45.67	YES	AQUARION WATER CO OF CT- NEW MILFORD	0		
CT0180201	WOODCREEK VILLAGE CONDOMINIUM ASSN, INC	77.00	YES	AQUARION WATER COMPANY OF CT WESTERN BROOKFIELD	75		

Table J-3 – Interconnections to Improve Resiliency

Goal was to identify small CWSs in the four coastal Connecticut counties with any of the following:

- One source of supply
- No storage or only bladder storage. Hydropneumatic storage will need to be reviewed vs. average day demand to determine if it is large enough to support the system without a source.
- Low CAT score (red).

The 78 following systems would be prioritized for interconnections from a resilience perspective:

PWSID	System Name	Municipality	CAT Color	Single Well	No Storage	Only Bladder Storage	Hydro-Pneumatic Storage	Average Day Demand (gpd)	Comment
CT0081011	BETHANY MOBILE HOME PARK	Bethany	Red	X		X		10,350	I believe Well #3 was installed recently – Check with DPH
CT0090114	ELMWOOD COURT LLC	Bethel	Yellow				X	4,050	Hydro tanks only total 380 gal.
CT0189971	39 HOP BROOK RD - APT COMPLEX	Brookfield	Yellow	X	X			2,700	
CT0184011	BROOKFIELD ELDERLY HOUSING	Brookfield	Green	X				2,775	
CT0180181	CANDLEWOOD ORCHARDS PROPERTY OWNERS CORP	Brookfield	Green			X		4,300	
CT0180161	WHISCONIER VILLAGE ASSOCIATION, INC.	Brookfield	Yellow	X				9,225	
CT0251021	CRESTVIEW CONDOMINIUM ASSOCIATION	Cheshire	Red	X				6,300	
CT0270041	EVERGREEN TRAILER PARK - SYSTEM #1	Clinton	Green	X		X		2,052	Four systems are immediately adjacent in park and could be consolidated to increase redundancy. Systems #1 and #2 already interconnected. Only System #4 has atmospheric storage.
CT0270091	EVERGREEN TRAILER PARK - SYSTEM #2	Clinton	Green	X			X	1,353	Hydro tank is ~120 gallons. Four systems are immediately adjacent in park and could be consolidated to increase redundancy. Systems #1 and #2 already interconnected. Only System #4 has atmospheric storage.
CT0270101	EVERGREEN TRAILER PARK - SYSTEM #3	Clinton	Green	X			X	3,361	Hydro tank is ~120 gallons. Four systems are immediately adjacent in park and could be consolidated to increase redundancy. Only System #4 has atmospheric storage.
CT0270051	NOD HILL APARTMENTS	Clinton	Yellow	X		X		3,600	
CT0280061	KNOB HILL CONDOMINIUMS, WELL #5	Colchester	Green	X				1,350	Knob Hill Condominiums System is adjacent and could be consolidated to increase redundancy.

PWSID	System Name	Municipality	CAT Color	Single Well	No Storage	Only Bladder Storage	Hydro-Pneumatic Storage	Average Day Demand (gpd)	Comment
CT0347021	CANDLEWOOD PARK INC	Danbury	Yellow			X		37,500	
CT0340141	CEDAR TERRACE PROP OWNERS ASSN	Danbury	Yellow				X	4,950	Hydro tank is only 120 gallons
CT0347031	SHADY ACRES MOBILE HOME PARK	Danbury	Green	X			X	9,286	Hydro tank is only 1,000 gallons.
CT0361011	RIDGEWOOD HILLS ASSOCIATION, SYSTEM #1	Deep River	Yellow				X	1,350	Hydro tank is only ~110 gallons. Interconnected with System #2, but no atmospheric storage in either system.
CT0363031	RIDGEWOOD HILLS ASSOCIATION, SYSTEM #2	Deep River	Yellow				X	1,350	Hydro tank is only ~110 gallons. Interconnected with System #1, but no atmospheric storage in either system.
CT0363041	RIDGEWOOD HILLS ASSOCIATION, SYSTEM #3	Deep River	Yellow				X	1,350	Hydro tank is only ~110 gallons. Interconnected with System #4, but no atmospheric storage in either system.
CT0363051	RIDGEWOOD HILLS ASSOCIATION, SYSTEM #4	Deep River	Green				X	1,350	Hydro tank is only ~110 gallons. Interconnected with System #3, but no atmospheric storage in either system.
CT0381011	TWIN MAPLES NURSING HOME	Durham	Green			X		7,500	
CT0419221	31 GRIST MILL RD	East Haddam	Yellow			X		2,250	
CT0413011	OAK GROVE SENIOR HOUSING CORP	East Haddam	Green				X	5,400	Hydro tank is only 3,000 gallons
CT0424011	CHATHAM ACRES ELDERLY HOUSING	East Hampton	Green	X				3,750	
CT0420071	CHATHAM APARTMENTS	East Hampton	Green	X				3,000	
CT0427011	MALLARD COVE CONDOMINIUM ASSN.	East Hampton	Red					8,000	
CT0421001	WESTSIDE MANOR	East Hampton	Yellow	X				2,250	
CT0500021	HEMLOCK APARTMENTS	Essex	Yellow	X				2,053	
CT0500011	HERITAGE COVE CONDOMINIUMS	Essex	Yellow				X	15,600	Hydro tank is only 10,000 gallons.
CT0501001	MEADOWBROOK MANOR LLC	Essex	Green	X			X	2,250	Hydro tank is only ~80 gallons.
CT0580061	CONNOLLYS TRAILER PARK	Griswold	Green	X		X		5,550	
CT0580031	LAKEVIEW MOBILE HOME PARK	Griswold	Yellow	X			X	7,425	Hydro tank is only 1,500 gallons.
CT0590071	COLONIAL EFFICIENCY APARTMENTS	Groton	Yellow				X	4,950	Hydro tank is only 3,950 gallons.
CT0597021	ROGERS MOBILE HOME PARK - GROTON	Groton	Yellow				X	4,275	Hydro tanks are only ~240 gallons.
CT0598011	WHIPPLES MOBILE HOME PARK	Groton	Red	X				11,000	This system may have connected to Aquarion – Mystic System – check with DPH
CT0606011	QUONNIPAUG HILLS - SECTION I	Guilford	Yellow	X				2,025	I believe this is somewhat adjacent to Quonnipaug Hills – Main System – these could be consolidated for redundancy.
CT0614021	HIGH MEADOW	Haddam	Yellow				X	2,850	Hydro tank is 3,000 gallons.
CT0711001	VILLAGE HILL APARTMENTS	Lebanon	Green	X		X		2,700	
CT0730031	LISBON MOBILE HOMES	Lisbon	Yellow	X		X		11,625	
CT0731021	ROUND HILL LLC - WELL# 1	Lisbon	Yellow		X			2,700	Interconnected with Round Hill LLC – Well #2 System – Neither system has storage
CT0731031	ROUND HILL LLC - WELL# 2	Lisbon	Yellow		X			2,700	Interconnected with Round Hill LLC – Well #1 System – Neither system has storage
CT0731011	TUNNEL HILL MOBILE HOME PARK	Lisbon	Yellow	X			X	3,000	Hydro tanks are only ~220 gallons.

PWSID	System Name	Municipality	CAT Color	Single Well	No Storage	Only Bladder Storage	Hydro-Pneumatic Storage	Average Day Demand (gpd)	Comment
CT0820501	OLD INDIAN TRAIL	Middlefield	Green	X				2,400	
CT0821001	REJA - RAINBOW SPRING WATER COMPANY	Middlefield	Yellow	X			X	2,700	Hydro tanks total ~240 gallons.
CT0859071	27 MAPLE DRIVE	Monroe	Red	X	X			2,850	
CT0869131	262 & 263-271 ROUTE 163	Montville	Red			X		2,550	May already be interconnected with Montville WPCA – Check with DPH
CT0860051	DEER RUN SUPPLY	Montville	Yellow	X			X	6,300	Hydro tanks only total 1,850 gal.
CT0861111	FOX LAUREL MOBILE HOME PARK, LLC	Montville	Green			X		3,000	
CT0866301	FREEDOM VILLAGE ELDERLY HOUSING	Montville	Green	X				3,225	
CT0860191	INDEPENDENCE VILLAGE ELDERLY HOUSING	Montville	Green	X				4,125	
CT0861051	MOUNTVIEW APARTMENTS	Montville	Yellow	X		X		7,875	
CT0860171	OAKRIDGE GARDENS, LLC	Montville	Yellow			X		5,250	
CT0860211	OAKRIDGE VILLAGE	Montville	Yellow				X	2,475	Hydro tanks are unknown size, but are four X-Trol tanks so total storage is likely no more than ~500 gpm.
CT0868011	ST. THOMAS MORE SCHOOL-THE COVE	Montville	Yellow	X		X		1,875	Relatively close to Saint Thomas More School – Main System
CT0866051	STONY BROOK MOBILE HOME PARK	Montville	Yellow			X		2,550	
CT0880031	IDLEVIEW MOBILE HOME PARK	Naugatuck	Green				X	4,200	Hydro tank is 8,000 gallons.
CT0911061	INTERLAKEN WATER COMPANY	New Fairfield	Yellow	X			X	2,714	Hydro tank is ~2,500 gallons. They wanted to go out of business – check with DPH (PURA Docket 14-04-22)
CT0990011	BLUE TRAILS WATER ASSOCIATION	North Branford	Green	X				17,100	
CT0990031	NORTHFORD GLEN CONDOMINIUM ASSOCIATION	North Branford	Red					6,300	
CT1020011	SCWA, CEDAR RIDGE DIVISION	North Stonington	Green	X			X	18,200	Hydro tank is only 3,500 gallons.
CT1040061	COUNTRYSIDE DRIVE ASSOCIATION	Norwich	Green	X			X	7,200	Hydro tanks only total ~480 gal.
CT1041001	PLEASURE VALLEY M.H.P. - SYSTEM #1	Norwich	Green	X				6,675	Three systems are immediately adjacent in park and could be consolidated to increase redundancy.
CT1041021	PLEASURE VALLEY M.H.P. - SYSTEM #2	Norwich	Green	X			X	5,475	Hydro tanks total ~360 gallons. Three systems are immediately adjacent in park and could be consolidated to increase redundancy.
CT1041031	PLEASURE VALLEY M.H.P. - SYSTEM #3	Norwich	Green	X			X	3,525	Hydro tanks total ~720 gallons. Three systems are immediately adjacent in park and could be consolidated to increase redundancy.
CT1051011	BOXWOOD CONDOMINIUM ASSOCIATION	Old Lyme	Yellow	X				2,100	
CT1050011	CHADWICK HOMEOWNERS ASSN., INC.	Old Lyme	Green				X	21,900	Hydro tank is only 5,000 gallons.
CT1056231	LAUREL HEIGHTS ASSOCIATION, INC.	Old Lyme	Green	X				3,375	
CT1059251	LYME ACADEMY APARTMENTS,LLC	Old Lyme	Yellow		X			3,600	
CT1050141	LYME REGIS, INC.	Old Lyme	Yellow	X			X	1,600	Hydro tanks total ~2,850 gallons.

PWSID	System Name	Municipality	CAT Color	Single Well	No Storage	Only Bladder Storage	Hydro-Pneumatic Storage	Average Day Demand (gpd)	Comment
CT1056221	LYMEWOOD ELDERLY HOUSING	Old Lyme	Yellow	X			X	3,750	Hydro tank is only 400 gallons.
CT1050131	MILE CREEK APARTMENTS	Old Lyme	Yellow				X	4,500	Hydro tanks total ~240 gallons.
CT1140021	LINCOLN PARK ELDERLY HOUSING	Preston	Green	X				2,500	
CT1180091	BROOKVIEW WATER COMPANY	Ridgefield	Yellow	X				4,125	
CT1219111	SALEM MANOR CONDOMINIUMS, SYSTEM #2	Salem	Yellow	X			X	1,875	Hydro tank is unknown size, but likely no more than ~120 gallons. Salem Manor Condominiums, System #1 is nearby and consolidation would increase redundancy.
CT1300071	OAKDALE MANOR WATER ASSOCIATION	Southbury	Yellow	X		X		3,000	
CT1370071	ARLINGTON ACRES MANUFACT HOUSE COMM, LLC	Stonington	Green				X	33,000	Hydro tank is only 5,000 gallons.
CT1440021	TASHUA VILLAGE ASSOCIATION, INC.	Trumbull	Yellow	X			X	2,625	Hydro tank is unknown size, but likely not larger than~200 gallons.
CT1479021	VOLUNTOWN HOUSING AUTHORITY	Voluntown	Yellow	X			X	3,150	Hydro tanks total ~660 gallons.
CT1660011	LAKE HILLS VILLAGE CONDOMINIUMS	Wolcott	Red				X	7,650	Hydro tank is only 5,000 gallons.

Notes: Number of wells and storage types from DPH-provided list. Average day demand from Final Water Supply Assessments dated December 2016 as prepared by the Western, Central, and Eastern Water Utility Coordinating Committees.

Table J-4

Municipalities	Source CWS	End CWS	Interconnection Route	Distance	Total Population Served	Currently Proposed by Utility?	Reason for Interconnection	Timeframe?	Interconnection Starting Elevation	Interconnection Ending Elevation	Interconnection Peak Elevation	Other CWS along route	Adjacent CWS 1	Additional Distance	Population Served	Adjacent CWS 2	Additional Distance	Population Served	Adjacent CWS 3	Additional Distance	Population Served	Adjacent CWS 4	Adjacent CWS 5	Additional Distance	Population Served	Adjacent CWS 6	Additional Distance	NTNCs along route	TNCs along route
Brookfield	Aquarion Water Company - Berkshire	Aquarion Water Company - Brookfield	Forest, White Turkey Road	2,400 feet	49	Yes	Consolidate systems/increase redundancy	5-Year	420	290	420	None																None	None
Brookfield	Aquarion Water company - Berkshire	Brookfield Hills Condominium Unit Owners (Yellow)	Park Lawn Drive, Vail Road	700 feet	193	No	Yellow scorecard system	N/A	440	440	445	Stony Hill Village (Green)	Stony Hill Village	0	392													None	None
Brookfield	Aquarion Water Company - Brookfield	Aquarion Water Company - Butternut	Sandy Lane, Old Grays Bridge Road, Grays Bridge Road, Stony Brook Road, West Whisconier Road, Pocoo Ridge Road, Knollcrest Drive	7,600 feet	124	Yes	Consolidate systems/increase redundancy	20-Year	330	500	500	None																Bobs Discount Furniture, Landmark Office Condo Association	Two
Brookfield	Aquarion Water Company - Brookfield	Whisconier Village Association, Inc. (Yellow)	Route 25	<100 feet	123	No	Yellow scorecard system	N/A	605	600	605	None																None	None
Brookfield	Aquarion Water Company - Brookfield	Cedarbrook Owners, Inc.	Route 25	<100 feet	96	No	Yellow scorecard system	N/A	615	615	615	None																None	None
Brookfield	Aquarion Water Company - Brookfield	Aquarion Water Company - Western Brookfield	North Mountain Road	2,800 feet	2712	Yes	Consolidate systems/increase redundancy	5-Year	280	440	440	None																None	None
Brookfield	Aquarion Water Company - Chimney Heights	Aquarion Water Company - Berkshire	Garella Road, Birch Drive	2,200 feet	2176	Yes	Consolidate systems/increase redundancy	5-Year	465	380	475	None																None	None
Groton	Aquarion Water Company - Mystic	Whipples Mobile Home Park	Private Driveway	500 feet	164	No	Red Scorecard System	N/A				None																None	None

Municipalities	Source CWS	End CWS	Interconnection Route	Distance	Total Population Served	Currently Proposed by Utility?	Reason for Interconnection	Timeframe?	Interconnection Starting Elevation	Interconnection Ending Elevation	Interconnection Peak Elevation	Other CWS along route	Adjacent CWS 1	Additional Distance	Population Served	Adjacent CWS 2	Additional Distance	Population Served	Adjacent CWS 3	Additional Distance	Population Served	Adjacent CWS 4	Adjacent CWS 5	Additional Distance	Population Served	Adjacent CWS 6	Additional Distance	NTNCs along route	TNCs along route
Seymour, Shelton	Aquarion Water Company - Valley	Aquarion Water Company - Main	Route 188, Housatonic River Crossing	10,000 feet	775308	Option	Emergency Interconnection / Redundant Supply	N/A	480	45	480	SCCRWA (additional supply), Aquarion - Hawkstone	SSCRWA	0	418900	Aquarion-Hawkstone	0	172										None	None
Brookfield	Aquaron Water Company - Western Brookfield	Candlewood Shores Tax District	Forest, Candlewood Lake Road, Candlewood Shores Road	1,400 feet	2662	No	Emergency interconnection/system redundancy	N/A	455	455	455	Candlewood Orchards Property Owners Corp (Green)	Candlewood Orchards Property Owners Corp	<50	144													None	None
Brookfield	Candlewood Shores Tax District	Hickory Hills (Yellow)	Hickory Hill Road	<100 feet	132	No	Yellow scorecard system	N/A	480	480	480	None																None	None
Middletown	Cromwell Fire District / MDC	Middletown Water Department	Route 3	700 feet	446222	No	Possible Emergency Interconnection	N/A	15	5	15	None																None	None
Colchester	CWC Westchester & Ponemah Village	Colchester Water & Sewer	Shailor Hill Road, Route 149, Pine Road, Cato Corner Road, Prospect Hill Road, Davidson Road, Mill Lane West, Van Cedarfield Road, Scofield Road, Route 16	24,000 feet	621	Option	Emergency Interconnection / Redundant Supply	N/A	465	305	465	CWC-Westchester Hills (Yellow) and Knob Hill Condominiums (Green) both 1,800 feet north along Route 149	CWC Westchester Hills	1800	225	Knob Hill Condominiums	1800	84										None	None
Bethany	CWC-Central (Naugatuck)	Bethany Mobile Home Park (Red)	Route 63	700 feet	138	No	Red Scorecard System	N/A	415	425	425	None																None	None
Essex, Old Saybrook	CWC-Guilford	CWC-Chester	Route 153	9,000 feet	38227	Yes	Increase redundancy	5-Year	45	35	65	None																Bolderdash, LLC (Middlesex Hospital Rehab Center)	None

Municipalities	Source CWS	End CWS	Interconnection Route	Distance	Total Population Served	Currently Proposed by Utility?	Reason for Interconnection	Timeframe?	Interconnection Starting Elevation	Interconnection Ending Elevation	Interconnection Peak Elevation	Other CWS along route	Adjacent CWS 1	Additional Distance	Population Served	Adjacent CWS 2	Additional Distance	Population Served	Adjacent CWS 3	Additional Distance	Population Served	Adjacent CWS 4	Adjacent CWS 5	Additional Distance	Population Served	Adjacent CWS 6	Additional Distance	NTNCs along route	TNCs along route
Old Saybrook, Old Lyme	CWC-Guilford	CWC-Soundview	Ferry Road, Route 156, Buttonball Road, Old Shore Road	21,000 feet	1648	Yes	Consolidate systems/increase redundancy	50-Year	20	20	45	Lyme Regis, Inc. (Yellow), Boxwood Condominium Assn (1,900' east on Ferry Road & Lyme Street)	Lyme Regis, Inc	1900	32	Boxwood Condominium Assn	1900	28										DEEP Marine Headquarters, Church of Christ the King,	Two
Old Lyme	CWC-Soundview	CWC-Point O' Woods	Route 156	5,000 feet	2656	Yes	Consolidate systems/increase redundancy	20-Year	45	25	65	None																None	None
East Hampton	East Hampton - Village Center	East Hampton - Royal Oaks	Walnut Avenue, Smith Street	3,500 feet	1459	As part of town water system	Consolidate systems/increase redundancy	20-Year	395	570	570	None																None	None
East Hampton	East Hampton Belltown Place Wellfield	East Hampton - Village Center	South Main Street, Main Street	3,200 feet		As part of town water system	New Town System wells	5-Year	515	380	515	None																East Hampton Community Center, Masonic Temple	Two
East Hampton	East Hampton Hampton Woods Wellfield	East Hampton - Village Center	Route 66	12,000 feet		As part of town water system	New town System wells	5-Year	570	435	575	CWC-Baker Hill, Chatham Apartments (Green), Mallard Cove Condominium Association (Red)	CWC- Baker Hill		203	Chatham Apartments		40	Mallard Cove Condominium		177							Lakeshore, LLC, American Distilling, Brooks Plaza, East Hampton Town Hall, McDonalds, East Hampton Mall	Eight

Municipalities	Source CWS	End CWS	Interconnection Route	Distance	Total Population Served	Currently Proposed by Utility?	Reason for Interconnection	Timeframe?	Interconnection Starting Elevation	Interconnection Ending Elevation	Interconnection Peak Elevation	Other CWS along route	Adjacent CWS 1	Additional Distance	Population Served	Adjacent CWS 2	Additional Distance	Population Served	Adjacent CWS 3	Additional Distance	Population Served	Adjacent CWS 4	Adjacent CWS 5	Additional Distance	Population Served	Adjacent CWS 6	Additional Distance	NTNCs along route	TNCs along route
East Hampton	East Hampton Oakum Dock Wellfield	East Hampton - Village Center	Oakum Dock Road, Route 66, Main Street	22,000 feet		As part of town water system	Need significant supply	20-Year	160	415	545	CWC-Spice Hill, Z, Inc. (Green) 1,500' south along Route 151, Chatham Acres Elderly Housing (Green) 500' south on private access, Westside Manor (Yellow), Mallard Cove (Red) 1,600 feet east along Route 66, Chatham Apartments (Green) 2,100 feet east along Route 66	CWC- Spice Hill		712	Z, Inc.	1500		Chatham Acres Elderly Housing	500		Westside Manor	Mallard Cove	1600		Chatham Apartments	2100	Chatham Corner Building (400 feet southeast along Sinco Place), more to the east on Route 66	Three in Cobalt, six others, more to the east along Route 66 (see Hampton Woods route)
Colchester, East Hampton	East Hampton WPCA (Future Town System)	Colchester Water & Sewer	Smith Street, Route 16	45,000 feet		Option	Emergency Interconnection / Redundant Supply	N/A	570	305	590	Gaia Gardens (Yellow) 1,700 feet to south along Gillettes Lane	Gaia Gardens	1700	276													Tri-Town Shopping Plaza	Five
Montville	East Lyme Water & Sewer	Deer Run Supply (Yellow)	Route 85	1,900 feet	84	No	Yellow scorecard system	N/A	210	190	210	None																None	None
Groton	Groton Utilities	Groton Long Point Association	Groton Long Point Road	<100 feet	2400	No	Redundant connection for emergency purposes	N/A	15	15	15	None																None	None
Ledyard, Preston	Ledyard WPCA	Norwich Public Utilities	Route 12	1,200 feet	44649	Yes	Redundant Thames River connection / emergency supply	50-Year	15	35	35	None																None	None
Ledyard	Ledyard WPCA-Gales Ferry	SCWA-Tower / Ferry View	Ferry View Drive	<100 feet	4748	Yes	Emergency Interconnection / Redundant Supply	5-Year	100	100	100	None																None	None
Ledyard	Ledyard WPCA-Gales Ferry	Ledyard WPCA-Highlands	Route 214	9,100 feet	4581	No	Consolidate systems/looping	N/A	165	295	165	None																41 Village Lane Office Park	One
Ledyard	Ledyard WPCA-Highlands	SCWA-Barrett	Hill Street	<100 feet	300	Yes	Emergency Interconnection / Redundant Supply	5-Year	320	320	320	None																None	None

Municipalities	Source CWS	End CWS	Interconnection Route	Distance	Total Population Served	Currently Proposed by Utility?	Reason for Interconnection	Timeframe?	Interconnection Starting Elevation	Interconnection Ending Elevation	Interconnection Peak Elevation	Other CWS along route	Adjacent CWS 1	Additional Distance	Population Served	Adjacent CWS 2	Additional Distance	Population Served	Adjacent CWS 3	Additional Distance	Population Served	Adjacent CWS 4	Adjacent CWS 5	Additional Distance	Population Served	Adjacent CWS 6	Additional Distance	NTNCs along route	TNCs along route
Ledyard	Ledyard WPCA-Highlands	SCWA-Christwood	Chriswood Terrace	800 feet	164	Yes	Emergency Interconnection / Redundant Supply	5-Year	235	235	235	None																None	None
Ledyard	Ledyard WPCA-Highlands	SCWA-Ledyard Center	Fairway Drive	300 feet	196	Yes	Emergency Interconnection / Redundant Supply	5-Year	315	315	315	None																None	None
Middletown	Middletown Water Department	Connecticut Valley Hospital	Eastern Drive	<100 feet	3132	No	Emergency interconnection to replace hydrant to hydrant connection	N/A	115	130	130	None																None	None
Durham, Middlefield, Middletown	Middletown Water Department	Town of Durham - Durham Center	Route 17	12,000 feet	140	Yes	Serve expanded Durham Center system	5-Year	360	180	360	Old Indian Trail (Green) 2,800' west along Snell Road and private access	Old Indian Trail	2800	32													Durham Manufacturing Company (would be consolidated into expanded Durham Center System	12 which would be consolidated into expanded Durham Center System
East Hampton, Middletown	Middletown Water Department / CVH / Pratt & Whitney	East Hampton - Village Center	River Road, Road A, CT River Crossing to Oakum Dock Wellfield	3,000 to 20,000 feet	366	Option	Need significant supply	N/A	15	10	170	None																NRG Middletown Operations	None
Montville	Montville WPCA	SCWA-Birchwood (Yellow)	Briarwood Park	400 feet	108	Yes	Consolidation by Montville	50-Year	190	255	300	None																None	None
Montville	SCWA-Hillcrest Division (Green)	SCWA-Chesterfield (Green) & Montville High and Middle School	Gay Hill Road, Old Colchester Road	8,500 feet	1824	Yes	Schools need high quality source	5-Year	265	410	450	None																The two schools	Two
Montville	Montville WPCA	SCWA-Mohegan	Occum Lane	<100 feet	2728	Yes	Consolidation by Montville	50-Year	200	200	200	None																None	None
Montville	Montville WPCA	Jensens, Inc. Marina Cove (Green)	Massapeag Road, Kitemaug Road	5,000 feet	560	Possible	Takeover desired, Green scorecard system	N/A	55	50	55	Kitemaug Orchard Association (Yellow)	Kitemaug Orchard Association	0	490													None	None
Montville	Montville WPCA	Mountview Apartments (Yellow)	Private Driveway	1,200 feet	105	No	Yellow scorecard system	N/A	230	270	270	None																None	None

Municipalities	Source CWS	End CWS	Interconnection Route	Distance	Total Population Served	Currently Proposed by Utility?	Reason for Interconnection	Timeframe?	Interconnection Starting Elevation	Interconnection Ending Elevation	Interconnection Peak Elevation	Other CWS along route	Adjacent CWS 1	Additional Distance	Population Served	Adjacent CWS 2	Additional Distance	Population Served	Adjacent CWS 3	Additional Distance	Population Served	Adjacent CWS 4	Adjacent CWS 5	Additional Distance	Population Served	Adjacent CWS 6	Additional Distance	NTNCs along route	TNCs along route
Norwich, Sprague	Norwich Public Utilities	Sprague Water & Sewer	Route 97	9,600 feet	1267	Option	Increase redundancy (floodprone wells)	N/A	115	75	145	Pleasure Valley MHP (3 systems, Green) 1,300 feet along Atlantic Avenue	Pleasure Valley System #1	1300	89	Pleasure Valley System #2	1300	73	Pleasure Valley System #3	1300	47							None	One
Montville, Preston	Norwich Public Utilities	Montville WPCA / Mohegan Tribe	Route 2A	9,100 feet	1300	Yes	Redundant Thames River connection	50-Year	70	155	160	Mohegan Tribe	Mohegan Tribe	200	NA													None	None
Colchester	Norwich Public Utilities	Colchester Water & Sewer	Mahoney Road, Chestnut Hill Road	19,000 feet	4020	Option	Emergency Interconnection / Redundant Supply	N/A	305	535	545	None																None	None
Franklin	NPU Shetucket River Wellfield	Norwich Public Utilities	Route 32	41,000 feet	36067	Option	New source of supply	N/A	160	125	450	None																Hilltop Realty, LLC, Southern New England Egg Co. (700 feet to east), Franklin Commons	Six, a seventh is 600 feet south along Route 32
Franklin, Windham	NPU Shetucket River Wellfield	Windham Water Works	Route 32	4,800 feet	57281	Option	Emergency interconnection / system redundancy (WWW only has one source)	N/A	160	185	250	None																None	None
East Hampton, Portland	Portland Water Department / MDC	East Hampton - Village Center	Collins Hill Road, Jobs Pond Road, Pepperridge Road, Penfield Hill Road, Middle Haddam Road, Grist Mill Lane (connect to future water main on Route 66)	15,000 feet	366	Option	Need significant supply	N/A	225	160	445	None																None	None
Chehsire	SCCRWA	Crestview Condominium Association (Red)	Private Driveway	200 feet	84	No	Red Scorecard System	N/A	260	270	270	None																None	None
Wallingford	SCCRWA	Wallingford Water Division	Pond Hill Road	<100 feet	37267	Yes	Emergency interconnection	5-Year	65	65	65	None																None	None

Municipalities	Source CWS	End CWS	Interconnection Route	Distance	Total Population Served	Currently Proposed by Utility?	Reason for Interconnection	Timeframe?	Interconnection Starting Elevation	Interconnection Ending Elevation	Interconnection Peak Elevation	Other CWS along route	Adjacent CWS 1	Additional Distance	Population Served	Adjacent CWS 2	Additional Distance	Population Served	Adjacent CWS 3	Additional Distance	Population Served	Adjacent CWS 4	Adjacent CWS 5	Additional Distance	Population Served	Adjacent CWS 6	Additional Distance	NTNCs along route	TNCs along route
Montville	SCWA-Chesterfield (Montville WPCA)	SCWA-Robin Hill	Old Colchester Road, Black Ash Road	8,200 feet	912	No	Yellow scorecard system	N/A	355	495	495	None																None	None
Ledyard	SCWA-Gray Farms	SCWA-Ledyard Center	Route 214, Forest	1,400 feet	656	No	Green scorecard systems/increase redundancy	N/A	205	250	250	None																None	None
Montville	SCWA-Montville	SCWA-Robin Hill	Chapel Hill Road, Black Ash Road	5,100 feet	388	No	Yellow scorecard system	N/A	605	540	605	None																None	None
Montville	SCWA-Montville	Freedom Village Elderly Housing (Green)	Liberty Road	300 feet	43	No	Green scorecard system	N/A	515	525	525	None																None	None
Montville	SCWA-Montville	SCWA-Seven Oaks	Old Colchester Road	2,000 feet	26	No	Consolidate systems/increase redundancy	N/A	485	480	485	None																None	None
Montville	SCWA-Montville	Oakridge Gardens, LLC	Williams Road	2,000 feet	70	No	Yellow scorecard system	N/A	465	365	465	None																None	One (600 feet north on Williams Road)
Waterford	Waterford WPCA	Waterford Country School (Green)	Vauxhall Street, Hunts Brook Road	4,700 feet	180	No	Green scorecard system	N/A	240	190	295	None																None	None
East Lyme	Waterford WPCA	East Lyme Water & Sewer	Route 1	5,200 feet	31823	No	Redundant connection for water banking project	N/A	10	50	60	None																None	None

Table J-5 Potential Interconnections Between Southern and Northern Counties

Municipalities	Source CWS	End CWS	Interconnection Route	Distance	Total Population Served	Currently Proposed by Utility?	Reason for Interconnection	Timeframe?	Interconnection Starting Elevation	Interconnection Ending Elevation	Interconnection Peak Elevation	Staring Hydraulic Grade Line	Ending Hydraulic Grade Line	Other CWS along route	Adjacent CWS 1	Additional Distance	Population Served
Franklin, Windham	NPU Shetucket River Wellfield	Windham Water Works	Route 32	4,800 feet	57,281	Option	Emergency interconnection / system redundancy (WWW only has one source)	N/A	160	185	250			None			
Southbury, Woodbury	Heritage Village Water Company	Aquarion Water Co of CT- Woodbury	Route 6	1,700 feet	8,942	No	Increase Supply/Redundancy	N/A	235	255	255						
Southbury, Woodbury	Heritage Village Water Company	Woodlake Tax District	Route 67, Transylvania Road	13,000 feet	912	No	Increase Supply/Redundancy	N/A	250	335	335						
Waterbury, Bristol, Plymouth	Waterbury Raw Water	Bristol Water Department (Reservoir #1)	Route 6, Route 109	40,000 feet	57,686	Yes	Increase Supply/Redundancy	N/A	500	600	775			CTWC- Naug. Region Terryville			
Wolcott, Bristol	Regional Water Authority	Bristol Water Department	Woodtick Road	35,000 feet	470,979	Yes	Increase Supply/Redundancy	N/A	730	755	1000						
Cheshire, Southington	Regional Water Authority	Southington Water Department	Knoffer Drive	<100	461,969	Yes	Increase Supply/Redundancy	N/A	160	160	160						
Meriden, Berlin	Meriden Water Division	Kensington Fire District	Chamberlain Highway (Route 71)	18,200 feet	65,994	Yes	Increase Supply/Redundancy	N/A	290	245	355						
Rocky Hill, Cromwell	Metropolitan District Commission	Cromwell Fire District	Shunpike Road (Route 3)	<100	405,203	Yes	Increase Supply/Redundancy	N/A	140	140	140						
Plainfield, Griswold	CTWC- Crystal Plainfield	CTWC-Gallup-Country Mobile	Plainfield Road (Route 12), Norman Road, Voluntown Road	47,000 feet	8,739	Yes	Increase Supply/Redundancy	N/A	175	295	330			Jewett City Water Company	Connolly Trailer Park	<100 feet	74

APPENDIX K

Private Well Parcel Statistics

Town	Assumed Well Status	Count	Sum Acres	Mean Acres	Min Acres	Max Acres	Range Acres	Std Dev Acres
Ansonia	Municipal Space No Well	4	24.20873666	6.052184165	0.463172674	11.78764725	11.32447457	4.74758959
	Open Space	2	64.9586277	32.47931385	23.64070702	41.31792068	17.67721367	12.49967766
	Private Well	80	51.65831257	0.645728907	0.030041277	14.54138851	14.51134723	1.636654835
Beacon Falls	DEEP Property No Well	2	560.4997101	280.249855	136.274826	424.224884	287.950058	203.6114386
	Municipal Space No Well	4	166.848884	41.712221	0.259025007	58.92664719	58.66762218	27.905508
	Open Space	25	654.0276312	26.16110525	0.530573785	119.4671478	118.936574	30.34421873
	Private Well	426	719.0718918	1.687962187	0.095277607	38.50912857	38.41385096	3.669658279
Bethany	DEEP Property No Well	4	74.40072441	18.6001811	8.857193947	35.01419067	26.15699673	12.01088253
	Municipal Space No Well	27	356.0532622	13.18715786	0.307670683	69.86229706	69.55462638	20.54078444
	Open Space	80	4424.327271	55.30409089	1.223107934	543.7822266	542.5591186	83.68664222
	Private Well	2177	6695.299949	3.075470808	0.014455081	65.33317566	65.31872058	4.627226099
Bethel	DEEP Property No Well	12	386.9118012	32.2426501	0.625233591	139.5604553	138.9352217	48.70866125
	Municipal Space No Well	56	564.0220673	10.07182263	3.03028E-05	158.6366272	158.6365969	24.75691326
	Open Space	86	1428.0406	16.60512326	0.023035355	256.3871765	256.3641412	34.94703792
	Private Well	2949	4885.151318	1.656545038	5.78966E-08	65.89157867	65.89157862	2.737216837
Bozrah	DEEP Property No Well	11	452.7951509	41.16319553	0.510704756	228.7016907	228.1909859	66.51917677
	Municipal Space No Well	21	537.1158622	25.57694582	0.075551212	340.3352966	340.2597454	76.32113725
	Open Space	100	5541.033944	55.41033944	1.722446084	373.9172058	372.1947597	53.77451093
	Private Well	859	3899.650386	4.539755979	0.008138501	76.18296051	76.17482201	7.774419626
Branford	DEEP Property No Well	4	18.23151779	4.557879448	1.318249702	11.79081726	10.47256756	4.899155252
	Municipal Space No Well	38	398.773254	10.494033	0.005076469	115.0065231	115.0014467	24.05983649
	Open Space	62	600.2263961	9.681070905	0.094300121	45.84713364	45.75283352	11.58962757
	Private Well	385	650.6915027	1.690107799	0.00035309	40.2921524	40.29179931	3.899951491
Bridgeport	Municipal Space No Well	3	104.0685234	34.6895078	10.63696861	68.23577118	57.59880257	29.95001859
	Open Space	4	1.209382638	0.30234566	0.114376478	0.561356306	0.446979828	0.223119242
	Private Well	106	61.28899446	0.578198061	3.83663E-06	9.2846241	9.284620263	1.322053548
Brookfield	Municipal Space No Well	33	542.0457624	16.42562916	0.629260421	160.7299805	160.10072	30.03778783
	Open Space	80	1171.915701	14.64894627	0.30863151	101.3642197	101.0555882	20.02349747

	Private Well	4157	6609.534708	1.589977077	1.295E-06	65.92366791	65.92366661	2.324008541
Cheshire	DEEP Property No Well	6	204.8777275	34.14628792	8.601348877	79.42569733	70.82434845	24.2444273
	Municipal Space No Well	15	228.7282225	15.24854817	1.954175115	43.45721436	41.50303924	14.38709267
	Open Space	62	1741.100131	28.08226017	1.115208745	364.2521973	363.1369885	64.69511656
	Private Well	1079	2447.612489	2.268408239	0.02140311	65.87030792	65.84890481	3.627089347
Chester	DEEP Property No Well	45	3180.10423	70.66898288	0.060828414	996.107666	996.0468376	183.1268126
	Municipal Space No Well	7	125.6264887	17.94664124	0.706196845	72.50401306	71.79781622	28.82759909
	Open Space	58	1422.536907	24.52649839	0.174361706	112.2005081	112.0261464	26.61942318
	Private Well	1073	3287.483294	3.063824133	0.01454311	69.83971405	69.82517094	5.102620851
Clinton	DEEP Property No Well	15	344.828125	22.98854167	0.674440145	133.4396362	132.7651961	36.11615638
	Municipal Space No Well	32	493.0857705	15.40893033	0.619053602	141.772995	141.1539414	29.47311279
	Open Space	38	543.4551852	14.30145224	0.193296999	68.31482697	68.12152997	15.73901487
	Private Well	1851	3424.530208	1.850097357	0.025875127	49.91153336	49.88565823	3.056809602
Colchester	DEEP Property No Well	37	2920.430756	78.93056098	0.001610512	957.9525146	957.9509041	207.8777708
	Municipal Space No Well	10	22.1822993	2.21822993	0.021512313	6.20053196	6.179019647	2.189973643
	Open Space	172	7301.155742	42.4485799	0.028062511	252.4178162	252.3897537	46.47715092
	Private Well	4091	15827.88757	3.868953208	4.66325E-06	78.09880829	78.09880363	7.691514037
Cromwell	DEEP Property No Well	1	7.762981892	7.762981892	7.762981892	7.762981892	0	0
	Municipal Space No Well	18	25.38952993	1.41052944	0.04839782	13.70942974	13.66103192	3.438652718
	Open Space	31	286.2736682	9.234634458	0.377442986	48.77675247	48.39930949	11.14743647
	Private Well	411	132.4396766	0.322237656	0.000671145	28.47200012	28.47132898	1.951690977
Danbury	DEEP Property No Well	19	487.211181	25.64269374	0.00399441	283.5921326	283.5881382	68.09207209
	Municipal Space No Well	71	703.3759545	9.906703584	0.009390786	133.6037598	133.594369	21.08295618
	Open Space	194	3030.704027	15.62218571	0.00030183	210.0159607	210.0156589	31.48178352
	Private Well	7006	8006.809568	1.142850352	6.63932E-08	79.89896393	79.89896386	2.607987936
Darien	DEEP Property No Well	1	0.723814249	0.723814249	0.723814249	0.723814249	0	0
	Likely no well - per LDH	107	113.4049305	1.059859163	0.071830921	3.672900677	3.601069756	0.833881778
	Municipal Space No Well	15	30.78168222	2.052112148	0.058706127	13.51976776	13.46106163	3.289873629
	Private Well	610	1131.379994	1.854721302	0.00649695	10.64186382	10.63536687	1.076244114
Deep River	DEEP Property No Well	34	1238.075812	36.41399447	0.003878635	263.7009277	263.6970491	63.08573523

	Municipal Space No Well	38	1008.92759	26.55072604	0.076196827	457.1191406	457.0429438	75.46721954
	Open Space	58	2213.881607	38.17037253	1.39653933	453.4443359	452.0477966	69.99685809
	Private Well	1243	3542.311909	2.849808454	0.001137428	79.33281708	79.33167965	5.546999297
Derby	Open Space	3	40.37474298	13.45824766	0.239605427	33.29611206	33.05650663	17.4941057
	Private Well	88	81.37708966	0.924739655	0.000150708	7.143274784	7.143124076	1.064616507
Durham	DEEP Property No Well	32	1960.510607	61.26595646	0.999823749	329.274292	328.2744682	96.07904634
	Municipal Space No Well	56	1681.136252	30.02029021	0.029384868	155.6229706	155.5935857	38.39994029
	Open Space	141	4562.565503	32.35862059	0.502464116	301.4533081	300.950844	53.84012994
	Private Well	3024	9277.689294	3.068018946	0.000825402	76.64492798	76.64410258	6.449535689
East Haddam	DEEP Property No Well	83	3308.381603	39.86001932	0.011035834	351.196991	351.1859551	81.94341207
	Municipal Space No Well	166	4066.325604	24.49593737	0.030658511	676.0704346	676.0397761	75.09155273
	Open Space	178	10303.49082	57.88477991	0.362624109	325.0527039	324.6900797	64.71031512
	Private Well	4793	16740.89797	3.492780715	9.65069E-06	100.9232635	100.9232539	7.415877588
East Hampton	DEEP Property No Well	56	3894.239796	69.53999636	0.00134256	577.8943481	577.8930056	126.7274667
	Municipal Space No Well	42	430.4684883	10.24924972	0.015144437	169.6016998	169.5865554	28.10472862
	Open Space	190	5900.840193	31.05705365	1.030150056	228.3450012	227.3148512	36.22793465
	Private Well	4969	11244.69887	2.262970189	2.17771E-05	74.88121033	74.88118855	5.196637357
East Haven	DEEP Property No Well	3	10.68041661	3.560138869	0.117802642	7.177751541	7.059948899	3.533236616
	Municipal Space No Well	21	5.630309499	0.268109976	0.01076239	4.763897419	4.753135029	1.032382567
	Open Space	28	221.6582904	7.916367515	0.114903122	30.98300934	30.86810622	7.975347309
	Private Well	391	328.396844	0.839889627	0.006256273	21.27058792	21.26433165	2.092229132
East Lyme	DEEP Property No Well	14	1508.450755	107.7464825	0.353091449	611.8219604	611.468869	192.9310433
	Municipal Space No Well	23	1911.968222	83.12905312	0.004568509	785.9516602	785.9470916	185.4048876
	Open Space	87	3841.456228	44.15466928	0.081968881	1050.228638	1050.146669	116.9365703
	Private Well	1625	3362.800148	2.069415476	3.43957E-06	79.24827576	79.24827232	6.577969389
Easton	DEEP Property No Well	119	2246.479526	18.87797921	0.195673198	454.4455261	454.2498529	50.67760528
	Municipal Space No Well	30	384.8011627	12.82670542	0.014237744	129.7295837	129.715346	28.90809737
	Open Space	100	5359.479015	53.59479015	0.734685779	553.1516113	552.4169255	81.87127723
	Private Well	1960	7153.910558	3.649954366	1.99783E-05	53.40594482	53.40592485	3.801046829
Essex	DEEP Property No Well	6	13.51963126	2.253271877	0.096329443	7.896582127	7.800252683	2.865311176

	Municipal Space No Well	34	556.4879746	16.36729337	0.069670513	113.216423	113.1467525	30.71875745
	Open Space	89	760.8795304	8.549208207	0.081355475	68.78185272	68.70049725	11.45909339
	Private Well	1621	2872.254608	1.771902905	0.007863289	51.01236343	51.00450015	3.087154721
Fairfield	DEEP Property No Well	9	142.8335488	15.87039431	0.432140946	61.71932983	61.28718889	20.40519286
	Municipal Space No Well	31	272.2128976	8.781061212	0.057470988	58.32919693	58.27172594	12.52813149
	Open Space	31	171.6007423	5.535507817	0.087959759	57.2857132	57.19775344	10.51995163
	Private Well	385	770.9429522	2.002449227	0.007421306	11.60289192	11.59547062	1.506113109
Franklin	DEEP Property No Well	10	706.4831858	70.64831858	10.6066761	184.1316833	173.5250072	55.86511705
	Municipal Space No Well	14	361.9817945	25.85584247	0.764582217	93.76229095	92.99770874	32.44971351
	Open Space	127	6335.771475	49.88796437	0.327572376	579.8250122	579.4974398	76.38712109
	Private Well	942	4605.366878	4.888924499	0.09692952	78.71701813	78.62008861	8.88103741
Greenwich	DEEP Property No Well	7	85.69387399	12.241982	0.012524626	38.58409882	38.57157419	16.16837278
	Municipal Space No Well	185	2712.087908	14.65993464	0.00106928	291.8632813	291.862212	41.14263399
	Open Space	65	1063.173879	16.35652121	0.073993802	125.5546417	125.4806479	26.64900873
	Private Well	3058	9970.684164	3.260524579	0.001627257	77.91654968	77.91492243	4.094208835
Griswold	DEEP Property No Well	81	4809.44043	59.37580778	0.000136966	1044.109375	1044.109238	154.0207088
	Municipal Space No Well	22	316.1628904	14.37104047	0.005896606	98.7037735	98.69787689	27.90566665
	Open Space	162	6359.833548	39.25823178	0.049706511	381.2493896	381.1996831	50.48839263
	Private Well	3003	10282.30794	3.424011967	4.91293E-08	78.51966095	78.5196609	7.855143261
Groton	DEEP Property No Well	13	808.5749016	62.19806935	0.167660072	400.617218	400.4495579	125.4998164
	Municipal Space No Well	82	212.2919672	2.58892643	9.48025E-06	41.95491791	41.95490843	7.473591421
	Open Space	220	2519.790206	11.45359184	6.9198E-06	196.0848389	196.0848319	29.73820768
	Private Well	1553	2905.352185	1.870799862	1.20982E-08	74.00895691	74.0089569	5.715987943
Guilford	DEEP Property No Well	21	936.8458514	44.61170721	1.054683924	293.5989075	292.5442235	83.97353126
	Municipal Space No Well	150	1421.756365	9.478375765	0.032479286	111.1289063	111.096427	16.57937599
	Open Space	188	7532.398856	40.06595136	0.265598387	464.2413635	463.9757651	76.86295306
	Private Well	5732	12227.58013	2.13321356	0.002132782	78.19076538	78.1886326	4.475633707
Haddam	DEEP Property No Well	99	6275.707847	63.39098836	0.032759283	1718.386841	1718.354082	207.2713458
	Municipal Space No Well	68	639.1350372	9.399044665	0.109137028	157.9244843	157.8153472	22.65308537
	Open Space	154	7526.844586	48.8756142	0.705866516	1177.613037	1176.907171	110.4701193

	Private Well	3721	13818.88518	3.713755761	0.002984377	75.81898499	75.81600061	7.11732387
Hamden	DEEP Property No Well	75	1595.909631	21.27879509	0.016457302	500.4230652	500.4066079	60.62220366
	Municipal Space No Well	42	399.0578662	9.501377766	0.127472043	100.7814178	100.6539458	21.15799069
	Open Space	86	1102.484222	12.81958397	0.18632929	201.7698975	201.5835682	25.58961373
	Private Well	907	1973.323839	2.175660242	0.004309044	72.15946198	72.15515293	4.437395448
Killingworth	DEEP Property No Well	47	2763.044612	58.78818322	0.975488782	795.7436523	794.7681636	125.0856851
	Municipal Space No Well	47	1544.032888	32.85176358	0.147470221	515.562439	515.4149687	90.77521688
	Open Space	97	5409.431077	55.76733069	1.318132758	464.3401184	463.0219857	79.24496165
	Private Well	2578	12949.14185	5.02294098	0.017958634	79.25918579	79.24122716	7.584316296
Lebanon	DEEP Property No Well	28	1461.412723	52.19331155	0.021779936	359.447113	359.4253331	80.66356285
	Municipal Space No Well	90	752.9674246	8.366304717	0.000580013	343.2229004	343.2223204	38.04894152
	Open Space	356	16061.57964	45.11679673	0.017227998	305.3052063	305.2879783	49.89791547
	Private Well	3191	15346.74271	4.809383489	3.24847E-06	84.69072723	84.69072399	9.724194846
Ledyard	DEEP Property No Well	14	349.3713576	24.95509697	0.001209421	195.5262604	195.525051	55.96517798
	Municipal Space No Well	320	3594.708589	11.23346434	2.95043E-09	224.5255127	224.5255127	27.98222764
	Open Space	270	7029.325144	26.03453757	0.000311483	725.111084	725.1107725	68.61814255
	Private Well	3178	8250.270134	2.596057311	1.42319E-06	74.05621338	74.05621196	6.655608879
Lisbon	DEEP Property No Well	1	5.285867214	5.285867214	5.285867214	5.285867214	0	0
	Municipal Space No Well	17	241.9219034	14.2307002	0.719039977	64.90801239	64.18897241	21.96514808
	Open Space	160	4045.814191	25.28633869	0.04124707	197.266449	197.2252019	35.8991773
	Private Well	1571	5097.388976	3.244677897	0.000198594	75.8399353	75.83973671	6.928082516
Lyme	DEEP Property No Well	29	2862.258838	98.69858064	0.030065997	1348.103027	1348.072961	274.4024435
	Municipal Space No Well	61	1157.897625	18.98192828	0.031390805	276.3095703	276.2781795	41.87643445
	Open Space	179	8049.760957	44.9707316	0.121379316	412.685791	412.5644117	64.37530877
	Private Well	1446	7959.980521	5.504827469	0.00792257	74.40679932	74.39887675	9.265278395
Madison	DEEP Property No Well	17	559.2388172	32.89640101	0.088727422	110.5992126	110.5104852	39.7766157
	Municipal Space No Well	166	1837.196306	11.06744763	1.70754E-05	430.4027405	430.4027234	39.9964434
	Open Space	151	7086.64085	46.93139636	0.067342877	2671.757813	2671.69047	233.111815
	Private Well	4543	7816.820266	1.720629598	4.78478E-05	71.95757294	71.95752509	2.597309478
Meriden	DEEP Property No Well	1	5.165017128	5.165017128	5.165017128	5.165017128	0	0

	Municipal Space No Well	19	432.9209852	22.78531501	0.321282506	323.5488586	323.2275761	74.16696722
	Open Space	77	802.041926	10.41612891	0.079794832	125.0138931	124.9340983	21.16691256
	Private Well	299	292.0559587	0.976775782	0.005538754	40.89017868	40.88463993	3.219209354
Middlebury	DEEP Property No Well	3	20.43818665	6.812728882	5.659934521	8.429861069	2.769926548	1.442161739
	Municipal Space No Well	41	977.6574965	23.84530479	0.027778929	457.9009094	457.8731305	72.88842975
	Open Space	393	2745.501999	6.986010176	0.029801738	268.013031	267.9832293	21.00752269
	Private Well	1656	3839.731144	2.318678227	7.46502E-08	67.516716	67.51671593	4.646382508
Middlefield	DEEP Property No Well	14	182.2342705	13.01673361	0.01119511	119.4271011	119.415906	31.22747127
	Municipal Space No Well	53	876.0588716	16.52941267	0.067781053	109.8432617	109.7754807	26.20887053
	Open Space	123	3038.221986	24.70099176	0.574935198	672.8903198	672.3153846	66.06317125
	Private Well	1954	3613.22243	1.849141469	0.000998989	61.32290649	61.32190751	4.602322112
Middletown	DEEP Property No Well	22	295.5573604	13.43442547	0.083783492	59.60703278	59.52324928	21.03983852
	Municipal Space No Well	31	348.9539326	11.25657847	0.188839316	86.37398529	86.18514597	20.82566095
	Open Space	354	7296.761212	20.61231981	0.064203486	487.6335144	487.5693109	45.98822179
	Private Well	2078	4517.91621	2.174165645	3.68654E-06	65.23184967	65.23184598	4.605249706
Milford	DEEP Property No Well	19	219.1964821	11.53665695	0.532497823	135.3786011	134.8461033	31.12256815
	Municipal Space No Well	5	19.07417691	3.814835382	1.002664208	7.974568844	6.971904635	2.797780584
	Open Space	73	322.6640128	4.420054969	0.007551651	66.79189301	66.78434135	8.682281655
	Private Well	74	161.971346	2.188801973	0.045952532	22.90247345	22.85652092	3.836582764
Monroe	DEEP Property No Well	41	508.4782716	12.40190906	0.499135524	107.7450867	107.2459511	20.40335993
	Municipal Space No Well	25	327.003563	13.08014252	0.14805527	139.1399231	138.9918678	30.16895788
	Open Space	150	1828.581018	12.19054012	0.055216778	120.6993866	120.6441698	19.20013848
	Private Well	2636	4759.759644	1.80567513	0.001226302	41.82435226	41.82312596	2.627694438
Montville	DEEP Property No Well	6	30.93858728	5.156431213	0.266621232	17.00918198	16.74256074	7.492271693
	Municipal Space No Well	50	1135.166134	22.70332267	0.000264601	289.5844116	289.584147	53.23787765
	Open Space	321	8880.954385	27.66652456	0.013018348	515.4589844	515.445966	52.96098613
	Private Well	4385	11593.35724	2.6438671	5.07592E-07	77.85799408	77.85799357	6.72798864
Naugatuck	DEEP Property No Well	3	269.1638737	89.72129122	4.440867901	259.0728455	254.6319776	146.6639945
	Municipal Space No Well	1	0.5949893	0.5949893	0.5949893	0.5949893	0	0
	Open Space	86	1059.751587	12.32269288	0.406912476	201.7708893	201.3639768	27.61321035

	Private Well	1264	1074.194752	0.84983762	0.002215628	55.06533813	55.06312251	1.973292669
New Canaan	DEEP Property No Well	2	7.664102852	3.832051426	0.411877453	7.252225399	6.840347946	4.836856418
	Municipal Space No Well	46	348.2376795	7.570384337	0.668788671	153.3252411	152.6564524	22.54880886
	Open Space	28	309.050482	11.03751722	1.270657182	59.14308929	57.87243211	14.37125426
	Private Well	3152	7684.748379	2.438054689	0.002567781	53.83073425	53.82816647	1.991633801
New Fairfield	DEEP Property No Well	20	1272.678048	63.6339024	0.454927444	572.2213135	571.766386	138.6883631
	Municipal Space No Well	41	1099.745269	26.82305535	0.001142365	470.750946	470.7498037	80.58290645
	Open Space	173	5745.992621	33.21383018	0.156397969	2712.261719	2712.105321	210.6929106
	Private Well	5418	6845.560364	1.263484748	9.73008E-07	72.75018311	72.75018213	2.348956093
New Haven	DEEP Property No Well	2	23.81357932	11.90678966	2.284183264	21.52939606	19.24521279	13.60842047
	Municipal Space No Well	4	15.19429779	3.798574448	0.811668396	12.09406662	11.28239822	5.532752194
	Open Space	35	102.0661669	2.916176197	0.063481808	11.98879528	11.92531347	3.05364096
	Private Well	39	19.89893161	0.510229016	0.002886041	3.025817871	3.02293183	0.720627109
New London	Municipal Space No Well	6	4.502634197	0.750439033	0.490879804	1.182801962	0.691922158	0.247161666
	Open Space	16	33.58824435	2.099265272	0.058283668	19.59712219	19.53883852	4.79235292
	Private Well	21	6.080436967	0.289544617	0.026090555	1.20801878	1.181928225	0.284038157
Newtown	DEEP Property No Well	38	2982.540272	78.4879019	0.001732989	821.0675049	821.0657719	186.7353089
	Municipal Space No Well	276	1957.725477	7.093208251	0.000930347	117.283905	117.2829747	14.42821504
	Open Space	370	4945.861286	13.36719267	0.014348174	171.831955	171.8176068	23.40950341
	Private Well	8266	20625.56412	2.495229146	4.44471E-06	78.36825562	78.36825117	4.081249089
North Branford	Municipal Space No Well	39	290.2252008	7.441671816	0.261051536	94.82520294	94.56415141	15.98132529
	Open Space	125	1894.735906	15.15788725	0.484962016	98.66083527	98.17587325	20.69870832
	Private Well	2975	4461.520566	1.499670778	0.000100977	52.25162125	52.25152027	2.815372458
North Haven	DEEP Property No Well	3	11.44603592	3.815345307	0.500617802	8.89222908	8.391611278	4.464715108
	Municipal Space No Well	11	182.2722774	16.57020703	0.957278728	51.35551071	50.39823198	16.25790199
	Open Space	55	688.3690082	12.51580015	0.461941123	82.10868835	81.64674723	15.8571928
	Private Well	714	1096.102831	1.535158026	0.100280382	35.49444199	35.3941616	2.909341424
North Stonington	DEEP Property No Well	57	4003.19916	70.23156421	0.043243654	1213.380981	1213.337738	182.7403116
	Municipal Space No Well	56	1916.428334	34.22193454	0.000312703	723.8373413	723.8370286	106.1626414
	Open Space	415	16520.15997	39.80761439	0.079228535	514.1489868	514.0697583	57.55510796

	Private Well	2399	11531.16487	4.806654801	2.88661E-06	73.69490814	73.69490526	8.549150617
Norwalk	Municipal Space No Well	21	63.63870738	3.030414637	0.048119202	13.42374802	13.37562881	3.482472996
	Open Space	65	265.5370316	4.085185102	0.020038081	60.90628433	60.88624625	10.06054184
	Private Well	1382	1330.809751	0.962959299	0.001161154	9.777908325	9.776747171	0.717939582
Norwich	DEEP Property No Well	2	2.149417698	1.074708849	0.492333353	1.657084346	1.164750993	0.823603326
	Municipal Space No Well	13	115.4472161	8.880555088	0.112177141	72.90399933	72.79182219	19.9131663
	Open Space	174	2484.078994	14.27631605	0.009981999	179.0155029	179.0055209	26.12474789
	Private Well	1560	3905.361569	2.503436903	1.22028E-05	77.65634918	77.65633698	6.333500976
Old Lyme	DEEP Property No Well	33	654.3931408	19.83009518	0.000127976	257.8425598	257.8424318	50.18483558
	Municipal Space No Well	140	929.1196863	6.636569188	0.000221739	145.2292938	145.2290721	15.55356199
	Open Space	357	4912.699684	13.76106354	4.65581E-06	373.5986938	373.5986892	34.31451941
	Private Well	3430	6975.49005	2.033670568	2.28063E-07	66.10422516	66.10422493	4.622454788
Old Saybrook	DEEP Property No Well	25	1162.021788	46.48087152	0.149867579	870.5715332	870.4216656	172.6751689
	Municipal Space No Well	47	638.6063329	13.58736878	0.032464683	143.353775	143.3213103	30.84077007
	Open Space	137	821.0686041	5.99320149	0.023967538	55.33192062	55.30795309	9.569667265
	Private Well	1137	2268.00487	1.994727238	0.005433762	58.30089188	58.29545811	3.820982006
Orange	Municipal Space No Well	11	24.68214193	2.243831085	0.196250349	7.155709743	6.959459394	1.903906746
	Open Space	80	474.4586779	5.930733474	0.047078539	110.8406219	110.7935434	13.80651211
	Private Well	708	790.4812398	1.116498926	0.008131965	30.40192032	30.39378835	1.293044857
Oxford	DEEP Property No Well	15	1337.143683	89.14291222	0.091709249	447.5583801	447.4666709	144.1136566
	Municipal Space No Well	66	497.7052423	7.54098852	0.145503253	156.9873199	156.8418167	20.43764679
	Open Space	340	3722.593919	10.94880564	0.002996596	195.6834869	195.6804903	22.03168331
	Private Well	4100	10180.88108	2.483141728	4.86457E-06	76.58430481	76.58429995	4.821210238
Portland	DEEP Property No Well	96	3592.698174	37.42393931	0.193289384	830.5300293	830.3367399	115.1344891
	Municipal Space No Well	31	298.159062	9.618034257	0.091618843	83.55687714	83.46525829	20.61497771
	Open Space	290	2748.657909	9.47813072	0.072765917	102.5161362	102.4433703	14.78743233
	Private Well	1270	2959.768645	2.330526492	0.003436611	73.45121765	73.44778104	5.086336684
Preston	DEEP Property No Well	30	492.957395	16.43191317	0.00757185	154.7327576	154.7251857	34.93674685
	Municipal Space No Well	23	142.7705589	6.207415605	0.000834324	62.67654037	62.67570605	13.05765105
	Open Space	254	8963.305596	35.28860471	0.126138613	263.1036682	262.9775296	48.16955736

	Private Well	1991	8969.059266	4.504801238	0.000713896	75.5872879	75.58657401	9.353526075
Prospect	DEEP Property No Well	1	4.867838383	4.867838383	4.867838383	4.867838383	0	0
	Municipal Space No Well	7	47.59625828	6.799465469	0.619964004	21.97166443	21.35170043	9.309734544
	Open Space	89	1906.522191	21.42159765	0.017936727	406.8887634	406.8708267	48.26788109
	Private Well	2534	3399.068326	1.341384501	1.0318E-05	74.0818634	74.08185309	3.250508212
Redding	DEEP Property No Well	89	1858.087517	20.87738783	0.089305572	511.5326538	511.4433482	60.4225626
	Municipal Space No Well	100	2594.685123	25.94685123	0.084037989	317.9404297	317.8563917	50.57465116
	Open Space	360	4490.511327	12.47364257	0.036874376	234.1594696	234.1225952	29.57084687
	Private Well	3576	11315.95158	3.164415991	0.016491208	54.61303329	54.59654209	4.130305117
Ridgefield	DEEP Property No Well	56	915.028722	16.33979861	0.001178085	451.8251648	451.8239867	60.46604723
	Municipal Space No Well	368	2576.818903	7.002225279	0.00019957	322.3706665	322.3704669	21.20058323
	Open Space	263	2070.880502	7.874070349	0.006134005	127.6899338	127.6837998	14.88318082
	Private Well	5767	9620.572423	1.668210928	2.45412E-07	49.15765762	49.15765738	2.169616796
Salem	DEEP Property No Well	22	1755.442852	79.79285691	0.026751408	373.9875793	373.9608279	113.2077166
	Municipal Space No Well	19	439.0182898	23.10622578	0.06461291	141.9135742	141.8489613	37.31096196
	Open Space	135	8865.212346	65.6682396	0.794208705	863.6704102	862.8762015	103.3154348
	Private Well	1644	7754.107321	4.716610292	2.80352E-05	79.5905838	79.59055577	9.079316008
Seymour	DEEP Property No Well	6	254.6251749	42.43752915	1.063015103	246.7567902	245.6937751	100.0969763
	Municipal Space No Well	7	25.51132667	3.644475239	1.769973636	6.963370323	5.193396688	1.678502084
	Open Space	75	578.3532765	7.71137702	0.042961773	58.60879135	58.56582958	10.79846619
	Private Well	1233	1640.069924	1.330145924	2.26095E-05	57.50672913	57.50670652	2.628432874
Shelton	DEEP Property No Well	2	22.03439152	11.01719576	1.895921826	20.1384697	18.24254787	12.8994293
	Municipal Space No Well	20	134.0336608	6.701683038	0.250771642	31.91513252	31.66436088	9.479705522
	Open Space	173	676.6992771	3.911556515	0.07553374	107.0286179	106.9530841	9.426003202
	Private Well	1817	2162.49203	1.19014421	5.18097E-05	45.84047699	45.84042518	2.301709274
Sherman	DEEP Property No Well	4	47.55859417	11.88964854	0.039252039	47.12265396	47.08340192	23.48895744
	Municipal Space No Well	29	777.5831935	26.81321357	1.117707133	119.6765442	118.5588371	28.91080193
	Open Space	455	6337.885356	13.92941836	0.030309759	433.4908447	433.460535	37.00137547
	Private Well	2037	6337.737717	3.11130963	8.18899E-06	73.82276154	73.82275335	5.74649799
Southbury	DEEP Property No Well	27	1341.245419	49.67575626	0.12617898	220.5419006	220.4157217	68.29508277

	Municipal Space No Well	109	1455.983017	13.35764236	0.245504737	445.5696106	445.3241059	44.33186676
	Open Space	285	4902.184392	17.20064699	0.056623243	339.0984192	339.0417959	39.00471889
	Private Well	4072	11719.94629	2.878179344	1.47659E-05	76.81436157	76.81434681	5.268882257
Sprague	DEEP Property No Well	12	244.1811726	20.34843105	0.475321323	65.1732254	64.69790408	20.52554792
	Municipal Space No Well	20	259.3320044	12.96660022	0.168439731	92.41742706	92.24898733	21.13391774
	Open Space	197	5084.36099	25.80893904	0.059919879	414.6664429	414.606523	49.03147209
	Private Well	856	3103.824766	3.625963511	2.75505E-05	70.00645447	70.00642692	7.743188326
Stamford	DEEP Property No Well	22	284.3642742	12.92564883	0.462973297	119.6784897	119.2155164	27.21802989
	Municipal Space No Well	43	558.8564539	12.99666172	0.181498989	82.61714172	82.43564273	20.86030025
	Open Space	128	1332.949606	10.4136688	0.035426352	138.1354065	138.0999801	19.65689651
	Private Well	4891	7011.250161	1.43350034	0.005634089	65.99864197	65.99300788	1.701682646
Stonington	DEEP Property No Well	14	881.2956367	62.94968833	0.012680559	220.75737	220.7446894	67.79995859
	Municipal Space No Well	112	1220.499802	10.89731966	0.00049167	142.9508514	142.9503598	22.47147701
	Open Space	789	7618.775635	9.656242883	7.4769E-05	186.3595428	186.3594681	25.13867922
	Private Well	2634	8068.040339	3.063037334	1.87861E-06	79.46302795	79.46302608	6.372542199
Stratford	DEEP Property No Well	5	60.93213797	12.18642759	2.543412685	22.58690262	20.04348993	7.973733924
	Municipal Space No Well	19	162.7324612	8.564866379	0.109836563	94.99900818	94.88917162	22.04174461
	Open Space	71	268.4811527	3.781424686	0.041831248	43.25723267	43.21540142	7.048740435
	Private Well	225	258.9320305	1.150809024	0.000183959	9.74747467	9.747290711	1.152901546
Trumbull	DEEP Property No Well	9	46.23024744	5.13669416	0.131384194	24.99738121	24.86599702	7.814376149
	Municipal Space No Well	16	132.8358637	8.302241479	0.069751397	92.52017975	92.45042835	22.76915563
	Open Space	135	319.7469224	2.368495722	0.001092218	67.30379486	67.30270264	7.782955802
	Private Well	163	138.0714494	0.847064107	0.000323131	8.663243294	8.662920163	0.840347782
Voluntown	DEEP Property No Well	143	15601.39928	109.1006942	0.02032974	3127.643311	3127.622981	303.0601498
	Municipal Space No Well	11	169.7847593	15.43497811	0.393401653	99.75404358	99.36064193	30.23341029
	Open Space	184	4200.637762	22.82955305	0.003857833	289.3086548	289.304797	48.20396316
	Private Well	1137	4609.771524	4.054328517	1.54843E-05	77.63448334	77.63446785	8.095067337
Wallingford	DEEP Property No Well	17	1090.08462	64.12262473	1.125436068	378.6803894	377.5549533	114.9500281
	Municipal Space No Well	140	1335.894714	9.542105103	0.085495807	74.87557983	74.79008403	16.12657863
	Open Space	255	3714.28631	14.56582867	0.099315211	270.7787476	270.6794323	36.20595996

	Private Well	4309	8363.091304	1.940842725	1.61745E-06	75.48191833	75.48191672	3.964232384
Waterbury	DEEP Property No Well	5	5.190794826	1.038158965	0.538885772	2.382413149	1.843527377	0.76723343
	Municipal Space No Well	5	8.849967902	1.76999358	0.011755456	5.423253059	5.411497603	2.238148303
	Open Space	532	1083.981897	2.037559957	0.016543098	175.6574554	175.6409123	8.857825596
	Private Well	292	189.6120921	0.64935648	0.005526272	15.53517914	15.52965287	1.632855752
Waterford	DEEP Property No Well	2	30.94626093	15.47313046	2.964025974	27.98223495	25.01820898	17.69054522
	Municipal Space No Well	23	354.1210535	15.39656754	0.264483243	63.32155228	63.05706903	18.36068402
	Open Space	156	3083.100776	19.76346651	0.069089197	189.5381012	189.469012	32.04303099
	Private Well	562	2505.773548	4.458671794	0.010137982	70.35257721	70.34243923	9.416133684
West Haven	Municipal Space No Well	8	1.772888806	0.221611101	0.001190525	0.331219941	0.330029416	0.102347818
	Open Space	9	28.46072838	3.162303153	0.375889987	5.606330872	5.230440885	1.90980474
	Private Well	23	7.463702026	0.324508784	0.00832162	0.776626766	0.768305146	0.243945748
Westbrook	DEEP Property No Well	19	737.6850639	38.82552968	0.032754358	317.6220703	317.589316	77.98721819
	Municipal Space No Well	27	179.2898278	6.640363991	0.262559891	60.78325653	60.52069664	11.86439607
	Open Space	161	2130.649254	13.2338463	0.039930742	145.6750336	145.6351028	22.83442356
	Private Well	1091	3274.818182	3.001666528	0.014629044	72.29962158	72.28499254	5.449592736
Weston	DEEP Property No Well	5	25.46370089	5.092740178	0.39667058	16.78112602	16.38445544	6.780731482
	Municipal Space No Well	111	1973.370033	17.77810841	0.007886263	1302.267944	1302.260058	123.4784951
	Open Space	239	1829.712373	7.655700304	0.077642098	166.8741913	166.7965492	17.19219875
	Private Well	3810	7799.90392	2.047218877	0.003208535	32.34482956	32.34162102	1.201711697
Westport	DEEP Property No Well	8	20.28988417	2.536235521	0.00552437	10.76736259	10.76183822	3.614778646
	Municipal Space No Well	19	41.82271717	2.201195641	0.026652768	11.17390347	11.1472507	2.858129854
	Open Space	92	179.7971118	1.954316433	0.017761108	17.79603958	17.77827847	2.929113237
	Private Well	910	1158.597557	1.273184129	0.001837215	6.396040916	6.394203702	0.729476676
Wilton	DEEP Property No Well	27	122.8888122	4.551437488	0.604492724	34.23189926	33.62740654	7.613664466
	Municipal Space No Well	112	953.5815553	8.514121029	0.075965576	158.107605	158.0316394	20.35429508
	Open Space	321	2278.403988	7.09783174	0.089471214	419.3545532	419.265082	28.34663103
	Private Well	4784	9806.339937	2.049820221	0.002406248	50.87863922	50.87623297	2.069152775
Wolcott	Municipal Space No Well	40	608.6688705	15.21672176	0.066535242	79.05032349	78.98378824	23.72364513
	Open Space	196	5287.431758	26.97669264	0.400978416	914.8486938	914.4477154	82.41406045

	Private Well	5703	6133.764701	1.075533	0.008930567	70.70700836	70.6980778	2.523500155
Woodbridge	DEEP Property No Well	2	76.45871544	38.22935772	26.11638451	50.34233093	24.22594643	17.130331
	Municipal Space No Well	35	683.6731035	19.53351724	0.215300456	262.0630188	261.8477183	51.87473891
	Open Space	74	1535.318995	20.74755399	0.110157304	307.4321899	307.3220326	42.68468984
	Private Well	2636	5486.621882	2.08141953	0.002180806	64.78399658	64.78181578	2.228780458

APPENDIX L

Private Well Fact Sheets

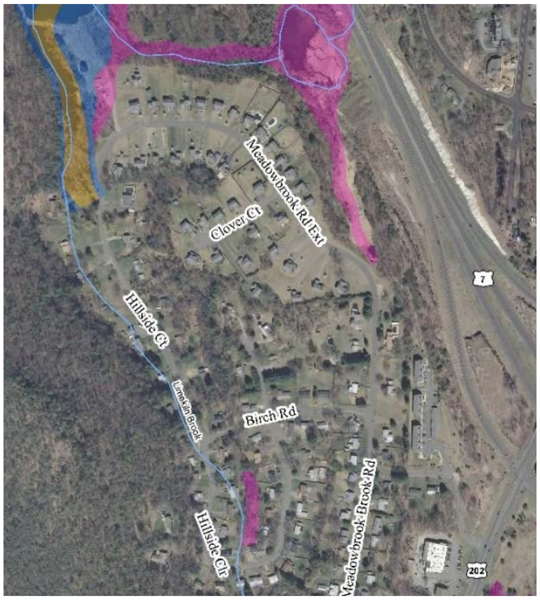
Drainage Project

Brookfield, CT | Meadowbrook Manor

In some areas, private wells are at risk of flooding despite not being in a mapped special flood zone area. When flooding is occurring due to poor drainage, a drainage project may be protective of private wells. The following is a successful example of such a project.

Meadowbrook Manor is a housing development in Brookfield, CT, which has experienced flooding for over 50 years. The development sits along Lime Kiln Brook, which overflows during heavy rains. The neighborhood is served entirely by private wells and septic systems, both which have become inundated during flooding events. On Tuesday May 19, 2015 voters passed a funding resolution, which authorized $2 million towards the project. In September 2015, a FEMA grant was awarded to the town, which covered $1.3 million of the cost. In early 2016, construction began on a 1/3 mile, 60 inch pipe in order to supplement the neighborhood's drainage.

Location



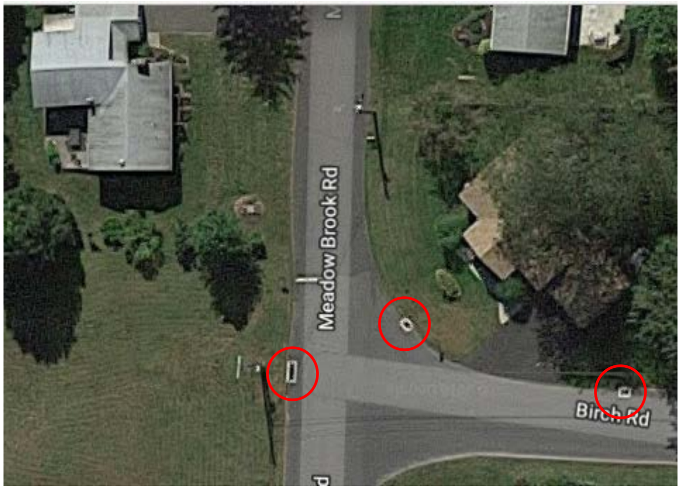
Flooding Issues

Flooded properties in Meadowbrook Manor during Hurricane Irene in 2011

Resiliency Project

Photo from The News-Times of the drainage project construction

Result



A new drainage system to alleviate flooding

Facts: Mitigates the risk of flooding to private wells
Cost Per Well: $$$

$ ≥ 1,000	$$$ ≥ 100,000
$$ ≥ 10,000	$$$$ ≥ 1,000,000

CIRCA Connecticut Institute for Resilience and Climate Adaptation
DPH Connecticut Department of Public Health
MILONE & MACBROOM

Resilient Wells

New Public Water System

New Fairfield, CT | Town Center

In areas where residents and businesses have no desire to relocate, development of a PWS can be pursued to mitigate flood risk. Sources of water supply outside of the special flood hazard area eliminates risk to private wells, and pressurized water mains are located underground and protected from flooding.

The New Fairfield town center is composed of several retail outlets, government buildings, and restaurants near the intersection of Route 37 and Route 39. Ball Pond Brook and its tributaries flow through this area, with many businesses encompassed in FEMA flood hazard areas. In March of 2004, an NTNC public water system was approved by DPH and subsequently installed by the New Fairfield Water Pollution Control Authority in order to serve the town government offices and a large shopping plaza. While the main goal of the water system was to mitigate potential groundwater pollution concerns, the system also served a portion of the shopping plaza which is in a FEMA flood hazard area, and is directly adjacent to the floodway. This water system greatly reduces the risk of a service disruption in the event of flooding, and mitigates water quality concerns from flooding and groundwater contamination.

Location

Various retail and municipal buildings located in the town center include the town clerk, post office, and a grocery store

Flooding Issues

While not in New Fairfield, this flooded commercial area in Norwalk is a good representation of the effects flooding can have on infrastructure. Photo: The Hour

Resiliency Project

Result

While this specific project was geared toward mitigating water quality concerns surrounding flooding and groundwater contamination, the creation of a new PWS can be implemented in areas where private wells are at risk. By connecting to a new PWS, private wells can be abandoned therefore eliminating any issues associated with private well vulnerability.

Facts: Eliminates risk to private well sources
Cost Per Well: $$$

$ ≥ 1,000	$$$ ≥ 100,000
$$ ≥ 10,000	$$$$ ≥ 1,000,000

Property Acquisition

Southbury, CT | Flood Bridge Road, River Trail

In some cases, the best way to reduce the risk of flooding to a private well is to eliminate the need for a well through property acquisition. This mitigation strategy allows the resident to relocate to a more resilient area. Property acquisition therefore eliminates risk to a private well and eliminates the risk of property damage. The following is a successful example of such a project.

Flood Bridge Road and River Trail occupy a low-lying area near the banks of the Pomperaug River in Southbury, CT. The residences in these low-lying areas have experienced severe, repeated flooding events (most notably after Hurricane Irene in 2011). In 2015, FEMA confirmed that it had allotted $1.4 million to purchase several vulnerable properties along the river banks.

Location

Vulnerable neighborhoods are circled in red, with the blue crosshatch indicating the FEMA flood hazard area.

Flooding Issues

Flooded properties along Flood Bridge Road during Hurricane Irene in 2011.

Resiliency Project

Demolition of a flooded house on River Trail Road, Southbury CT.

Result

Open space where vulnerable properties once stood.

Facts: Eliminates the risk to private wells from flooding
Cost Per Well: $$$

$ ≥ 1,000	$$$ ≥ 100,000
$$ ≥ 10,000	$$$$ ≥ 1,000,000

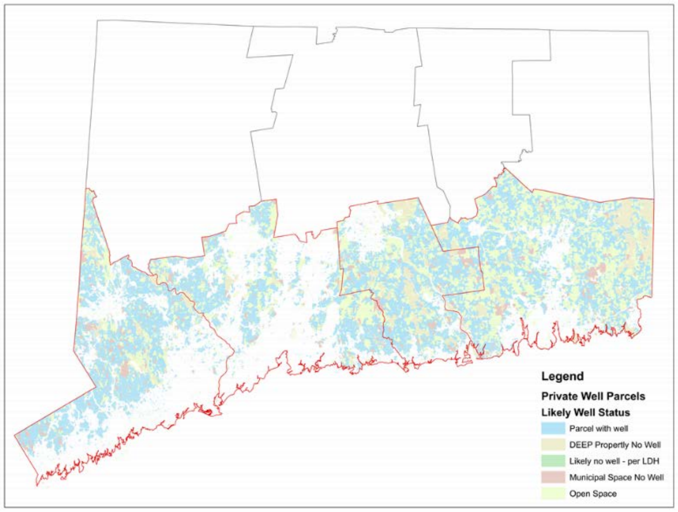
Resilient Wells

Smart Development

Connecticut

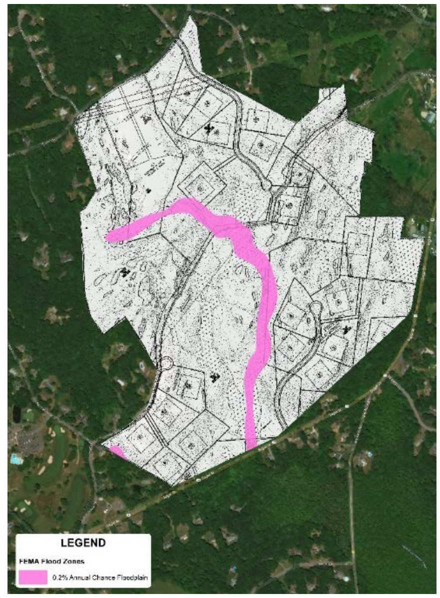
One of the simplest ways to eliminate private well risk is to avoid development or strictly regulate development in areas at risk of flooding. Most towns in the state have provisions in their ordinances and regulations that heavily regulate construction in flood zones. However, even development outside the flood zone can be vulnerable to flooding under certain conditions. Large subdivisions can increase the flow in small brooks and streams due to storm water runoff and constriction of flood plains. Additionally, bridges and culverts within subdivisions can become clogged with debris, causing flooding in areas that are outside of established flood zones.

Location



The strategy of smart development can be implemented anywhere there is open space being considered for development

Flooding Issues

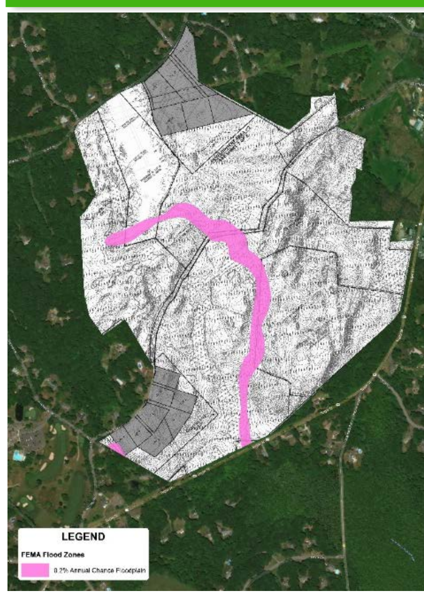


A site plan which shows development placing multiple parcels adjacent to the 0.2% flood hazard area. Strong storms and erratic precipitation could mean increased flooding concern for these parcels.

Resiliency Project

- Identify open space that may be used for future development.
- Establish whether or not there are flood zones within this space.
- If flood zones are present, create development plans that place infrastructure away from the hazard area and therefore preventing flooding damage.

Result



The same site plan with the chosen parcels for development in grey. These parcels are located away from the flood hazard area, and therefore protecting infrastructure, including future wells.

Facts: Mitigates risk to private wells for flooding
Cost Per Well: Not Applicable

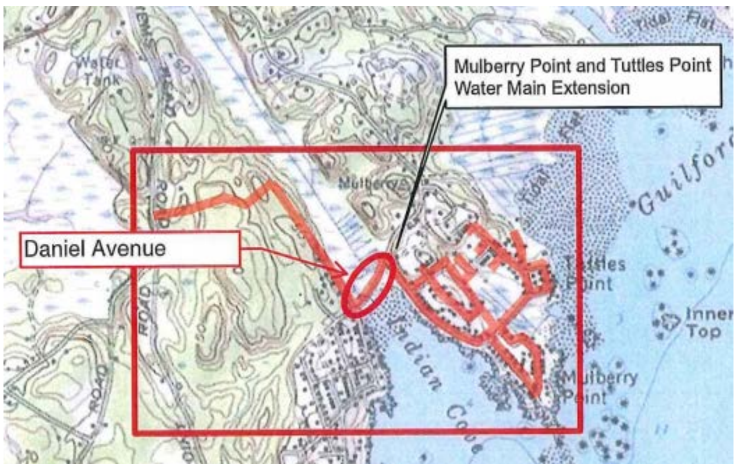
Water Main Extension

Guilford, CT | Mulberry Point, Tuttles Point & Long Cove

Similar to developing a public water system, extension of an existing public water system into a flood prone area is a method that can mitigate private well risk. The following is an example of a current project.

These neighborhoods are densely populated and served by both private wells and septic systems. Recent contamination of a private well from an above ground oil tank has highlighted the risk of drilled wells in the area from multiple sources, including volatiles, sodium, nitrates, and others. Connecticut Water plans to extend a pipeline from its Guilford System in order to alleviate concerns over direct contamination, flooding, and salt water intrusion. A 2011 feasibility study performed on behalf of the Town of Guilford found that “extending water mains to and throughout the project area was feasible, cost-effective, and constructible in a short time frame.”

Location

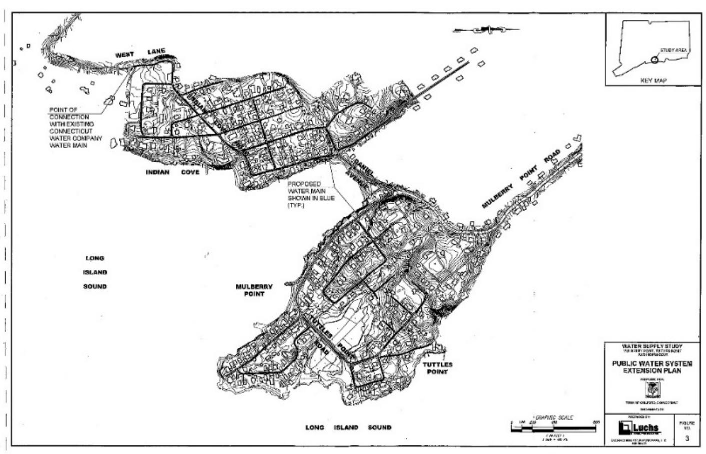


The CT DEEP draft plans show the plan for extension through Daniel Ave. to Mulberry and Tuttles Point

Flooding Issues

A private well located on Daniel Avenue in close proximity to the coastline. This well may be vulnerable to saltwater intrusion

Resiliency Project



A map of the proposed water main, with the dark lines indicating the path of the extension.

Result

Reliable, clean, and resilient water supply for homes like these along Mulberry Point Road. Photo: Trulia

Facts: Eliminates the risk of flooding to private wells
Cost Per Well: $$$

$ ≥ 1,000	$$$ ≥ 100,000
$$ ≥ 10,000	$$$$ ≥ 1,000,000

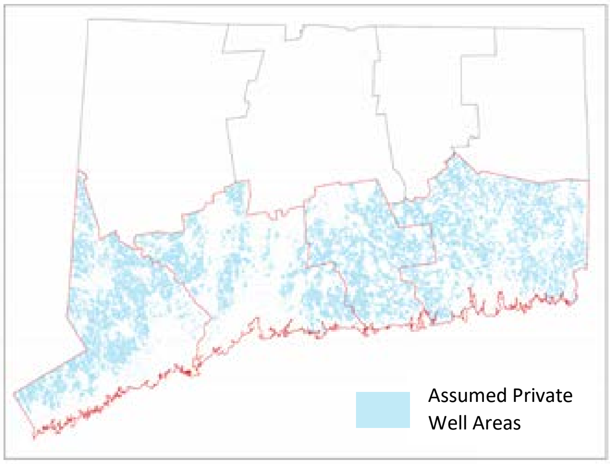
Resilient Wells

Well Protection

Connecticut

In certain cases, it is not feasible to take advantage of external mitigation efforts in order to protect private wells. There are, however, steps that can be taken to bolster the defenses of the well itself in order to protect against flooding and subsequent contamination. The following are several examples of technology that can be used to isolate the well from external forces.

Location



Any residential private well has the option to protect their well when other means of resilience and mitigation are not realistic.

Flooding Issues

For example, wells that are not fitted with upgraded sanitary seal caps may be more vulnerable to contamination from floodwaters. A sanitary cap typically has bolts running from top to bottom and includes a rubber gasket for an air tight seal.

Resiliency Project

FEMA-recommended & other protective efforts

- Extend well casing above flood level
- Seal exposed portions of well
- Mound earth to protect existing well or newly implemented extension
- Install backflow valve
- Place grout between casing and the bore hole
- Installation of a sanitary cap

Result

Extending well casings above flood level and mounding surrounding earth helps mitigate flooding.

Facts: Mitigates the risk to private wells from flooding
Cost Per Well: $

$ ≥ 1,000	$$$ ≥ 100,000
$$ ≥ 10,000	$$$$ ≥ 1,000,000

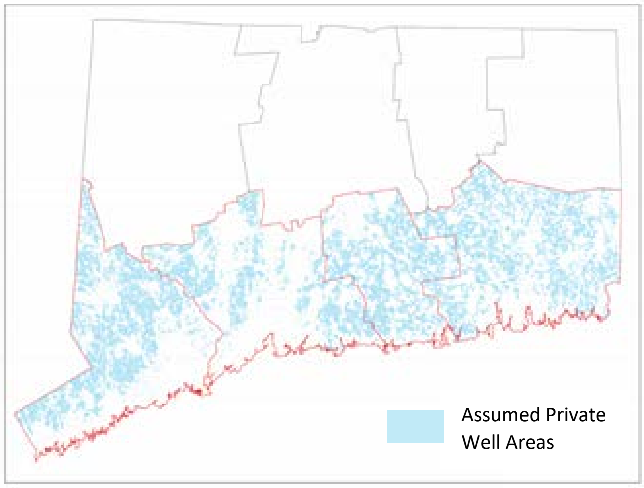
Resilient Wells

Well Relocation

Connecticut

In certain cases, it is not feasible to take advantage of external mitigation efforts to protect private wells, and well protection or upgrades may not be adequate. By relocating a private well on the property, the resident may be able to continue to rely on a private water source but have a safer and cleaner water. Well relocation must adhere to the most up to date standards and regulations protective of water quality. Depending on the parcel size, lot layout, and setbacks from pollution sources, this method of mitigation may not be viable.

Location

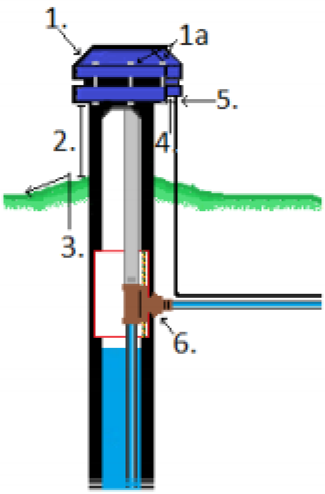


Any residential private well has the option to relocate their well when other means of resilience and mitigation are not realistic.

Flooding Issues

Some homes that are vulnerable to flooding may have areas on the property that are at lower risk of flooding.

Resiliency Project



By relocating a well on the property, the resident is ensuring a safer drinking water source. Also, when the well head is located above any present flood level, this will also reduce the risk of flooding.

Result

Well relocation results in a more resilient source with appropriate well protection.

Facts: Mitigates the risk of flooding to private wells
Cost Per Well: $ to $$

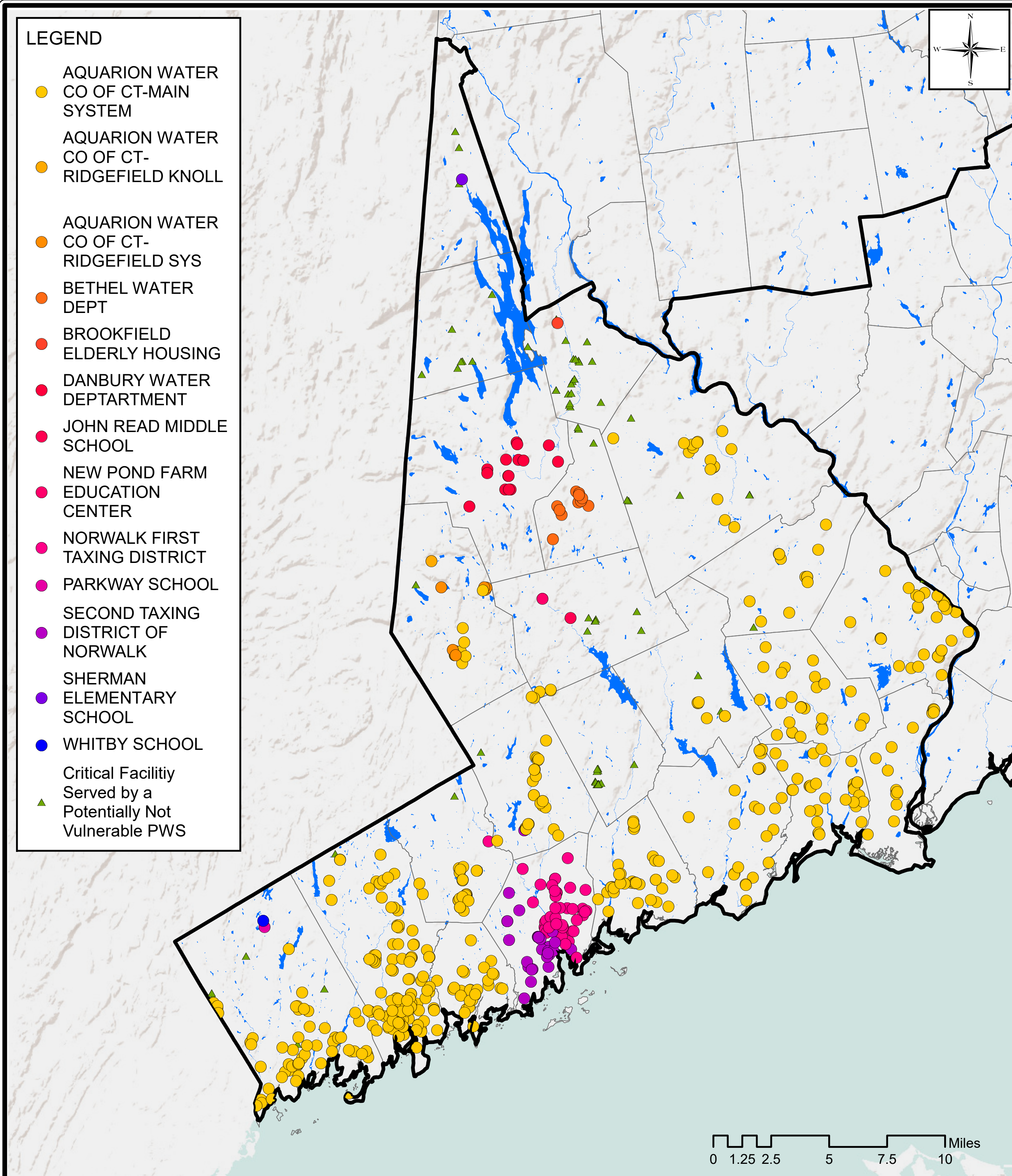
$ ≥ 1,000	$$$ ≥ 100,000
$$ ≥ 10,000	$$$$ ≥ 1,000,000

Resilient Wells

APPENDIX M

County Critical Facilities Maps

MXD: Y:\1958-104\Vulnerable Critical Facilities.mxd



MILONE & MACBROOM

99 Realty Drive
Cheshire, Connecticut 06410
(203) 271-1773
www.mminc.com

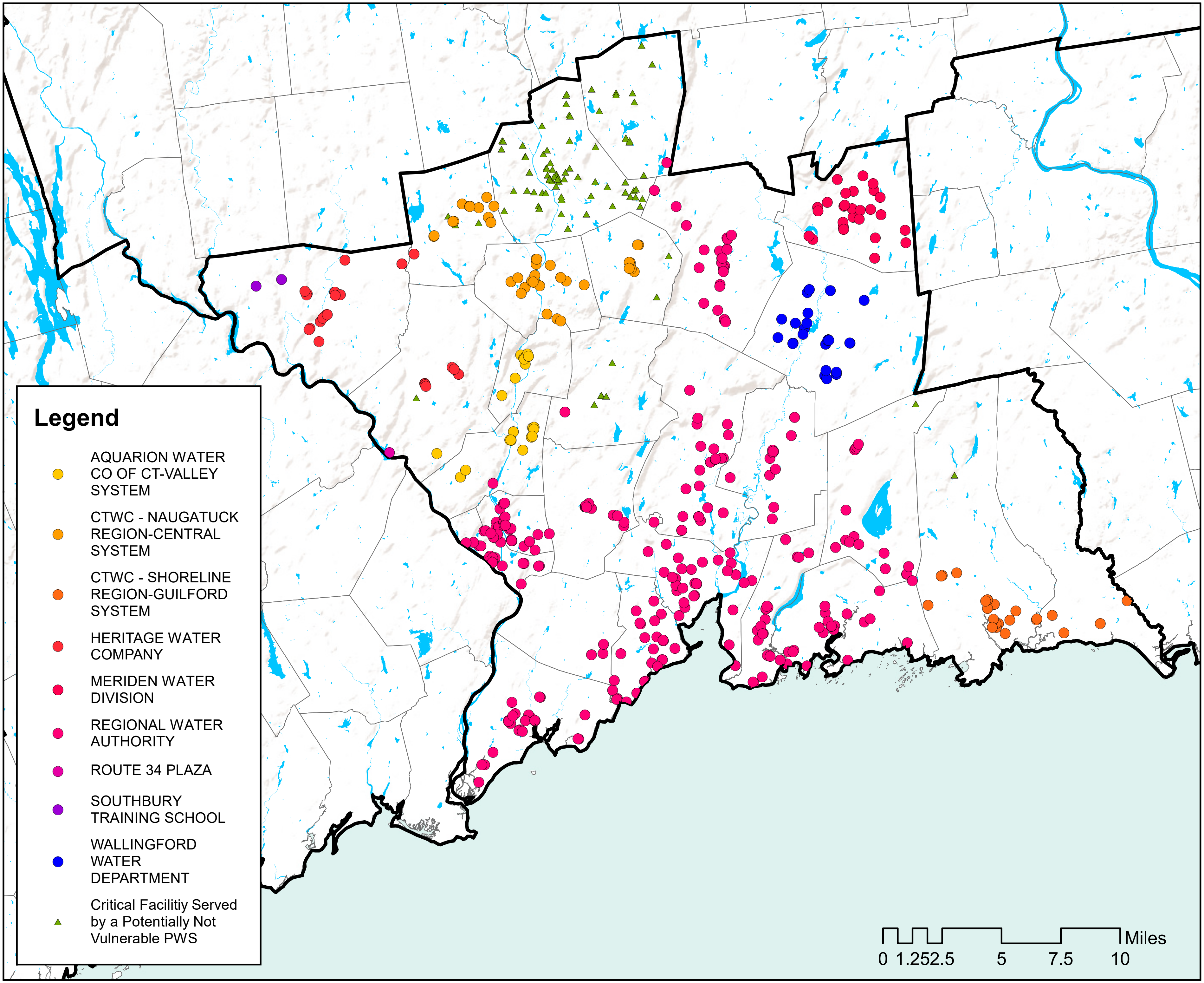
Potentially Vulnerable Critical Facilities

Fairfield County

Drinking Water Vulnerability Assessment and Resilience Plan

SOURCE: 2004 AERIAL PHOTO, CTDEEP, 2006

DATE: NOVEMBER 1, 2018		
SCALE: 1"=30,448.68'		
PROJ. NO.: 1958-104		
DESIGNED VLB	DRAWN VLB	CHECKED SGB
DRAWING NAME:		
FIG. 1		



MILONE & MACBROOM
99 Realty Drive
Cheshire, Connecticut 06410
(203) 271-1773
www.mminc.com

Potentially Vulnerable Critical Facilities

New Haven County
Drinking Water Vulnerability Assessment & Resilience Plan

VLB	VLB	DOG
DESIGNED	DRAWN	CHECKED

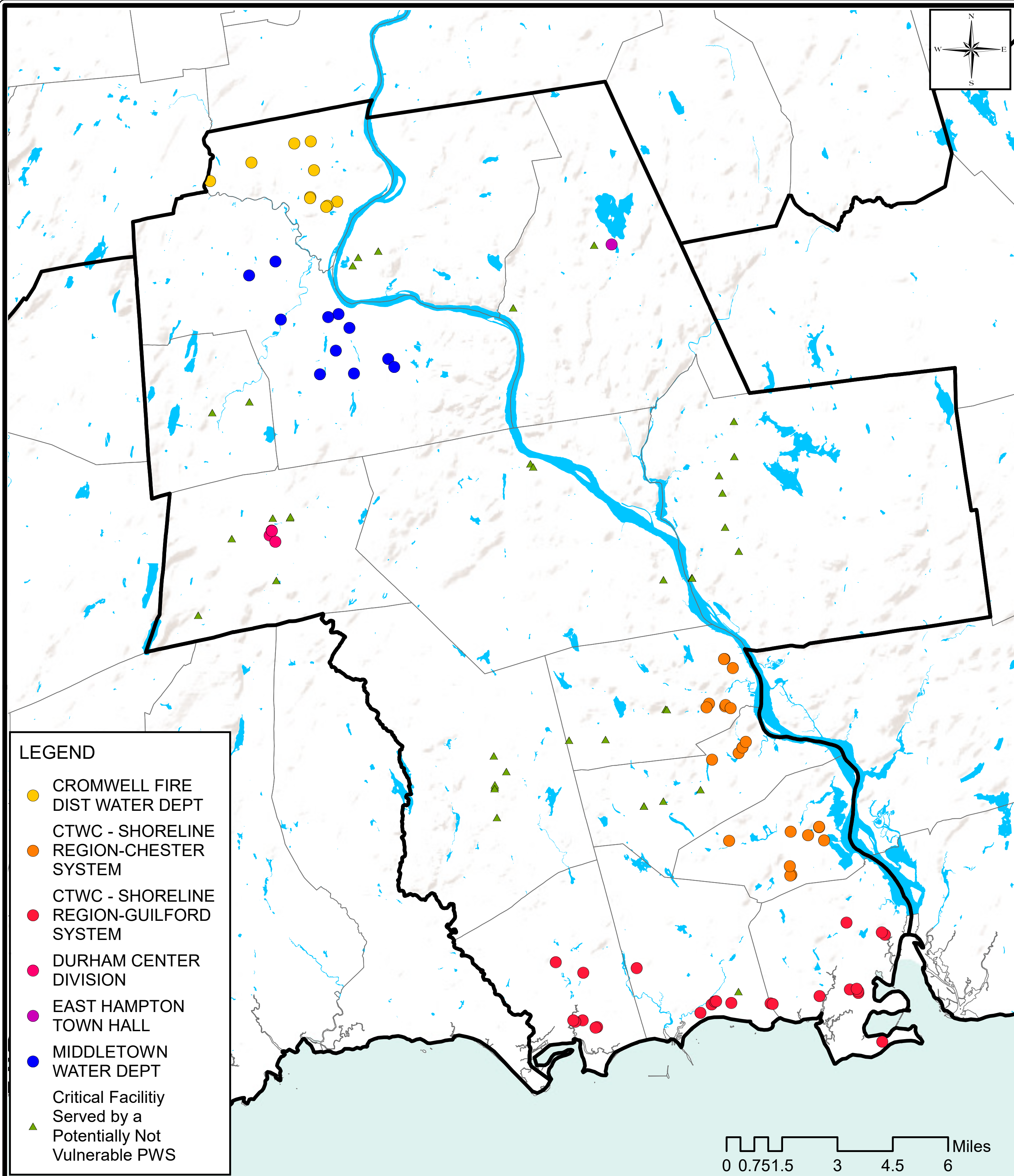
1"=27,091'
SCALE

November 1, 2018
DATE

1958-104
PROJECT NUMBER

FIGURE 1
SHEET NAME

MXD: Y:\1958-104\Vulnerable Critical Facilities.mxd



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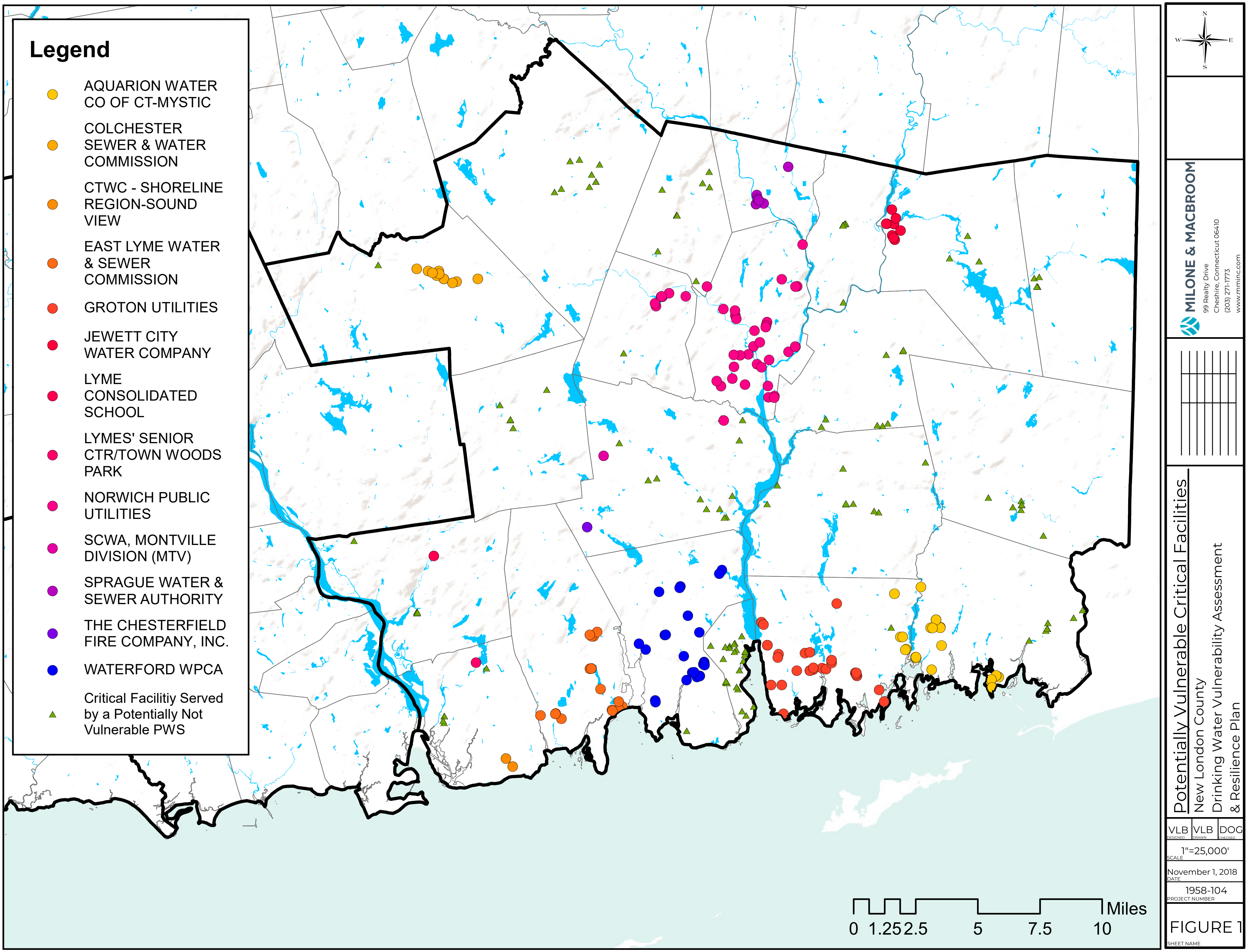
Potentially Vulnerable Critical Facilities

Middlesex County

Drinking Water Vulnerability Assesment and Resilience Plan

SOURCE: 2004 AERIAL PHOTO, CTDEEP, 2006

DATE: NOVEMBER 1, 2018		
SCALE: 1"=912879'		
PROJ. NO.: 1958-104		
DESIGNED	DRAWN	CHECKED
VLB	VLB	SGB
DRAWING NAME:		
FIG. 1		



Legend
AQUARION WATER CO OF CT-MYSTIC
COLCHESTER SEWER & WATER COMMISSION
CTWC - SHORELINE REGION-SOUND VIEW
EAST LYME WATER & SEWER COMMISSION
GROTON UTILITIES
JEWETT CITY WATER COMPANY
LYME CONSOLIDATED SCHOOL
LYMES' SENIOR CTR/TOWN WOODS PARK
NORWICH PUBLIC UTILITIES
SCWA, MONTVILLE DIVISION (MTV)
SPRAGUE WATER & SEWER AUTHORITY
THE CHESTERFIELD FIRE COMPANY, INC.
WATERFORD WPCA
Critical Facilitiy Served by a Potentially Not Vulnerable PWS
0 1.25 2.5 5 7.5 10 Miles
MILONE & MACBROOM
99 Realty Drive
Cheshire, Connecticut 06410
(203) 271-1773
www.mminc.com
Potentially Vulnerable Critical Facilities
New London County
Drinking Water Vulnerability Assessment
& Resilience Plan
VLB DESIGNED
VLB DRAWN
DOG CHECKED
1"=25,000' SCALE
November 1, 2018 DATE
1958-104 PROJECT NUMBER
FIGURE 1 SHEET NAME