H.R. 1579
Secure and Resilient Water Systems Act

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SECURE AND RESILIENT WATER SYSTEMS ACT

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Executive Summary

In the 1970s, what is often hailed as the "heyday of environmentalism," elected officials recognized both the fundamental importance and simultaneous vulnerability of water in the United States and passed some of the most important environmental laws that we still benefit from today. The Clean Water Act and Safe Drinking Water Act focused on clean source and drinking water, respectively. At the time of their passage by a bipartisan Congress, there was an understanding that protecting this critical resource well into the future was not only beneficial for people and the environment, but also beneficial for the country and its long-term prosperity. The Safe Drinking Water Act is integral for drinking water quality because it establishes and regulates federal water quality standards, but it must be updated as the ecological, political and economic realities of the country change.

The Secure and Resilient Water Systems Act is an amendment to the Safe Drinking Water Act that was created to combat some of the vulnerabilities currently facing water systems, a number of which are longstanding, like infrastructure degradation, while others are relatively new, like climate change. How these threats will impact communities depends on their size, location and the technical capabilities of their water systems. This bill is both a resource and a tool for communities to confront the vulnerabilities that exist within their water distribution systems.

In this report, we define the threats identified within the Act and detail the specific harm they may pose to water systems. We also propose solutions to mitigate the threats and provide case studies of communities that are implementing new strategies for maintaining a clean, viable water supply. Finally, we provide specific measurements that can help assess whether or not community water systems will be able to achieve the intended outcomes of the bill.

Background and Context

The Secure and Resilient Water Systems Act, H.R. 1579

Lack of access to safe drinking water not only affects human health, but it also poses risks to the country's economic and political security. From a policy perspective prioritizing the systems that source, clean, and distribute the water is essential to the maintenance of this important resource for long-term use.

In the United States, 88% of the population depends on a community water system (CWS), including many public services, utilities and economic activities (EPA, 2004). A CWS is defined by the Environmental Protection Agency (EPA) as a public water provider that has at least 15 water connections or that serves at least 25 people per day for at least 60 days out of the year (EPA, 2004).

In order to ensure safe drinking water and the systems that distribute it, H.R. 1579, the Secure and Resilient Water Systems Act (SRWSA), was introduced in 2017 by Representative Scott Peters (CA) to amend the Safe Drinking Water Act (SDWA) (115th Congress, 2017)address four major threats to community water systems (CWS) which are:

- **Industrial pollution,**
- **Impacts of climate change,**
- **Intentional acts of sabotage** and
- **Infrastructure degradation.**

This bill mandates CWS to evaluate source water and distribution systems vulnerabilities to the threats outlined above ("Source Water and Distribution System Vulnerability Assessments") and to develop protection plans ("Source Water and Distribution System Protection Plans"), both of which are submitted to the EPA for review (115th Congress, 2017). The bill authorizes $50 million annually in grants for five years for CWS implementation and EPA technical support mechanisms.

If enacted, the SRWSA allows flexibility for small and large CWS alike to assess the threats unique to their specific systems because there are not specific mandates in addressing threats. This allows CWS to prioritize and address threats to their water system in the way that is most appropriate. Compliance with this bill will be challenging, particularly for smaller CWS, because of limited funding, personnel, and access to technical expertise than larger CWS.

The Safe Drinking Water Act

The Safe Drinking Water Act (SDWA) applies to all public water providers and was enacted in 1974 (Table 1) after studies across the nation revealed widespread water quality problems, human health risks, and unequally distributed public water supplies across communities (Tiemann, 2017). Public water providers include CWS, which are the focus of the SRWSA as well as non-community water systems like schools, rest areas, or campgrounds that either do not operated year-round or do not serve the same population year-round (EPA, 2004).

Table 1. The Safe Drinking Water Act and Its Major Amendments

Year	Title	Relevance
1974	Safe Drinking Water Act	Established regulations to prevent contamination of public drinking water, initially monitoring 22 contaminants Applies to all public water supplies (EPA, 2017)
1986	Amendments of 1986	Disinfection required for all public water systems Added significantly to the number of contaminants regulated by the federal government, mainly at the parts per billion (ppb) level Established a system for ongoing additions of contaminants to the list of those regulated by federal government (Patton & Harms, 1988)
1996	Amendments of 1996	Granted additional flexibility to states Added risk assessment and cost analysis to EPA analysis of contaminants (EPA, 2017)
2002	Public Health Security and Bioterrorism Preparedness and Response Act	Required each CWS serving a population greater than 3,300 to assess its vulnerability to sabotage (107th Congress, 2002)
2005	Energy Policy Act of 2005	Exempted hydraulic fracturing operations from regulation by the SDWA
2015	Grassroots Rural and Small Community Water Systems Assistance Act	Provided technical and financial assistance to small CWS from EPA to comply with SDWA regulations (Tiemann, 2017)
2017 ***(introduced)***	**Secure and Resilient Water Systems Act**	**Requires vulnerability assessments and threat mitigation by CWS** **Provides grants and technical assistance to CWS by EPA**

Why is This Bill Needed?

As we learn more about new and emerging threats like climate change and hydraulic fracturing, additional regulation is needed to mitigate risks. The SRWSA focuses on four main threats, and while CWS are required to address some aspects of these threats, like water contamination from industrial pollution, they are not currently required to take action to prevent threats. Additionally, while the Bioterrorism Act of 2002 established the requirement of vulnerability assessments for sabotage, it only applies to CWS serving more than 3,300 people, and no mitigation plan is currently required (US Congress, 1974). This bill is unique in its focus on both mitigation and prevention (US Congress, 1974) to create sustainable and reliable drinking water systems.

Previous amendments to the SDWA have improved the Act's breadth, regulatory capabilities, and ability to better support CWS. However, some amendments have actually removed important regulation like the Energy Policy Act of 2005. Some threats, such as the impacts of climate change, are not directly addressed by any aspect of the SDWA and are worsening. Representative Scott Peters represents California's 52nd congressional district in San Diego County, where the impacts of drought exacerbated by climate change are acutely felt. In light of recent public drinking water crises in Flint, MI and Charleston, WV, safe drinking water remains in the nation's spotlight. Given the extra attention on drinking water and the increasing threats to CWS's future resiliency, policy solutions like SRWSA are needed now more than ever.

The goal of the SRWSA is to improve the availability of clean drinking water and maintain drinking water systems for future water consumption. The SRWSA establishes a protocol for CWS to focus on increasing drinking water system resiliency and preventing potential contamination of water supply. The SRSWA requires CWS to evaluate existing vulnerabilities and plan long-term. This bill, while flawed, will likely improve both water availability and quality in the short-term and into the future.

Threat I: Industrial Pollution and Agricultural Runoff

Industrial pollution includes contamination from discharged wastewater and leaks from pipelines, storage tanks, and contaminated sites or contaminants from unconventional oil and gas drilling. Agricultural runoff is water that leaves farms because of rain, melted snow, or irrigation. Runoff can pick up and carry pollution, which can be deposited into ponds, lakes, coastal waters, and underground sources of drinking water (Swanson, What Is Farm Runoff Doing To The Water? Scientists Wade In, 2013).The ingestion of water polluted from industrial activities can cause gastrointestinal illness, neurological disorders, and reproductive problems, with children and the elderly at greatest risk (Centers for Disease Control and Prevention, 2009).

Industrial Pollution and Drinking Water Systems

Figure 1. Industrial Pollution in the Elk River.

(Source:RT, 2014. https://www.rt.com/usa/superfund-toxic-pollution-clean-426/)

Industrial pollution is a significant threat to drinking water systems due to the discharge of untreated sanitary and toxic industrial wastes and dumping of industrial effluent (Bhatnagar & Sillanpaa, Utilization of Agro-industrial and Municipal Waste Materials as Potential Adsorbents for Water Treatment - A Review, 2010). Untreated wastewater threatens drinking water because of both the organic and inorganic compounds such as heavy metals and phenols that are present. Water polluted with heavy metals and trace elements such as cadmium and arsenic can cause kidney damage, bone deterioration, cancers, and skin lesions (Jarup, Hazards of Heavy Metal Contamination, 2003). Phenol and phenolic compounds are the most common chemical pollutants in industrial discharge, as they are found in many manmade products and are used by a variety of industries (Rajkumar & Palanivelu, 2004). While the EPA regulates the discharge of phenolic compounds (EPA, 2004), it is the detection of phenolic compounds that is critical in order to maintain clean drinking water, since it is common for wastewater

Case Study: Hydraulic Fracturing

Hydraulic fracturing, commonly called “fracking”, is a process that utilizes highly-pressurized liquid to break open rock along a drilled wellbore underground so oil and gas trapped in the rock can flow and be produced (Klass, 2014). After fracturing the rock, this non-potable liquid; which is a mixture of water, sand, and chemicals; is pumped out of the wellbore and is called “produced water.” Drinking water supplies can be contaminated through improper storage and disposal of produced water.

One ongoing investigation of groundwater contamination is in Pavilion, Wyoming where a former EPA investigator confirmed the presence of trimethyl benzenes in groundwater, as well as other organic compounds such as methanol and ethanol that are specifically used for well stimulation in hydraulic fracturing (DiGiulio & Jackson, 2016). In a subsequent scientific study in collaboration with Stanford University, upward migration of fluids into groundwater was found to be a source of contamination. However, opposing interest groups, including the Wyoming Department of Environmental Quality, continue to deny the study’s conclusiveness.

Figure 2. Hydraulic fracturing site in Pavillion.

(Source: Banerjee, 2016. insideclimatenews.org) containing the compounds to be disposed of near drinking water sources (Vorob'eva, Terletskaya, & Kushchevskaya, 2007)

Agricultural Runoff and Drinking Water Systems

Excess nutrients impact water quality after precipitation or when water and soil containing nitrogen and phosphorus wash into nearby waters, leaching into groundwater. High levels of nitrates from fertilizers in runoff can contaminate drinking water and cause potentially fatal "Blue Baby" Syndrome in very young infants by disrupting oxygen flow in the blood (National Institute of Health, 2017). Other pollutants in runoff include contaminants from soil erosion, feeding operations, grazing, plowing, application of pesticides, and irrigation water

Figure 3. Agricultural Runoff in Central Iowa

(Source: Stewart, 2017. http://livegreennebraska.com/world-water-day/)

Prevention vs. Remediation

It can be extremely difficult for CWS to remediate water that is already polluted. Treatment and recycling of hazardous waste and discarded chemicals are necessary to reduce solid waste buildup and the leaching of toxic chemicals. Common solutions include biological or chemical treatments such as pH manipulation that allow for the sedimentation of contaminants (Kjellstrom, et al., 2006). Of course, prevention of future pollution is safer and more cost effective than remediation (Ross, 2015). Prevention requires the adoption of cleaner production processes by minimizing the use of chemicals in industrial, agricultural, and domestic activities (Kjellstrom, et al., 2006).

Some CWS are tackling immediate threats of contamination from industrial pollution and agricultural runoff with downstream methods such as filters close to consumers, residences, and schools (Abramsky, 2017). However, more comprehensive and long-term solutions are required for most other instances of industrial contamination.

Coping with Drinking Water Pollution

The primary method for decreasing the impact of industrial pollution and agricultural runoff is to minimize the use of these harmful water pollutants. When this is not feasible, remediation is necessary. Adsorption technologies that remove contaminants and improve recycled water quality have been a topic of recent research for water quality improvement (Ali, 2012). Adsorption is the process of bonding pollutants to a solid medium (Ali, 2012). These techniques have been utilized to address both agricultural runoff and industrial pollution. The recent development of more efficient and less expensive adsorption media can be appropriately scaled to different CWS sizes. Several examples of research include: the study of activated carbon to remove toxic textile dyes from recycled water near old mills (Kant, 2012), different metal compounds for the removal of arsenic from groundwater (adsorption media), and nanoparticles for the removal of a variety of contaminants (Ali, 2012).

Threat II: Impacts of Climate Change

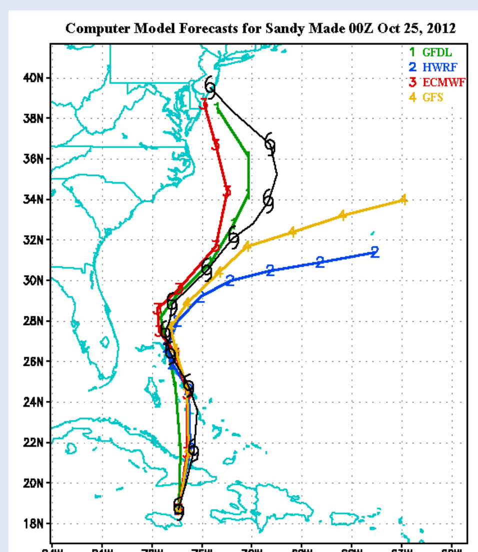
Climate change threatens the availability of both groundwater and surface water supplies, which feed drinking water systems. Climate change contributes to sea-level rise which in turn threatens the drinking water supply of several coastal regions through salinization, causing salt water intrusion into the groundwater supplies (Levin, et al., 2002). Drought conditions in some places of the U.S., such as California are depleting surface water supplies (Maddocks, Reig, & Gassert, 2014) while in other regions, such as in Pennsylvania, flash floods and storm surges are causing runoff that can introduce contaminants in to the surface water supply (Spadoni & Levis, 2016).

Climate change is also causing a gradual increase in water temperature (Swinton, Eichler, Farell, & Boylen, 2015). Higher water temperatures may accelerate processes that deteriorate water quality. For example, the rate of eutrophication and algal bloom growth are expected to increase in warmer waters, both of which would have negative effects on water quality. This phenomenon is enhanced by excessive runoff that increases the nutrient content of rivers and lakes,

Case Study: Hurricane Sandy Prediction Models

In 2012, Hurricane Sandy swept through the Northeastern part of the U.S., severely affecting drinking water systems in New Jersey by introducing large amounts of untreated sewage and debris into the systems (Gammon, Satellites Track Hurricane Sandy Water Pollution, 2012). Several computer simulations were used to predict the course of the hurricane (Figure 2). The American model (GFS) predicted Hurricane Sandy would travel East and die-off in the Atlantic Ocean. The European model (ECMWF) correctly predicted that the hurricane would impact the southern coast of New Jersey. This discrepancy between the models underscores their inherent complexity and uncertainty. The European model resulted in greater accuracy due to, among other things, operating on higher resolution because of stronger computer power capability. (NOAA, 2012).

Figure 4. Computer Model Forecast for Sandy.



(Source: Morris Bender, NOAA/GFDL)

promoting the growth and survival of pathogens and algae (Pandey, Kass, Soupir, Biswas, & Singh, 2014). Warming water from the impacts of climate change can also cause decreased function and operation of existing water infrastructure like hydroelectric power plants, structural flood defenses, and irrigation systems (Means, Laugier, Daw, & Owen, 2010).

Climate Prediction Models

The simulation of the long-term effects of climate change can be useful to determine policy actions, and can be used to predict future drinking water supplies, as well as precipitation patterns and the short-term impact of abrupt weather events, such as hurricanes, on drinking water systems. While useful, these complex models also carry underlining uncertainties, making the extent of which they can be fully utilized is dependent on the resolution of the model.

Mitigation Of Climate Change Impacts On Drinking Water Systems

One of the major challenges climate change poses to CWS is that it is an ever-evolving threat. Although CWS are experienced in planning for short-term variability, planning for the long-term mitigation to climate change may be more challenging (Jiménez Cisneros, et al., Freshwater resources, 2014). The impacts of climate change on CWS can be addressed by enhancing water treatment and the construction of green infrastructure (National Climate Assessment, 2014). CWS may want to adopt more flexible and cooperative governance systems to address climate variability uncertainties (National Climate Assessment, 2014). Resource managers, NGOs, local, tribal and state governments in the Colorado River basin provide one example of how CWS are applying these long-term planning goals through collaboration of water management under changing climatic conditions (National Climate Assessment, 2014).

Figure 5. Rain Garden as Green Infraestructure in Philadelphia.

(Source: Philadelphia Water Department. https://www.pwdplanreview.org/stormwater-101/stormwater-management)

Improving water treatment methods such as reclamation, recycling, and treatment of wastewater are options to address water scarcity caused by more extreme and long lasting droughts as a result of climate change. The primary method for wastewater treatment is through mild chlorination and filtration by using a horizontal subsurface slow bed (Verlicchi, Galletti , & Massotti , Promising practice to reclaim treated wastewater for reuse: Chemical disinfection followed by natural systems, 2009). Reverse osmosis is another water treatment method, which removes small ions from water (Howell, Future of membranes and membrane reactors in green technologies and for water use, 2003). Nanofiltration of water removes coloration and large ions, while microfiltration removes protozoan parasites and turbidity (Verlicchi, Galletti, & Massotti, Promising practice to reclaim treated wastewater for reuse: Chemical disinfection followed by natural systems, 2009). These treatment methods are most effective in providing safe drinking water when combined in hybrid systems where reverse osmosis, ultrafiltration techniques, and ozone filtration are employed in sequential steps to purify the water (Verlicchi, Galletti , & Massotti , Promising practice to reclaim treated wastewater for reuse: Chemical disinfection followed by natural systems, 2009). When water is purified through these methods and followed by treatment, it can then be used as a potable water source and decrease water scarcity. The use of reverse osmosis membranes made from polymer materials can also address increased salinization of freshwater due to sea level rise (Greenlee, Lawler, Freeman, Marrot, & Moulin, 2009). Salinized water is sent through the reverse osmosis membrane resulting in freshwater on the one side of the membrane and a concentrated salt solution on the other side. This process is repeated one to four times to ensure the purity of the water (Virginia Cooperative Extension, 2015). However, this method does contain a drawback: if the water contains certain contaminants, like boron, this method is ineffective in completely removing these chemicals (Virginia Cooperative Extension, 2015).

Case Study: The "Toilet to Tap" System

Communities can alleviate the impacts of climate change on drinking water systems through water conservation and reuse. In Wichita Falls, Texas potable reused water is produced to provide drinking water. The current system in use, called "Toilet to Tap," supplies up to one third of the city's daily demand for potable water (Witchita Falls Direct Potable Water Reuse Project, 2016). The used water is disinfected and pumped to the Cypress Water Treatment Plant where it undergoes the process of microfiltration. Subsequently, the water is treated through reverse osmosis and transported to a holding lagoon where it is blended in a 50/50 ratio with the water from Lake Arrowhead (Public Works Department, 2014). Finally, this blended water is treated through the standard treatment process including chlorination, coagulation, flocculation, sedimentation and fluoride treatment (Public Works Department, 2014). The city of Wichita Falls continuously receives the highest rating for drinking water systems and has collaborated with the Texas Commission on Environmental Quality to put additional checks in place for quality testing of reused drinking water (Public Works Department, 2014).

Figure 6. Lake Arrowhead in Wichita Falls, Texas in 2009 (left) and 2013 (right).

(Source: Pubic Works Department, 2014)

Extreme weather events such as heavy rain or floods can overwhelm current infrastructure because the volume of water during storms often exceeds the capacity of existing infrastructure. Excess water can lead to overflows in wastewater treatment and enters water sources. “Green infrastructure” is a new movement in water infrastructure renewal that aims to simulate natural water cycles and reduce the amount of stormwater that enters the pre-existing sewer and water system, also known as “gray infrastructure” (EPA, 2016). The vast majority of current water infrastructure is gray infrastructure, which consists of a traditional centralized system of pipes and storm drains that serve to collect and remove stormwater from system surfaces quickly (Chini, Canning, Schreiber, Peschel, & Stillwell, 2017). New implementation methods like green infrastructure can be less expensive and are less disruptive alternatives to excavating the entire aging gray infrastructure. Green infrastructure does not replace current infrastructure, but rather attempts to take the strain off of the present infrastructure.

Threat III: Intentional Acts of Sabotage

Intentional acts of sabotage can include pollution through biological, chemical or radiological agents, physical damage to the treatment or supply infrastructure, or the interruption of computerized systems through cyber-attacks (Nuzzo, 2006). Although intentional acts are not common, there is higher awareness of CWS as targets for terrorism, especially after the terrorist attacks of September 11th, 2001, commonly referred to as 9/11 (Copeland, 2010). Contamination of a drinking water system can result in illness or death, but can also have major psychological or economic consequences for an impacted region (Sobel & Watson, 2009).

Figure 7. Jerome Park park closed to the public as a protection measure.

(Source: Da Cruz, 2014. https://livingnewdeal.org/projects/jerome-park-reservoir-improvements-bronx-ny/)

Sabotage: A Potential Threat to Public Health

The biological, chemical, or radiological agents added to a drinking water system and can threaten public health. Symptoms can include gastritis, paralysis, or death, depending on the dosage and the interaction of the pollutant with other compounds in the water (Sobel & Watson, 2009). Some common biological agents that pollute water systems are bacteria, neurotoxins, and microbes (Khan, Swerdlow, & Juranek, 2001).

Following 9/11, the federal government focused on water infrastructure security as part of "critical infrastructure" under the USA PATRIOT Act (Moteff & Parfomak, 2004). Additionally, the Public Health Security and Bioterrorism Preparedness and Response Act of 2002 amended the SDWA to strengthen safeguards for drinking water systems by assessing their vulnerability to terror attacks. Even though there is no federal standard to address the readiness, response and recover actions for CWS, the EPA has developed tools and protocols to address this gap. The Large Water System Emergency Response Plan Outline (EPA, 2003) and the Emergency Response Plan Guidance for Small and Medium Community Water Systems are tools that are available for CWS. These guides were developed to help CWS comply with the Public Health Security and Bioterrorism Preparedness and Response Act of 2002 by outlining recommendation plans unique to each CWS, including prevention and emergency response plans in cases of terrorism (EPA, 2003; EPA, 2004).

In the case of an attack that produces a short-term CWS outage, the response can be as straightforward as issuing a public health notification. A long-term CWS outage, however, may be more complex, requiring procedures to lessen health impacts as well as provide alternative water sources (EPA, 2004). An area of growing concern is cyber security, since many CWS depend on automated systems. Water facilities are vulnerable to malicious software that can obstruct operations. CWS can implement preventative measures such as limiting the number of individuals with authorized access to networks, updating software periodically, and installing antivirus software and firewalls (EPA, 2012).

Figure 8. Salad Bar in The Dalles, Oregon.

(Source: Bovson, 2013. NY Daily News)

Preventing Intentional Acts of Sabotage

Current methods for preventing intentional acts of sabotage rely on computer monitoring software at treatment and distribution sites. One tool developed and utilized by the EPA is a sabotage-threat monitoring database, the Water Information Sharing and Analysis Center (WaterISAC) (AWWA Research Foundation, & EPA, 2005). WaterISAC uses a Blast Vulnerability Assessment tool, which calculates the impact of various scenarios where intentional attacks target water systems (AWWA Research Foundation, & EPA, 2005). In addition to utilizing software technology, the National Aeronautics and Space Association (NASA) and the Defense Intelligence Agency (DIA) have developed and deployed satellites with devices such as remote sensing data and hydrological modeling tools to help state governments better manage and protect their drinking water resources (Defense Intelligence Agency, 2012).

Case Study: Salmonella Poisoning

There are few publically documented cases of sabotage against water systems in the U.S. One widely-covered case occurred in The Dalles, Oregon in 1984 involving Salmonella (Sobel & Watson, 2009). In the 1980s, Bhagwan Shri Rajneesh, an immigrant from India formed a religious group called the Rajneeshees, in the town of Antelope, Oregon. With hundreds of members, the group elected Rajneesh for the City Council. They wanted to broaden their group by winning the Sheriff's office and Judgeship positions in the neighboring town of The Dalles. However, they were opposed by Oregon's Attorney General. They decided to fight this decision by altering the results of the election. With the intent of inducing illness to keep the townspeople from voting, the Rajneeshees cultured Salmonella Typhimurium in a basement laboratory and introduced it to the drinking water in salad bars around town (Crowe, 2007). Seven hundred people fell ill due to the incident, resulting in abdominal cramps, fever and diarrhea (Sobel & Watson, 2009). Initially, the investigation focused on the salad bar operations, and it took about a year to identify the responsible party and characterized the event as an intentional act of sabotage (Crowe, 2007).

Security and Information Restriction

With the increase in federal policies to strengthen water infrastructure security following 9/11, there have been tradeoffs between this increased security and information restrictions. For instance, the vulnerability assessments and emergency response certifications as mandated by the Public Health Security and Bioterrorism Preparedness Act of 2002 are exempt from disclosure requirements under the federal Freedom of Information Act (Defense Intelligence Agency, 2012). Proponents of public disclosure argue that water utilities are historically open institutions that disclosed more information before the enactment of the Freedom of Information Act and would like access to undisclosed information.

Threat IV: Infrastructure Degradation

Figure 9. Aging infraestructure in the US

(Source: Foxbussiness.com)

The failure to replace aging infrastructure can lead to problems for CWS, like corrosion in pipelines, filtration, and the deterioration of water quality over the long-term. Studies conducted by the Natural Resources Defense Council indicate that most of the U.S. drinking water plants still use century-old treatment technologies, which are not always kept up-to-date (Fedinick, Wu, & Olson, 2017). In 2011, the EPA estimated that aging community water infrastructure replacement requires a total investment of $371.4 billion over a 20-year period for adequate repairs (EPA, 2013).

Potential Introduction of Pollutants to the Drinking Water Supply

Safe and secure infrastructure is critical to any CWS, as water must flow efficiently to maintain clean drinking water throughout the system. Infrastructure degradation includes pipe breakage, pipe corrosion, septic system failure and build-up in the pipes or wastewater systems (Wedgworth & Brown, 2013). Pipeline leaks and bursts can interrupt the flow, leading to contamination of the water systems (Janke, Tryby, & Robert, 2014). Improperly maintained pipes that corrode and contain buildup can also cause water contamination (Renner, 2009). There are also several instances in which the breakdown of sewer or septic systems has introduced water-borne pathogens into the community water system. In Cabool, Missouri, a water line breakage led to E. coli outbreaks, and in Gideon, Missouri, deteriorating water storage tanks led to salmonellosis outbreaks (Janke, Tryby, & Robert, 2014).

Figure 10. Treated and not treated pipes against corrosion.

(Source: nrdc.org)

Case Study: Deteriorating Infrastructure Caused Salmonellosis Outbreak

In 1993, the town of Gideon, Missouri suffered a serious salmonellosis outbreak after the community water system was flushed in response to a foul taste and odor event (Janke, Tryby, & Robert, 2014). The flushed water was contaminated with salmonellosis that was delivered across the town. The tainted water sickened over half of the town’s population of 1,100 and caused seven deaths. A field study by the psouri Department of Health and the CDC discovered the source of the salmonellosis bacteria in the town’s largest municipal water tank. Deteriorated tank hatches allowed bacteria-laden bird droppings to enter the tank and then were delivered throughout the community during the flushing event.

Water Quality Monitoring Schemes: Are they Effective?

There are no requirements for continuous monitoring of any contaminant throughout an entire drinking water system. Often, the sampling conducted at the source does not capture the actual amount of contamination in drinking water because contamination may occur within the pipeline delivery system after delivery to homes or public infrastructures. At-the-tap testing exists for some contaminants, including lead, copper, coliform, disinfectants, and disinfection byproducts. Drinking water crises such as the lead contamination that occurred in Flint, Michigan in 2014 have raised concerns about the validity of current monitoring systems and water treatment. It has been well documented that the lack of treatment against corrosion in Flint's pipeline supply caused the lead contamination in the water system (Pieper, Tang, & Edwards, 2017).

Measuring Success

Outcomes

The purpose of the SRWSA is to ensure the availability of clean drinking water and the maintenance of delivery systems for the present and future. To meet this goal, several outcomes are needed:

- **Clean drinking water sources**,
- **Resilient water systems**,
- **Secure water systems** and
- **Infrastructure replacement**.

Inputs, Processes and Outputs

Program measurement requires evaluating program inputs and outputs to meet program goals. The SRWSA relies on several people and resources to provide clean drinking water. The major inputs are the EPA and the CWS managers. The EPA must provide guidance to CWS for SRWSA program implementation, and the CWS managers are responsible for conducting vulnerability assessments for the CWS. Other inputs include but are not limited to: various state and local regulatory agencies, federal, state and local funds, private contractors and water sampling technicians.

Water sampling is the major process by which water quality is determined. Over 90 contaminants, including microorganisms, disinfectants, disinfection by-products, inorganic chemicals, organic chemicals, and radionuclides have standards and treatments that are legally enforceable by the EPA (EPA, 2009). These standards all have Maximum Contaminant Levels (MCLs), which establish the maximum amount of the contaminant allowed in drinking water before the contaminant begins to affect public health, and are typically in either parts per million (ppm) or parts per billion (ppb) (EPA, 2017). Other processes include, but are not limited to: water source filtration, desalinization, and pH balancing.

The success of the SRWSA can be measured through the following outputs:

Threats to Safe Drinking Water	Outcomes	Outputs
Industrial Pollution & Agricultural Runoff	Clean drinking water sources	Increased water samples with contaminants that are less than or equal to the MCL
Impacts of Climate Change	Resilient water systems	Expanded reservoir storage Minimized system losses (evaporation, leaking) Curtailed runoff and flooding
Intentional Acts of Sabotage	Safe and secure water systems	Reduced frequency and severity of sabotage Raised detection through frequent monitoring and facility inventories Increased cybersecurity through limited connection to the internet, use of firewalls and password protection Improved emergency response time through installing early warning signs
Infrastructure Degradation	Infrastructure replacement	Increased pipe replacement - 16,000 to 20,000 miles of pipe per year before 2035 (ASCE, 2013) Augmented tanks and cistern replacement

Challenges to Program Measurment

Not all contaminants have federal standards for water monitoring and management. Without this threshold, measuring water contamination and quality is impossible to evaluate and manage. When evaluating the impacts of climate change variability, evaluating predicted risks is challenging. Consensus around climate change indicators and guidance instruments is limited, making monitoring climate change adaptation difficult (Preston, Westway, & Yuen, 2010).

Determining if an intentional act was committed can be difficult if there is no clear cause or party that takes responsibility. Detecting the source of contamination is challenging, unless a group takes responsibility. Thus, using the frequency of intentional acts of sabotage as an indicator of success is undermined if independent verification by a third party is not possible. Finally, monitoring US infrastructure replacement rate is difficult without standardized measures of reporting across local, state and federal government.

Conclusion

Community water systems and the safe drinking water they provide are essential resources for the majority of Americans. The four major threats identified by the bill each pose distinct dangers to human and environmental health, but can be addressed through policy-based assessment and mitigation as well as the use of technologies, as discussed above.

While the SRWSA raises controversies that may not have immediate solutions, understanding them is vital for enabling lawmakers to pragmatically implement corrective solutions. Evaluating the potential success of the bill is complex, as it involves layered threats that need to be measured simultaneously. The extent by which these measures will be defined as successful requires an understanding of the magnitude of threats in each particular CWS. Ultimately, federal intervention is needed to provide adequate support: in this case, for safe and quality drinking water. Divisions do exist among the public and decision-makers about the nature of the threats and how to best tackle them, but H.R. 1579: the Secure and Resilient Water Systems Act represents an opportunity to strengthen the Safe Drinking Water Act in order to protect the United States' water security well into the future.

References

107th Congress. (2002). *Public Health Security and Bioterrorism Preparedness and Response Act of 2002*. From https://energy.gov/sites/prod/files/2014/03/f12/PL107-188.pdf

109th Congress. (2005). *Energy Policy Act of 2005*. From https://www.gpo.gov/fdsys/pkg/BILLS-109hr6enr/pdf/BILLS-109hr6enr.pdf

115th Congress. (2017). *H.R.1579 - Secure and Resilient Water Systems Act* . From https://www.congress.gov/bill/115th-congress/house-bill/1579.

Abramsky, S. (2017). *Contaminated water challenges schools in California's San Joaquin Valley*. From UPI: https://www.upi.com/Top_News/US/2017/07/07/Contaminated-water-challenges-schools-in-Californias-San-Joaquin-Valley/5731499435470/

Ali, I. (2012). New Generation Adsorbents for Water Treatment. *Chemical Reviews*, 5073-5091.

ASCE. (2013). *Report Card for America's Infraestructure: Drinking Water.*

AWWA Research Foundation, & EPA. (2005). Distribution System Security Primer for Water Utilities., (pp. 1-128).

Bhatnagar, A., & Sillanpaa, M. (2010). Utilization of Agro-industrial and Municipal Waste Materials as Potential Adsorbents for Water Treamtnent- A Review. *Chemical Engineering Journal*, 277-296.

Bhatnagar, A., & Sillanpaa, M. (2010). Utilization of Agro-industrial and Municipal Waste Materials as Potential Adsorbents for Water Treatment - A Review. *Chemical Engineering Journal*, 277-296.

Brown, H. (2014). *Next Generation Infrastructure: Principles for Post-Industrial Public Works.* Washington, D.C.: Island Press. doi:10.5822/ 978-1-61091-202-0_2

Centers for Disease Control and Prevention. (2009). *Public Water Systems FAQ*. From www.cdc.gov/healthywater/drinking/public/faq.html

Chini, C. M., Canning, J. F., Schreiber, K. L., Peschel, J. M., & Stillwell, A. S. (2017). The Green Experiment: Cities, Green Stormwater Infrastructure, and Sustainability. *Sustainability, 9*(1), 105. doi:10.3390/su9010105

Copeland, C. (2010). *Terrorism and Security Issues Facing the Water Infraestructure Sector.* Washington D.C.: Congressional Research Service. From https://fas.org/sgp/crs/terror/RL32189.pdf

Crowe, K. (2007). Salad Bar Salmonella. *Forensic Examiner, 16*(2), 24-25.

Defense Intelligence Agency. (2012). *Global Water Security: Intelligence Community Assessment*. Retrieved July 15, 2017 from https://www.dni.gov/files/documents/Newsroom/Press%20Releases/ICA_Global%20Water%20Security.pdf

DiGiulio, D., & Jackson, R. (2016). Impact to Underground Source of Drinking Water and Domestic Wells from Production Well Stimulation and Completion Practices in the Pavilion, Wyoming field. *Environment Science and Technology*, 4526-4530.

EPA. (2003). *Large Water System Emergency Response Plan Outline: Guidance to Assist Community Water Systems in Complying with the Public Health Security and Bioterrorism Preparedness and Response Act of 2002.* Office of Water. From https://www.epa.gov/sites/production/files/2015-03/documents/erp-long-outline.pdf

EPA. (2004). *Emergency Response Plan Guidance for Small and Medium Community Water Systems to Comply with the Public Health Security and Bioterrorism Preparedness and Response Act of 2002.* Office of Water. From https://www.epa.gov/sites/production/files/2015-04/documents/2004_04_27_watersecurity_pubs_small_medium_erp_guidance040704.pdf

EPA. (2004). *Technical Support Document for the 2004 Effluent Guidelines Program Plan.* Office of Water. From https://www.epa.gov/sites/production/files/2015-10/documents/petro-refining-elg-study_2004.pdf

EPA. (2004). *Understanding the Safe Drinking Water Act.* From https://www.epa.gov/sites/production/files/2015-04/documents/epa816f04030.pdf

EPA. (2009). *National primary drinking water regulations.* From https://www.epa.gov/sites/production/files/2016-06/documents/npwdr_complete_table.pdf

EPA. (2012). Cyber Security 101 for Water Utilities. Office of Water.

EPA. (2012). *Cyber Security 101 for Water Utilities.* Office of Water. From https://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=P100KL4T.txt

EPA. (2013). *Drinking water infrastructure needs survey and assessment: Fifth Report to Congress.* Office of Water. From https://www.epa.gov/sites/production/files/2015-07/documents/epa816r13006.pdf

EPA. (2015). *About the Water Infrastructure and Resiliency Finance Center*. Retrieved from Water Infrastructure and Resiliency Finance Center:

https://www.epa.gov/waterfinancecenter/about-water-infrastructure-and-resiliency-finance-center#goals

EPA. (2015). *Regulation Timeline.* From https://www.epa.gov/sites/production/files/2015-10/documents/dw_regulation_timeline.pdf

EPA. (2016). *Safe Drinking Water Act (SDWA) and Federal Facilities.* From https://www.epa.gov/enforcement/safe-drinking-water-act-sdwa-and-federal-facilities

EPA. (2016). *What is Green Infrastructure?* From https://www.epa.gov/green-infrastructure/what-green-infrastructure

EPA. (2017). *How EPA regulates drinking water contaminants.* From https://www.epa.gov/dwregdev/how-epa-regulates-drinking-water-contaminants#decide

EPA. (2017). *Summary of the Safe Drinking Water Act*. From https://www.epa.gov/laws-regulations/summary-safe-drinking-water-act

Fedinick, K. P., Wu, M., & Olson, E. (2017). *Threats on Tap: Widespread Violations Highlight Need for Investment in Water Infrastructure and Protections.* NRDC. Retrieved from https://www.nrdc.org/resources/threats-tap-widespread-violations-water-infrastructure

Gammon, C. (2012). Satellites Track Hurricane Sandy Water Pollution. *Scientific American*.

Gammon, C. (2012, November 17). *Satellites Track Hurricane Sandy Water Pollution*. From Scientific Amercian: https://www.scientificamerican.com/article/hurricane-sandy-water-pollution/

Georgakakos, A., Fleming, P., Dettinger, M., Peters-Lidard, C., Richmond, T., Reckhow, K., . . . Yates, D. (2014). Water Resources. Climate Change Impacts in the United States. In T. Richmond, G. Yohe, & M. Melillo, *The Third National Climate Assessment, J. M. Melillo* (pp. 69-112). U.S. Global Change Research Program.

Greenlee, L. F., Lawler, D. F., Freeman, B. D., Marrot, B., & Moulin, P. (2009). Reverse osmosis desalination: Water resources, technology and today's challenges. *Water research*, 2317-2348.

Howell, J. A. (2003). Future of membranes and membrane reactors in green technologies and for water use. *Desalination*, 1-11.

Howell, J. A. (2003). Future of Membranes and membrane reactors in green technologies and for water use . *Desalination*, 1-11.

Islam, S., & Tanaka, M. (2004). Impacts of Pollution on Coastal and Marine Ecosystems Including Coastal and Marine Fisheries and Approach for Management: A Review and Synthesis. *Marine Pollution Bulletin*, 624-629.

Janke, R., Tryby, E. M., & Robert, M. C. (2014). Protecting Water Supply Critical Infrastructure: An Overview. In *Securing Water and Wastewater Systems* (pp. 29-85). Springer International Publishing. doi:10.1007/978-3-319-01092-2_2

Jarup, L. (2003). Hazards of Heavy Metal Contamination. *Br Med Bull*, 167-181.

Jarup, L. (2003). Hazards of Heavy Metal Contamination. *British Medical Bulletin, 68*(1), 167-181.

Jiménez Cisneros, B., Oki, T., Amell, N., Benito, J., Cogley, J., Döll, P., . . . Mwakalila, S. (2014). Freshwater resources. In I. P. Change, *Climate Change 2014: Impacts,Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* (pp. 229-269). From https://www.ipcc.ch/pdf/assessment-report/ar5/wg2/WGIIAR5-Chap3_FINAL.pdf

Jiménez Cisneros, B., Oki, T., Amell, N., Benito, J., Cogley, J., Döll, P., . . . Mwakalila, S. (2014). Freshwater resources. In I. P. Change, *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* (pp. 229-269). From https://www.ipcc.ch/pdf/assessment-report/ar5/wg2/WGIIAR5-Chap3_FINAL.pdf

Kant, R. (2012). Textile Dyeing Industry an Environmental Hazard. *Natural Science*, 22-26.

Kelly, S., & Hilton, J. (2009). *Community Water Systems.* Utton Transboundary Resource Center. From http://uttoncenter.unm.edu/pdfs/water-matters-2015/13_Community_Water_Systems.pdf

Khan, A., Swerdlow, D., & Juranek, D. (2001). Precautions against biological and chemical terrorism directed at food and water supplies. *Public Health Reports, 1*(116), 3-14.

Kjellstrom, T., Lodh, M., McMichael, T., Ranmuthugala, G., Shrestha, R., & Kingsland, S. (2006). Air and Water Pollution: Burden and Strategies for Control. *Disease Control Priorities in Developing Countries*, 817-832.

Klass, V. (2014). What's the Big Fracking Deal. *Western State Law Review*, 164.

Levin, R. B., Epstein, P. R., Ford, T. E., Harrington, W., Olson, E., & Reichard, E. G. (2002). U.S. drinking water challenges in the twenty-first century. *Environmental Health Perspectives*(110 (Suppl 1)), 43–52.

Maddocks, A., Reig, P., & Gassert, F. (2014, March 27). *Drought Is Only One Explanation for California's Water Crisis*. From World Resources Institute: http://www.wri.org/blog/2014/03/drought-only-one-explanation-california%E2%80%99s-water-crisis

Means, E. G., Laugier, M. C., Daw, J. A., & Owen, D. M. (2010). Impacts of climate change on infrastructure planning and design: Past practices and future needs. *American Waterworks Association, 102*(6), 56-65.

Morrison, R., Sangster, T., Downey, D., Matthews, J., Condit, W., Sinha, S., . . . Sterling, R. (2013). *State of Technology of Water Distribution Systems.* Water Supply and Water Resources Division. United States Environmental Protection Agency. From www. epa. gov/gateway/science

Moteff, J., & Parfomak, P. (2004). Critical Infrastructure and Key Assets: Definitions and Identification. *CRS Report for Congress.*

National Climate Assessment. (2014). *Response Strategies - Adaption.* From http://nca2014.globalchange.gov/report/response-strategies/adaptation

National Climate Assessment. (2014). *Water resources.*

National Climate Assessment. (2014). *Water resources.* From http://nca2014.globalchange.gov/report/sectors/water

National Institute of Health. (2017). *Agricultural Runoff: What is Agricultural Runoff?* From NIH: https://toxtown.nlm.nih.gov/text_version/locations.php?id=1

NOAA. (2012). *Hurricane Sandy*. From National Weather Service: https://www.weather.gov/mfl/sandy

Nuzzo, J. B. (2006). The Biological Threat to U.S. Water Supplies: Toward a National Water Security Policy. *Biosecurity and Bioterrorism: Biodefense Strategy, Practice and Science, 4*(2), 147-159.

Pandey, P. K., Kass, P. H., Soupir, M. R., Biswas, S., & Singh, V. P. (2014). Contamination of water resources by pathogenic bacteria. *AMB Express, 4*(51), 1-16. doi:10.1186/s13568-014-0051-x

Patterson, C. L., Impellitteri, C. A., Fox, K. R., Haught, R. C., Meckes, M. C., & Blannon, J. C. (n.d.). *Emergency Response for Public Water Supplies after Hurricane Katrina.* United States Environmental Protection Agency. United States Environmental Protection Agency.

Patton, J. L., & Harms, L. L. (1988). Drinking Water Policy in the United States. *Journal of Professional Issues in Engineering, 114*(4), 394-400.

Pieper, K. J., Tang, M., & Edwards, M. A. (2017). Flint Water Crisis Caused By Interrupted Corrosion Control: Investigating “Ground Zero” Home. *Environmental Science & Technology, 51*(4), pp. 2007-2014. doi:10.1021/acs.est.6b04034

Preston, B., Westway, R., & Yuen, E. (2010). Climate adaptation planning in practice: an evaluation of adaptation plans from three developed nations. *Mitigation and Adaptation Strategies for Global Change, 16*(4), 407–438. From https://link-springer-com.ezproxy.cul.columbia.edu/content/pdf/10.1007%2Fs11027-010-9270-x.pdf

Public Works Department. (2014). *Steps in the DPR water treatment process.* Wichita Falls Texas.

Rajkumar, D., & Palanivelu, K. (2004). Electrochemical Treatment of Industrial Wastewater. *Journal of Hazardous Materials*, 123-129.

Renner, R. (2009, December). Out of Plumb: When Water Treatment Causes Lead Contamination. *Environmental Health Perspectives, 117*(12), A542-A547. From http://www.jstor.org/stable/30249850

Rosenberg, N. J., Epstein, D. J., Wang, D., Vail, L., Srinivasan, R., & Arnold, J. G. (1999). Possible Impacts of Global Warming on the Hydrology of the Ogallala Aquifer Region. *Climate Change, 42*(4), 677-692.

Ross, D. (2015). *Industrial Pollution is Threatening our Drinking Water: A Dispatch from Los Angeles County.* From Truth Out: www.truth-out.org/news/item/32021-industrial-pollution-is-threatening-our-drinking-water-a-dispatch-from-los-angeles-county

Sobel, J., & Watson, J. C. (2009). Intentional Terrorist Contamination of Food and Water. In *Beyond Anthrax: The Weaponization of Infectious Diseases* (pp. 207-224). Humana.

Spadoni, D., & Levis, E. (2016). North-Central PA Flooding Causes Gasoline Pipeline Leak in Lycoming County. Gamble Township: Pennsylvania Pressroom.

Steinzor, R. I. (1996). Unfunded environmental mandates and the “new (new) federalism: Devolution, revolution, or reform? *Minnesota Law Review*, 97-228. From http://digitalcommons.law.umaryland.edu/cgi/viewcontent.cgi?article=1873&context=fac_pubs

Swanson, A. (2013). *Agricultural runoff: what is agricultural runoff?* From NPR: http://www.npr.org/sections/thesalt/2013/07/09/199095108/Whats-In- The-Water-Searching-Midwest-Streams-For-Crop-Runoff

Swanson, A. (2013). *What Is Farm Runoff Doing To The Water? Scientists Wade In*. From NPR: http://www.npr.org/sections/thesalt/2013/07/09/199095108/Whats-In-The-Water-Searching-Midwest-Streams-For-Crop-Runoff

Swinton, M. W., Eichler, L. W., Farell, J. L., & Boylen, C. W. (2015). Evidence for water temperature increase in Lake George, NY: impact on growing season duration and degree days. *Lake and Reservoir Management, 31*(3), 241-253.

Tiemann, M. (2017). *Safe Drinking Water Act (SDWA): A Summary of the Act and Its Major Requirements.* Congressional Research Service. From https://fas.org/sgp/crs/misc/RL31243.pdf

United States Environmental Protection Agency. (2006). Revitalizing America's Mills: A Report on Brownfields Mill Projects. 1-32.

US Congress. (1974). *The Safe Drinking Water Act.* From https://www.gpo.gov/fdsys/pkg/USCODE-2010-title42/pdf/USCODE-2010-title42-chap6A-subchapXII.pdf

US Environmental Protection Agency. (2009). *National primary drinking water regulations.* From https://www.epa.gov/sites/production/files/2016-06/documents/npwdr_complete_table.pdf

US Environmental Protection Agency. (2017). *How EPA regulates drinking water contaminants.* From https://www.epa.gov/dwregdev/how-epa-regulates-drinking-water-contaminants#decide

Verlicchi, P., Galletti , A., & Massotti , L. (2009). Promising practice to reclaim treated wastewater for reuse: Chemical disinfection followed by natural systems. *Desalination*, 490-508.

Verlicchi, P., Galletti, A., & Massotti, L. (2009). Promising practice to reclaim treated wastewater for reuse: Chemical disinfection followed by natural systems. *Desalination*, 490-508.

Virginia Cooperative Extension. (2015). Decreasing runoff and increasing stormwater infiltration. *Virginia Polytechnic Institute and State University*, 426-446.

Vorob'eva, T. V., Terletskaya, A. V., & Kushchevskaya, N. F. (2007). Standardized and Unified Methods for Determining Phenols in Natural and Drinking Waters and Main Trends of Their Development. *Journal of Water Chemistry and Technology, 29*(4), 203-213. doi:10.3103/S1063455X07040030

Wedgworth, J. C., & Brown, J. (2013, March). Limited Access to Safe Drinking Water and Sanitation in Alabama's Black Belt: A Cross-Sectional Case Study. *Water Quality, Exposure, and Health, 5*(2), 69-74. doi:10.1007/s12403-013-0088-0

Witchita Falls Direct Potable Water Reuse Project. (2016, July 05). Retrieved 2017, July from Our Texas Water: http://ourtexaswater.org/projects/wichita-falls-direct-potable-water-reuse-project