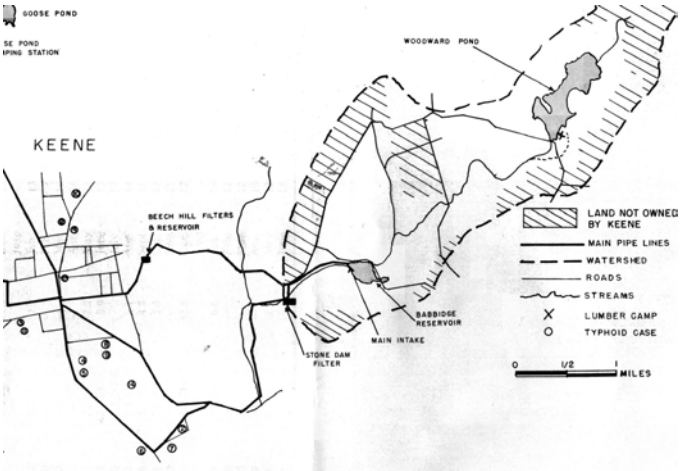
Chapter 5 – Disasters, War and Emergency Planning

As hard as we all work on building and operating good water supplies, as good as our skills and experience make us, we can only control the situation so much until something bigger than we can handle comes along. These times help define our history.

There are four types of extraordinary events that are discussed fairly frequently in the history of the NEWWA Journal: public health incidents, water supply failures, natural disasters and social disasters such as wars.

Public Health Incidents

The early years of the Journal record a significant number of waterborne disease investigations that found some source of typhoid contribution from within the source watershed. The absence of effective treatment in the early days was the real culprit and once disinfection was widely practiced, the incidence of waterborne disease dropped off to near nothing. There was still an occasional problem, one notable one being the 1959 Keene NH outbreak which had hundreds of cases of gastroenteritis but, most notably, 14 cases of typhoid, one of which was fatal. This was traced back to an infected person at a logging camp in the watershed and was made possible by the absence of residual disinfection, something that was immediately rectified after the incident. The supply was actually filtered but the event came during heavy rains while a filter was being cleaned. Other relatively minor incidents included a 1978 Campylobacter outbreak in Vermont with 3,000 cases, a 1976 Giardia outbreak in Berlin NH with 750 cases, a 1985 Giardia outbreak in Pittsfield MA with 700 cases and a 2002 Norovirus outbreak in Connecticut with 142 cases. New England has been relatively well off compared to other regions of the country.



1959 Keene typhoid incident, note logging camp near pond

The focus on public health incidents in the past several decades has been more on breakdowns of the protection barriers. With the advent of effective treatment, complacency can be a problem where there are high risk sources, examples being the Milwaukee WI and Walkerton Ontario sources that often had runoff from cattle grazing. The lessons here were learned elsewhere but were significant for the entire industry. In both the 1993 Milwaukee cryptosporidium incident and the 2000 Walkerton *E coli* incident, the real issue was failure of the treatment process. The Milwaukee incident is believed to be the result of improper filtration backwashing combined with the intake being susceptible to high cryptosporidium loadings during storm events. It is clearly the largest waterborne disease incident in modern times with over a hundred deaths and 400,000 cases of illness. It is also an example of how effective a biological agent can be and why we need to be vigilant in securing water systems. In a historical footnote, this was not a

first large waterborne health incident for Milwaukee. In 1916, there was an incident involving a night-time operator that did an unauthorized shutdown of their chlorination after receiving a complaint of chlorine taste, leading to 60,000 cases of gastroenteritis, 400-500 cases of typhoid and 40-50 deaths. This speaks volumes for selection of a well protected source to minimize reliance on the treatment barriers always being 100% effective.

The Walkerton incident that caused seven deaths and up to 2,000 illnesses was an example of operator inattention and, worse, operator dishonesty. The loss of chlorination that caused the incident to occur was unreported and water quality tests were falsified to hide the lapse. Fortunately this is rare within the industry and serves as a reminder of the importance of our actions in protecting the public.

The occurrence of other health disasters is worth noting. The 1918 pandemic, commonly called the "Spanish Flu", was an example of a viral epidemic with enormous impact. It hit New England hard, starting in Boston's military hospital that was treating cases of the flu in returning World War I soldiers and then expanding out to the general public through person to person transmission. In a matter of months, this flu passed through the entire country causing infected persons to be severely ill at best and causing death in a relatively high percentage of cases. The epidemic was so virulent and the strain of flu so deadly that otherwise healthy people died very rapidly. Since the only possible response was to limit contact to avoid infection, this pretty much cleared the streets and affected society at all levels. The lesson from this for water suppliers is important and the current Avian Flu and SARS scares make this a timely issue. Water suppliers will need to be prepared to operate through pandemic conditions someday where a significant percentage of staff is unavailable and other businesses that provide critical services like chemicals, materials or services may be equally unable to fulfill needs.

3 Unreal Biological Infestations

Fiction is stranger than truth when it comes to some reservoir stories:

1. "**Champie**" is the name for the sea serpent that roams Lake Champlain, Burlington VT's water supply. Sightings are attested to by many residents.

2. **Stephen King** wrote his book "*Dreamcatcher"* after visiting Quabbin Reservoir. The Intake is featured in the climactic final scene where an intelligent space fungus tries to infect Boston's water supply. Stephen King also featured Bangor's 1875 Water Works and Thomas Hill Standpipe in other stories.

3. Providence's Scituate Reservoir, when it was being constructed in the 1920's, was the inspiration for **H. P. Lovecraft**'s short story "*The Colour Out of Space*". Lovecraft tells of a strange growth that arrived on a meteorite, possessing people in the final days before the area was inundated by reservoir filling.

No word on regulation of alien growths or sea serpents in SDWA amendments.

Water supply disasters – Things just break sometimes

Many water supply problems came early in the development of water supply technologies and were the result of a sometimes painful learning curve. For example, soils engineering really didn't come of age until the early 1900's, which meant engineering specialties like dam design in the 1800's were done more through lore handed down from mentor engineer to student engineer rather than through sound understanding of principles. Hydrology and hydraulics were still

young fields in the 1800's and the absence of reliable records of floods and drought meant there was an inadequate understanding of nature's extremes.

Catastrophic failure of water facilities occasionally caused problems beyond the interruption of the water supply. Collapse of water containing facilities was a significant hazard to the downhill areas.

Dam failures

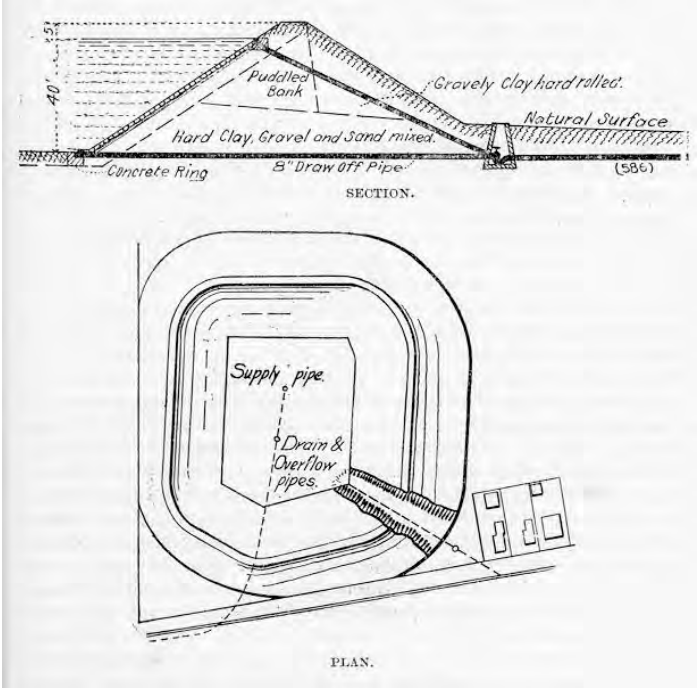
Most early colonial dams had been built privately for mills and failure was not unknown. The first major dam failure in the US was in 1874 in Williamsburg MA, killing 144 people and causing $1 million in damages. Many early timber dams, such as the original Holyoke Dam on the Connecticut River had failed but with lesser consequences. As late as 1889, the Johnstown, PA dam failed, taking 2,200 lives, still the largest US loss of life due to a dam failure. The Johnstown failure in particular, was clearly the result of inadequate understanding of proper maintenance and flood management by the non-technical owners.

In the water supply world, there had been an 1842 failure of New York's Croton dam during construction. Within New England, there had been several failures of water supply dams including the 1848 failure of Boston's original Lake Cochituate stone dam during filling, the 1867 failure of Hartford's Dam No. 1 on Trout Brook during a flood event while under construction and the 1876 failure of Worcester's original Lynde Brook dam. The Worcester event was clearly the most destructive. Failure was preceded by substantial leakage from the old earthen structure and gradual undermining of the dam. The flood swept away the gatehouses, leaving a hole 150' wide by 20' deep and causing a water level drop of 16' in an hour and a half. Owing to the warning, no lives were lost but downstream mills, houses and railroad embankments were washed away causing $750,000 in damages. Worcester rebuilt the dam and continues to use this source to this day. In each of these older incidents, the underlying cause was a lack of engineering knowledge, be it an underlying soils issue as in Lake Cochituate or Lynde Brook or inadequate flooding protection as on Trout Brook.

As with all dams, water suppliers have been subject to monitoring requirements regarding physical condition of the dam and follow-up remediation steps to assure safety. During the 1936 and 1955 hurricanes, non-water supply dam collapses in New England caused extensive damage to downstream communities. Nationally, following some particularly catastrophic dam failures in the 1970's, federal regulation came in the form of the 1972 National Dam Inspection Act which directed states to assume primary responsibility for dam condition and directed the Corps of Engineers to inspect all high hazard dams. This continues to be a timely issue with 2 national examples of privately owned dam failures (Hawaii and Missouri) with resulting fatalities in 2006.

Examples of distribution storage failures

- Portland ME distribution reservoir – In 1882, one of the city's open reservoirs breached and in 30 minutes discharged 6 million gallons into the streets of the city, causing some damage but injuring no one.
- Fairhaven MA tank – In 1901, the city's new steel elevated tank collapsed one night in high wind. As with many other early tanks, the wind stresses were not adequately addressed.
- Other early uncovered tanks, such as an early steel tank in Bath ME, had such little reinforcing in the top ring that they were buckled by wind forces.



1882 Portland ME Distribution Reservoir breach


1901 Fairhaven MA Tank


1901 Fairhaven MA Tank after the failure


1921 Bath ME Failure of open top tank

- Saugus MA Tank – On September 22, 1987, a 40 year old steel elevated tank in Saugus MA ruptured. The escaping water crushed several cars and damaged an adjacent cable television building but, fortunately, did not cause any deaths or extensive property damage.

- New London CT Tanks – In 1943, New London had constructed three new 1.2 MG prestressed reinforced concrete tanks in a cluster. In 1960, there was a catastrophic breach and flooding from 2 of the three tanks. The cause was later determined to be soil settlement and failure of the piping in the space between the tanks and subsequent undermining and

collapse of 2 of the tank floors. The event caused no loss of life and minimal damage but resulted in a review of all similar reinforced concrete tanks.

New London CT prestressed concrete tanks, failure occurred at pipe manifold in center

1988 Holden MA dome failure

Water Supply Irony – Part 1

Water tanks help provide fire protection, right? How about a water tank that burns down? This happened in Boston during the early 1900's to an early iron plate tank in the Orient Heights neighborhood of East Boston. The tank had a wood framed and shingled enclosure with an internal stairway to a public viewing platform. It caught fire and burned to the ground, causing significant damage to the iron tank. Other historic wooden enclosed tanks such as those in Bangor ME and Scituate, MA now have internal sprinkler systems.

East Boston Tank

Water Supply Irony – Part 2

How about when the Water Department offices burn down? This happened in 1925 to Fairhaven MA. In a 1940 paper, they declared themselves as being the most hard luck Water Department in NEWWA, having had 4 recent major disasters - the others being the 1938 hurricane, a 1901 elevated tank collapse and a 1933 lightning strike that collapsed their pump station chimney.

Breaks

1916 Pumping out a basement after a 48" pipe break in Boston MA

Every water system superintendent has been woken up in the night to control flooding from some ruptured pipe, often with resulting flooding of homes or sensitive facilities. Every community could tell stories about "the big break" in their system but only one can claim the largest pipe break in New England. That dubious honor apparently goes to Providence, RI which had a rupture in its 102" prestressed concrete aqueduct in a Cranston neighborhood on 11/17/1996. A rather large chunk of wall blew out in a section that had experienced reinforcing wire failure from corrosion. An 80 acre area of Cranston was flooded and the pressure loss affected 600,000 customers. Fortunately, there was a backup pipe, smaller but large enough to provide supply during the 2 month repair.

Power failures

While most water systems have taken care to develop backup power for critical facilities, recent national experience is worth noting. The 2003 power failure that affected most of the northeastern and mid-western states demonstrated that not everyone was ready. Both Cleveland and Detroit suffered service outages when their large source water pumping systems couldn't operate. Only the far western parts of New England were directly affected and there were no significant water supply problems. The great Northeast blackout of 1965 had similarly affected the entire New England area but the outage was much briefer, so any water systems that couldn't pump probably were able to continue service on storage. These incidents are ample reinforcement to consider maintaining strong backup power readiness.

Natural disasters

In the 125 year history of the organization, there have been many significant natural destructive events, such as floods, hurricanes, blizzards and earthquakes. Some examples of these events are described below.

1936 flood in Hartford CT

Spring Floods

The most notable floods in New England were the following:

- 1927 Vermont flood (84 dead, $28M damages) – This flood caused extensive flooding of riverfront villages and washing out of mains on bridges and streets near the rivers.
- 1936 Storm and rapid snowmelt (24 dead, $113M damages, Merrimack River valley cities very hard hit, 77,000 homeless, Hooksett NH 18-20' under water). Noted among the stories after this incident was the flooding of the Lawrence Experiment Station up to the lab benches. The Lawrence engineering staff also disconnected and pulled their electric motors up to the second floor to avoid flood damage.

In both these cases, water supply facilities along the rivers were flooded and significantly damaged causing extended loss of service in many communities.

Hurricanes and High Wind Events

In general, hurricane damage to water supplies is due to several factors. In addition to the expected damages due to high winds and falling tree limbs, power failures affect everyone. Coastal storm surges cause salt water fouling of coastal groundwater and low lying water reservoirs. River flooding can cause washouts of roads and bridges and, with them, the pipes. Any water facilities, like intakes or pump stations, in the coastal storm surge areas or river flood

plains can experience extensive flooding damage. The most significant storms included the following:

1954 Hurricane – Bristol RI staff closing a valve during the storm

1954 Tidal surge ocean water pouring into Kickemuit Res., Bristol RI

- Unnamed Category 3 1938 hurricane (700 killed, 400M damages) – This storm caused extensive wind damage to facilities and knocked down most of the trees in central New England. In addition to the building damages, this storm had significant lasting effects on water quality and watershed runoff of many surface sources. A follow-up review in Massachusetts noted that 24 communities had lost mains and 14 had sources flooded out. 10 additional communities lost power and 2 had standpipes damaged, including East Brookfield which had their standpipe overturned completely.
- Carol 1954 (66 dead, $500M damages) - This storm produced a devastating storm surge in Connecticut, Rhode Island and the Buzzard Bay area of Massachusetts, destroying 5,000 buildings. Coastal supplies were especially hard hit with water quality problems from salinity and wind blown debris.
- Diane 1955 (90 dead, 1500 homes damaged) - This storm dumped up to 20” of rain and caused the Blackstone River to go 17’ over flood stage at Woonsocket RI. Roads and bridges were washed out with loss of water supply pipes.
- Donna 1960 (50 deaths, $387M in damages) - This storm crossed Long Island and hit Connecticut with extensive storm surge damage along the coast and up to 130 mph winds in Rhode Island.

Blizzards

The Great blizzard of 1978, a storm with 24” to 38” of snow, followed an earlier 20” snowfall causing near complete paralysis of most of southern New England. This was an interesting challenge for most operators with many staff having to bunk in at their facilities for lack of relief shift operators.

Earthquakes

New England has the potential for substantial earthquake events but they are much less frequent than those of the west coast, where the need to harden piping across fault areas and to have substantial response resources in place has been deemed necessary. Northern New England is much closer to the more active Quebec earthquake area but southern New England has more vulnerable construction in its older communities. Either way, the risk of damage from a repeat of some of the earlier recorded earthquakes is substantial and lessons could be learned from west coast experience. The following are some of the region's bigger events:

- 1638 in NH - Estimated at 6.5-7 magnitude, damage was limited due to very simple construction in early colonial days.
- 1755 in Cape Ann, MA - Estimated at 6.0 magnitude, many buildings fell as far away as Boston.
- 1940 in Tamworth NH –Estimated at 5.5, apparently caused a Chicopee MA pipe failure.

Social Conflicts and War

Nature's fury is at least fairly short-lived. War can go on for years and the after effects last longer. Several such major events dominated the history of water supply and were documented by many NEWWA Journal papers.

Earlier wars

Prior to World War I, wars didn't have too much direct impact on New England water supplies mainly because they were elsewhere. It is notable that medical men were as unfamiliar with germ theory as the water suppliers at the time. The result was that these wars were extremely deadly to the participants from the lack of proper sanitation, with more men dying from typhoid in remote war zones than from flying bullets.

World War I

New England men went to fight this war with at least some understanding of sanitation but were faced with new threats such as chemical warfare. Even the water supplier's new friend, chlorine gas, was used a chemical weapon on the battlefield.

World War I water wagon

One subject discussed at some length in the NEWWA Journal was the water supply issues associated with the Allied Expeditionary Force (AEF). Bacteria testing and water treatment via disinfection were now practiced in the field. A noteworthy paper in 1919 by Col. Francis Longley, a member of NEWWA who had served in the AEF, documents the experiences of his 26th Engineers, a U.S. Army Regiment whose special

purpose was the water supply for the Allied Forces in their zone. They supplied safe water to not only the men but also the horses being used by the troops. They performed water quality testing and treatment in a live war where chemical weapons were used in combat for the first time and sanitary conditions were horrendous. As was common in wars of this period, more casualties in this unit were from disease (21) than from battle wounds (5).

"Hardened" pump station at St. Jacques

The war was clearly limited to Europe but the US had declared war on countries from which many people had emigrated to the US. The idea that enemy sympathizers in the US could sabotage critical infrastructure was a novel one that caused some amount of concern for the security of water supplies at home.

The other notable impact on water supplies in this period was in the lack of resources at home. Coal was in short supply to the point that the steam stations struggled to maintain operation. Gasoline and diesel fuel were in similar short supply. Metal for pipes was scarce so distribution system expansion was limited and new pipe materials like reinforced concrete were looked at more seriously.

1919 - 26th Engineers mobile water treatment truck

Mobile chemical feed

1919 Boston Police Strike
Shortly after World War I, the increase in union activity led to strikes in many industries. The most disruptive was a 1919 strike by Boston policemen which led to rioting in the downtown neighborhoods. As was the case during the World Wars, key water facilities required full time guards.


MA National Guard protecting Chestnut Hill Reservoir in Brighton MA during 1919 Police Strike

World War II

The concerns during WWII were similar to those of World War I but now improved airplane technology meant that bombs could conceivably be delivered over the US mainland. This caused much consternation in the water supply world since it was apparent from the extensive bombing in Europe that water utilities were suffering great damage. Contingency plans were called for to contain pipe ruptures due to bombing and to build redundant facilities for critical aqueducts or pump stations. One common technique was to add hydrants to suction and discharge piping of pump stations to allow a fire engine pump to serve as a backup.

Many more chemical and biological agents were now available as weapons. In fact, active testing and/or use of such had occurred in some theaters of the war. Experts now began to be concerned over the use of such materials away from the battlefield, with US water supplies being considered a likely target to demoralize the US public. Briefings were provided to water suppliers regarding these agents and their likely effects in drinking water. Response measures focused on the use of higher chlorine doses and delivery of extra chlorine at additional points in the distribution system.


WW II Bomb crater in England, water leaking from broken main

The idea of saboteurs now included both enemy sympathizers (a.k.a. Fifth Columnists) and also the possibility of spies being landed on our shores by submarines. Arrests of such infiltrators

were apparently made by the FBI in separate incidents on Long Island NY and Jacksonville FL, according to one NEWWA paper. The reaction in the water supply world, as one of the critical infrastructures, was to fortify facilities and guard them with armed troops in some cases. This is not unlike the reaction to today's threat of terrorism.

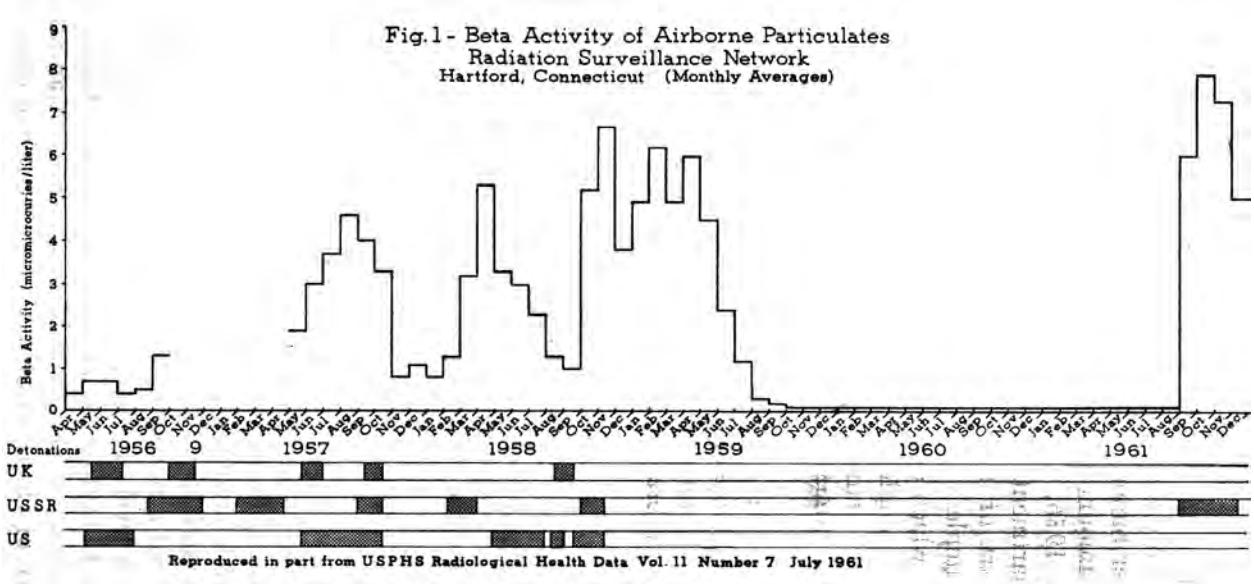
Shortages in many materials essential to the war effort such as iron, steel and rubber affected the water supply industry. Vendors of many new materials like asbestos cement pipe and reinforced concrete pipes and tanks took the sales approach that it was patriotic to use less metal by using their product. With the draft taking many New England men, labor for system improvements or even just maintenance was in short supply as well.

Ads run by a prestressed concrete pipe manufacturer emphasizing the metal saved by using their product

The Cold War

The end of World War II, brought about by the use of the atom bomb, began the Cold War era. During this period, other nations developed not just nuclear capabilities, but also the ability to deliver many nuclear missiles or bombs to target cities in the US. This raised anxiety among water suppliers in the same way that the public began to fear the bomb. NEWWA Journal articles quoted briefings of the probable deaths within a certain radius of cities like Boston and counseled that water suppliers needed to come up with response plans for post nuclear attack scenarios.

The threat of radiation from fallout turned to reality in a limited way as a result of the open air H-bomb testing done in the early days of nuclear escalation. With Russia, the US and others conducting bomb testing, fallout became a worldwide problem which, for a time, produced measurable radioactivity in surface waters.



1962 chart of beta radiation measures in airborne particulates after worldwide H bomb test detonations

The 9/11/01 World Trade Center Attack and Terrorism

The events of 9/11/01 and the days that followed reinvigorated concerns over attacks on water supplies by terrorists. With large stockpiles of chemical and biological agents in the hands of foreign governments around the world, the idea that a terrorist group could procure such materials was a major concern. The 9/11/01 attacks also demonstrated a clear intent to cause maximum casualties and a level of planning and resources that made the future threats very credible. Up to this time, security at most water utilities had been focused on vandalism and theft, but now the idea of defending many vulnerable locations in a far-flung water system against a motivated, well financed, technically astute enemy was an entirely new situation. Other recent incidents like the Oklahoma Federal Building bombing and terrorist bomb attacks worldwide also raised concerns that explosive attacks could occur on any critical infrastructure and that water supply should protect itself from such threats as well.

DHS Orange level - Guarding key water supply facilities

Post 9/11 Welding hatch covers

The threat of water supply poisoning is not a new one, but there are relatively few contamination incidents in the past. The possibility of an unknown contaminant being injected at any point and any time in the distribution system is a difficult problem to monitor and defend against, leading to much research and the development of new distribution system water quality monitoring strategies aimed especially for this issue.

After 9/11/01, the 2002 Bioterrorism Act required all water suppliers serving 3,300 people or more, to conduct vulnerability assessments and update emergency plans accordingly. Much effort has since gone into the protection of New England water systems and the development of response measures against the terrorist threat.

The intentional contamination aspects of terrorism will likely have far reaching effects. Already much research funding has been allocated by the federal government. Some version of minimum water security standards and broader contamination monitoring may eventually become regulated at the state or federal level as a preventative measure.