



WATER SHORTAGE

CHAPTER 4.7

The City's complex water supply system is a remarkable feat of engineering. It originates in upstate reservoirs and extends over 125 miles to supply New Yorkers with high-quality water. Water shortages are possible due to a failure of a major component of the water system's infrastructure due to age or other factors. A water shortage can also be caused by an upstate drought, which can affect reservoir water levels. Droughts have occurred in the past and may occur again – in a future that is being shaped by climate change.

WHAT IS THE HAZARD?

The City's Department of Environmental Protection (DEP) manages our water supply system, ensuring the steady flow of water from large upstate watersheds through a complex network of reservoirs, aqueducts, tunnels, and neighborhood water mains.

Each day, more than one billion gallons of water is delivered to New York City, almost all by simple gravity. We use water daily for our basic needs – drinking, bathing, cooking, and laundry. Therefore it comes as no surprise that residential buildings (that is, not mixed-use, commercial/residential buildings) are our largest water consumers, accounting for 62 percent of total water usage. Water is also used for institutional, commercial, and manufacturing purposes. For example, hospitals use water in the form of steam to sanitize medical equipment and water is also used in some manufacturing processes, including bottling plants in New York City.

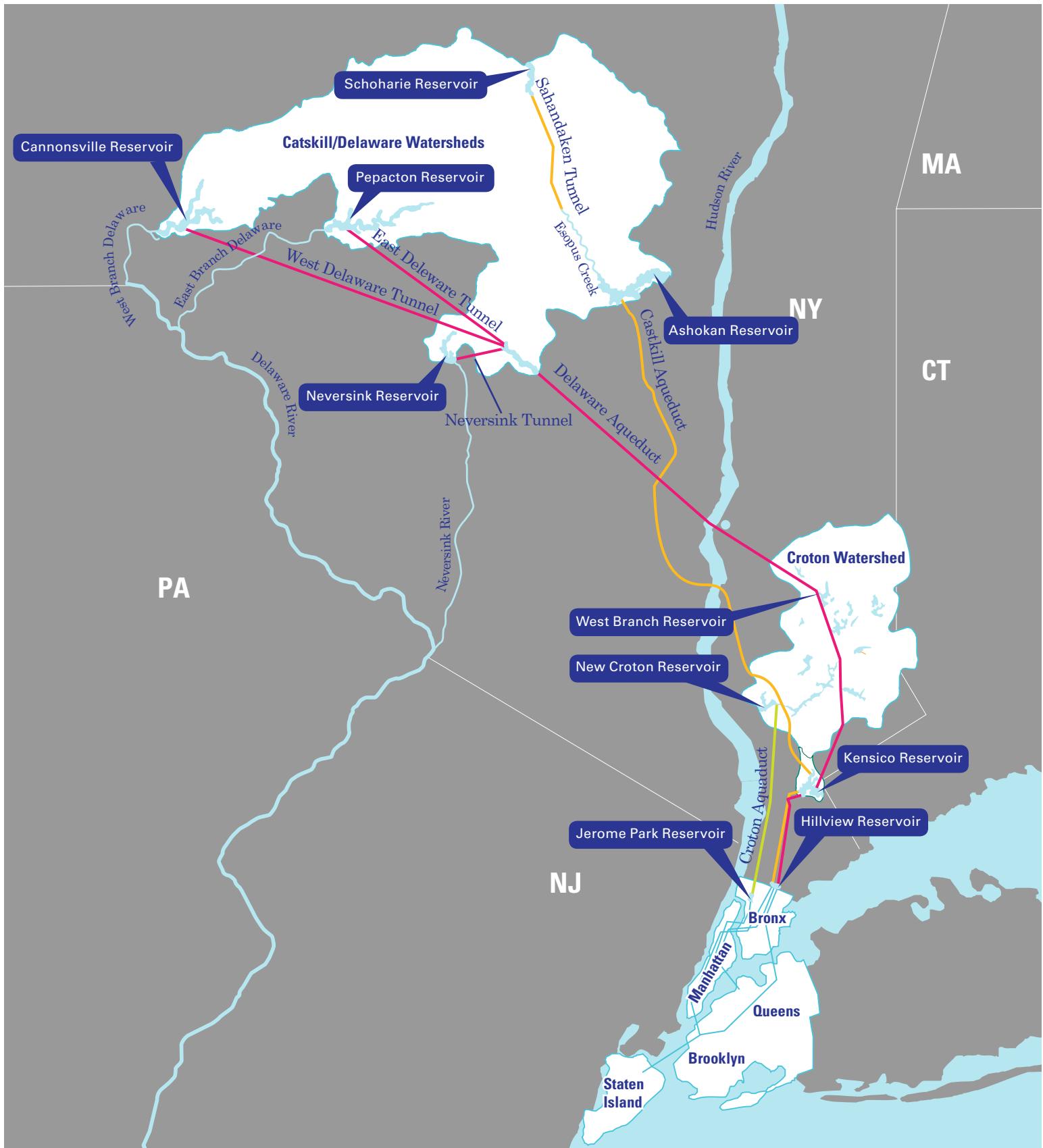
Water shortages could be caused by drought or failures in our water-supply infrastructure. Water contamination is beyond the scope of this brief profile, which focuses on drought and infrastructure. For information about it, see DEP's web site.

WATER SHORTAGE CAUSED BY DROUGHT

Occasional drought is a normal feature of many climates in the United States. It results from climate conditions that can develop over several months or years. A drought can last briefly, or for a long time. A brief drought's impacts can be worsened by extreme heat and/or wind.

Water shortages due to a drought affect New York City on a citywide basis. Because the reservoirs that supply our water are upstate, rainfall in that region, not within our city, is what determines how adequate our water supply is.

New York State has a generally temperate, moist climate. Average precipitation in New York City's watershed is approximately 45 inches per year, but normal fluctuations in regional weather patterns can lead to periods of dry weather. Since 1939, New York City has experienced nine periods of drought. The last severe drought in New York State occurred from 1962-1965. At least five less-severe drought emergencies have occurred since the 1960s.



WATER DELIVERY SYSTEM (SOURCE: NYC DEP, 2011)



N

0

25

50 MILES

Croton Aqueduct

Delaware Aqueduct and Tunnels

Catskill Aqueduct Tunnels



PHOTO OF CANNONSVILLE RESERVOIR: PHOTOS ARE FROM SAME VIEW;

LEFT PHOTO IS RESERVOIR AT 6.5% CAPACITY Y (DEC. 20, 2001).

SOURCE: NYSDEC AND NYC DEP

The most recent period of dryer weather occurred in December 2001, when DEP issued a Drought Watch because reservoir water-storage levels were at 44 percent. A month later DEP issued a Drought Warning; a Drought Emergency was issued in April 2002. Over the next eight months, increased precipitation and reduced water consumption alleviated drought conditions. Normal conditions were restored on January 2, 2003 ending a 14 month drought event.

The New York City Panel on Climate Change projects future disruptions in precipitation patterns and rising temperatures for New York City. While annual rainfall is predicted to increase here, along with the intensity of severe storms, it is more likely than not that more late-summer, short-duration droughts will occur. It is unclear whether longer duration droughts will increase.

A 2011 study by the Lamont-Doherty Earth Observatory predicts that a severe drought similar to the one that occurred in the 1960s could easily return to the greater Catskills region without warning, and that its duration cannot be forecast. That is, the wetter conditions that have prevailed since the 1970s may not persist in the future.

WATER SHORTAGE CAUSED BY INFRASTRUCTURE FAILURES

New York City's water supply system dates back to the 1840s, when the Croton Aqueduct in Westchester County opened. Water travels daily through a complex system of reservoirs, aqueducts, tunnels, and water mains to New York City as well as many

upstate communities. Due to the system's age, size, and extent, parts of it may be subject to failure.

A water shortage can occur from a failure at any point in the water systems infrastructure. Depending on its location and scale, a failure can have varying degrees of impact. For example, a water main break may only impact a specific area of the city, while a dam failure or a collapse of tunnels or aqueducts could impact the distribution of water to all of New York City.

Of particular concern now is the Delaware Aqueduct, which delivers approximately half of the city's drinking water – 500 million gallons per day. It is leaking as much as 35 million gallons per day. New technologies have permitted DEP to perform inspections of it, and a major project to repair it is under way.

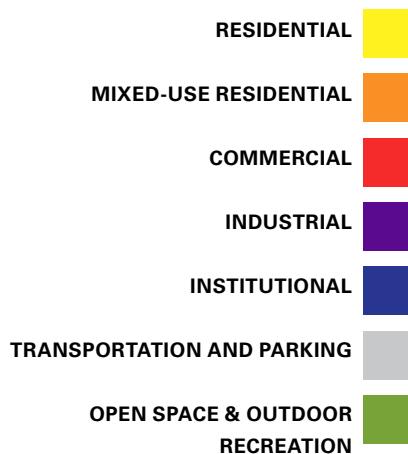
Among other portions of the system that may need maintenance or repair, most notable are City Water Tunnel No. 1, completed in 1917, and City Water Tunnel No. 2, completed in 1936. They have been delivering water to our homes, businesses, and institutions continuously since they were placed in service. Because of concerns that a reduction in water pressure might damage part of the system, neither tunnel has ever been shut down for inspections and repairs.

Water main breaks occur frequently. Some of the causes include the age of the mains and pipe material. For instance, 46 percent of the City's 6,785 miles of water main were built before 1941. The majority of mains are composed of unlined cast iron or cement-lined cast iron, which is susceptible to internal corrosion and leaks.

WATER USAGE BY LAND USE IN MILLIONS OF GALLONS

(SOURCE: NYC DEP, 2011)

TOTAL: 835 MILLION GALLONS PER DAY



*THIS DOES NOT INCLUDE NON-REVENUE WATER, WHICH IS APPROXIMATELY 21 PERCENT OF TOTAL WATER USAGE

DEP's decades-long, intensive efforts and multi-billion-dollar investments in maintaining and repairing our water supply system are discussed on the following pages, in "How Do We Manage the Risk?"

Water shortages may also occur as a result of planned outages for system repair.

WHAT IS THE RISK?

VULNERABILITY

A water shortage, caused by drought or an infrastructure failure has the potential to be severe. Because New York City is embedded in a regional economy and is a global financial center, severe impacts could reverberate far beyond its borders. What follows is a brief sampling of vulnerabilities and consequences.

People at risk

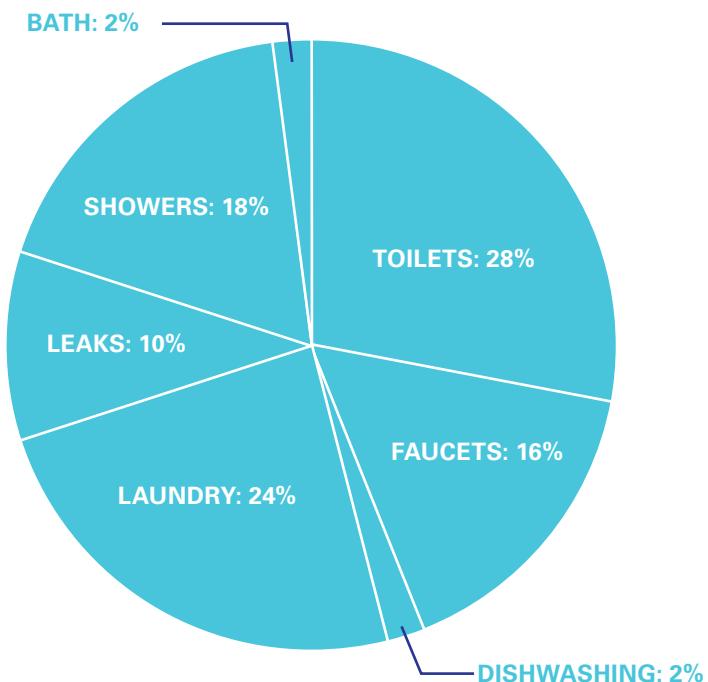
A water shortage could affect public health broadly, with effects most pronounced among people with pre-existing health conditions that make them more susceptible to illness and the spread of disease. During prolonged droughts, some indirect health effects might not be readily identifiable, making it difficult if not impossible to prevent and monitor them.

Dehydration is a major risk. With water in short supply, people may wash their hands less frequently and thoroughly and otherwise not maintain good personal hygiene. They may wash fruits and vegetables less thoroughly. Compromised sanitation and hygiene may raise rates of illness.

Even air quality can be affected during periods of drought. The Centers for Disease Control caution that when air laden with particulate matter from dust is not washed clean by rainfall, poor air quality can increase chronic respiratory illnesses such as asthma, as well as the risk of acute respiratory infection.

Localized disruptions in the distribution system such as a water main break or illegally opened fire hydrants may also impact water pressure.

INDOOR WATER USE IN A TYPICAL SINGLE FAMILY HOME (SOURCE: NYC DEP, 2011)



The food supply system

Within our tri-state region, severe drought would harm the hundreds of farms that supply food to us, limiting growing seasons and suppressing crop yields, with consequences for the many farmers markets that operate within the city, and the many Community Assisted Agricultures that transport farm goods to us from tri-state area farms.

It should be noted that, because New York City imports most of its food, a prolonged severe drought in any region of the world that supplies a significant quantity of our food supply could produce some shortages and higher prices. Higher prices may create further hardships for low-income households and strain the budgets of commercial and institutional kitchens.

Economy at risk

According to the National Weather Service, droughts are among the costliest weather-related events. Obviously vulnerable are businesses that use water heavily. Such businesses may be forced to suspend some or all of their operations if the City curtails water usage.

Recreational activities could decline as a result of a water shortage. Certainly, a prolonged severe drought would curtail tourism, a significant sector of New York City's economy.

Buildings and infrastructure at risk

In general, a water shortage does not cause structural damage to buildings, highways, and bridges. But it does pose a risk, albeit very low, of aggravating "soil shrinkage," the reduction in soil volume that occurs as soil loses moisture. The condition can compromise the foundations on which infrastructure stands, including retaining walls and bulkheads, affecting their stability.

The ability to cool equipment and buildings that use water-dependent cooling systems may be disrupted during a water shortage.

Our city's energy and steam supply systems could be affected by a water shortage. A number of power-generation plants rely on our water supply to produce power. Water-use restrictions during a prolonged severe drought would disrupt or reduce that power supply. This includes the city's steam system, which relies heavily on water during



NEW YORK CITY WATER TUNNEL NO. 3

SOURCE: NYC DEP

DEP's largest and longest-running project – one of the country's largest infrastructure projects – is City Water Tunnel No. 3. Initiated in 1970, it is scheduled for completion in 2018, at an estimated total cost of \$5 billion. The tunnel is a critical piece of infrastructure. When it is completed, it will add capacity to the system, deliver water to customers, and allow DEP to inspect and repair as needed City Water Tunnels No. 1 and 2.

Tunnel No. 3 is being constructed in stages. Stage 1 was put into service in 1998. Stage 2 was put into service in October 2013. Manhattan and the Bronx are served by the first two sections. Stage 3 will connect Brooklyn and Queens to the upgraded system. `

winter months, when it consumes a peak of 1.6 million gallons of water per hour to heat homes and buildings in parts of Manhattan. Hospitals also rely on steam to sterilize medical equipment.

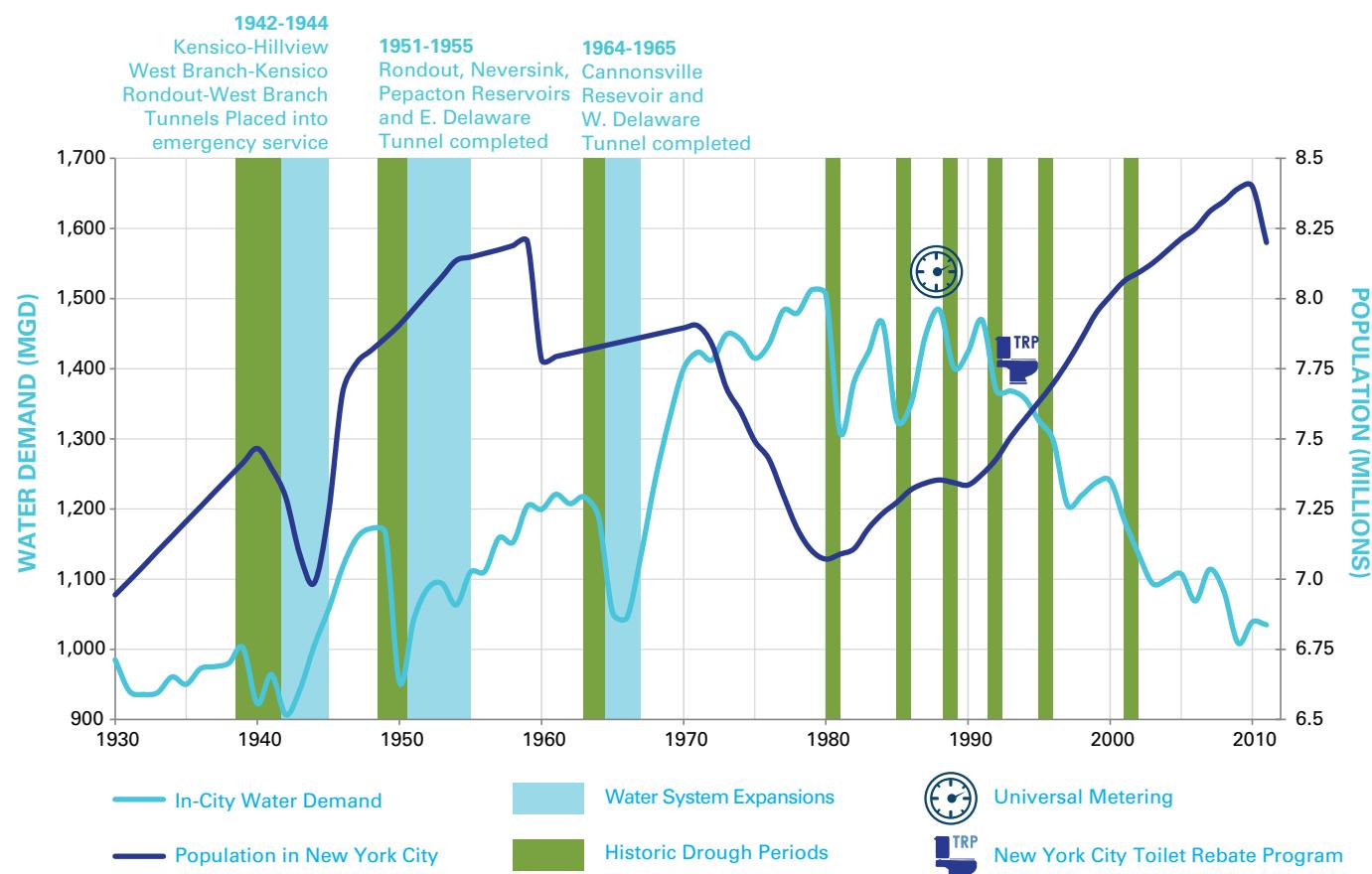
Environment at risk

The impacts of a water shortage are greater on the natural environment than on the built environment.

Green infrastructure can be affected by drought within the city or by limited water supply to the city. All vegetation in the city helps purify air and reduce heat. For example, the vegetation on green roofs provides insulation, offsets some of the urban heat island effect, and improves air quality.

A water shortage would affect the nearly 500 community gardens in our city. Like green roofs, they help reduce air pollution and offset the urban heat island effect. They also increase access to fresh produce.

TIMELINE SHOWING NYC WATER DEMAND COMPARED WITH POPULATION GROWTH (SOURCE: NYC DEP, 2011)



A prolonged drought may affect wetlands, plant species, and biodiversity. Our wetlands range from approximately 5,600 acres to just over 10,000 acres, in Jamaica Bay, on Staten Island, and along the Long Island Sound. They protect wildlife and improve water quality. Jamaica Bay Park alone is home to 325 species of birds, 50 species of butterflies, and 100 species of finfish.

HOW DO WE MANAGE RISK?

Strategies for managing the risk of water shortage include measures to protect infrastructure; regulatory controls and programs to promote and incentivize long-term water conservation; robust protocols for monitoring reservoir water levels; contingency planning for drought conditions; and communication efforts designed to inform water users of water shortage conditions and actively enlist them in water conservation efforts.

PROTECTING INFRASTRUCTURE

Maintaining our water supply system, repairing leaks and cracks, and creating redundancy are crucial to ensuring the system's continued performance under normal conditions, and to reducing the impacts of any water shortages.

DEP's Water for the Future program addresses the leak in the Delaware Aqueduct. In 2013, DEP began building a three mile tunnel, the Delaware Bypass Tunnel, to bypass the section of the aqueduct that is leaking in Orange County. To connect this tunnel, the Aqueduct will be shut down for six to eight months in 2022, during which time DEP will augment available supply and minimize demand.

DEP is also working on a number of projects that will increase the capacity of the Catskill and Croton Water Systems. Some of these infrastructure improvements will enable the Catskill Aqueduct to provide up to 60 million gallons of water per day of additional flow from the Catskill watershed.

Because of factors related to the surrounding area and water quality, the Croton water supply has been taken offline since 2008 so that DEP can construct a water filtration plant to reduce the risk of water contamination. This new facility will help increase the capacity of water supply to New York City.

DEP's Water Distribution System Optimization program targets local water main leaks, implements system repairs, and upgrades water distribution infrastructure.

The Department of Buildings' Retaining Wall Rule regulates inspections and filing requirements for retaining walls to determine safety and maintenance conditions. The rule requires regular inspections of retaining walls that are 10 feet or higher and that face a public right-of-way (sidewalk or entrance).

REDUCING DEMAND THROUGH REGULATORY CONTROLS AND PROGRAMS

Long-term water conservation strategies help reduce water demand and thus extend how long water remains available during a prolonged water shortage. They also help to meet the demands of a growing population. They take the form of regulatory controls and programs that encourage conservation.

Both building design and the equipment used in buildings can reduce water use, with bathrooms a key target. The Department of Buildings Construction Codes encourages water conservation strategies in new buildings as part of an approved water conservation plan.

During the 1980s and 1990s, DEP instituted a number of programs to incentivize water efficiency and reduce water demand by 30 percent. Even during the droughts of 1989, 1991, and 1995, water demand decreased when restrictions were put in place despite population increases during this period. The timeline shows that as New Yorkers began to use water more efficiently, water demand was reduced as the population grew – demonstrating the success of regulatory controls and programs that incentivize water conservation.

DEP's water conservation programs now include these:

- Toilet Replacement Program. Because residential buildings account for the largest share of water use, DEP has identified opportunities to conserve water in these building types. Older toilets can use 3.5 to 5.0 gallons of water per flush; high-efficiency models consume as little as 1.28 gallons per flush. From 1994-1997, DEP ran a Toilet Rebate Program that successfully reduced water demand. In 2013, DEP launched a Toilet Replacement Program. The program provides discounts for owners of residential and multi-family buildings who replace old toilets with high-efficiency models.
- The Municipal Water Efficiency Program is retrofitting City-owned properties, with savings estimated at up to nine million gallons of water a day.
- The Residential Water Efficiency Program offers building owners free surveys that identify opportunities for water savings, including leak detection.
- The Non-Residential Water Efficiency Program encourages major water users such as hospitals, hotels, universities, and restaurants to implement water-efficiency measures.
- DEP's website enables customers to see how their behavior is affecting their water use and helps them identify leaks by providing daily and sometimes hourly information. DEP is conducting a pilot program to help customers evaluate monthly billing, so that by better understanding their usage patterns they can reduce their demand.

RESERVOIR MONITORING, BACKUP SUPPLIES, AND WATER SHORTAGE PROTOCOLS

Monitoring

DEP closely measures and monitors reservoir levels. Its Operations Support Tool is a predictive modeling tool that helps the agency monitor and predict water supply

reliability. It uses ensemble streamflow forecasts from the National Weather Service to assist with making these predictions. DEP also closely monitors the condition of our in-city water distribution system.

Alternative water supplies

The City has alternative drinking water sources, and while their capacity falls far short of the more than 1 billion gallons of water we consume each day, they could make a difference in water shortage situations:

- DEP's groundwater supply system in southeast Queens County consists of 68 wells. It has a State Department of Environmental Conservation permitted capacity of 68 million gallons per day on an annual basis.
- Several interconnections between private utilities in Nassau County are available during an emergency.
- The Chelsea Pump Station in Dutchess County near Poughkeepsie can tap water from the Hudson River. This could augment the city's water supply by 100 million gallons per day under emergency conditions. This pumping station was used during the droughts of 1985 and 1989.

Water shortage protocols

During a planned or unplanned water shortage, reducing the amount of water we consume is imperative. DEP's Water Shortage and Contingency Plan – to be released in the spring of 2015 as an update to the current Drought Management Plan – defines formal operational phases (Watch, Warning, and Emergency) for managing a water shortage and actions for each phase.

Actions in the Drought Management Plan address all water system customers, including City agencies, the private sector, and households. Action items will change with each phase as water shortage conditions progress. Some of the actions include reducing water usage, communication with customers, enforcement of emergency rules, and implementation

of alternative water sources. DEP also evaluates the option of raising water rates to encourage water conservation and increase revenues to maintain operations, for each water shortage phase. The plan will be expanded to address issues related to infrastructure failure and planned system repairs.

One of the city's main utility providers, Con Edison, supplies steam to customers in Manhattan. It implements protocols during water shortages to prioritize all water leaks requiring urgent repairs, to modify operations to conserve water, and to encourage steam customers to reduce steam usage.

COMMUNICATION

As a water shortage initially develops, clear communication with water users is essential. They must be informed about the potential seriousness of the situation and about steps they can take to curtail their water use.

Since water shortages can vary in duration, location, and severity messaging may have to be tailored. For situations where the water shortage is localized such as a water main break, messaging is targeted to the affected customers.

During a drought, DEP employs many strategies to inform customers of water supply status, water restriction rules, and steps for conserving water. Additionally, DEP works with other City agencies and the Mayor's office to ensure that messaging is clear, concise, accurate, and reaches a broad audience. The agency develops messages intended for residents, community groups, and elected officials using many communication tools: media announcements, social and digital media posts, notifications to elected officials, direct community outreach (including meetings), direct mail, phone calls, and emergency alerts.

Notify NYC and the Advanced Warning System would be used to inform the public of emergency conditions. The City would use social media, notifications, alerts, and targeted outreach tools to communicate updates on water shortage conditions and practical information on how the public can conserve water.