# Clean Water: Tap Into Tomorrow Overview and Research Questions

We turn on the faucet and clean water flows out. Most of us don't think about how convenient it is to be able to drink, cook, wash, shower, flush, and water our yards whenever we want. We don't usually worry about whether water will flow from the tap, but plenty of engineers, city planners, developers, and other professionals think about it all the time. It takes expertise, planning, and constant work to keep a reliable water supply flowing. Unfortunately, people in many parts of the world cannot take clean water for granted. One in four people worldwide currently don't have access to clean water; that's 2 billion people. And it's estimated that by 2025, half of the world's population will be living in water-stressed areas—that is, areas where there is not enough water to meet everyone's needs.

Today's engineers, architects, and city leaders face the critical task of creating resilient cities. A resilient city withstands drought, flooding, big population changes, natural disasters, economic recessions, and any other short or long-term threats. When it comes to a city's water supply system, resilience means providing adequate clean water for both residential and commercial uses under all possible circumstances. Resilience requires preventing and fixing leaks, identifying and removing contaminants, and making sure the supply always meets demand in the face of disruptions and longer-term changes. A resilient water supply ensures that clean and safe water is provided to all residents for their wellbeing, to keep their communities stable and cared for, and the city economy strong and durable.

**Your Challenge:** Choose a threat to your city's water supply and design a resilient system to maintain a reliable supply of clean drinking water.

**WHAT IS A WATER SUPPLY SYSTEM?**

A water supply system provides potable water, which is safe to drink. Water comes from rivers, lakes, aquifers (water beneath the ground), collected rainwater, and sometimes reused water. Water sources must be protected from pollution and from depletion. Public utilities treat all water to clean it of impurities and make sure it is potable; then water must be pumped to homes and businesses. A network of national, state, and local agencies, along with utilities, businesses, industries, and ordinary citizens, collaborates to protect source water, build and maintain treatment systems, and layout water transport structures. All of these elements are part of our water supply system. Sometimes a city has its own water utility, but often a water district serves a greater region.

## Research Questions

For the competition, your team will choose one potential threat to your future city's clean drinking water. The problem should be plausible—a realistic possibility--for your city's location, climate, and urban challenges. As your team creates your city's resilient water supply system, think about what innovations and systems you can design to help your water supply system withstand a specific threat or stressor.

Remember your city exists at least 100 years in the future. Your engineering solutions should reflect this and be innovative, futuristic, and scientifically plausible.

## Today's Water Supply Systems

Below are questions to help you start your research and consider how to make your future city resilient. As you learn about today's water supply systems, look for innovations that engineers and others are developing that you may want to use in your future city.

**KEY TERMS**

You may find it helpful to know these terms as you are doing your research.

**Backup Plan:** A set of steps for proceeding when things are not going normally or as expected

**Flexibility:** Capable of change or modification without losing function

**Redundancy:** The use of duplicate or overlapping systems in case a part of the system fails

**Resilience:** In the case of cities, the capacity of individuals, communities, and systems to adapt, survive, and grow in the face of stress and shocks

**Risk:** A chance of loss or injury

**Stressor:** In the case of cities, a situation or change that would make current systems vulnerable to failure and affect the health and wellbeing of the people in a city

**Vulnerability:** The inability of people or systems to withstand the effects of a threat

### 1. WATER COLLECTION

As a part of the water cycle, water collects naturally on both the surface of the earth and underground. A portion of precipitation (such as rain or melting snow and hail) flows across the earth's surface into creeks, streams, and rivers, and collects in lakes and ponds. Humans may direct surface water into engineered reservoirs to collect it for later use.

Some precipitation also seeps into the soil and down through various layers of rock, and pools in layers called aquifers. To collect this water for human use, wells are drilled down into the aquifers and pumps are used to bring the water up to the surface. Start your research by learning more about how water is collected (and where it comes from) in your own community.

- Investigate different methods of collecting water from its source. How does the city or region where you live collect water?
- What are the sources of the water that comes into your home?
- How many people are served by your city or region's water supply?
- Why do we collect water? It isn't just for drinking and cooking! You may be surprised at how many ways water is used. List as many as you can find.

### 2. WATER STORAGE

To ensure a steady supply of water throughout the seasons, it's necessary to store large amounts of water. Engineers call this phase raw water storage, because the water hasn't undergone treatment yet. Sometimes the surface catchment itself—a lake, for example—can act as a form of storage. Often water is stored in engineered reservoirs and storage tanks. Dams can be used to create massive reservoirs of water by preventing water from flowing out of a river or valley. In some places, aqueducts and canals are used as an efficient way to move water from raw storage.

- How much water does your city need every day?
- How has your city determined how much water needs to be stored?
- Where are the closest dams to your city? What is their water source? How much water do they store?
- Research reservoirs near your city. Sometimes they are sources of recreation. What activities are allowed at reservoirs near you? Which activities are not permitted at reservoirs near you and why?
- List methods of storing water. How much water is stored for your city? How does storage change seasonally?

**CLEAN WATER: TAP INTO TOMORROW RESOURCES**

Start your research with a suggested set of websites, books, and videos. Download the list at futurecity.org/resources (filter for Research Resources & Websites).

### 3. WATER TREATMENT

Water treatment processes vary a great deal, depending on local conditions and standards. In general, water must be cleaned of debris, sediment (sand and silt), particulates, microorganisms (bacteria and viruses), and dissolved compounds. The treatments include both physical methods like filtration and chemical methods like chlorination. Sometimes water is treated with additives to enhance taste, prevent cavities, or prevent pipe corrosion. Only water that meets strict standards for clarity, disinfection, and purity is ready to be distributed to homes and businesses.

- Find descriptions of various water treatment processes. How are they similar and different? What are some of the main options available to water utilities?
- What does your city's treatment plant use to disinfect water?
- Does your city add fluoride to the water? What are the benefits and risks of this additive?

### 4. TRANSPORT

Water needs to be moved from storage to treatment facilities to the people who use it. Treated water also has to be stored somewhere while it is waiting to be used. This type of storage is called finished water storage (as opposed to raw water storage). More commonly, a complex set of pumps and pipelines are used to transport water, within which maintaining the right pressure level is key to keeping water in motion without creating leaks or bursts. Maintaining the right pressure is also important for firefighting, because firefighters count on a minimum pressure at the hydrant to effectively extinguish fires.

- How is water transported by your regional water utility?
- How will your city monitor pipes for leakage, to make sure no water is wasted?
- How are water pipelines vulnerable to stressors or challenges?
- What materials are the pipes made from? How do these materials ensure there are no long-term effects on the water and that the pipes can withstand a range of stressors?

### 5. MONITORING

Monitoring the quality of drinking water throughout the world is essential. The Environmental Protection Agency has established national requirements that all potable water in the US must meet. Every water treatment plant tests its water regularly to make sure it is safe to drink. In Canada, water quality is measured according to its *Guidelines for Canadian Drinking Water Quality.*

Every country has its own monitoring system. For example, Egypt has the Egyptian drinking water quality standards. They are used for monitoring the water of the Nile River, the most important source of fresh water in Egypt. Many stressors on water quality have to be measured, such as water flowing into the Nile from drains that carry return flows from farms (which has fertilizer, pesticides, and sewage from animals in it).

Drinking water in China comes mostly from wells that bring up groundwater. In 2018, engineers set up more than 10,000 monitoring wells to gauge the quality of this water—however, they will need more to keep up with the demand.

- Find a recent annual water quality report for your city or region online. What does it say about the quality of your water?
- What are some substances that can show up in tests of our drinking water?
- What diseases does disinfecting our water protect us from?
- If a family gets its water from a private well, how do they make sure the water stays safe to drink?

- How will your city decide which tests to run and which pollutants to test for?
- Who will do the testing in your future city—a city employee, consultant test firm, chemist, engineer, or technician? Will the test be double checked by someone else for quality control?

### 6. DEMANDS ON OUR WATER SYSTEMS

Maintaining a continuous, reliable supply of water has become more difficult as populations grow, demand increases… and the sources do not. Besides these issues, there are special circumstances that stress our water systems. What if there's a major fire that requires huge quantities of water to put out? What if there's a drought? What if there's a leak or a break in a main pipe that isn't detected? What if there's a chemical spill that enters the water at its source? Engineers think carefully about these possibilities. They also plan water systems that serve communities as they grow.

- How has the population of your city changed over the past 20 years? What changes are planned to handle increased water demand in your city?
- Is a shortage of water an issue where you live? If so, what measures has the city or region taken to conserve water? For example, some cities irrigate parks with gray water, which is water reclaimed from sinks, showers, and washing machines (not toilets).
- What are some ways that city residents can conserve water?

### 7. EFFECTS OF THREATS ON THE DRINKING WATER SUPPLY

Explore a range of potential issues before selecting one that could affect your future city's drinking water. Remember to choose a problem that could really happen in your future city's geographic location.

- What issues have occurred in the past where your future city is located?
- How might the problem you are focusing on affect each element of your city's water supply system—the source, the storage, the treatment plant, and the methods of getting water into your city's homes and businesses?
- What solutions have engineers come up with - in the past as well as in the present - to maintain water supply systems?
- Does your city have a disaster plan in case of serious water problems? For example, can the city tap another source, get water from a nearby city, or transport in bottled water? Would your city ration water if necessary?
- What are some ancient water supply systems? How have they withstood the tests of weather, threats, and time?