NTX Future City Junior, 2020

DELIVERABLE #1
RESEARCH ESSAY: CLEAN WATER: TAP INTO TOMORROW

Students write a 1,000-word essay that introduces their city and provides a solution to this year's challenge—Clean Water: Tap into Tomorrow. Choose a threat to your city's water supply and design a resilient system to maintain a reliable supply of clean drinking water.

Suggestions and Resources for Completing the Essay Assignments
See the Research Essay Outline (attached). Go over the outline with the students and have them list what they want to say in each section. Then suggest that they divide the sections so that everyone writes at least one part of the draft. When it's time to write the final version, they'll have plenty of material to work with. Also remind students that they can include up to four graphics in their essay.

Research Essay Resources (see attached forms or download from website: http://futurecity.org/resources)

- Study the Clean Water: Tap into Tomorrow Real World Case Studies to get inspiring and instructive real-life examples of problems that were solved via innovative solutions.
- Also study the Research Questions and background information on Water Supply Systems in the Tap into Tomorrow Overview and Research Questions handout.
- Use the Research Cards as a way for the team to document and organize the information and relevant sources that they find.
- Review the Research Strategies for more ideas and information on citing sources in the bibliography.
- Analyze Essays from past NTX Junior winners to give the students a strong sense of what they are aiming for in their own essays. Go to Junior Team Center (http://www.dfwfuturecity.org/team_junior.html).
- Review the Research Essay Rubric (attached) to make sure you understand what the judges will be looking for in your paper.

Research Essay Assignment
Students research and write a 1,000-word essay that describes the unique attributes of their city and provides a solution to this year's challenge: Clean Water: Tap into Tomorrow.

First, students need to decide what their future city will be like. They can imagine what it would be like to walk down the main street of a city at least 100 years in the future. What would they hear, see, smell, and feel? How would the people who live in this future city describe it? What would make it futuristic and innovative? Students should think deeply about their city: what is its population, geographic location, cultural preferences, unique characteristics, and community needs?

Tap into Tomorrow Overview
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 other short and 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 of water always meets demand in the face of disruptions and longer-term changes. As a part of a resilient city, a reliable water supply ensures that clean and safe water is provided to all its residents for their well-being, to keep their communities stable and cared for, and the city economy strong and durable.

A resilient city ensures its residents are safe and healthy, their communities are stable and cared for, and the economy of the city is strong and durable. The students' challenge: Choose a threat to your city's water supply and design a resilient system to maintain a reliable supply of clean drinking water.

Research Essay Requirements

- Students select a threat or stressor to the drinking water supply for their city based on its climate, geography, or issues specific to that city, such as rapidly growing or shrinking population, industrial base, or another factor.
- Although the focus of the essay is water supply system, the general theme of resiliency can be applied to other aspects of their city as well.
- The essay cannot exceed 1,000 words and should be free of grammatical and spelling errors.
- The essay can include a maximum of four graphics.
- The essay must cite at least three sources of information used during the idea development process. MLA style is preferred (see attached Research Strategies for more detail).
- Students should use a variety of sources of information, such as interviews with experts, reference books, periodicals, and websites. (Note: Wikipedia is not accepted as a source of research.)
- The essay must be submitted as a Word document via the Junior Team Center (http://www.dfwfuturecity.org/team_junior.html).

Competition Scoring

Teams can earn up to 60 points for their Research Essay. Make sure they have thoroughly covered these categories in the rubric to maximize points:

- Introduce City & Define Problem 15 points
- Specs and Solutions 21 points
- Judge Assessment of Solution 12 points
- Writing Skills 12 points

Total 60 points

Scoring Deductions
5 points – Late submissions (1-20 December) are accepted with a small point deduction.
10 points – For essays that exceed the 1,000-word limit.

SUGGESTED ESSAY OUTLINE

In the Research Essay, you will share your vision of your future city and your solution to Powering the Future challenge: design a resilient power grid for your future city that can withstand and quickly recover from a natural disaster.

You can use the following outline as a guide to help you organize and draft your essay.

Introduction
Briefly introduce your future city by including basic information people should know, such as your city's name, population, age, and location. Include any unique features of your city – what makes your city futuristic and innovative.

Define the Problem
Describe the threat and its effect on your city's water system. Include:

- The threat or disaster you chose
- The immediate challenges that this threat creates and any potential lasting effects on your city and residents
- How the drinking water supply system is likely to be disrupted by this threat. What are the system's vulnerabilities?
- The impact to the health and safety of the people in your city, including vulnerable populations (i.e., elderly, young, and/or economically-disadvantaged)

Describe Your Solution
Here's where you get to describe the innovative design of your future city's water system and how you've prepared it to withstand and recover from your selected threat. Be sure to:

- Describe your city's water supply system. Be sure to highlight which aspects are futuristic and innovative, and include water collection, storage, treatment, transport, monitoring, and demands.
- Describe the (one) innovative way you have prepared your water supply system to withstand your selected threat. Include how the solution ensures the health and safety of city residents.
- Describe some of the risks connected with using this solution and how the solution reduces these risks.
- Discuss the tradeoffs/compromises connected with your water supply system and how your design reduces or eliminates these tradeoffs.
- Explain the types of engineering involved in designing your resilient city and what kinds of engineers were most helpful.

Conclusion
The impact of your resilient city. Share why people want to live in your city and what makes it a great place to live. Tie together the potential effects of a specific drinking water issue and the need for a resilient water supply system. Summarize how the design of your system will keep the people in your city safe and healthy.

Clean Water: Tap Into Tomorrow: Real-World Case Studies

Case Study: Cape Town

Four million people live in Cape Town, South Africa. Their water supply comes from rain, which is collected and stored in six reservoirs scattered around the city. But a drought that began in 2015 has created a serious water shortage; in 2018, reservoirs only held one fifth of their capacity. Residents live in dread of "Day Zero," when the reservoirs will run dry and fresh water will stop flowing from taps.

Day Zero has been postponed several times as Cape Town institutes measures to make water last longer. The city has repaired leaky pipes. It has also lowered water pressure in pipes, so that less water comes out when people turn on their faucets. Each person is only allowed 13 gallons of water a day—the amount that an older toilet uses for three or four flushes—and fines are imposed when this limit is exceeded. Nobody hoses down the sidewalk or washes their car any more. Farmers also have water restrictions that are 60% less than in pre-drought days. Once a farm hits its limit, their water is simply cut off.

With droughts becoming more common and more severe, water conservation can't solve all of Cape Town's problems. And even in non-drought years, residents will have to practice water conservation. Cape Town has an online "water dashboard" that shows residents the level of water in the reservoirs and how much water they should be using. This kind of information helps most people make necessary changes to their behavior. Those who continue to use too much water receive letters from the city and are warned that water-restricting devices will be installed if necessary.

1 https://www.abc.net.au/news/2018-11-11/drought-put-cape-town-on-a-countdown-to-day-zero/10477538)

Case Study: Fog Water Harvesting

About five inches of rain a year falls on Mount Boutmezguida in southern Morocco. People living in the region used to subsist on the rainwater they captured in cisterns or pulled up from wells, but drought cycles have become more frequent. The wells and cisterns are drying up.

Although the region has so little rain, it does have another potential source of water. Heavy swathes of fog roll in from the Atlantic Ocean and cover Mount Boutmezguida. Fog is a low-lying cloud composed of water droplets. Engineers have figured out a simple, cost effective way to capture these droplets: wind pushes the fog against giant nets to which the water droplets cling, gather, and slide down into troughs. The troughs connect to pipes and the clean water goes straight into people's houses.

The first fog-harvesting nets failed. They ripped apart in the high mountain winds, which often reach 75 miles an hour. Engineers tested a number of prototype fabrics to find one that could resist these winds and be economical, food-safe, and UV-resistant. A 3D mesh system turns out to work best. The nets are easy to take care of too; a wrench and a socket wrench are all the villagers need to keep them functioning well. As of 2018, Mount Boutmezguida has the biggest fog-harvesting system in the world, and 800 homes receive 18 liters of water a day—up from the 8 liters of rainwater per family that used to be painstakingly collected.

Case Study: SmartBall Technology

Leaky pipes lose billions of gallons of water every year, all over the world. Finding those leaks has always been a challenge; water pipes are often many feet below the ground, traveling for miles beneath streets and sandwiched between other pipes and cables. Unless the leak is unmistakable, as in when a water main bursts and a fountain of water suddenly erupts, leaks can seep water for years without detection.

A new technology called a SmartBall can now find these leaks three or four times more effectively than other tools. The SmartBall looks a little bit like a bowling ball. It contains a hydrophone—a microphone designed to listen to sounds underwater. It can find extremely small leaks no matter how big the pipe or what materials the pipe is constructed from, and it provides data about the exact location of the leak. The SmartBall also contains a magnetometer that keeps the ball rolling through the pipe. It is encased in foam so that its own noises don't interfere with detecting the sounds of leaks.

The SmartBall can inspect pipelines that are 30 miles long, all the while emitting a sound every few seconds so that above-ground sensors know exactly where it is. In 2017 the city of Ottawa in Ontario, Canada used the SmartBall to assess the condition of a critical transmission main. It traveled along the pipeline for a couple of miles before its sensors detected the sound of a leak. The city could excavate at exactly the right spot to fix the leak, instead of expending money and manpower on incorrect guesswork. Now cities throughout North America and the rest of the world are making use of SmartBalls to save water and maintain pipelines.

Case Study: Nevada

Nevada relies on the Colorado River for its water; the Colorado River relies on snowmelt from the Rocky Mountains to keep it flowing. But the Colorado River Basin has been in a drought for 19 years. The reservoirs formed by dams along the river—Lake Mead and Lake Powell are the biggest—are at concerningly low levels. The region is expected to get even drier as climate change continues.

Six other states also depend on the Colorado River. Nevada, Arizona, and California form what is known as the lower basin, while Colorado, New Mexico, Utah, and Wyoming are in the upper basin. These states must work together and make sacrifices to avoid triggering mandatory water restrictions set by the federal government. In 2019, these states negotiated a deal to conserve water that includes drought contingency plans (DCPs) for each state. This plan will be in effect through 2026. Through a series of complex regulations that have been hashed out despite political disagreements, Lower basin states have agreed to stop taking water from Lake Mead if it hits a dangerously low level, and to take less from it to prevent this degree of depletion. These states are also implementing water conservation efforts, with saved water being stored in Lake Mead.

The seven states "bank" water that has been saved via conservation to use as needed. Nevada just completed a new water intake system that can reach water at lower levels in Lake Mead. It is also building a new pumping station at Lake Mead to preserve access to Colorado River water for the southern part of the state. Specific conservation methods include recycling wastewater for irrigating golf courses and parks; some water is recycled and returned to the Colorado River. Groundwater is being tapped in addition to river water, although how much and how fast to use it are topics of debate. Researchers are investigating the possibility of desalination projects with California and Mexico, to make use of seawater and brackish water.

Nevada pays residents to replace lawns, which require a huge amount of water to maintain, with landscaping that is drought tolerant. Residents are only supposed to water their yards on certain days of the week and at certain times of day to minimize water evaporation. Residents also have tiered pricing for their water use. If they use more than a certain amount, the price increases substantially. These incentives have helped people to change their behavior around water.

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?

Essay Rubric (FC Jr.)

	0 **No Points** Requirements missing	1 **POOR** Poor-Fair quality. Fulfills less than 50% of requirements.	2 **GOOD** Average-Above average quality. Fulfills at least 90% of requirements.	3 **EXCELLENT** Excellent quality. Fulfills 100% of requirements with additional distinctive features.
I. INTRODUCE CITY AND DEFINE THE PROBLEM (15 points)				
1. City overview ● Introduce city: location, geography, climate, development, etc.	No description of city	Underdeveloped description of city.	Clear and developed description of the city.	Clear and thoroughly developed description of city.
2. Features and innovations ● Attributes or features that make this city unique	No description of unique features.	Underdeveloped description of unique features.	Clear and developed description of unique features.	Clear and thoroughly developed description of unique features.
3. Describe the future city's water supply system ● Collection, storage, treatment, transport, monitoring and demands	No discussion	Underdeveloped description of water supply system.	Clear and developed description of water supply system.	Clear and thoroughly developed description of water supply system.
4. Describe the selected threat to the water supply system ● Realistic threat (based on location, geography)	No description of threat or threat is not a realistic given location, geography.	Underdeveloped description of threat.	Clear and developed description of water supply threat.	Clear and thoroughly developed description of water supply threat..
5. Describe the impact of the threat on city and its citizens ● Immediate impact of threat and potential long-lasting effects ● Impact on health and safety of vulnerable population groups	No description of impact on city or citizens.	Underdeveloped description of effects on city and vulnerable populations	Clear and developed description of the effects on city and vulnerable populations.	Clear and thoroughly developed description of the effects on city and vulnerable populations.
III. SPECS AND SOLUTION (21 points)				
6. Describe one innovative solution for a resilient water supply system. ● Allow water supply to withstand threat	No solutions.	Underdeveloped description of solution.	Clearly outlines the solution to withstand and recover from threat.	Clear and thorough description of solution to withstand and recover from threat.
7. Describe technology involved ● Innovative and futuristic	No description of technology	Underdeveloped description of technology. Not particularly innovative.	Clear and developed description of the technology. Innovative.	Clear and thoroughly developed description of technology. Innovative and futuristic.
8. Resiliency assessment and plans ● Conditions that can cause system to fail ● Ability to identify damage and repair system	No description	Limited assessment of conditions and ability to identify damage and repair system.	Clear assessment of conditions and ability to identify damage and repair system.	Clear and thorough assessment of conditions and ability to identify damage and repair system.
9. Risks, tradeoffs, and compromises ● Benefits, drawbacks, risks ● Tradeoffs & compromises	No discussion of benefits, risks or tradeoffs	Description of one risk and/or tradeoff.	Description of more than one benefit, risk, or tradeoffs.	Description of more than two benefits, risks, or tradeoffs.
10. Describe benefits to citizens ● How will the resilient grid keep residents safe and happy?	No description	Underdeveloped description	Clear and developed description of benefits	Clear and thoroughly developed description of benefits

Essay Rubric (FC Jr.)

	0 **No Points** Requirements missing	**1** **POOR** Poor-Fair quality. Fulfills less than 50% of requirements.	**2** **GOOD** Average-Above average quality. Fulfills at least 90% of requirements.	**3** **EXCELLENT** Excellent quality. Fulfills 100% of requirements with additional distinctive features.
IV. SPECS AND SOLUTION (Cont'd)				
11. Engineering disciplines involved	Engineering disciplines are not identified or not relevant to solution	Discusses one relevant Engineering discipline.	Clear description of more than one relevant engineering discipline	Clear and detailed description of more than one relevant engineering discipline.
12. Role of 1-2 engineers	Role of engineers are not identified	Underdeveloped discussion of role of one engineer	Clear description of role of 1-2 engineers involved in system and solution	Clear and detailed description of role of 1-2 engineers involved in system and solution
IV. JUDGE ASSESSMENT OF SOLUTION (12 points)				
13. Effectiveness and quality of solution ● Effective solution for maintaining reliable supply of clean drinking water despite threat ● Appropriate design and application of technology ● Ensures citizen safety and health	Not effective	Solution is somewhat effective. Technology and design need improvement. Questionable ability to ensure citizen safety and health.	Solution is effective, but technology and design could be improved; good ability to ensure citizen safety and health.	Solution is a highly effective, with excellent technology application; excellent ability to ensure citizen safety and health.
14. Innovative and futuristic solution ● Reasonable extrapolation and application of technology ● Degree to which solution involves engineering	Not innovative or original	Somewhat original or innovative. Not futuristic. Little engineering involved.	Solution is moderately innovative, original or futuristic. Some engineering involved.	Solution is highly innovative, original and futuristic. Excessive engineers involved.
15. Plausibility of solution ● Based on sound scientific principles	Implausible or not scientifically sound	Solution is not very plausible (science fiction)	Solution is plausible	Solution is highly plausible and scientifically sound
16. Tradeoffs & compromises ● Accounting for risks, benefits ● Assessing consequences and making logical decisions	Does not explore tradeoffs	Some consideration of tradeoffs, but ignores major issues.	Adequate assessment of tradeoffs, but analysis and decisions could be improved.	Excellent assessment of risks, benefits, tradeoffs in the decision-making process.
V. WRITING SKILLS (12 points)				
17. Organization	Poorly organized	Fair organization	Good organization	
18. Writing skills	Poor writing	Fair writing	Good writing	
19. Grammar & spelling	Many errors	Some errors	Few, if any, errors	
20. Maximum number of Graphics ● If used, max of 4 (does not include tables)	Exceeds maximum of 4 graphics, illustrations		Does not exceed maximum of 4 graphics and/or illustrations	
21. List of references ● At least three acceptable references ● Wikipedia not recognized as an acceptable reference	No references	Less than three acceptable references	At least three acceptable references	
22. Word count ● Does not include title, references ● Includes all captions and words in graphics, illustrations and tables.	No word count at end of document or inaccurate count		Accurate word count at end of document	