CONSERVATION STATION

WEEK OF RESOURCEFULNESS | CLASSROOM ACTIVITIES

ENERGY-WATER NEXUS STEM INVESTIGATIONS

Clean Water and Sanitation (SDG 6)

KEY LEARNING OBJECTIVES

Students will be able to

- **Analyze** models to determine patterns and trends facing the water industry.
- **Differentiate** between commonly used pipe materials used to transport water.
- **Construct** a plan to replace aging water pipes and monitor water loss and contamination.

OVERVIEW

In this activity, students will work in small engineering design teams to investigate the challenges communities are facing with water, analyze data, and determine how leaking or aging infrastructure is a problem that water and wastewater companies must work to solve. Students will:

- Research the challenges that water utilities are facing
- Determine strengths and weaknesses of commonly used pipe materials
- Brainstorm a list of pipes that replace the older ones in their town
- Develop a plan to monitor water loss and contamination in leaking pipes

Each group will communicate their plan to another group and incorporate feedback to make any design improvements.

CONNECTION TO THE ENERGY-WATER NEXUS

- Water is an integral part of producing energy, food, and generating power.
- Our resources are limited, and as the world population continues to grow, basic infrastructure will need to be replaced that efficiently and safely carries critical supplies of water.

NATIONAL STANDARDS

Next Generation Science Standards

- **HS-LS2-7 Interdependent Relationships in Ecosystems**
  Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.
- **HS-ESS3-3 Human Sustainability**
  Create a computational simulation to illustrate the relationships among the management of natural resources, the sustainability of human populations, and biodiversity.

Standards for Technological Literacy

- **Standard 5**
  Students will develop an understanding of technology on the environment.

BACKGROUND

According to the United Nations Sustainable Development Goals, 26% of the world's population lacks access to clean drinking water and 46% lacks access to safely managed sanitation. While these numbers might seem distant for many, it is an issue that continues to impact those living around the world and in the United States. The American Society of Civil Engineers 2021 Infrastructure Report Card states that there is a water main break every two minutes, and an estimated six billion gallons of treated water lost each day, which is enough to fill over 9,000 swimming pools! The United States drinking water infrastructure uses over two million miles of underground pipes to deliver water safely to Americans.

Unfortunately, our water infrastructure is aging. What exactly is infrastructure? Infrastructure is how our goods are delivered, our supply chains connected, and our health and safety protected. Bridges, roads, power plants, and pipes are examples of infrastructure—they are the necessary structures and systems that serve as the backbone of our economy and quality of life. Wastewater treatment facilities and drinking water systems are all approaching the end of their design lives, which is approximately 100 years. How does this affect us? Water main breaks cause disruptions to our economy and leaking pipes can allow potentially harmful contaminants into our drinking water.

KEY VOCABULARY

- Infrastructure
- Contamination
- Wastewater

MATERIALS

- Computer
- Internet Access
- Poster Paper (10)
- Markers (10)

TEACHER PREPARATION:

- Create large visuals of the three graphics taken from the America Water Works Association's 2018 STATE OF THE WATER INDUSTRY REPORT.

PROCEDURE

1. Open the lesson by explaining that making sense of statistics, graphs, charts, or maps, requires patience and careful observation. It also necessitates a willingness to put together pieces of a puzzle to figure out what story a graph may tell. Display the graphics from the **Water and Sustainability Maps and Charts** handout on the board one at a time and invite the class to answer the following questions for each model:
    a. What do you notice?
    b. What do you wonder?
    c. What do you think is going on?
2. Share with students that the three graphics were taken from the American Water Works Association's 2018 State of the Water Industry Report. Ask the class to use this information to draw possible conclusions.
3. Share with students that according to the United Nations, 129 countries are not on track to have sustainable managed water resources by 2030. Share that more than 178 countries have adopted a comprehensive plan of action to ensure availability and sustainable management of water and sanitation for all.
4. Divide students into 10 equal groups. Distribute a sheet of poster paper and markers to each group. Show the following website 10 Challenges of Water Utilities | TWRI on the board. Make sure each student/group has access to a device they can use to review the website. Assign each group one of the 10 challenges water utilities are facing. Have each group summarize their assigned challenge in three to five sentences on their poster paper. If time permits, they can also include a graphic for the visual learners in the class. When finished, have each group share their results with the class.
5. Place students in small design teams of three to complete the engineering design challenge. Review the objective and directions for each section of the process. Remind students that the engineering design process emphasizes open-ended problem solving and often leads to innovative ways to solve problems.
6. End the activity by having two design teams exchange plans with one another. They should evaluate the plan and determine if the design meets all the requirements. If it does not, indicate what the team didn't meet and why.
7. Based on the peer feedback, teams can make any necessary improvements to their design.

EXTENSION

1. Students can research a Consumer Reports product review on the best water leak detector systems.
2. Students can use the America's Infrastructure Report Card 2021 to find their state and determine their report card grade for infrastructure. Grades are included for dams, bridges, airports, drinking water, energy, wastewater, stormwater, etc.

Sources

Wastewater Technology Fact Sheet: Pipe Construction and Materials

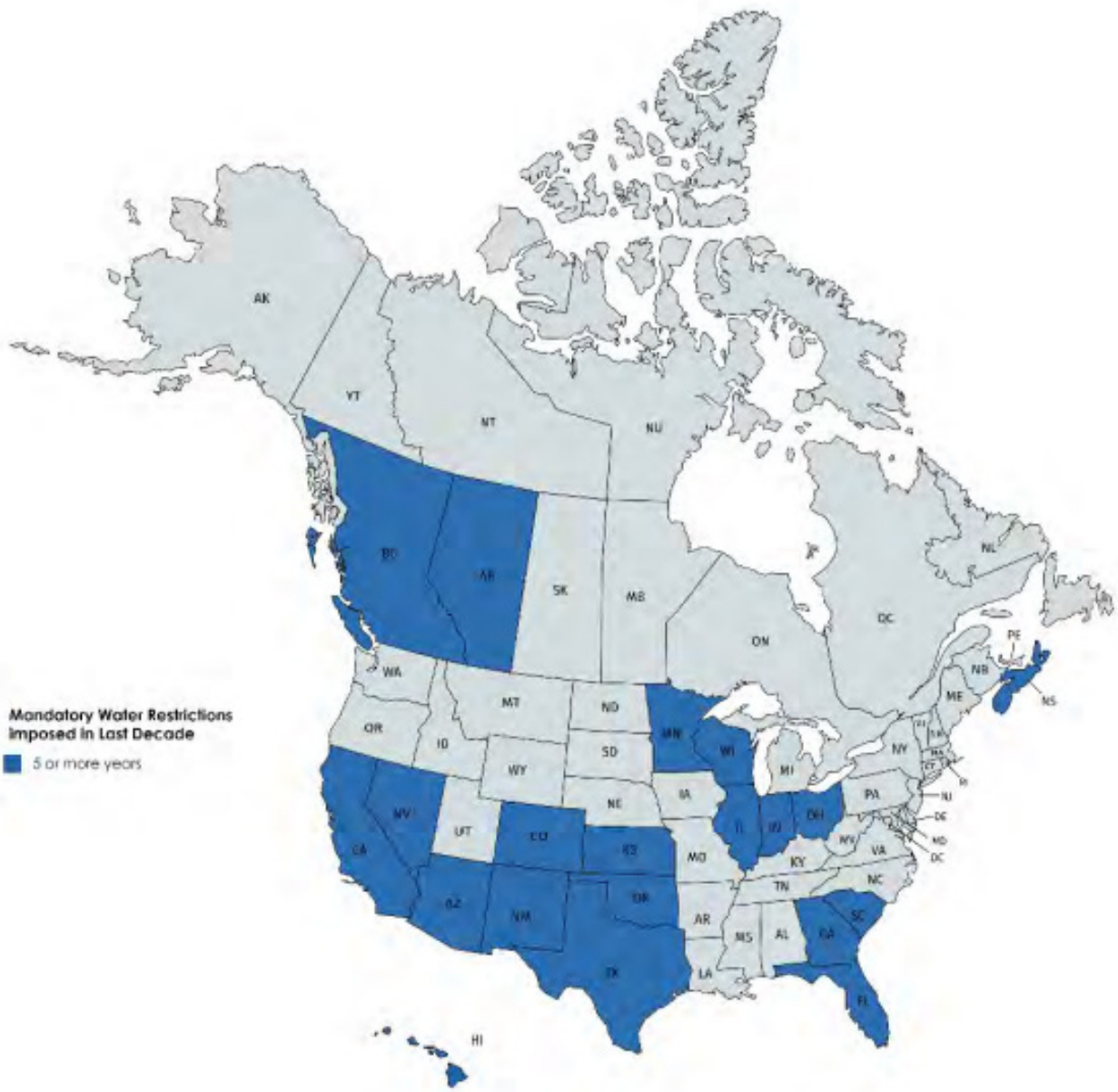
There's A Perfect Pipe for Every Water and Wastewater Project

America's Infrastructure Report Card 2021 | GPA: C-

STATE OF THE WATER INDUSTRY REPORT

10 Challenges of Water Utilities | TWRI

THE 17 GOALS | Sustainable Development


Mandatory Water Restrictions Imposed in Last Decade
5 or more years
AK
YT
NT
NU
BC
AB
SK
MB
ON
QC
NL
PE
NB
NS
ME
WA
OR
CA
ID
NV
MT
WY
UT
AZ
CO
NM
ND
SD
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KS
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MN
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AR
LA
WI
IL
MS
MI
IN
KY
TN
AL
OH
WV
VA
NC
SC
GA
FL
PA
NY
NJ
MD
DC
HI

Rank	2014	2015	2016	2017	2018
1	State of water and sewer infrastructure	Renewal & replacement of aging water and wastewater infrastructure	Renewal & replacement of aging water and wastewater infrastructure	Renewal & replacement of aging water and wastewater infrastructure	Renewal & replacement of aging water and wastewater infrastructure
2	Long-term water supply availability	Financing for capital improvements	Financing for capital improvements	Financing for capital improvements	Financing for capital improvements
3	Financing for capital improvements	Long-term water supply availability	Public understanding of the value of water systems and services	Long-term water supply availability	Public understanding of the value of water systems and services
4	Public understanding of the value of water resources	Public understanding of the value of water systems and services	Long-term water supply availability	Public understanding of the value of water systems and services	Long-term water supply availability
5	Public understanding of the value of water systems and services	Public understanding of the value of water resources	Public understanding of the value of water resources	Public understanding of the value of water resources	Public understanding of the value of water
6	Groundwater management and overuse	Watershed/source water protection	Watershed/source water protection	Watershed/source water protection	Watershed/source water protection
7	Watershed protection	Cost recovery (pricing water to accurately reflect its true cost)	Public acceptance of future water and wastewater rate increases	Emergency preparedness	Aging workforce / anticipated retirements
8	Drought or periodic water shortages	Emergency preparedness	Water conservation/efficiency	Cost recovery (pricing water to accurately reflect its true cost)	Public acceptance of future water and wastewater rate increases
9	Emergency preparedness	Water conservation/efficiency	Cost recovery (pricing water to accurately reflect its true cost)	Public acceptance of future water and wastewater rate increases	Emergency preparedness
10	Cost recovery	Compliance with future regulations	Groundwater management and overuse	Water Conservation/efficiency	Governing board acceptance of future water and wastewater rate increases and Cost recovery (pricing water to accurately reflect its true cost)

Ranking	Category	Weighted Average	% Ranked Critically Important
1	Renewal and replacement of aging water and wastewater infrastructure	4.59	64
2	Financing for capital improvements	4.44	55
3	Public understanding of the value of water systems and services	4.37	50
4	Long-term water supply availability	4.30	50
5	Public understanding of the value of water	4.26	44
6	Watershed / source water protection	4.17	41
7	Aging workforce / anticipated retirements	4.16	43
8	Public acceptance of future water and wastewater rate increases	4.12	35
9	Emergency preparedness	4.10	34
10	Governing board acceptance of future water and wastewater rate increases	4.09	35
10	Cost recovery (pricing water to accurately reflect its true cost)	4.09	32
11	Talent attraction and retention	4.08	33
12	Asset management	3.98	27
13	Cybersecurity issues	3.92	27
13	Data management	3.92	25
14	Improving customer, constituent, and community relationships	3.91	26
14	Compliance with current regulations	3.91	25
15	Groundwater management and overuse	3.88	26
16	Compliance with future regulations	3.86	21
17	Certification and training	3.84	22
18	Water rights	3.77	27
19	Drought or periodic water shortages	3.74	23
20	Water loss control	3.73	17
21	Water conservation / efficiency	3.72	25
22	Energy use/efficiency and cost	3.70	16
23	Physical security issues	3.58	15
24	Water quality issues from premise plumbing systems	3.56	12
25	Expanding water reuse / reclamation	3.46	18
26	Climate risk and resiliency	3.43	15
27	Financing for water research	3.40	12

ENGINEERING DESIGN CHALLENGE

Objective:

Today you will develop a plan to replace the aging pipes that are used to transport water to your school and determine how to monitor possible water loss and contamination.

Data Table

Describe the problem.	
What are the requirements?	
What are the constraints?	
Research	
Use the resources below to determine strengths and weaknesses of commonly used water pipe materials. • Wastewater Technology Fact Sheet: Pipe Construction and Materials • There's A Perfect Pipe for Every Water and Wastewater Project	
Option 1—PVC Pipe	
Strengths of the design	Weaknesses of the design
Option 2—Concrete Pipe	
Strengths of the design	Weaknesses of the design

Option 3—Ductile Iron Pipe	
Strengths about the design	Weaknesses about the design
Option 4—Vitrified Clay Pipe	
Strengths about the design	Weaknesses about the design
Option 5—Steel Pipe	
Strengths about the design	Weaknesses about the design
Option 6—HDPE Pipe	
Strengths about the design	Weaknesses about the design
Imagine	
Based on the information you have provided in the charts, decide which option is most likely to be successful. Which one did you choose? What factor was the most important in helping you decide?	
Plan	
Develop a plan to monitor water loss and possible contamination. How can you incorporate technology, sensors, and the internet of things in your plan?	

Plan
Develop a plan to monitor water loss and possible contamination. How can you incorporate technology, sensors, and the internet of things in your plan?
Improve
Exchange plans with one other group. Compare their design to the requirements listed earlier. Does it meet all the requirements? If not, what didn't it meet and why not?
Based on peer feedback, what changes can you make to improve your design?