WATER TOWER SHOWDOWN

Student Design Journal

Name:

Team Members:

American Water Works Association
VirginiaSection

Bedford Regional Water Authority

Lynchburg Water Resources

Salem Water Department

Western Virginia Water Authority

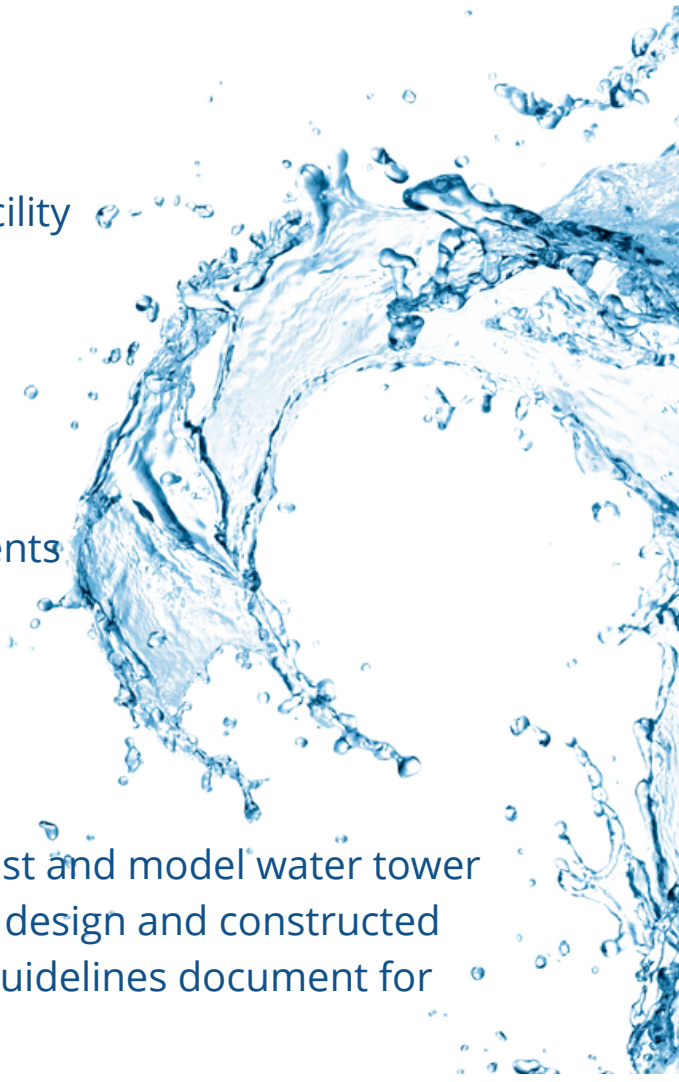
PROJECT OVERVIEW

When

Friday, July 17th
9:30 to Noon

Where

Smith Mountain Lake Water Treatment Facility
1500 Radford Church Road
Moneta, VA 24121



Who

The competition is for middle school students (individuals or teams up to 4) in the Roanoke/Bedford/Lynchburg region.

What

Teams must bring a completed materials list and model water tower to the competition. Towers may be of any design and constructed from any materials. Review full rules and guidelines document for more details.

Judging Criteria

Your tower will be judged based on

- Structural efficiency
- Hydraulic efficiency
- Cost efficiency
- Design Ingenuity



Ready to design your water tower?

THE CHALLENGE

The challenge for your team is to build a structurally efficient model water tower that holds water and can be filled and drained quickly, while also being aesthetically pleasing.

UNDERSTANDING THE CRITERIA

There are four criteria that judges will use to evaluate your tower. It is critical to understand these criteria before you begin designing your tower. These criteria are the same elements that water utilities use when designing real water towers to be built in communities. The four criteria are:

1. Structural Efficiency
2. Hydraulic Efficiency
3. Cost Efficiency
4. Design Ingenuity

1. Structural Efficiency

Structural efficiency is a way for judges to evaluate the strength of your tower based on the ratio of the mass the tower can support to the weight of the actual tower. This is important to consider when designing your tower. You want to be able to support the maximum amount of weight while making your tower as light as possible.

Structural efficiency is calculated by dividing the weight of the model when it is empty (no water) by the average height of the tank multiplied by the amount of water it holds. The lower the number, the better. This criterion is similar to what engineers use in the real world! **For this competition, your tower must be between 1.5 and 2.5 feet high.** In real life, water towers can be hundreds of feet tall!

$$\text{Structural Efficiency} = \frac{\text{Weight of the tower when empty (pounds)}}{\text{Average tank height (ft)} \times \text{Amount of water the model holds (gal)}}$$



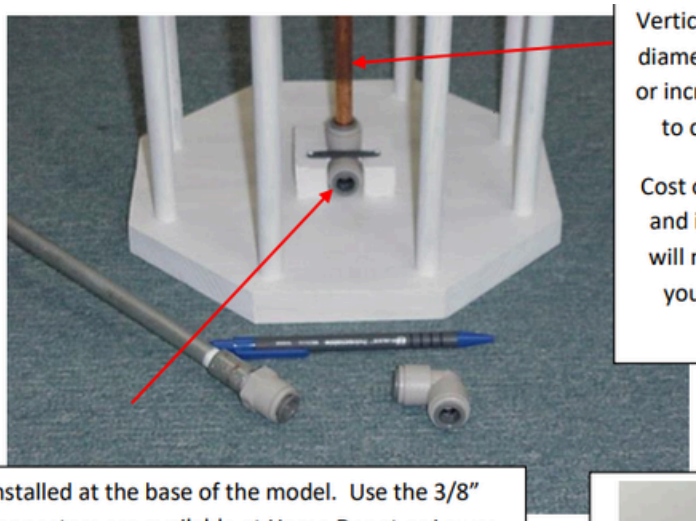
Calculate the structural efficiency of this model water tower based on it's measurements.

Structural Efficiency =

**Design hint: You may want to calculate this score for your tower while you are building and adjust your design to improve your score.*

2. Hydraulic Efficiency

Hydraulic efficiency evaluates how quickly water can flow into and out of a water tower. For this competition, judges will time how long it takes to fill and drain your model with 1 gallon of water. The judges will fill the tank through a standard 3/8th diameter connector. **You MUST have the proper size connector in an accessible location to avoid a penalty.** The less time it takes to fill and drain the tank through the connector, the better your score.



Vertical tube may be any diameter - use a reducer or increaser as necessary to change tube size.

Cost of the vertical tube and increaser/reducer will not count towards your Cost Efficiency score.

Connector must be installed at the base of the model. Use the 3/8" diameter connector. Connectors are available at Home Depot or Lowes.

SharkBite 3/8 in. O.D. x 3/8 in. O.D. Quick Connect Elbow (*Model No.* 25431Z) or

John Guest 3/8 in. O.D. Polypropylene Push-to-Connect Elbow (Model No. 803369) Either of the two are acceptable.

Make sure that the model numbers on the connector match and it looks like the connector in the picture.



Connector should look like the above picture and allow for a 3/8" outer diameter tube to connect.





3. Cost Efficiency

Cost efficiency measures your ability to use resources and funds wisely and creatively while designing your model. In real life, engineers have budgets that they have to work within, if they exceed the budget it could mean increased cost for the utility and customers. **In this competition, the less money spent the better! You must bring your completed materials list form and receipts with you to the competition.**

List all items used to build your model and their costs on the materials list form. If you used a recycled item, put the letter "R" in the cost column. You may use as many recycled materials as you wish. No receipt is necessary for recycled items. A penalty of 1 point will be given for each missing receipt for items purchased new. The cost of the connector is not taken into consideration for cost efficiency, since it is required of all models. Donated items count towards total cost and require receipts or they will be subject to the 1 point penalty.

Points will be assigned as follows:

Item Amount	Point Amount
$0.00 - $5.00	1
$5.01 - $10.00	2
$10.01 - $15.00	3
$15.01 - $20.00	4
More than $20.00	5



4. Design Ingenuity

Design ingenuity evaluates the unique and creative factors integrated into your model. Ingenuity judges will evaluate how much imagination and skill were used in creating your model. Water towers are part of a communities landscape and should be aesthetically pleasing. Judges will evaluate design ingenuity based on several items including:

1. Craftsmanship: Is the model sturdy? Do the parts fit together nicely?
2. Imagination: Is the model's design unique? Are the materials unique or used creatively?
3. Artistic merit: Does the model have creative ideas, colors, or themes? Is the model aesthetically pleasing?





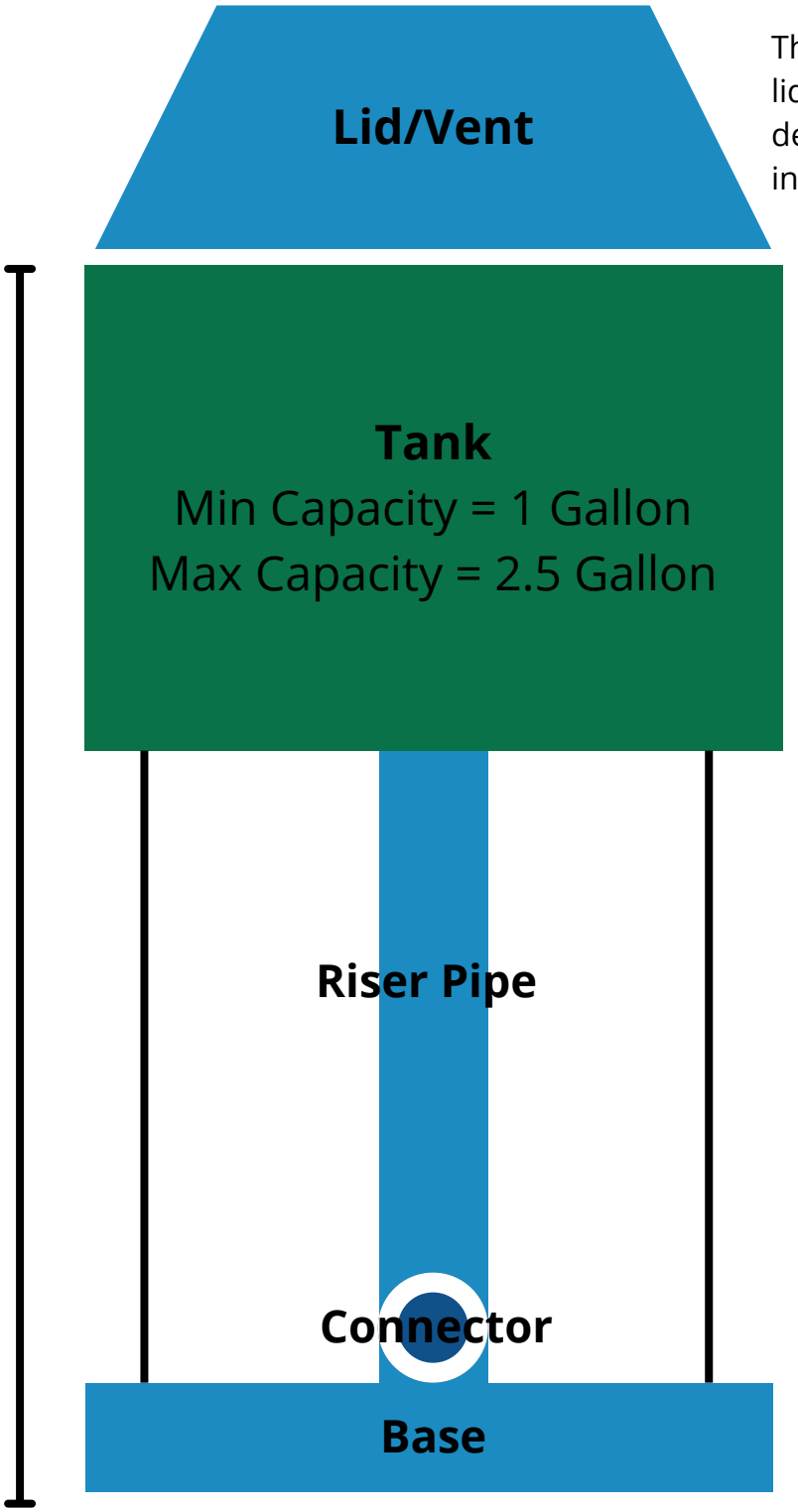


4. Design Penalties

In the real world, engineers must design based on location and other physical restraints. In this competition, your design should meet these requirement to avoid penalties.

- The base of the model must fit in a 1 foot square.
- The tower must be between 1.5 and 2.5 feet high.
- The tank must have a vent or removable lid large enough to place a funnel through so the judges can fill the tank and tell when it is full.
- When full, the tank must hold between 1 and 2.5 gallons of water and should not leak.
- Towers must be able to support themselves when filled to overflow with no outside support.
- The model must use the 3/8" diameter connectors as specificized.
- The team must provide receipts for all purchased materials.
- Towers can not require electrical supply.

Model Water Tower Requirements



The tank must have a vent or lid. so judges can fill the tank to determine volume and view the inside of the tower.

Tower cannot exceed 2.5 feet from the base to its hydraulic overflow point (meaning where water can overflow from the tank)

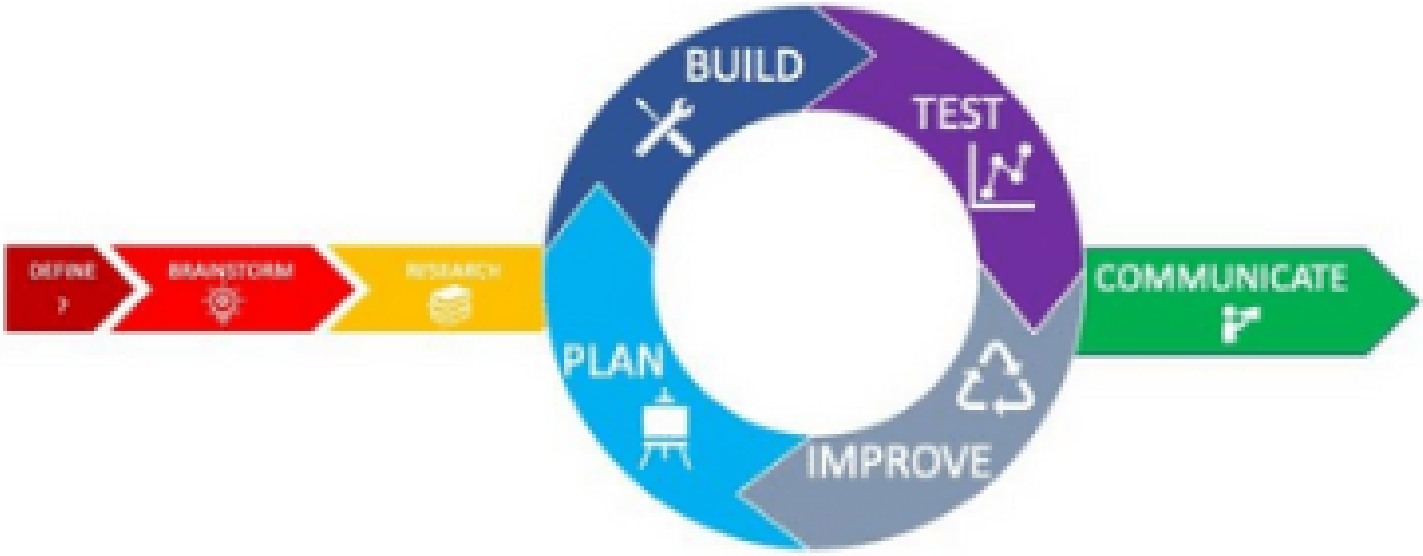
From base to bottom of tank must be at least 1.5 ft tall

Base must fit in a 1 ft square or smaller

Additional notes:

Your model must be an elevated tank design including a riser pipe, a tank, and supporting structure to hold the tank and a base. The Maximum and minimum volume requirements INCLUDE the storage in your riser pipe. The maximum 2.5 feet height refers to the length from the base to the overflow point on the tank. The tank must function without electrical supply.

The Engineering Design Process



Define the Problem

Using what you have learned about the water tower model tower challenge, define the problem in your own words.

What is the problem? What do I need to do?

What are things I need to consider in order to solve the problem?

Brainstorm

Before solving the problem, engineers brainstorm different ideas that could help them solve the problem. In the space below draw and label you water tower. List any materials that you think might work to build your tower. This list and model may change after you do more research on water towers and that's okay! It's time to get creative!

Tower Ideas and Sketches	*Materials*

Research

Using the informational text below and websites linked in the resource section, write down 5 things need to consider when designing your water tower and the correlation to the competition criteria.

1.

2.

3.

4.

5.

Water Towers: Past, Present, and Building Considerations

Water towers are remarkable structures that have a long history and play a vital role in providing us with a reliable water supply. We will explore the history of water towers, understand how they work, and discover important considerations when building one.

A Brief History of Water Towers:

The idea of using elevated containers to store water dates back to ancient civilizations. In the Middle Ages, stone towers called "water keeps" were built to store and distribute water. However, water towers as we know them today began to emerge during the 19th century, with advancements in technology and urban growth. They have since become an integral part of modern water supply systems.

How Water Towers Work:

Water towers work based on a simple principle: gravity and hydraulic pressure. Here's how they function:

- Water Supply: Water is pumped into a large, elevated tank located on top of the tower. The height of the tower allows for gravity to create pressure, pushing the water downward through pipes.
- Water Distribution: As water flows down from the tower, it enters the community's water distribution system. This system consists of a network of pipes that carry the water to homes, businesses, and other buildings.
- Water Pressure: The height of the water tower determines the water pressure delivered to our faucets. The greater the height, the stronger the water pressure, making it easier for us to use water for everyday tasks.

Considerations When Building a Water Tower

Building a water tower requires careful planning and consideration. Here are a few important factors to keep in mind:

- *Location:* Selecting the right location is crucial. Water towers are usually built on high ground to maximize gravity's effect on water distribution. Consider land availability, accessibility, and the tower's visual impact on the surrounding area.
- *Capacity:* Determine the amount of water your community needs and design the tower's storage capacity accordingly. It should be able to handle peak demand periods and ensure a consistent water supply.
- *Structural Integrity:* Water towers must be structurally sound and capable of withstanding various environmental factors, such as wind, earthquakes, and extreme weather conditions. Consult with engineers and architects to ensure the tower's stability.
- *Maintenance and Inspection:* Regular maintenance and inspections are essential to keep the water tower in good working condition. Consider access points, safety measures, and maintenance schedules when designing the tower.
- *Cost Efficiency:* Building and maintaining a water tower involve costs. Consider the overall construction expenses, ongoing maintenance, and operational costs. Strive for cost efficiency while ensuring the tower's functionality and longevity.

Water towers have a rich history and are vital components of our water supply systems. They utilize gravity and hydraulic pressure to distribute water to our homes and businesses. When building a water tower, factors such as location, capacity, structural integrity, maintenance, and cost efficiency should be carefully considered. Understanding these aspects helps ensure a reliable and efficient water supply for communities. Water towers truly are impressive structures that contribute to our daily lives in ways we may not always notice.

Additional Websites for Research:

- Wonderopolis - How Do Water Towers Work? Website: https://wonderopolis.org/wonder/how-do-water-towers-work
- Kids Encyclopedia Facts - Water Tower Facts for Kids Website: https://kids.kiddle.co/Water_tower#:~:text=A%20water%20tower%20is%20a,to%20the%20tower%20by%20pipes.
- How Water Towers Work You Tube: https://youtu.be/zSsxXhhGocg
- How Water Towers Work by Practical Engineering YouTube: https://youtu.be/yZwfcMSDBHs

Plan

Now that you have learned more about water towers, let's plan the design for your team's tower. Draw a diagram of what your water tower design. Be sure to include measurements, storage capacity, and creative embellishments. List all the materials you will need to construct your tower.

Model Water Tower Design	*Materials*

Build

Gather your materials and build your model water tower! Use the space below for any notes or calculations that you need to make. Keep track of the materials you use on the materials sheet on the following page.

Model Water Tower Build Notes and Calculations

Materials List Form

Team Name:

Participants:

Complete and bring this form and all receipts on the day of the contest. List the materials and costs used to construct your model water tower. Put an 'R' in the cost column where recycled materials are used. Use additional sheets if necessary to list all materials. A penalty will be given for not bringing this form and required receipts. Donated items still require receipts and count towards total.

Material	Cost
Total	

Test

Let's test your model water tower! Check that your model meets all the criteria below to evaluate the effectiveness of your design.

Model Water Tower Requirements:

- ▢ The base fits within 1 square foot
- ▢ The tank height is between 1.5 and 2.5 feet
- ▢ There is a vent or removable lid for filling the tank
- ▢ The tank can store between 1 and 2.5 gallons of water without leaks
- ▢ The tower can support themselves when filled to overflow without outside support.
- ▢ The model uses the specified 3/8" diameter connector.
- ▢ Receipts are provided for purchased items
- ▢ The tower does not require electricity supply

Structural Efficiency:
Calculate the structural efficiency of your tower.

Weight of tower when empty (pounds): _____

Average tank height (feet): _____

Amount of water the model holds (gallons): _____

$$Structural\ \ Efficiency = \frac{Weight\ of\ \ the\ tower\ \ when\ \ empty\ \ (pounds)}{Average\ \ tank\ \ height\ \ (ft) \times Amount\ \ of\ \ water\ \ the\ \ model\ \ holds\ \ (gal)}$$

Structural efficiency of my tower =

Hydraulic Efficiency:

- ▢ The model fills up and drains quickly using the provided connector
- ▢ There is a vent or removeable lid for filling/draining the tank
- ▢ The tank holds between 1 and 2.5 gallons of water without leaks
- ▢ The tower can support itself when filled to overflow without outside support.

Cost Efficiency:

- ▢ The model was built using cost effective materials
- ▢ Receipts for all purchased or donated materials are provided.
- ▢ Calculate how many points you will receive based on your materials list and the below scoring guide.

Cost Efficiency Point Amount Calculations

Total points for cost efficiency =

Item Amount	Point Amount
$0.00 - $5.00	1
$5.01 - $10.00	2
$10.01 - $15.00	3
$15.01 - $20.00	4
More than $20.00	5

Design Ingenuity:

- ▢ Is the model sturdy?
- ▢ Do the parts fit together nicely?
- ▢ Is the model's design unique?
- ▢ Are the materials unique or used creatively?
- ▢ Does the model have creative ideas, colors, or themes?
- ▢ Is the model aesthetically pleasing?

Improve

After engineers test a prototype, they always look for ways to improve it. Based on your testing, what are some ways you can improve your design? In the space below, draw and label a diagram of your water tower with improvements. After you have designed your new plan, make appropriate changes to your model tower, adjust your materials list, and retest your tower.

Improved Model Water Tower Diagram

Changes I made to the original design:

Communicate

Share your design with your class and judges! At the competition you will present your model water tower to a series of judges at multiple different stations. Prepare answers to the questions below.

How did you develop your design?

What are three things you learned during the design process?

How did you calculate the structural efficiency score for your model?

What makes your model creative, effective, and unique?

What changes did you have to make to your model during the design process?

What materials did you choose to use and why?

VIRGINIA

SECTION • AWWA

Bedford Regional Water Authority

LYNCHBURG WATER RESOURCES

SALEM WATER DEPARTMENT

WESTERN VIRGINIA WATER AUTHORITY