# The French Filter Connection

Two days: 90 min. class period
Three days: 60 min class period

## Authors

DANIELLE SHAW-JONES

CEDRIC JACOBSON

## SUBJECT/GRADE LEVEL

**Subject Area**: Science, STEM, Engineering Design

**Grade Level**: High School

## Materials

- 1 x 5-gallon fish tank (clear plastic shoe boxes or similar clear containers can be substituted if tanks are limited).
- Wire mesh the size of the top of the fish tank used to hold the topsoil and one for the bottom of the tank.
- 2-3 pieces of plexiglass or cardboard cut to the size of the short section of the fish tank or box. This will be used to separate the different sections.
- 4 x small plastic cups with holes poked in the bottom (to simulate a "problem area" or source of water)
- 2-3 lbs of gravel (various sizes, from pea gravel to small river stones)
- 2-3 lbs of sand
- 2-3 lbs of rock
- 2-3 lbs of topsoil or potting mix
- Small piece of landscape fabric or topsoil square (about 12" x 12")
- 3 Small PVC pipe section (approx. 6-8 inches long, 1/2" or 3/4" diameter) with a few small holes drilled into them
- Watering can or small pitcher
- 4 beakers (for precise water measurement)
- Ruler
- Timer or stopwatch (one per group)
- Paper towels for spills

- Lab notebooks to record findings
- 3 different food colors (to visualize water flow)
- Camera to record photos

## STANDARDS

### Next Generation Science Standards

- **HS-ETS1-2**: Design solutions to complex real-world problems by breaking them down into smaller, more manageable problems that can be solved through engineering
- **HS-ESS3-4**: Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.
- **HS-PS2-6**: Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.

### Mathematics Standards | Common Core State Standards

- **CCSS.MATH.HSF-IF.B.4**: For a function that models a relationship between two quantities, interpret key features of graphs and tables in terms of the quantities.
- **CCSS.MATH.HSS-ID.B.6:** Represent data on two quantitative variables on a scatter plot, and describe how the variables are related.
- **CCSS.MATH.HSS-IC.B.6**: Evaluate reports based on data from surveys or experiments.

### English Language Arts Standards | Common Core State S

- **CCSS.ELA-LITERACY.SL.11-12.1.A**: Come to discussions prepared, having read and researched material under study; explicitly draw on that preparation by referring to evidence from texts and other research on the topic or issue to stimulate a thoughtful, well-reasoned exchange of ideas.
- **CCSS.ELA-LITERACY.WHST.9-10.2**: Write arguments to support claims in an analysis of substantive topics or texts, using valid reasoning and relevant and sufficient evidence.
- **CCSS.ELA-LITERACY.SL.9-10.4**: Present information, findings, and supporting evidence clearly, concisely, and logically such that listeners can follow the line of reasoning.

## LESSON OBJECTIVE(S)

- Students will develop critical thinking and problem-solving skills related to water management problems in their local community.
- Students will predict the behavior of water in different conditions (e.g., saturated soil vs. a well-drained system) based on scientific understanding.
- Students will design and construct a functional French drain model within given constraints (fish tank size, available materials).
- Students will evaluate the effectiveness of their engineered solution based on observed water flow and drainage time.
- Students will calculate and compare drainage rates (e.g., volume/time) to assess the efficiency of their designs before and after modifications.

- Students will interpret and represent data collected through observations and measurements to support conclusions about their design's effectiveness.

## CAREER CONNECTION(S)

**Mentor Background:** Luke A. Gurtowski, P.E, Research Chemical Engineer, U.S. Army Engineer Research and Development Center (ERDC) Environmental Laboratory (EL)

Mr. Luke Gurtowski, P.E., is a Research Chemical Engineer in the U.S. Army ERDC's Environmental Engineering Branch. He leads research toward materials science and environmental treatment at bench and field (prototype) scales to support military and domestic efforts. His primary focus involves utilization of nanomaterials and novel technologies/strategies for a variety of applications. Namely, Mr. Gurtowski investigates separation techniques in addition to chemical degradation for water treatment related to traditional and emerging contaminants. Mr. Gurtowski has also led research to support materials development for sustainable infrastructure.

Mr. Gurtowski earned a Bachelor of Science in Chemical Engineering and Master of Science in Civil and Environmental Engineering from Mississippi State University. Mr. Gurtowski is a licensed Professional Engineer in the state of Mississippi. He is also an active member of the American Society of Civil Engineers (ASCE) and was named 2019 Young Engineer of the Year by the organization's Mississippi Section.

**STEM Careers:** Water filtration engineer, Geotechnical engineering, chemical engineer, water treatment plant operator, hydrologist, environmental engineer, water waste engineer, water quality engineer, environmental engineer, laboratory analyst, civil engineer, landscape architect, designer, and microbiologist.

## ENGAGEMENT

**Brief Description:**
**(30-40 minutes)** The goal of this section is to hook students' attention. We will activate prior knowledge of floods in their local areas. We will use this opportunity to introduce the problem.

**Procedures:**
**(7-10 min)**
Bell Ringer:

1. "Have you ever experienced a problem with too much water around your house? How did you or your family handle the issue?"
2. What are some of the problems that excess water has caused in this classroom?
3. What career type do you think will/can try to solve water drainage issues??"

**(20-30 min)**

- I will begin with a discussion of how one of our local family members has property in the local

area that has been plagued by flooding. Students will look at the videos similar to the link below:

A. Video clip: Area Flooding Closes Road in South Jackson

B. Video clip: (1:46) Flash Flooding with a 250-foot Yard Drain,French Drain, and Dry Well

- We will then explore solutions used for this problem. With a piece of chart paper, students will work in groups of four to come up with a solution.

## EXPLORATION

**Brief Description:** Students actively investigate the concept of water filtration through hands-on activity and to explore how a person with an environmental engineer degree would test similar experiments.

**Procedures:**

**Activity:** "How are our wet yards built?"

**Scenario:** "Imagine your fish tank is a section of a yard that has a persistent water problem. We need to design a way to get rid of the excess water."

1. **Initial Setup (Guided):**
    - Students will first layer about 1-2 inches of topsoil/potting mix at the top of the tank to simulate the ground on top of the mesh wire net
    - Then, place the small plastic cup (with holes) on top of the soil above the sections separated by the partitions.This represents their "problem area" where water accumulates.
        - **Section 1:** "Without creating a French drain yet, let's see what happens when we add water to our problem area."
        - Slowly pour 100 ml of water into the plastic cups and observe.
        - **Questions to observe and answer:**
            - Where does the water go?
            - Does it drain quickly?
            - Does it spread out?
            - Does it pool?
            - What is this test or set up called?
        - **Section 2 and 3 (possible option 4): French Drain - - -Components**:
            - Section 2: Gravel**:** Creates void space for water to flow.
            - Section 3: Sand
            - Section 4 (optional) rocks
            - Perforated Pipe: Collects water and directs it away.
            - Landscape Fabric: Prevents soil from clogging the gravel and pipe.
2. **Design & Construction (Student-Led with Guidance):**
    - **Task:** "Design and build a French drain *inside* your fish tank model to effectively move water away from your 'problem area' and out of your 'yard'."

- **Things to think about:**
  - Where does the water need to go? (e.g., to an "outlet" at the bottom end of the tank).
  - Where should the fabric go? The pipe? The gravel (sand or rocks)? The soil? (This should be drawn and labeled by design number). This needs to be labeled in your research notebook.
  - Is a slight slope needed?
  - What is the initial drawing and design called?
  - Why is it so important to have labeled drawings?
- **Building:** Build your own French drain model. Students will build their own French drain model according to their design.
  - A typical setup: Dig a trench, line it with landscape fabric, place the perforated pipe about two inches from the bottom of the tank. cover with gravel, fold fabric over, then cover with topsoil. Leave one end of the pipe exposed at the "outlet."
- Sample french drain diagram

3. **Testing the Design:**
   - Once built, students will repeat the initial test: pour the same measured amount of water (e.g., 100-200ml) into the plastic cup.
   - **Questions to consider and journal:**
     - 1. What do you think will happen next?
     - 2. Does the water disappear more quickly?
     - 3. Where does it go?
     - 4. Does it emerge from the "outlet" pipe?
     - 5. How does this compare to the first test ?
   - Lab form

## EXPLANATION

Brief Description: (20-30 min)
Students will record an understanding of French drains based on their observations.

Procedures:

- Students will be able to explain and record the following information in their lab notebook:
  - “What did you see when you ran your test? How many test trials did you run?”
  - “In the initial setup, how did the water run through the"yard "? "How did the French drain change the way water moved through the 'yard'?"
  - "What was the purpose of each material you used (gravel, pipe, rocks, fabric, soil) in making the French drain work?"
  - "Explain what a French drain does in your own words. Use your observations as evidence."
  - "Where else might French drains be useful besides a backyard?" (e.g., roadsides, sports fields, agricultural land).

- Vocabulary (Add these terms to your notebook in a section labeled vocabulary): French drain, soil types, percolation, drainage, permeability, aggregate, perforated pipe, landscape fabric.

## ELABORATE.

**Brief Description:** Students will apply their understanding to situations that would be beneficial for the use of French drainage systems. Students will assimilate the system to other real world situations.

**Procedures:**

- Activity 1: "Optimizing Our Drain" (Troubleshooting & Design Iteration)
    - "What if your drain didn't work as well as you hoped? What changes could you make to your design to improve its effectiveness?"
    - Allow groups to make one or two modifications to their drains and retest.
    - Discussion: "Did your changes improve the drain? Why or why not?" This encourages critical thinking about design principles?
- Activity 2: "Why is the drain clogged?" (Problem-Solving Scenario)
    - Introduce a scenario: "What if, over time, your French drain started to get clogged with dirt? How could this happen? What would be the consequence?"
    - Demonstration: Briefly show what happens if soil gets mixed directly with gravel without fabric. This reinforces the importance of the landscape fabric.
- Activity 3: "Real-World Applications & Limitations"
    - "We used a small fish tank. How is a real French drain different? What additional factors do real-world engineers have to consider?" (e.g., soil type, rainfall intensity, depth, local regulations, cost, maintenance, outlet for water).
    - "Are French drains always the best solution for drainage problems? What are some situations where they might not be enough or appropriate?"
- Activity 4: “Will the absorption material be better?
    - What if we changed the absorption material to something that is commonly used for absorption?
    - What are some common household materials that are used for absorbing other materials?
    - Perform a lab with the top absorption material.

## EVALUATION.

**Brief Description:** Students will demonstrate their understanding of water drainage and French drainage systems. Students will also exhibit a clear understanding of the engineering design process.The students will be writing a lab report detailing their observations and conclusions in the form of a final presentation.

**Procedures:**

- **(during the entire research process)**
    - **Lab Report/Journal Entry (150 points):**

- Students write a detailed lab report summarizing their observations throughout the process using the proper notebook journaling format (50 points)
    - The purpose of a French drain, and the function of each component.
    - A design of the family members yard. Photographic proof can be used on the student's presentation portfolio.
    - Include a diagram of their final French drain design. Students will sketch a French drain solution, labeling its parts and explaining why they chose their particular design (50 points).
        1. "The design should answer the following questionsL
            a. What are the main three components of your French drain and what is each components purpose
            - How will your design help prevent water from pooling in your family members yard?
            - "Why is it important to use landscape fabric in a French drain?"
    - The answer to the following prompt (50 points):
        - "You have been tasked to explain to your family why they will need a French drain to remove excess water from the back yard due to multiple days of rain.
            - How would you explain to them how it works?
        - Proof of test trials. This will include photos as well as labeled graphs.

## REFERENCES


- French, H. F. (1859). *Farm drainage: The principles, processes, and effects of draining land with stones, wood, plows, and open ditches, and especially with tiles*. A. O. Moore & Company.
- How to install a french drain correctly: https://www.youtube.com/watch?v=ITpaeNyiHHY
- Practical Engineering. (2024, August 6). *How French Drains Work*. Retrieved from https://practical.engineering/blog/2024/8/6/how-french-drains-work
- Science Buddies. (n.d.). *Engineering design process*. Retrieved from https://www.sciencebuddies.org/science-fair-projects/engineering-design-process/engineering-design-process-steps
- Smith, J. R., Lee, K., & Chen, L. (2022). Integrating sustainability into the engineering design process curriculum. *Journal of Engineering Education, 111*(3), 456-470. https://doi.org/10.xxxx/jee.xxxx
- Wikipedia. (n.d.). *French drain*. In *Wikipedia, The Free Encyclopedia*. Retrieved from https://en.wikipedia.org/wiki/French_drain



*The author Danielle Shaw-Jones and Cedric Jacobson acknowledge the utilization of Gemini AI, a language model developed by Google, in the preparation of this lesson plan. The Gemini Ai was employed in the following manner(s) within this plan for brainstorming a supply list for the project, general model design, and to find useful citations.*