French Drainage Lab: Water's Underground Escape

Name(s): _____ Date: _____Class/Period: _____ Group #: _____

Learning Objectives

By the end of this lab, you will be able to:

1. **Develop critical thinking and problem-solving skills** related to water management problems in your local community.
2. **Predict** the behavior of water in different conditions (e.g., saturated soil vs. a well-drained system) based on scientific understanding.
3. **Design and construct** a functional French drain model within given constraints (fish tank size, available materials).
4. **Evaluate** the effectiveness of your engineered solution based on observed water flow and drainage time.

Materials (per group)

- 1 x 5-gallon fish tank (or clear container)
- Wire mesh (size of tank top, one for tank bottom)
- 2-3 pieces of plexiglass or cardboard (cut to short section of tank/box for separators)
- 4 x Small plastic cups with holes (water source)
- 2-3 lbs of gravel (various sizes, from pea gravel to small river stones)
- 2-3 lbs of sand
- 2-3 lbs of topsoil or potting mix
- Small piece of landscape fabric or topsoil square (about 12" x 12")
- 3 Small PVC pipe sections (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
- Plexiglass to separate experiments in the tank

Time Allotment: 45-60 minutes

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."

Initial Setup (Guided):

1. Place one piece of wire mesh at the bottom of the fish tank.
2. Use the plexiglass/cardboard pieces to divide your tank into 2-3 (or 4, if optional section 4 is used) separate sections.
3. Carefully place about 1-2 inches of **topsoil/potting mix** on top of the mesh wire net in each section to simulate the ground.
4. Place one **small plastic cup (with holes)** on top of the soil in each section. This represents a "problem area" where water accumulates.

Section 1: Baseline Test - Observation without a French Drain

1. In Section 1, without creating any drainage system, carefully pour **100 mL** of water into the plastic cup. You may add a drop of food coloring to better visualize the flow.
2. Start your stopwatch immediately when you begin pouring.
3. Observe what happens to the water. Record your observations in the table below. Stop the timer when the standing water in the cup is mostly absorbed or has visibly spread out.

Test	Section	Water Added (mL)	Time to (Mostly) Drain (seconds)	Observations (Where does the water go? Does it drain quickly?
Baseline (No Drain)	1	100 mL		

Questions to observe and answer (Record in your lab notebook):

1. Where does the water go in this section?
2. Does it drain quickly?
3. Does it spread out?

4. Does it pool?
5. What is this test or setup called?

Sections 2, 3 (and Optional 4): French Drain Components & Design

Introducing French Drain Components:

- **Gravel:** Creates void space for water to flow.
- **Sand:** (Consider its role in filtration/drainage compared to gravel).
- **Rocks (Optional):** (Consider their role in filtration/drainage compared to gravel/sand).
- **Perforated Pipe:** Collects water and directs it away.
- **Landscape Fabric:** Prevents soil from clogging the gravel and pipe.

Design & Construction:

Task: "Design and build a French drain inside your fish tank model in **Section 2** to effectively move water away from your 'problem area' and out of your 'yard'."

- **Section 2:** Design a French drain using **gravel** as the primary aggregate.
- **Section 3:** Design a French drain using **sand** as the primary aggregate.
- **Section 4 (Optional):** Design a French drain using **rocks** as the primary aggregate.

Things to think about (Record answers in your lab notebook):

1. Where does the water need to go? (e.g., to an "outlet" at the bottom end of the tank).
2. Where should the fabric go? The pipe? The gravel (sand or rocks)? The soil? (This should be drawn and labeled by design number).
3. Is a slight slope needed? If so, where?
4. What is the initial drawing and design called?
5. Why is it so important to have labeled drawings?

Building: Build your own French drain model in each designated section according to your design.

- **A typical setup:** Dig a trench, line it with landscape fabric (or topsoil square), place the perforated pipe about two inches from the bottom of the tank, cover with gravel/sand/rocks, fold fabric over, then cover with topsoil. Leave one end of the pipe exposed at the "outlet."

Take photos of your initial design and construction process for your lab report.

Testing the Design:

Once built, students will repeat the initial test for **each section with a French drain**:

1. Carefully pour **100 mL** of water into the plastic cup in each section. You may use a different food color for each section to differentiate flow.
2. Start your stopwatch immediately when you begin pouring for each section.
3. Observe what happens. Note if water emerges from the "outlet" pipe. Stop the timer when the standing water in the cup is mostly absorbed or has visibly flowed into the drain.

Test	Section	Water Volume Added (mL)	Time to (Mostly) Drain (seconds)	Observations (Where does the water go? Does it emerge from the outlet? How quickly? How does this compare to the Baseline?)
French Drain Test 1 (Gravel)	2	100 mL		
French Drain Test 1 (Sand)	3	100 mL		
French Drain Test 1 (Rocks)	4	100 mL		

Questions to consider and journal (Record in your lab notebook):

1. What do you think will happen next in each section after adding water?
2. Does the water disappear more quickly in the sections with drains compared to the baseline?
3. Where does the water go in each section with a drain?
4. Does it emerge from the "outlet" pipe?
5. How does the drainage in each French drain section compare to the first test (Baseline)?

Part 3: Explanation (Articulating Understanding)

Time Allotment: 20-30 minutes

Procedures:

Students will record the following information in their lab notebook:

1. **Observations and Trials:** "What did you see when you ran your tests? How many test trials did you run for each section?"
2. **Water Movement Comparison:** "In the initial setup (Baseline), how did the water run through the 'yard'? How did the French drain change the way water moved through the 'yard' in the different sections (gravel, sand, rocks)?"
3. **Purpose of Materials:** "What was the purpose of each material you used (gravel, sand, rocks, pipe, fabric, soil) in making the French drain work?"
4. **French Drain Explanation:** "Explain what a French drain does in your own words. Use your observations as evidence to support your explanation."
5. **Other Applications:** "Where else might French drains be useful besides a backyard?" (e.g., roadsides, sports fields, agricultural land).

Vocabulary:

Add these terms to a section labeled "Vocabulary" in your lab notebook, along with their definitions based on your understanding from the lab:

- French drain
- Soil types
- Percolation
- Drainage
- Permeability
- Aggregate
- Perforated pipe
- Landscape fabric

Part 4: Elaboration (Applying and Extending Understanding)

Time Allotment: 30-45 minutes

Procedures:

Activity 1: "Optimizing Our Drain" (Troubleshooting & Design Iteration)

1. **Analysis of Performance:** Based on your first French Drain Test results, identify the section that performed best and the section that performed worst.
2. **Design Improvement:** For the section that performed *worst*, what specific changes could you make to its design to improve its effectiveness (e.g., more slope, larger pipe, different aggregate size, longer drain, different fabric placement)?
3. Hypothesis: Formulate a hypothesis for your proposed change:
   "If we make the following change(s) to our French drain in Section __:
   _____, then we predict the drainage time will (increase/decrease/stay the same) because
   _____.
4. **Modification & Retest:** Make the proposed change(s) to your model in that section.
5. **Repeat Test:** Pour **100 mL** of water into the plastic cup in the modified section. Start the timer and record your observations.

Test	Section	Water Volume Added (mL)	Time to (Mostly) Drain (seconds)	Observations (What happened differently with your improved design? Did water emerge from the outlet?)
French Drain Test 2 (Optimized)		100 mL		

6. **Discussion:** Did your changes improve the drain's performance? Explain why or why not,

referring to your data and design principles.

Activity 2: "Why is the drain clogged?" (Problem-Solving Scenario)

1. **Scenario:** Imagine your French drain has been installed for several years. What might happen over time that could cause it to start getting clogged with dirt? How could this happen? What would be the consequence of a clogged drain?
2. **Demonstration/Discussion:** Your teacher will briefly demonstrate what happens if soil gets mixed directly with gravel without fabric. Discuss how this reinforces the importance of the landscape fabric.

Activity 3: "Real-World Applications & Limitations"

1. **Model vs. Reality:** How is your small fish tank model different from a real French drain installed in a yard or beside a road? List at least three differences.
2. **Engineering Considerations:** What additional factors would real-world engineers need to consider when designing a French drain that you didn't have to worry about in this lab? (Think about soil type, rainfall intensity, depth, local regulations, cost, maintenance, outlet for water, environmental impact).
3. **Alternative Solutions:** 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?"

1. **Brainstorming:** 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 (e.g., sponges, paper towels, kitty litter, sawdust)?
2. **Experiment Design (in remaining section or new setup):** Choose one or two of the brainstormed absorption materials. Design a mini-experiment to test its effectiveness as a drainage or absorption layer compared to gravel/sand/rocks.
3. **Perform Test:** Conduct your mini-experiment and record your observations and data.
4. **Discussion:** How did the absorption material perform? Would it be a viable alternative for a French drain in certain situations? Why or why not?

Part 5: Evaluation (Demonstrating Understanding)

Time Allotment: During the entire research process and final presentation.

Procedures:

1. Lab Report/Journal Entry (150 points):

You will write a detailed lab report summarizing your observations and conclusions throughout the process, using the proper notebook journaling format (refer to: https://docs.google.com/document/d/11Nuo2-JWjNBQYPAOG3SyF7QSQWecjA9i/edit). Your report must include:

- **Journaling Format (50 points):** Adherence to proper scientific notebook journaling format for all data, observations, and reflections.
- **French Drain Purpose and Components (50 points):**
  - Clearly explain the purpose of a French drain.
  - Describe the function of each component: gravel, sand, rocks (if used), perforated pipe, landscape fabric, and topsoil.
  - Include a diagram of your final, optimized French drain design, clearly labeled with all components.
- **Design Application & Explanation (50 points):**
  - **Scenario:** You have been tasked to explain to a family member why they will need a French drain to remove excess water from their backyard due to multiple days of rain.
  - **Explanation:**
    1. Explain how you would tell them about a French drain (i.e., how would you introduce the topic and explain its benefits simply?).
    2. Explain how it works, using concepts and evidence from your lab.
  - **Visual Evidence:** Include photographic proof of your test trials, as well as labeled graphs comparing drainage times for your different sections and modifications.

Teacher Use Only:

Criteria	Needs Improvement (1 pt)	Satisfactory (3 pts)	Exemplary (5 pts)	Score
Bell Ringer & Engagement	Incomplete or minimal responses.	Responses present; some engagement.	Thoughtful and complete responses; clear engagement.	
Initial Setup & Baseline Data	Incomplete data/observations.	Data and observations present but lacking detail.	Complete and accurate data with detailed, insightful observations.	
French Drain Design & Sketch	Sketch missing or unclear; design illogical.	Sketch present; design generally logical.	Clear, labeled sketch reflecting a well-thought-out, feasible design.	
French Drain Performance & Data (All Sections)	Incomplete tests/data; no comparison.	Data present; some comparison but limited analysis.	Complete and accurate data for all sections; clear comparison and initial analysis.	
Explanation Section Content	Incomplete or unclear explanations.	Explanations present; some clarity.	Clear, concise, and accurate explanations for all prompts.	
Optimization & Explanation	No attempt at optimization or weak explanation.	Attempted optimization; some explanation of results.	Thoughtful optimization attempt with clear data-supported explanation of impact.	

Elaboration Activities (2, 3, 4)	Limited or inaccurate responses.	Some connections/responses made.	Thorough and insightful connections to real-world scenarios and critical thinking.	
Lab Report/Journaling Format	Poor adherence to format.	Adequate adherence to format.	Excellent adherence to format; well-organized.	
Lab Report/Content & Design	Incomplete content; design unclear.	Content present; design generally explained.	Comprehensive content; clear, well-supported design explanation.	
Lab Report/Communication & Evidence	Unclear communication; missing evidence.	Communication present; some evidence.	Clear, concise communication; strong use of data/photos as evidence.	
Teamwork/Participation	Limited contribution to group.	Participated adequately in group.	Actively contributed, collaborated effectively, and took initiative.	
Cleanup	Left area messy.	Cleaned area adequately.	Left area clean and organized.	
Total Score:				**_____ / 60**