

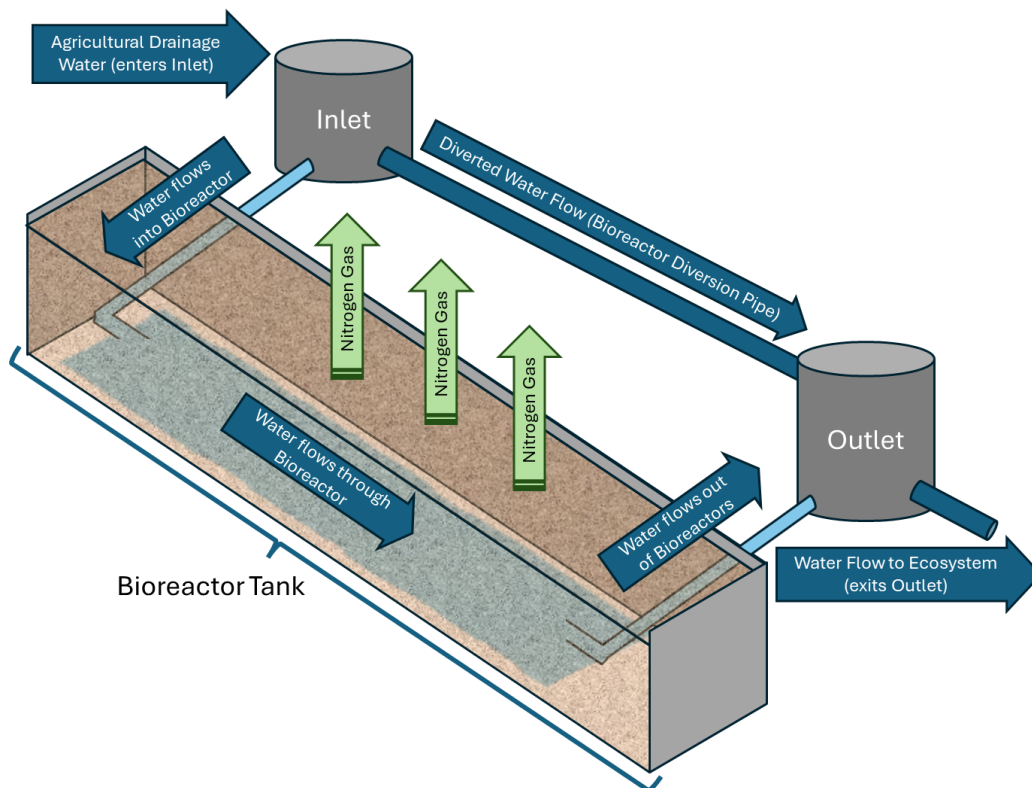
## Better Bioreactors

### Introduction

New technologies are helping farmers reduce nitrates in their agricultural drainage water. Water with high nitrate loads are problematic because they can increase the amount of algae present in water sources downstream, which harms other organisms in those ecosystems. Farmers are receiving a lot of pressure to better manage nitrate levels in their drainage water.



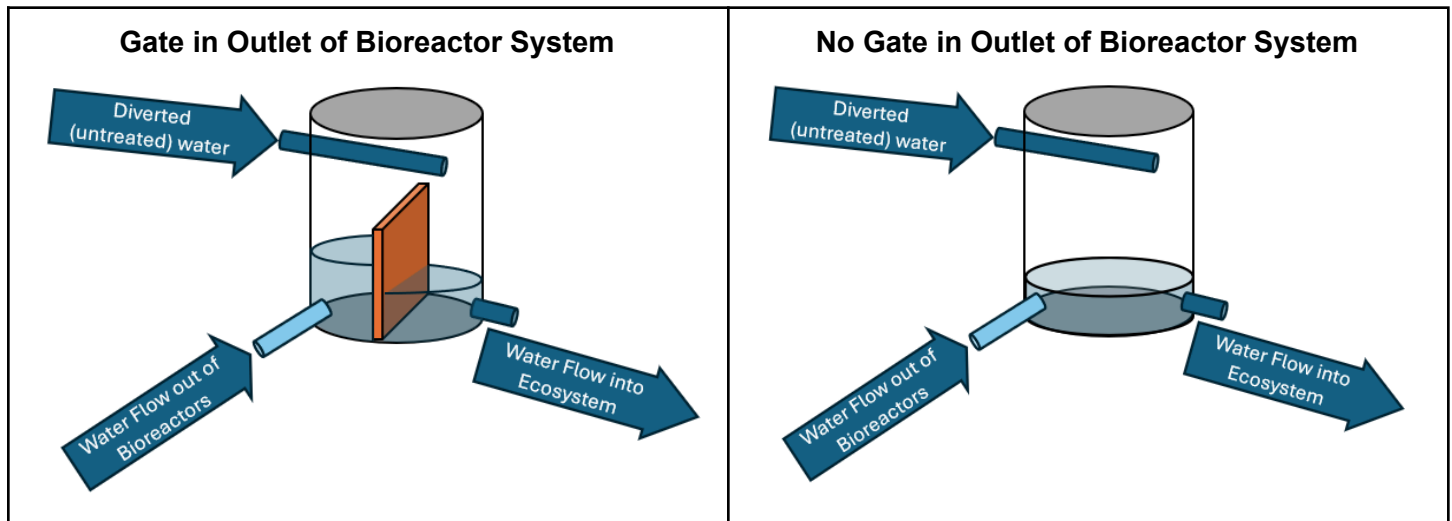
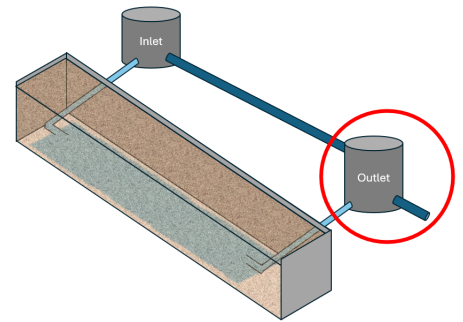
**Bioreactors** are one recent technological innovation that uses bacteria to reduce nitrate loads. Bioreactor tanks are buried underground at the edges of a crop field (see images to the left). Review the model of a **bioreactor system** (shown below). The tanks are filled with wood chips and fitted with pipes that bring water into and through the wood chips. Bacteria living on the wood chips do a special kind of cellular respiration that converts nitrates into nitrogen gas. When tanks are at full capacity, such as during heavy rains, water must be diverted at the inlet through a **diversion pipe**. This bypasses the bioreactor, sending the untreated water straight into the ecosystem.





Caroline is a farmer who installed bioreactor systems to help remove nitrates from the agricultural drainage water of her 50-acre crop field.

She installed one system **with a gate** within the outlet (circled in red) and one **without a gate** to test which design to recommend to other farmers (see images below). Bioreactors with gates retain water longer than bioreactors without gates, and Caroline isn't sure which is better for nitrate removal.



Help Caroline figure out whether she should recommend a bioreactor system **with a gate** or **without a gate** within the outlet to other farmers.

### Prompt 1

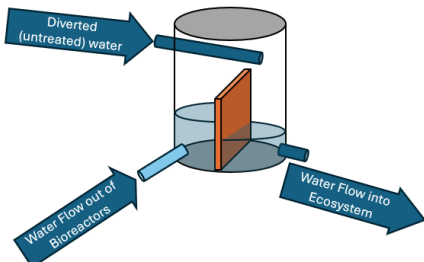
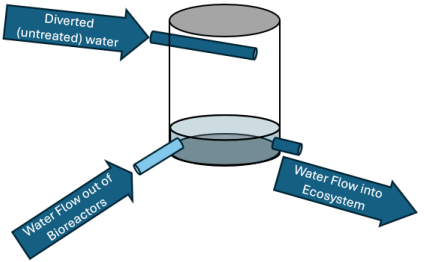
Caroline's bioreactor systems were installed with sensors that can be used to collect data to determine how well they are removing nitrogen. Sensors in Caroline's bioreactors measure:

- Nitrate levels in water entering and leaving the bioreactor system (mg nitrates / 1000 L water)
- Percent of water diverted around the bioreactor directly to ecosystem (when tanks are full)

Caroline shows you data she's collected a few weeks after she installed her systems and needs your help to interpret the data.

- a. Review the data on the next page and do calculations to be able to compare the total number of nitrates exiting each bioreactor system. **Show your work on the table.**



	<b>Total Nitrates Entering the System</b> (Bioreactor OR Diversion Pipe)	<b>% Water Exiting the Diversion Pipe</b> (untreated because tanks were full)	<b>Calculate the Nitrates Exiting the Diversion Pipe</b> (from untreated water)	<b>Nitrates Exiting the Bioreactor</b> (nitrates remaining after water was treated)	<b>Calculate the Total Number of Nitrates Exiting Diversion Pipe AND Bioreactor</b>
<b>Gate in Outlet of Bioreactor System</b> 	63,000 mg nitrates per 1000 L of water	10%		28,000 mg nitrates per 1000 L of water	
<b>No Gate in Outlet of Bioreactor System</b> 	63,000 mg nitrates per 1000 L of water	2.5%		47,000 mg nitrates per 1000 L of water	



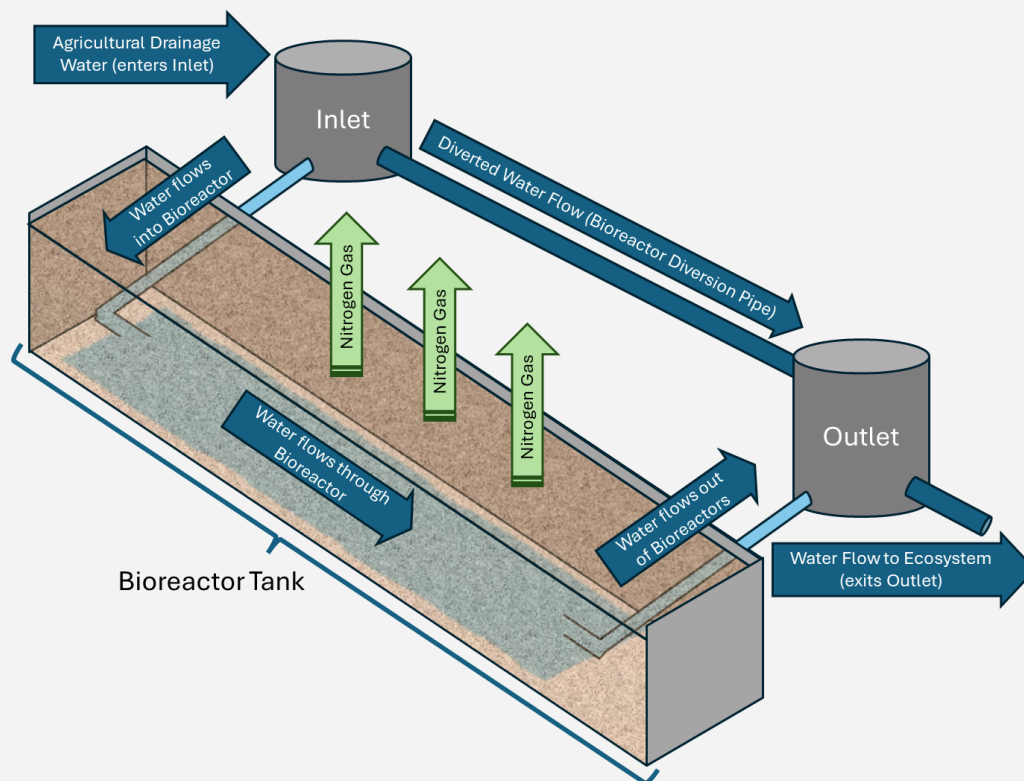
- b. Which bioreactor system is better at preventing nitrates from entering natural ecosystems? Use evidence from your calculations to support your response.



## Prompt 2

- a. Should Caroline recommend a bioreactor system with a gate or without a gate within the outlet to other farmers?

- b. Add to the model below to help Caroline illustrate the evidence for her recommendation to other farmers. Include all of the following:
- If you've decided to add gates to the outlet, revise the model accordingly
  - Add labels with numbers and calculations (from the table) to show how your recommendation reduces the amount of nitrates
  - Add captions to explain why you made your recommendation





- c. Explain how your recommendation for Caroline's improved bioreactor will help to protect nearby rivers and lakes. Support your explanation with:
- a description of how the bioreactors will reduce the impacts of her farm on nearby ecosystems
  - your mathematical calculations in Prompt 1
  - information from the model you added to above (Prompt 2b)



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