



# COALITION Quarterly

## Mesocosms Matter



[BCleanWater.org](http://BCleanWater.org)

# A Note from The Helm

## Small Experiments. Big Answers.

This past year, Barnstable Clean Water Coalition (BCWC) took a bold and necessary step forward in our long-term Marstons Mills Cranberry Bog Eco-Restoration effort. Recognizing the complexity of rebuilding a functioning and sustainable wetland system across 64-acres of retired cranberry bogs, our team built and monitored three mesocosms. Mesocosms are small-sized experimental wetland cells used to determine which restoration designs will remove nitrogen most effectively. The data collected from the mesocosms will help inform the full-scale restoration.

For more than a decade, the BCWC team and various scientific partners have documented how polluted groundwater flows beneath the bogs and down the Marstons Mills River, carrying excess nutrients from thousands of uphill septic systems. Once in the river, the water flows four miles downstream to the Three Bays estuary in under six hours. We've recounted numerous times that excess nitrogen is the primary driver of harmful algae blooms that result in eelgrass loss, fish kills, and declining shellfish habitat in the bays across Cape Cod. The science is irrefutable, unless we intercept and remove nitrogen before it reaches our estuaries, water quality will continue to deteriorate.

## Restored wetlands can fix this, but only if we build them properly.

Rather than gamble on an expensive, large-scale restoration project without knowing how effective a wetland system will function to reduce nitrogen, thorough analysis of the mesocosms' performance will provide clear evidence to guide science-based decision making. Rather than guessing, we are testing, and what we are



learning is remarkable: our two planted wetland mesocosms, simulating shallow emergent and subsurface flow wetlands are achieving early results that indicate what the scientific literature indicates: wetland systems are often able to reduce total nitrogen by over 50%. Numbers like that could be a game changer for our estuary.

These numbers tell us that nature-based solutions, when constructed properly, can deliver the kind of significant nitrogen reduction that the Cape's waters so desperately need. The woodchip/stone bioreactor mesocosm, meanwhile, is giving us insight into carbon-driven denitrification strategies for areas where planted wetland systems may not be feasible.

This is real, local, measurable science. We're proving, one experiment at a time, that cranberry bogs can still save the Cape.

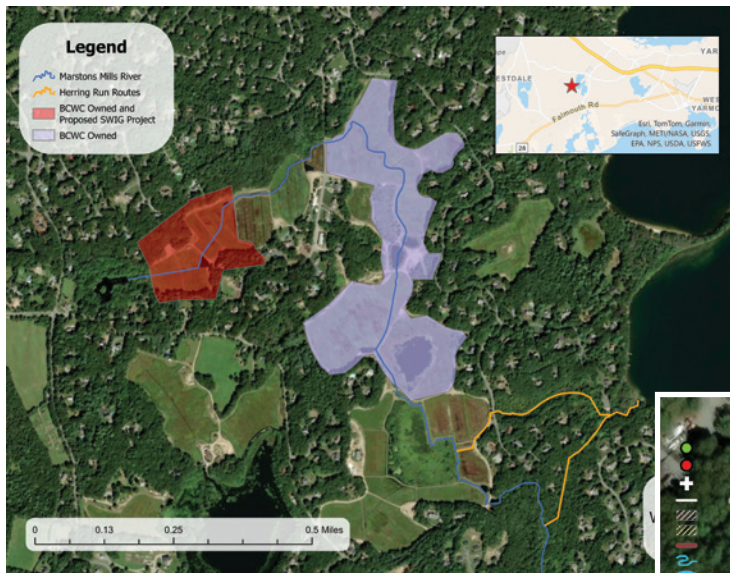
As always, thank you for supporting the science-based solutions that BCWC is pursuing.

# What is the Comprehensive Study Area?

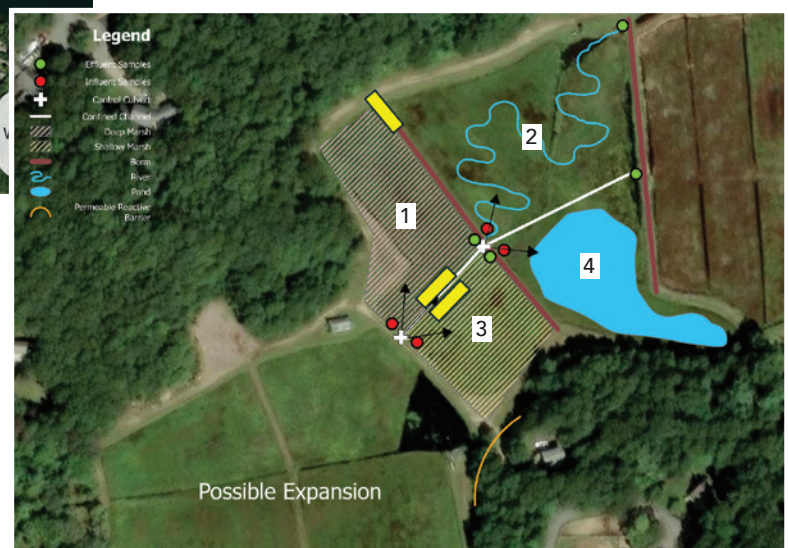
BCWC is pursuing a multi-stage ecological restoration of 64-acres of retired cranberry bogs in Marstons Mills. The Comprehensive Study Area (CSA) is a 10-acre portion of these bogs that will be used to develop a comprehensive “toolbox” for regional cranberry bog restorations. This test area is located near the headwaters of the Marstons Mills River (MMR). The MMR transits cranberry bogs, swamps, and a pond before entering the Three Bays estuary, the third most impaired estuary on Cape Cod due to nitrogen pollution. The excess nitrogen contaminating the groundwater is mainly from household septic systems. Fed by this groundwater, the river flow reaches the estuary in just six to eight hours.

This project will provide an opportunity to study different approaches to cranberry bog restoration for the purposes of nutrient attenuation from a cost/benefit perspective. The plan being developed will design, build and monitor side-by-side restoration approaches in discreet miniature parcels within the CSA. These parcels will include shallow marsh, deep marsh, sinuous stream with associated wetlands, a pond, a wood chip Permeable Reactive Barrier and possibly an area with recirculated water using solar power. Each of these parcels would be “sized” based on water flow and separated in a manner that would allow for input and output measurements and monitoring. Each parcel would be carefully budgeted in terms of time and cost to both “construct” and “operate”.

This restoration and study will take approximately six years to complete and will result in an “eco-restoration roadmap”. Cost estimates for each unique approach will be applicable to other cranberry bog restorations and river systems on the Cape and across southeast Massachusetts.



*In the graphic above, the CSA is highlighted in red and the 47-acre eco-restoration site is highlighted in purple. The image to the right shows a preliminary design of the CSA, which includes: 1. deep marsh (subsurface flow wetland), 2. sinuous stream, 3. shallow marsh (shallow emergent wetland), 4. shallow pond.*



# Testing Wetland Designs with Mesocosms

As part of the eco-restoration of the Marstons Mills cranberry bogs, BCWC is using mesocosms to compare the effectiveness of various wetland designs in removing nitrogen from the water flowing through the bogs. Mesocosms are small-scale experimental systems that recreate a natural ecosystem. Led by Water Resources Consultant Scott Horsley, three mesocosm structures were built adjacent to the bogs that are within the Comprehensive Study Area (CSA).

These 12 ft. long by 3 ft. wide and 3 ft. deep cells simulate different wetland restoration designs, allowing us to measure nitrogen removal in a controlled, reproducible environment.

Groundwater is pumped from a 30-foot deep well into all three mesocosms. Flow and residence time are controlled through a fixed hydrologic system with the water being tested as it flows in and out of each mesocosm. The findings will help determine which wetland designs are more effective at nitrogen

attenuation. This data will inform the design of BCWC's CSA project, as well as being used for bog restorations in other locations.

Each mesocosm receives groundwater pumped every two hours through a PVC manifold, which distributes consistent flows across the system. Water levels are managed through a three-tier adjustable outlet system, allowing our team to fine-tune depths and residence times to simulate real-world wetland conditions. This control is essential for understanding how long water must stay within each system to maximize nitrogen removal.

The shallow emergent and subsurface flow wetland mesocosms each receive two gallons of groundwater per cycle, totaling approximately 24 gallons per day. This translates into a residence time of several days, meaning water remains in the system long enough for both plants and microbes to process nitrogen effectively.

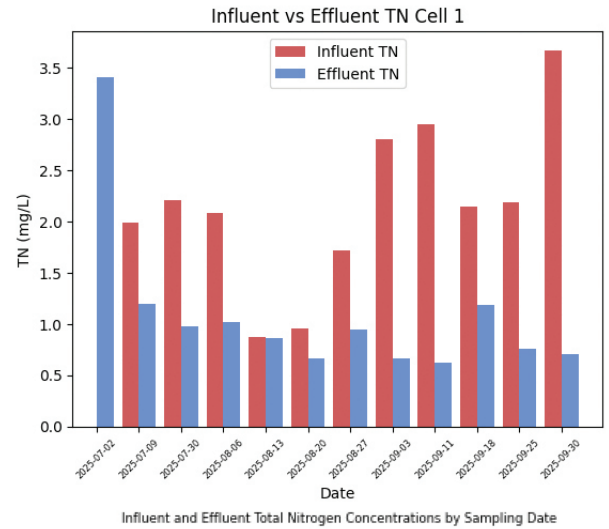


*Aerial photo of the CSA with the location of the three mesocosms (in white).*

# Inside the Mesocosms and How They Work

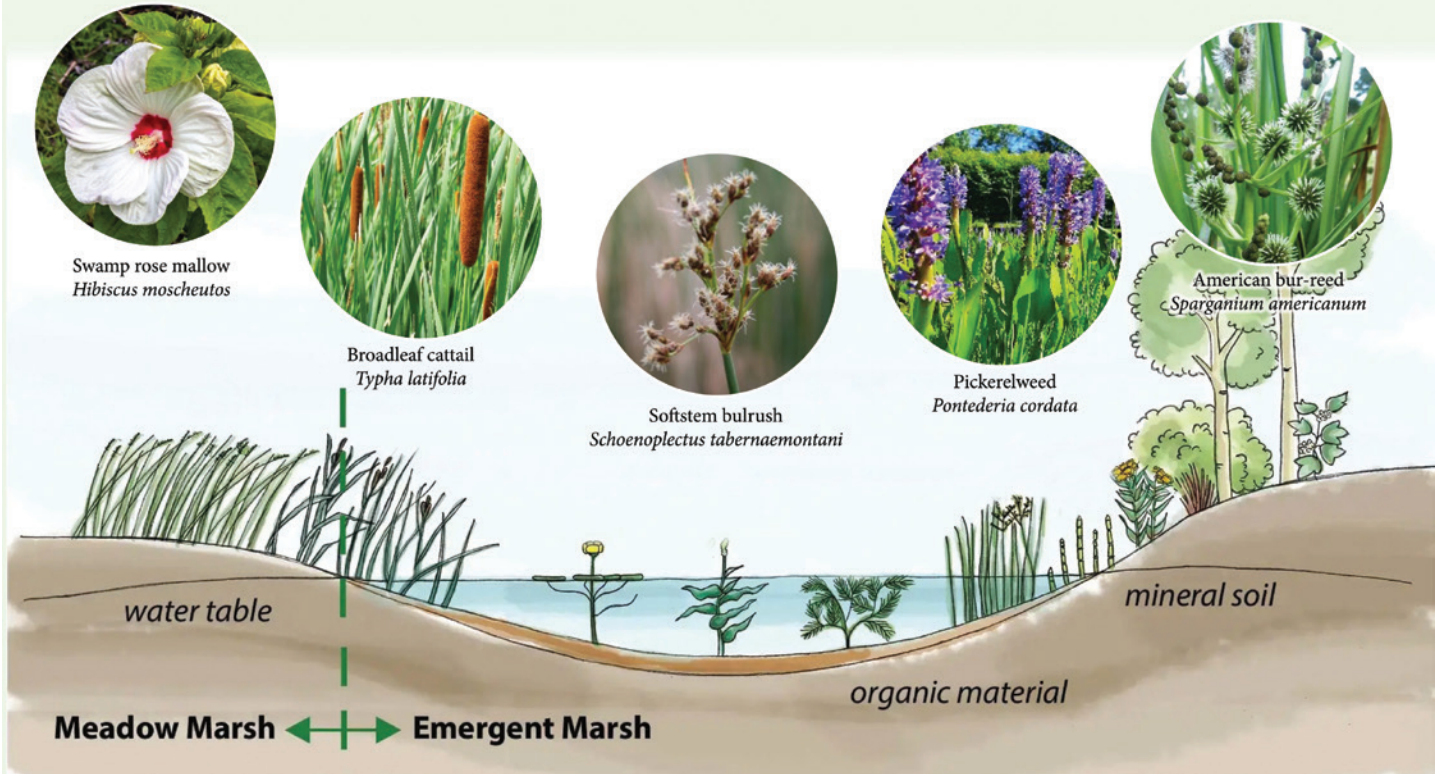


## Season 1 performance for Mesocosm 1



## Mesocosm 1: Shallow Emergent Wetland

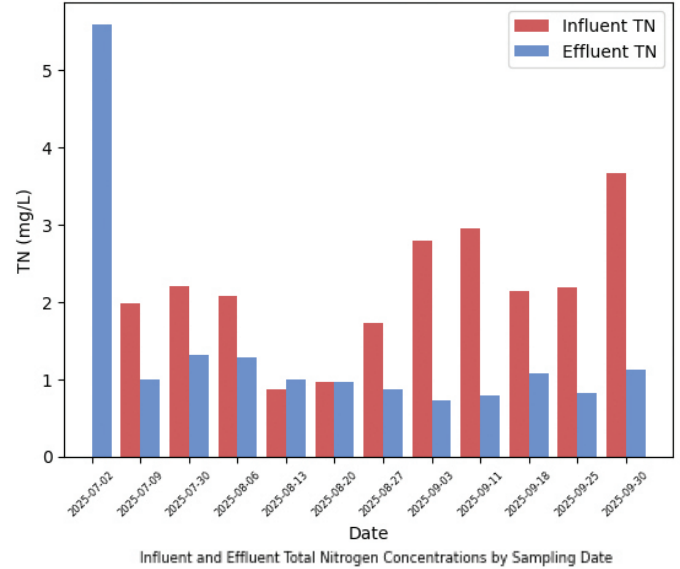
This mesocosm contains soil from the bogs with surface water that is between one and three inches deep to replicate a shallow marsh ecosystem. It was planted with native, emergent vegetation that prefers these conditions. The sunlight, shallow water, plants, and microorganisms in the soil all work together to attenuate nitrogen.



# Inside the Mesocosms and How They Work



Season 1 performance for Mesocosm 2  
Influent vs Effluent TN Cell 2



## Mesocosm 2: Subsurface Flow Wetland

This mesocosm contains soil from the bogs with nitrogen-loaded groundwater flowing between one and twelve inches below the substrate’s surface, mimicking a deep marsh. This type of wetland supports root-zone contact with flowing water and promotes microbial processes such as denitrification within the oxygen poor soils. Dense native plantings that prefer saturated soils help stabilize the soil while maximizing biological activity.



Northern blue flag  
*Iris versicolor*



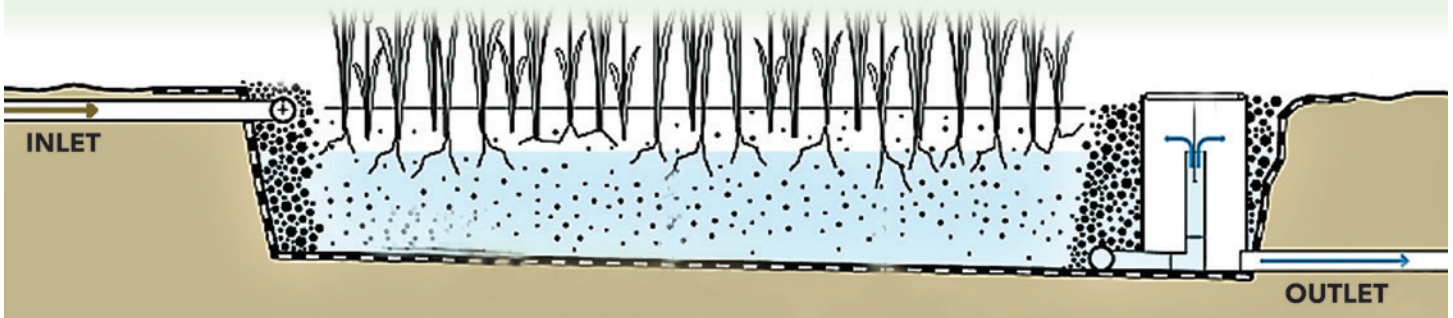
Fox sedge  
*Carex vulpinoidea*



Swamp milkweed  
*Asclepias incarnata*



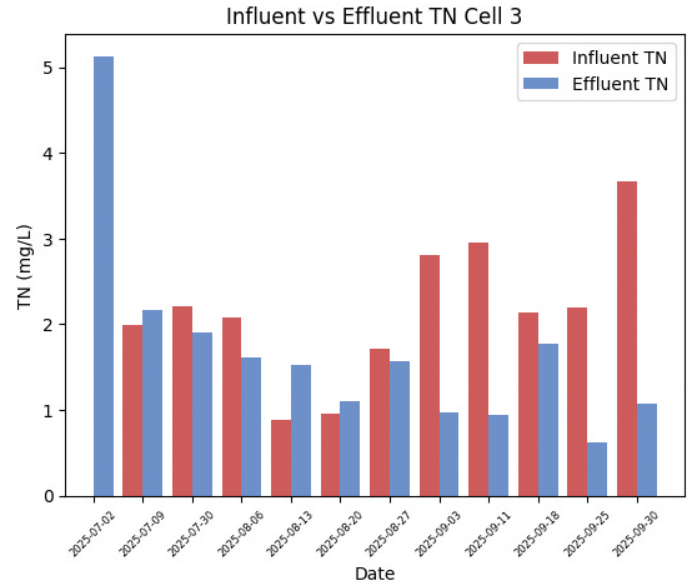
Blue vervain  
*Verbena hastata*



# Inside the Mesocosms and How They Work

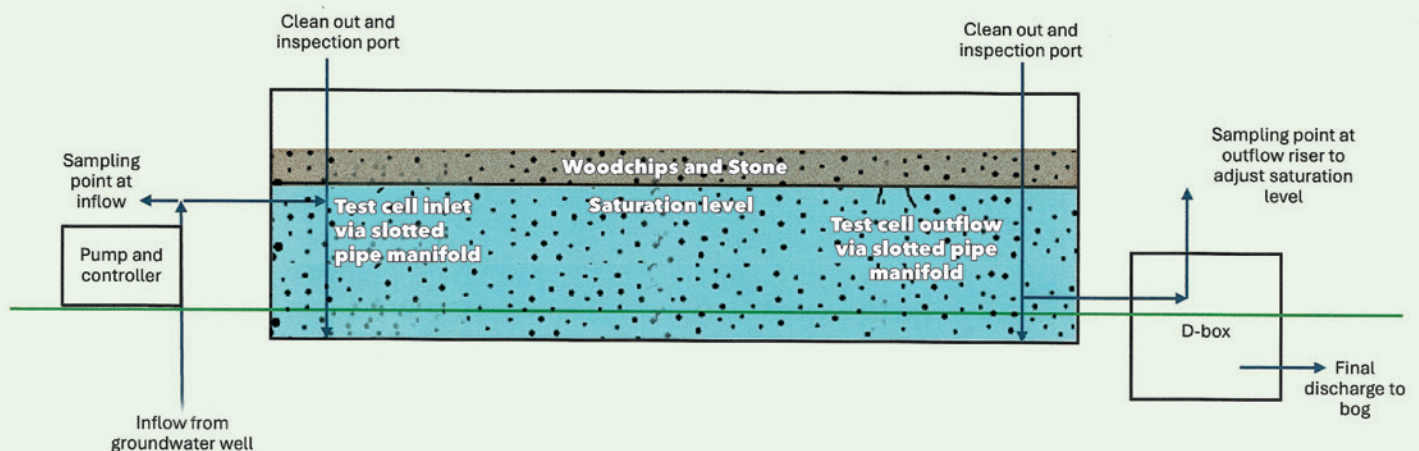


Season 1 performance for Mesocosm 3



## Mesocosm 3: Woodchip/Stone Bioreactor

This mesocosm was built with a 1:1 mixture of native woodchips and crushed bluestone. The system works as a bioreactor, with biological reactions occurring. The carbon in the woodchips feed bacteria that consume oxygen. These biological processes allow nitrogen from the water to be converted to nitrogen gas. This mesocosm needs a higher flow of groundwater per cycle with a total of approximately 72 gallons per day. This translates into a residence time of roughly three days. Unlike the other two mesocosms which utilize plants and soil, this design uses woodchips which are a carbon-rich source to fuel the denitrifying bacteria that convert nitrate into nitrogen gas. Since organic substrates degrade over time, the increased flow helps to maintain oxygen-poor conditions essential for denitrification, which helps us understand how the system removes nitrate. This system can function even in areas unsuitable for dense planting and provides a comparison point for evaluating how carbon-based zones might be incorporated into bog restorations.



# What We Learned From the Mesocosms

After 10 weeks of sampling, from the summer into fall, the mesocosms revealed clear trends in how different wetland designs process nitrogen-rich groundwater.

Both wetland mesocosms demonstrated exceptionally strong performance. With 78–83% reductions in nitrate and 47–54% reductions in total nitrogen, these systems showed how effective plant-based wetlands can be when residence times are prolonged and environmental conditions promote microbial activity. Vegetation remained robust and water levels required minimal intervention, a promising indication that these systems will be stable and resilient when scaled up.



*The three mesocosms at work in the CSA.*

The woodchip/stone bioreactor also performed well, removing 62% of nitrate and 22% of total nitrogen. Even without the presence of plants, the bioreactor proves to be capable of high rates of nitrate removal. This makes it an attractive option for use in areas where vegetation may struggle to establish.

One of the most interesting findings occurred during the dry September period, when nitrate concentrations spiked in the groundwater flowing into the mesocosms. With little rainfall, there is less clean water recharging and diluting the septic plume flowing into the bogs, leading to higher nitrogen concentrations. This discovery underscores the need for restoration designs that maintain performance during droughts.



*Collecting samples from the Shallow Emergent Wetland mesocosm.*

# What Does This All Mean

Wetland restoration is one of the most powerful nature-based tools available for improving water quality on Cape Cod. However, not all wetlands function the same, and small differences in depth, substrate, or flow can dramatically influence nitrogen removal performance. The mesocosms allow our team to compare different designs under identical environmental conditions, evaluate which configurations remove the most nitrogen by determining optimal flow rates and residence times, assessing plant survivorship, and refining structural elements before using in larger restoration projects. Basically, this project serves as the scientific test kitchen, the results of which can be used in future wetland restorations across the region.

BCWC's cranberry bogs sit at the headwaters of the Marstons Mills River, the single largest source of nitrogen to the Three Bays estuary,

where water reaches the bays in a matter of hours. Consequently, this restoration site offers one of the most immediate opportunities to improve water quality downstream.

The data generated through the mesocosm project is already guiding several aspects of the full-scale bog restoration. Across all three mesocosms, residence time is the most crucial factor. The longer water remains in contact with plant roots and microbial communities, the greater the opportunity there is for nitrogen to be absorbed, transformed, and ultimately removed from the groundwater. These findings are influencing how we shape meandering channels and various retention features. Observations about organic nitrogen are highlighting where carbon-based zones, like the woodchip/stone bioreactor, could enhance denitrification. Plant survivorship studies are informing which species will be reintroduced to create a resilient, native wetland community.



*Measuring dissolved oxygen in mesocosms.*



*Woodchip/Stone bioreactor with solar power panel.*

# Notes from The Field

## How Well is Our Water Behaving?

If you've read previous editions of our newsletters, you know about BCWC's Marstons Mills Cranberry Bog Eco-Restoration project. You probably also know that one of the main goals of this restoration is to reduce nitrogen by slowing down and spreading out the water as it moves through the bogs before it flows down the Marstons Mills River and into the Three Bays estuary.

So far, we have a good idea of how the surface water behaves through our weekly Marstons Mills River streamflow monitoring program that began in 2017. But what about the groundwater entering the bogs? Where is it entering and how much is there? How do we intercept it to slow it down? More importantly, how much nitrogen is in this water, and where is the nitrogen-rich water coming from? These are complex questions to answer with many variables, including fluctuating levels of permeability between the sand and peat in the bogs, groundwater table variations, differing elevations, and rainfall amounts that can vary widely from season to season.

To help answer these questions, a network of 41 groundwater monitoring wells was installed last June by the Horsley Witten Group and Desmond Drilling with funding from Massachusetts Division of Ecological Restoration and technical assistance provided by U.S. Geological Survey. These wells are anywhere from 5 to 100ft. deep with a slotted opening at the bottom. The varying depths of the wells reflect the depth of the peat layer. This way we can sample water from above, within, and below the less permeable peat layer in the bogs. The wells were also strategically installed in rows on either side of the river. By comparing water levels in these wells, we can determine the direction of groundwater flow within the bogs, how it interacts with the peat layer, and how it relates to the watershed. Using a water pump, water samples are taken from each well to analyze the nitrogen concentrations of the groundwater throughout the restoration site.

BCWC hopes this new data will further our understanding of the water transiting the bogs, which will inform our restoration design and management of the restoration for maximum nitrogen removal benefits.

Look for me out in our bogs and stop by to say hi.

- Luke Cadrin, Field Operations Manager



*Network of monitoring wells in the bog restoration area.*



# Meet Our AmeriCorps Member Carter Henry

BCWC is lucky to have Carter Henry serving as our Year 27 AmeriCorps member.

Carter hails from Hockessin, Delaware and recently graduated from Kent State University with a Bachelor's in Zoology. He has been passionate about animals his whole life and can often be found hiking and searching for reptiles and salamanders. Carter hopes to become an ecologist/conservation biologist specializing in salamanders. A personal goal is to visit all the U.S. National Parks.

Since last October, Carter has been assisting Luke Cadrin, BCWC Field Operations Manager, with the weekly collection of streamflow data and water samples at 17 stations along the Marstons Mills River. In addition, he conducts wildlife surveys and helps Luke with other field projects.

Carter is the coordinator for AmeriCorps' WetFest, an engaging, interactive method of teaching local students about the fundamentals of water and Cape Cod's sole source aquifer.

Recently, Carter and his fellow AmeriCorps members were instrumental in aiding people in need during the blizzard of 2026. They assisted local Cape Codders at the emergency shelters and personal care centers that were open throughout the storm and its aftermath.

Huge thanks to the AmeriCorps crew for supporting the Cape Cod community during a difficult week.

Now that spring is here, we hope he finds lots of local reptiles and salamanders while out in the bogs with Luke.



*Carter collecting streamflow data in the Marstons Mills River.*



*Carter with a red-cheeked salamander.*



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**Mission Statement**

*Barnstable Clean Water Coalition works to restore and preserve clean water in Barnstable. BCWC utilizes science as its foundation to educate, monitor, mitigate and advocate for clean water.*

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**Save The Dates**

**10<sup>TH</sup> ANNUAL**



**Wednesday, July 1<sup>st</sup>**  
 5:00 pm to 7:00 pm

Wianno Club  
 107 Sea View Avenue  
 Osterville, MA



**Clean Water Challenge**  
**GOLF TOURNAMENT**

**Tuesday, October 13<sup>th</sup>**  
 Oyster Harbors Club Golf Course  
 145 Grand Island Drive  
 Osterville, MA

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