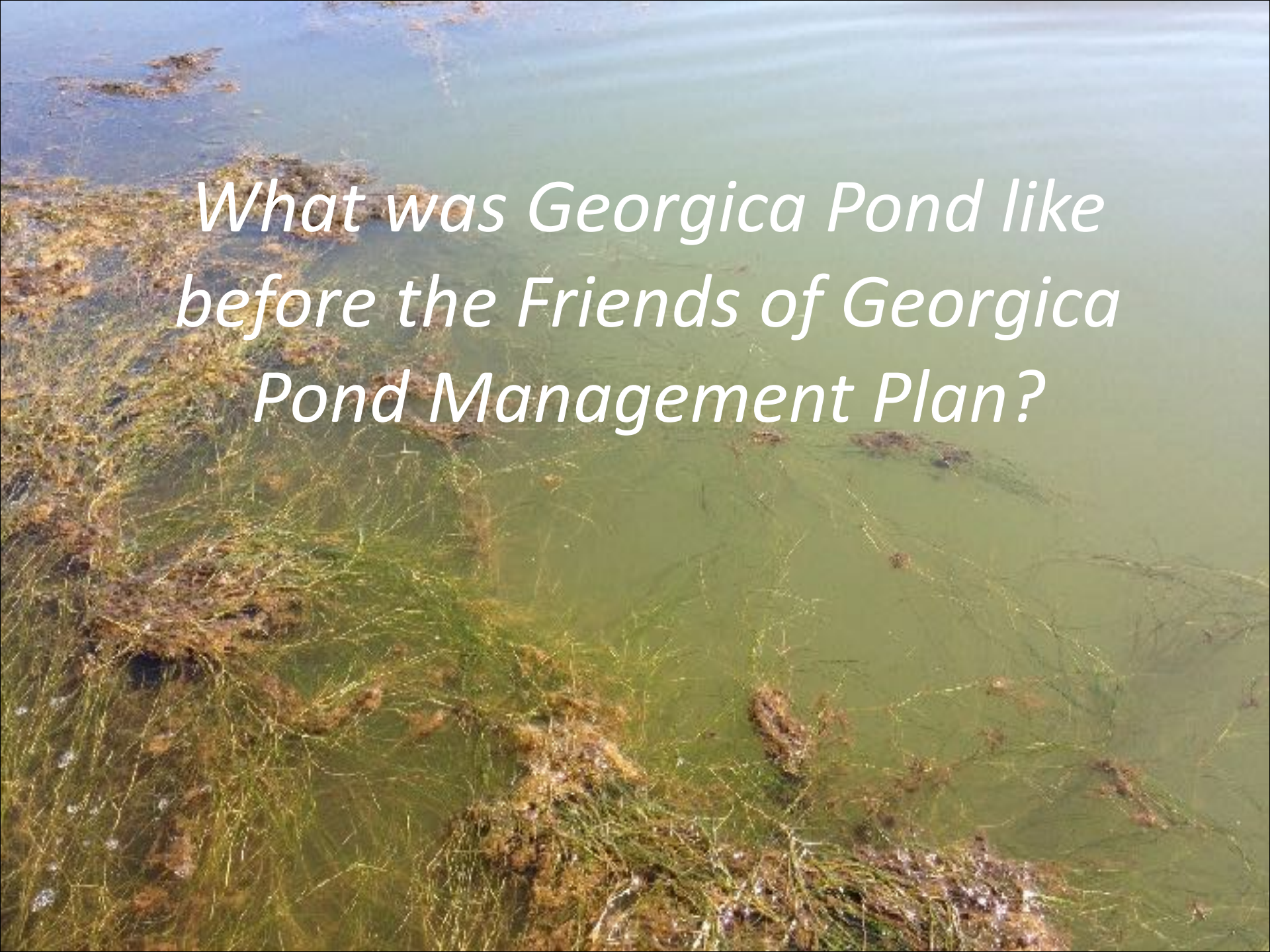
# Working Towards a Sustainable Remediation of Georgica Pond

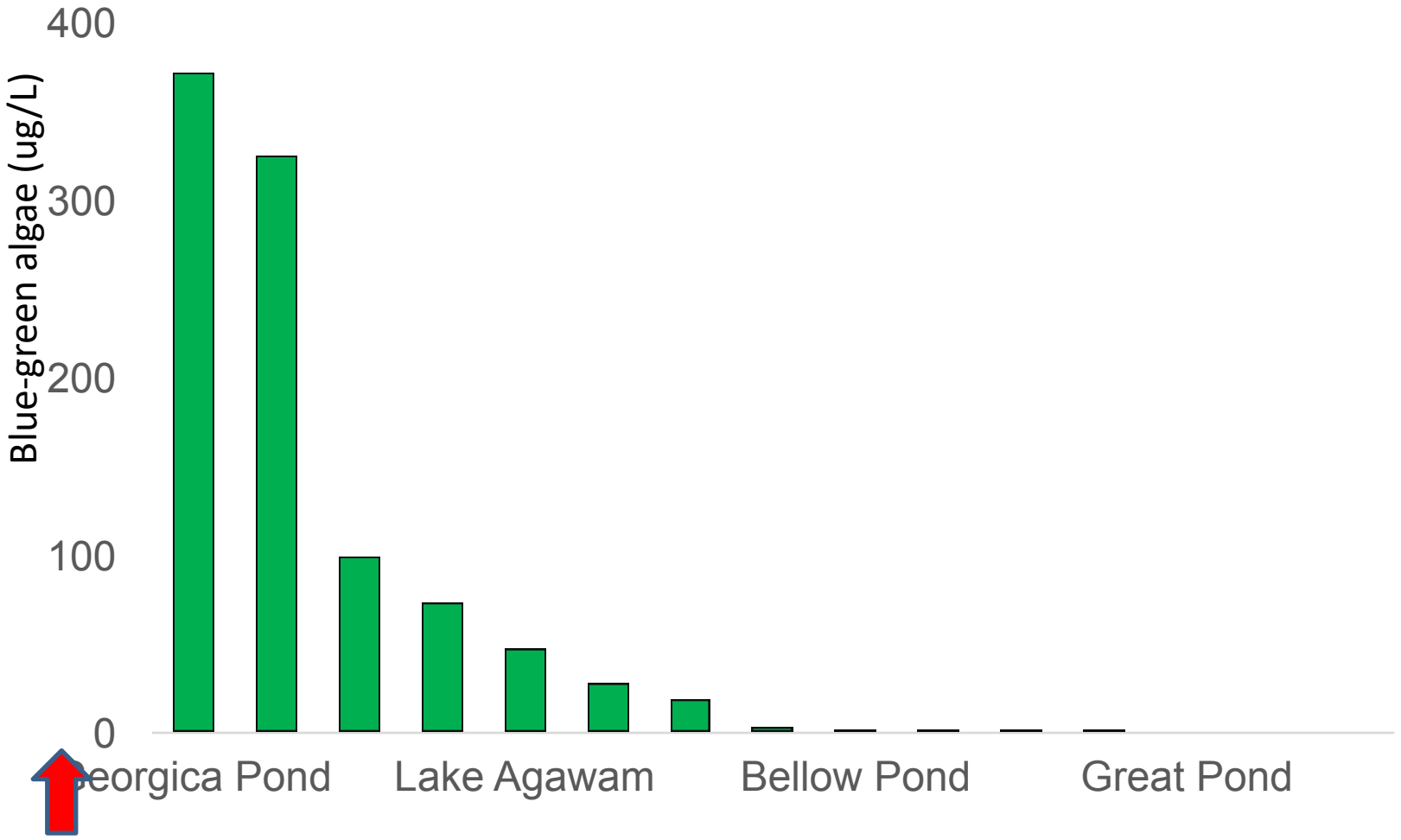
**Christopher J. Gobler, PhD**

Stony Brook University
School *of* Marine and Atmospheric Sciences

GOBLER LABORATORY


What was Georgica Pond like before the Friends of Georgica Pond Management Plan?

# Blue green algae, August **2015**



# Why remediate Georgica Pond?

- Blooms of macroalgae
- Blooms of toxic blue-green algae
- Low oxygen
- Kills of fish, eels, birds, dogs
- Pathogenic bacteria

# Overview

- Recent findings on Georgica Pond
- Actions to improve the health of Georgica Pond

# Real-time monitoring buoy

An investigation led by the Gobler Lab of Stony Brook University

Georgica Pond

Chart View | Table View | Site Information

GP_south
Site Id

40.934192 Latitude

-72.22572 Longitude

Georgica Pond Buoy - The Gobler Lab of Stony Brook University
Description

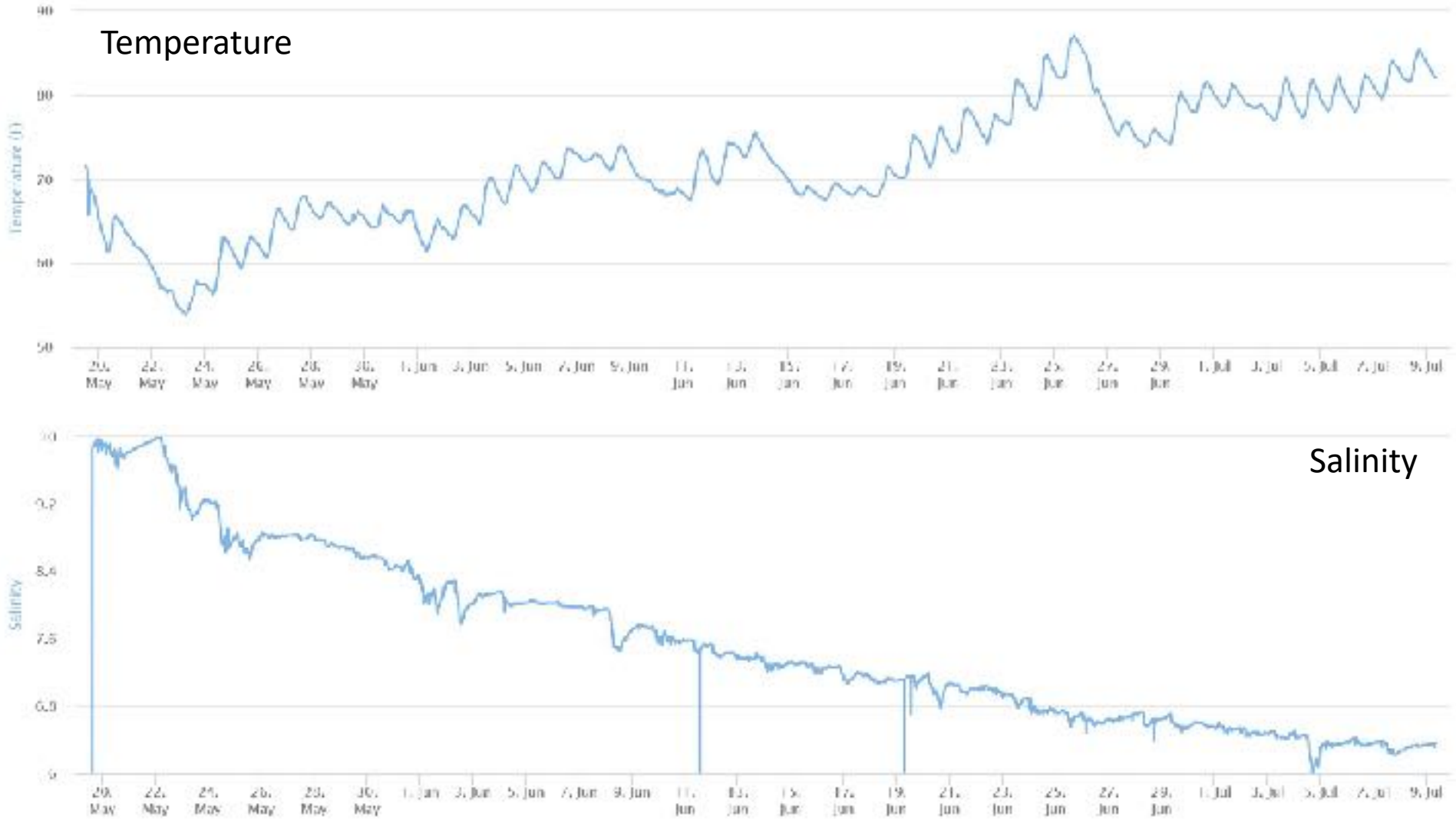
As part of The Georgica Pond Project, the Gobler laboratory has installed a water quality monitoring buoy in Georgica Pond. This device is making continuous, real-time measurements of key water quality indicators that are instantly telemetered to this web site.

# Real-time monitoring buoy

# Cut opened and then closed naturally in spring

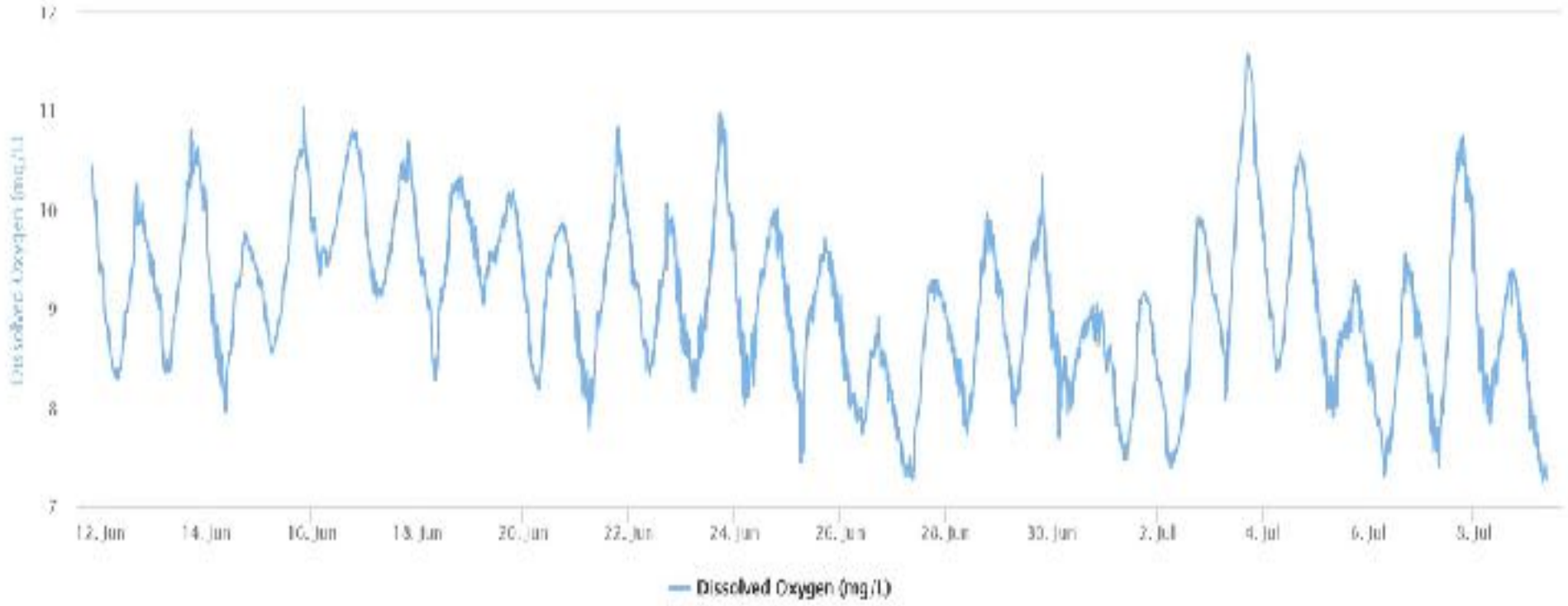
# Temperature, salinity, 2025

*Blue-green algae blooms threat when salinity < 15*

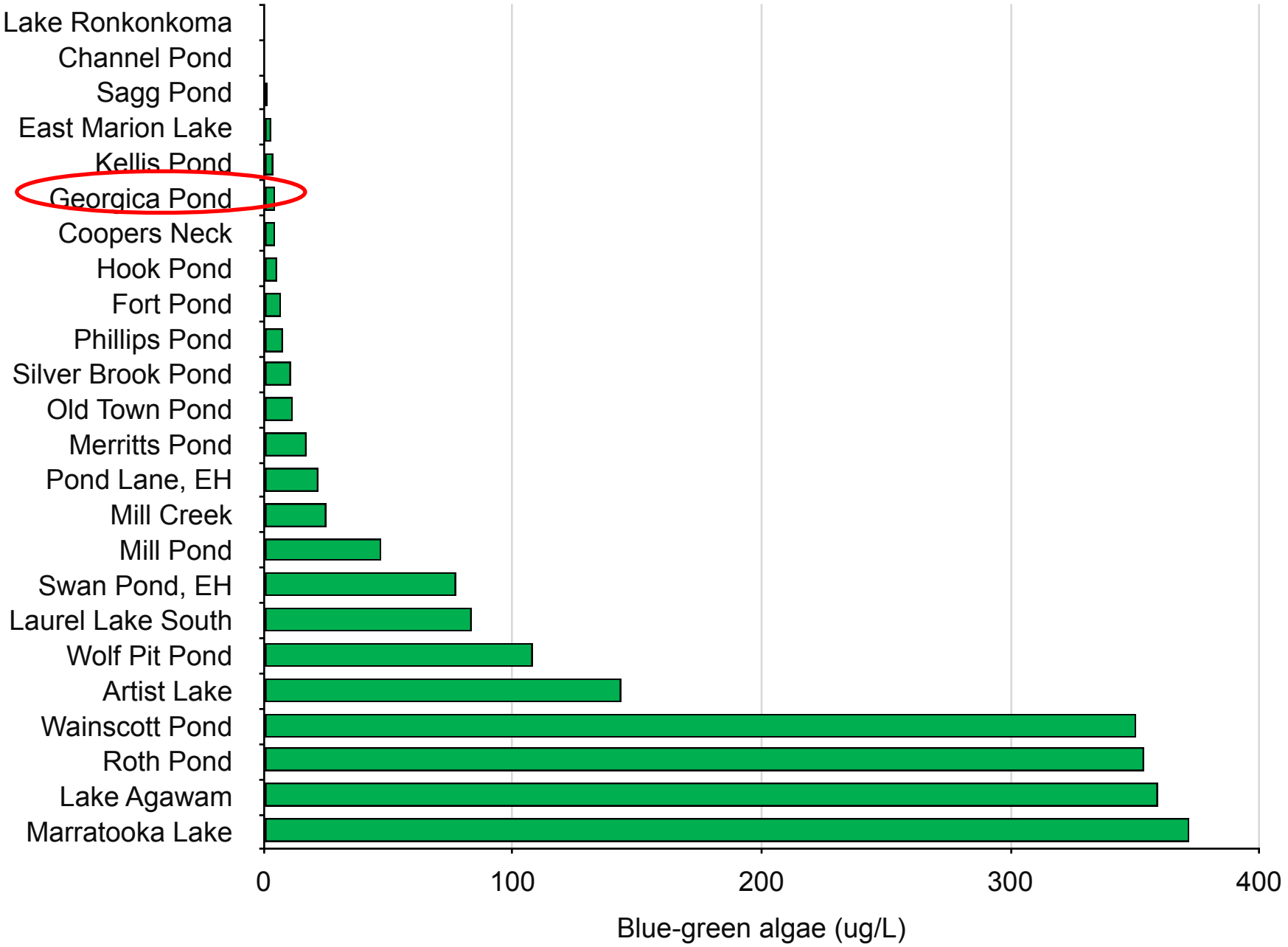


# Dissolved oxygen, 2025

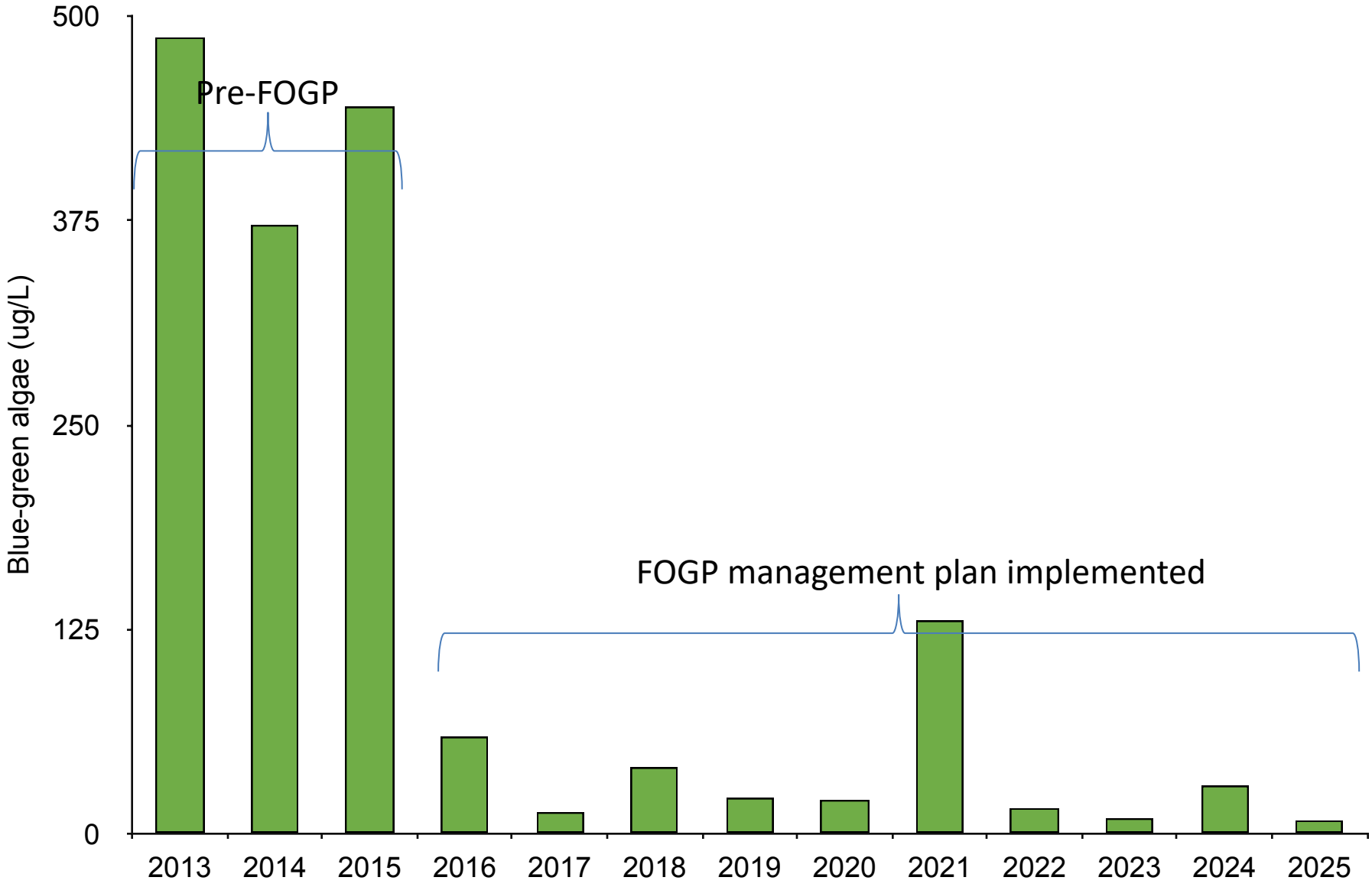
## NYSDEC minimum standard = 3mg/L



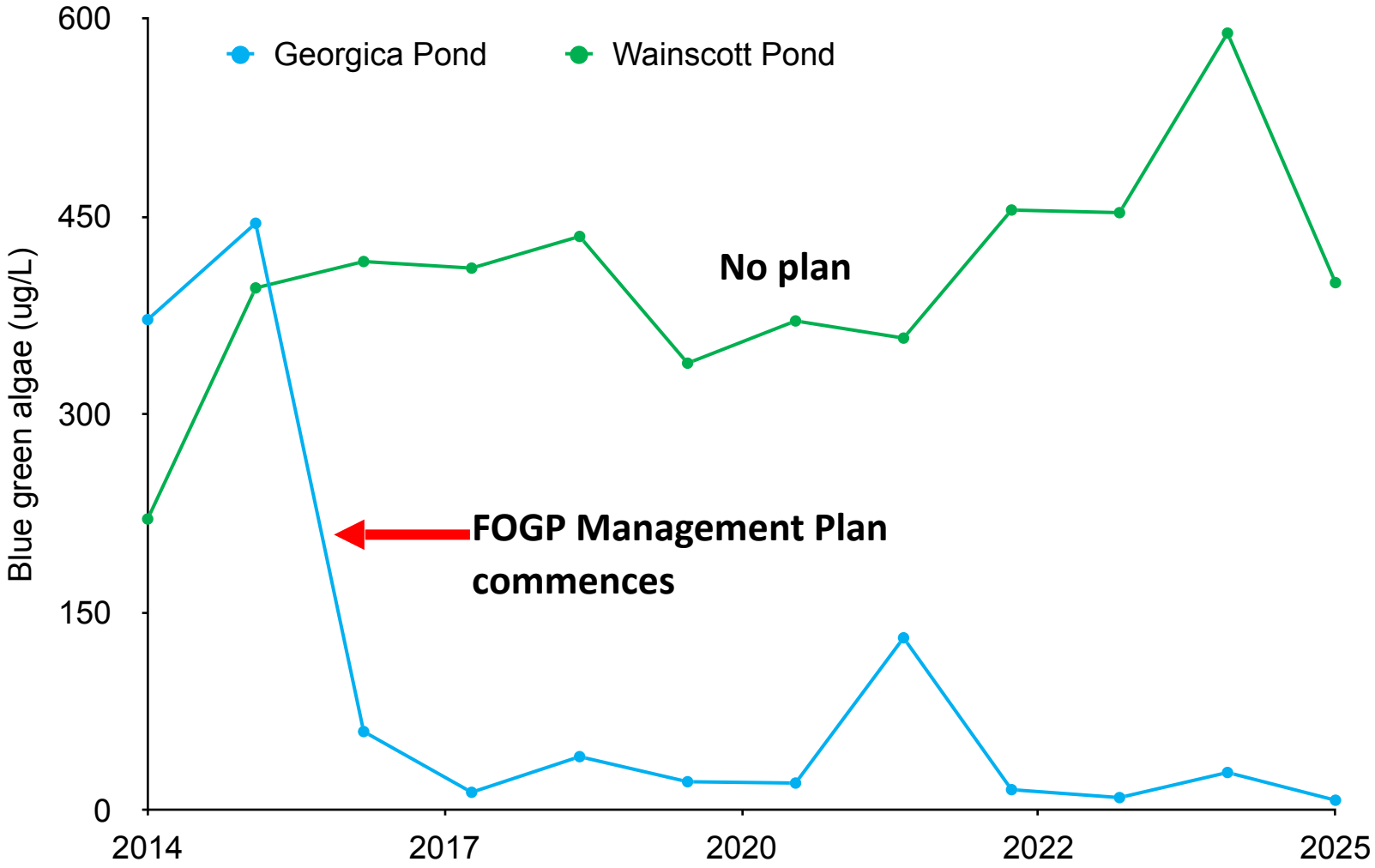
# Comparison of local ponds, peak blue-green algae, 2025



# 13-year trend in blue-green algae

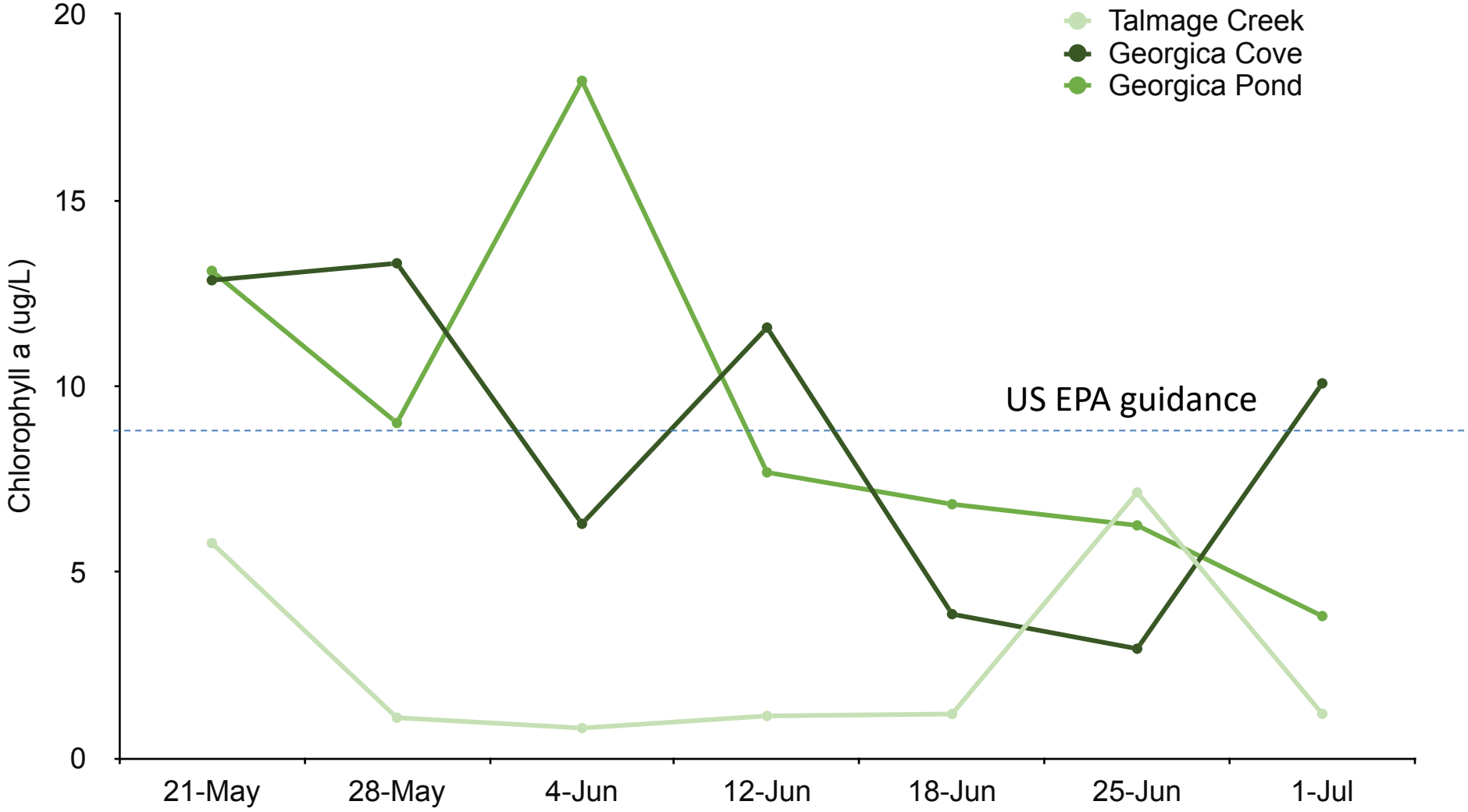


# *FOGP management plan is working!*



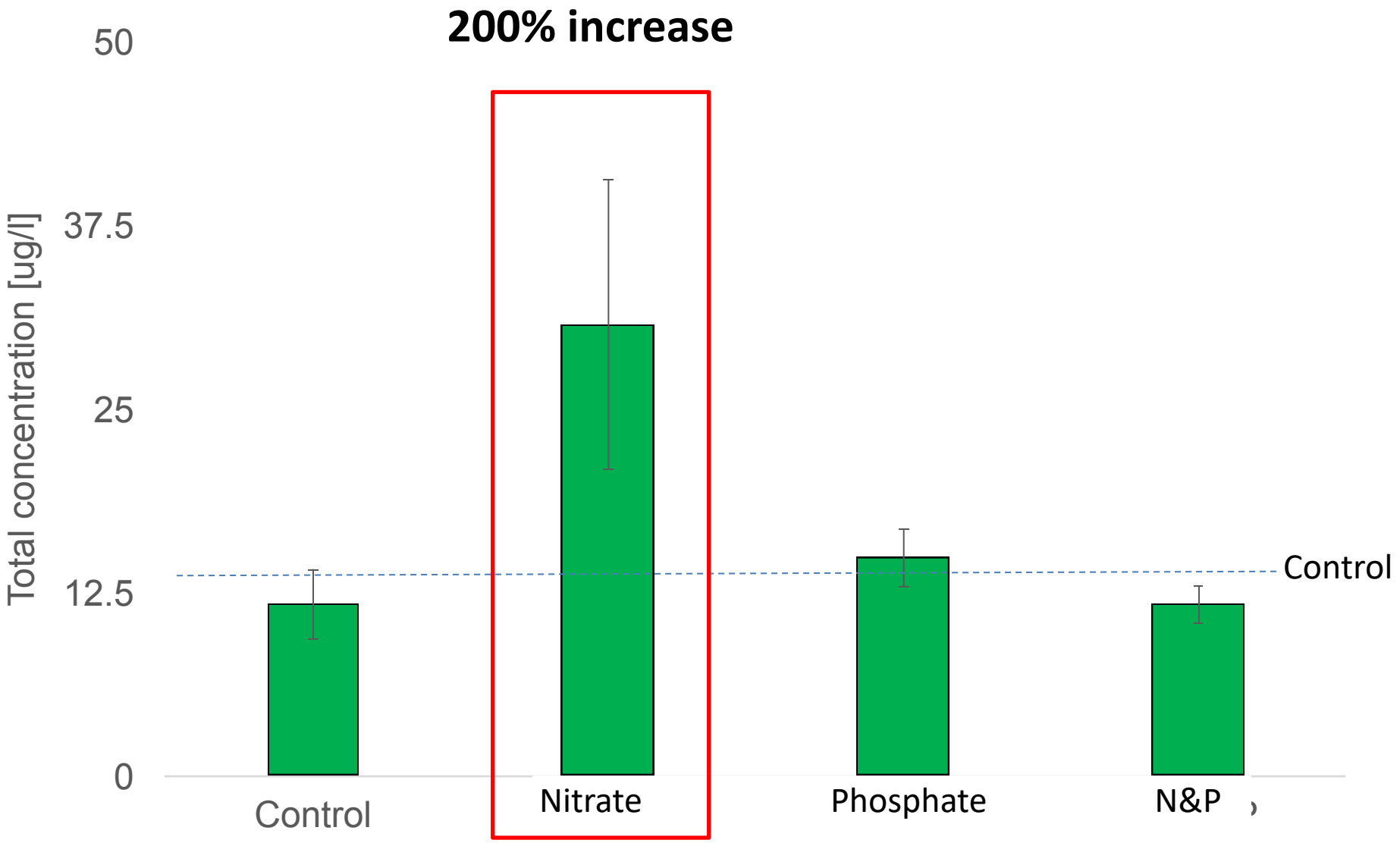
# Total algae, 2025

*Still work to be done!*



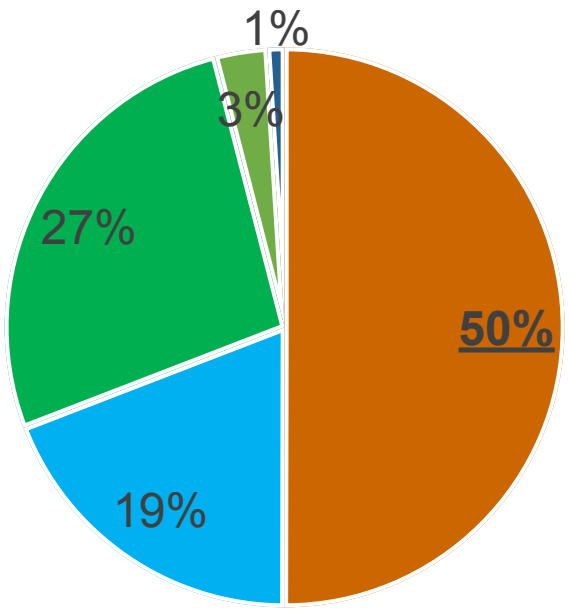
# *What promotes algal blooms in Georgica Pond?*

# Nutrients controlling blue-green algae



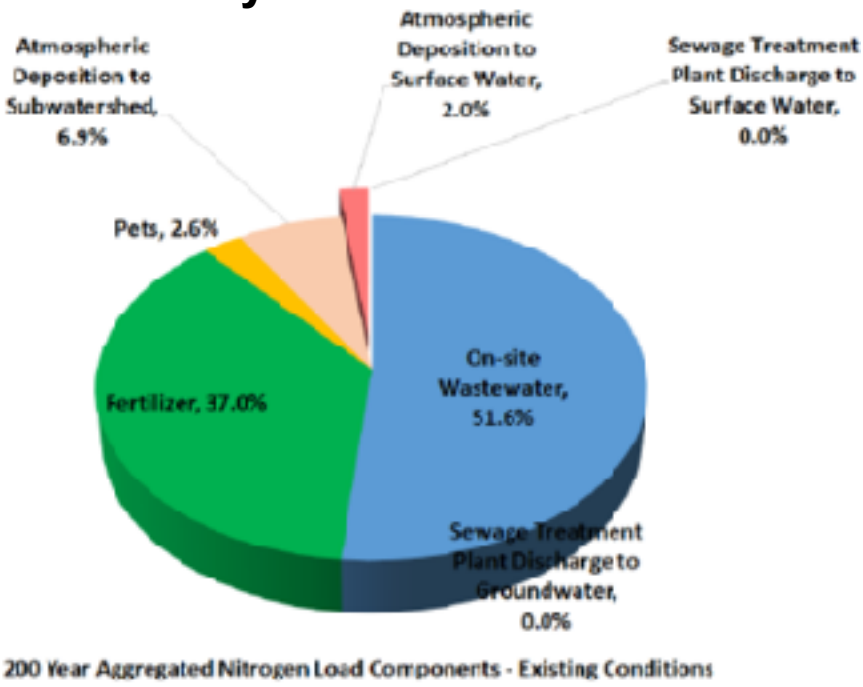
# Sources of N to Georgica Pond

## Gobler study

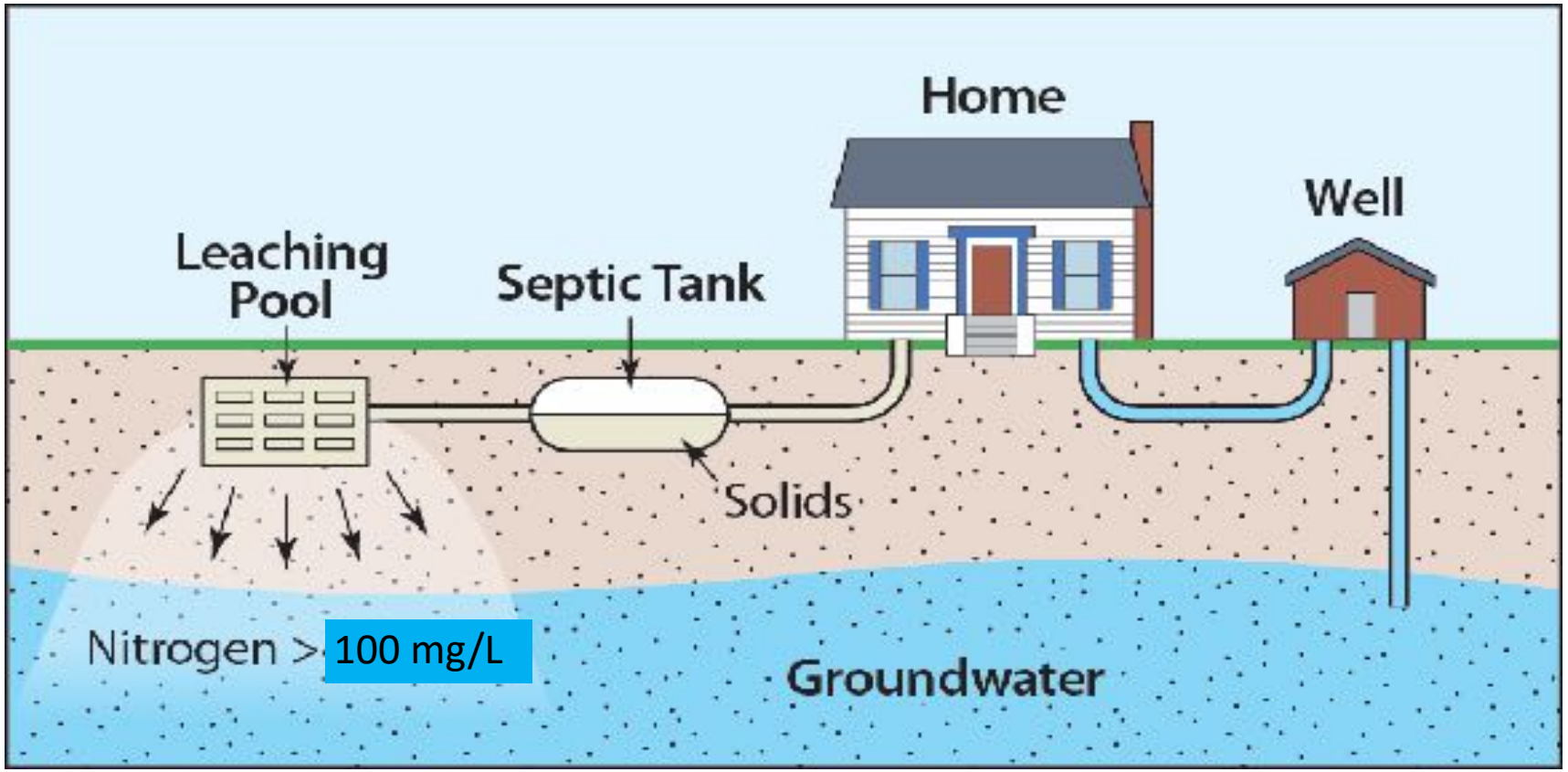



- Cesspool/Septic
- STP
- Atmospheric
- Residential Lawns
- Parks and Golf Lawns
- Agriculture

## Suffolk County study



# Suffolk County septic systems



***FROM WORST TO FIRST!***

Reclaim Our Water

# SUFFOLK COUNTY SUBWATERSHEDS WASTEWATER PLAN

*"We are in a county that will no longer allow our water quality crisis to go unaddressed, but will come together to Reclaim Our Water"*

Suffolk County Executive Steve Bellone
2014 State of the County

Suffolk County
Department of Health Services
July 2020

This document was prepared with funding provided by the New York State Department of Environmental Conservation as part of the Long Island Nitrogen Action Plan and by New York State Department of State under the Environmental Protection Fund.

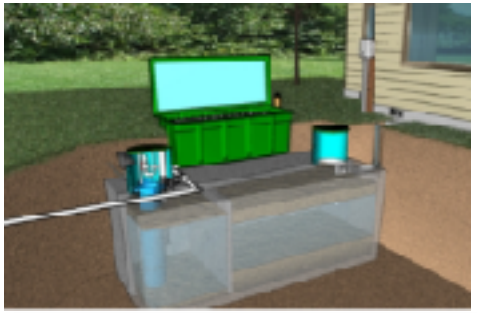
CDM Smith

# I/A OWTS with General Use Approval & Provisional Approval in Suffolk County

Hydro-Action

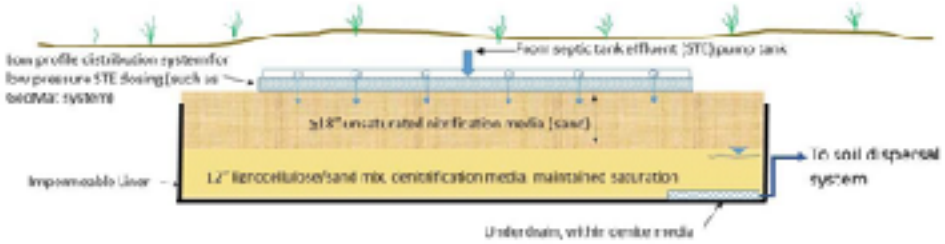
Fuji Clean

SeptiTech STAAR



Orenco Advantex AX-20

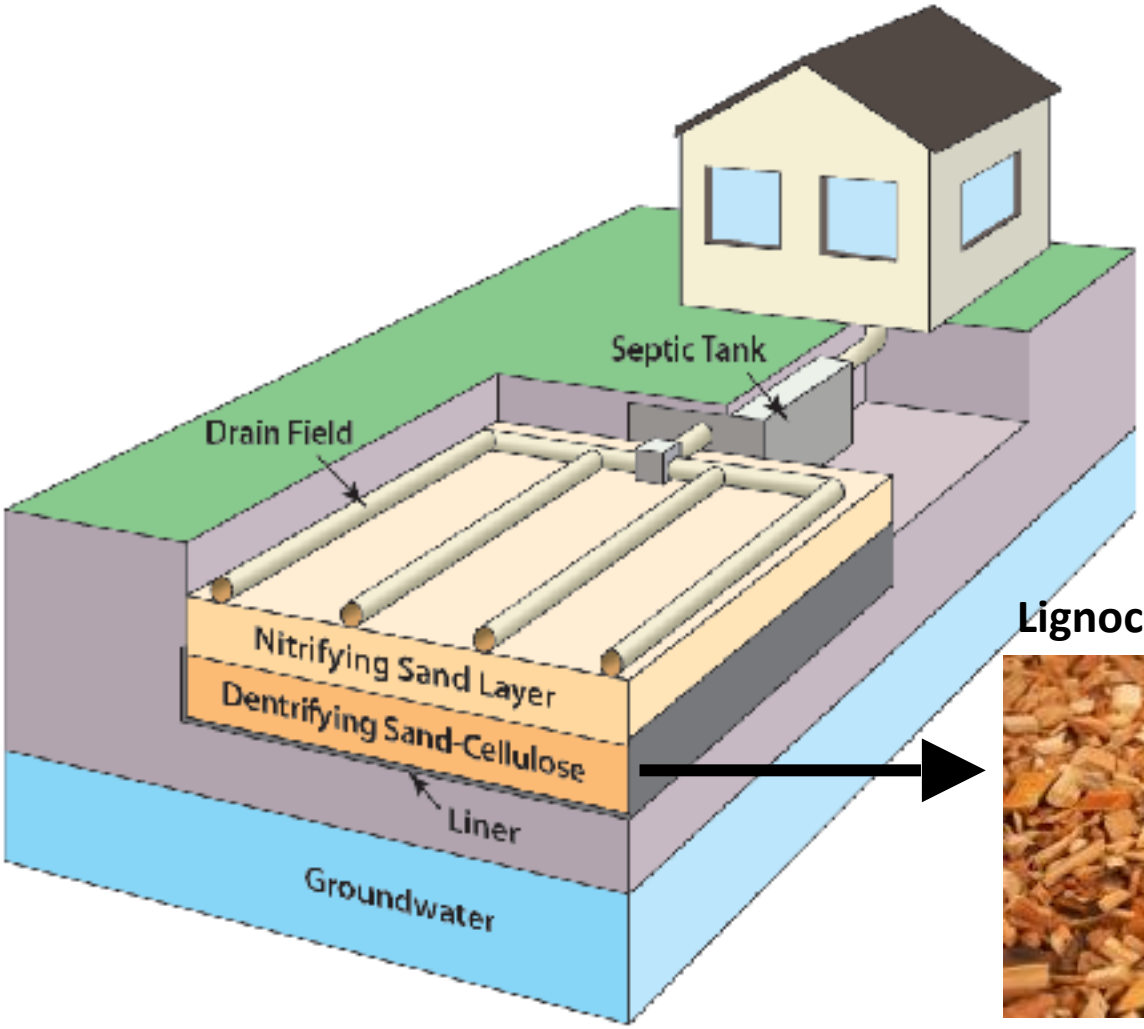
Norweco Hydro-Kinetic




Nitrogen Reducing Biofilter (NRB)
Lined & Boxed

# Nitrogen Removing Biofilters (NRB)

NYS CENTER FOR CLEAN WATER TECHNOLOGY




**<u>Materials list</u>:**

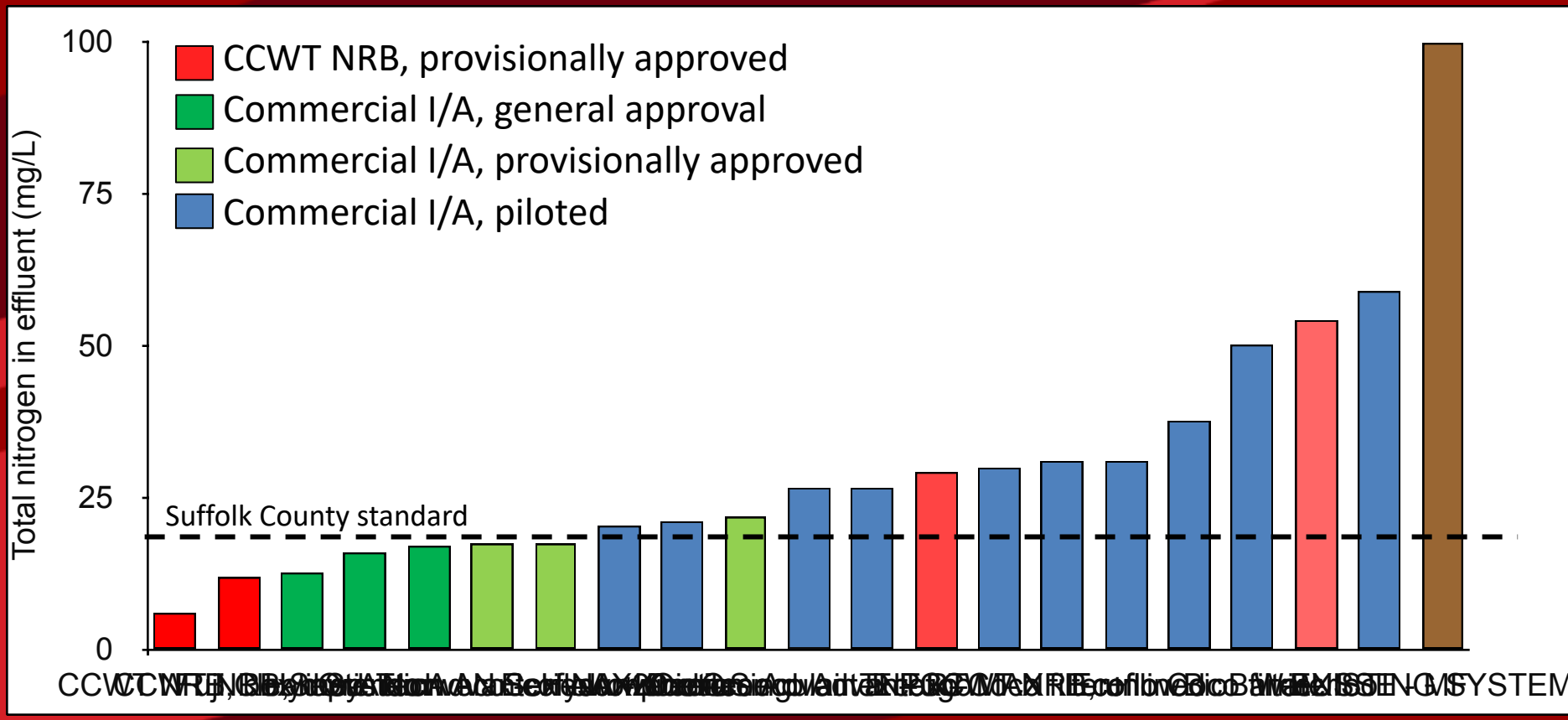
- Sand
- Wood chips
- PVC pipe
- Home Depot pump

**Lignocellulose = wood, chips**

**Carbon source to promote denitrification**

Stony Brook University

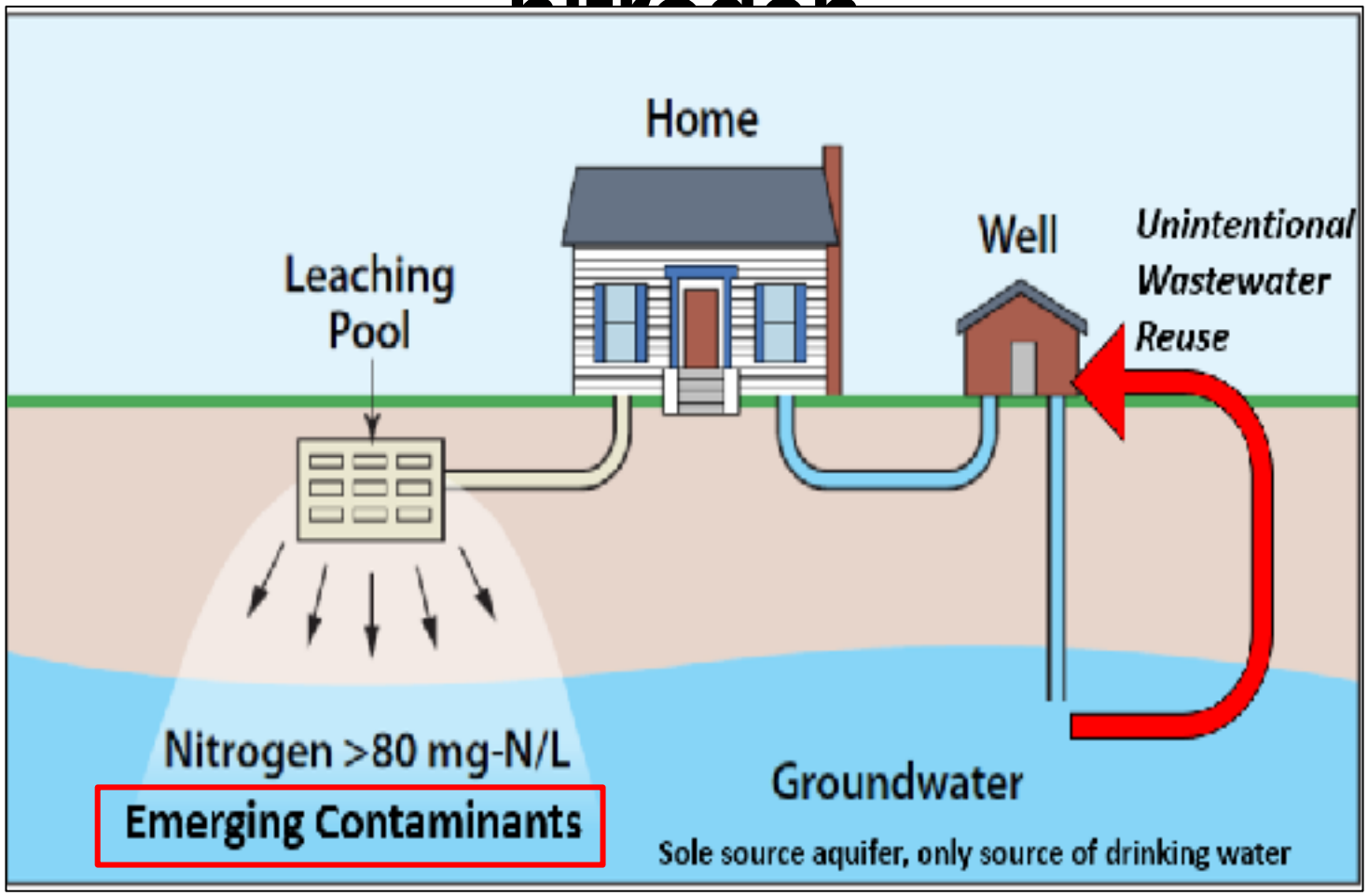
# Comparison of I/A performance in Suffolk County






FAR BEYOND

# Wastewater contains more than nitrogen



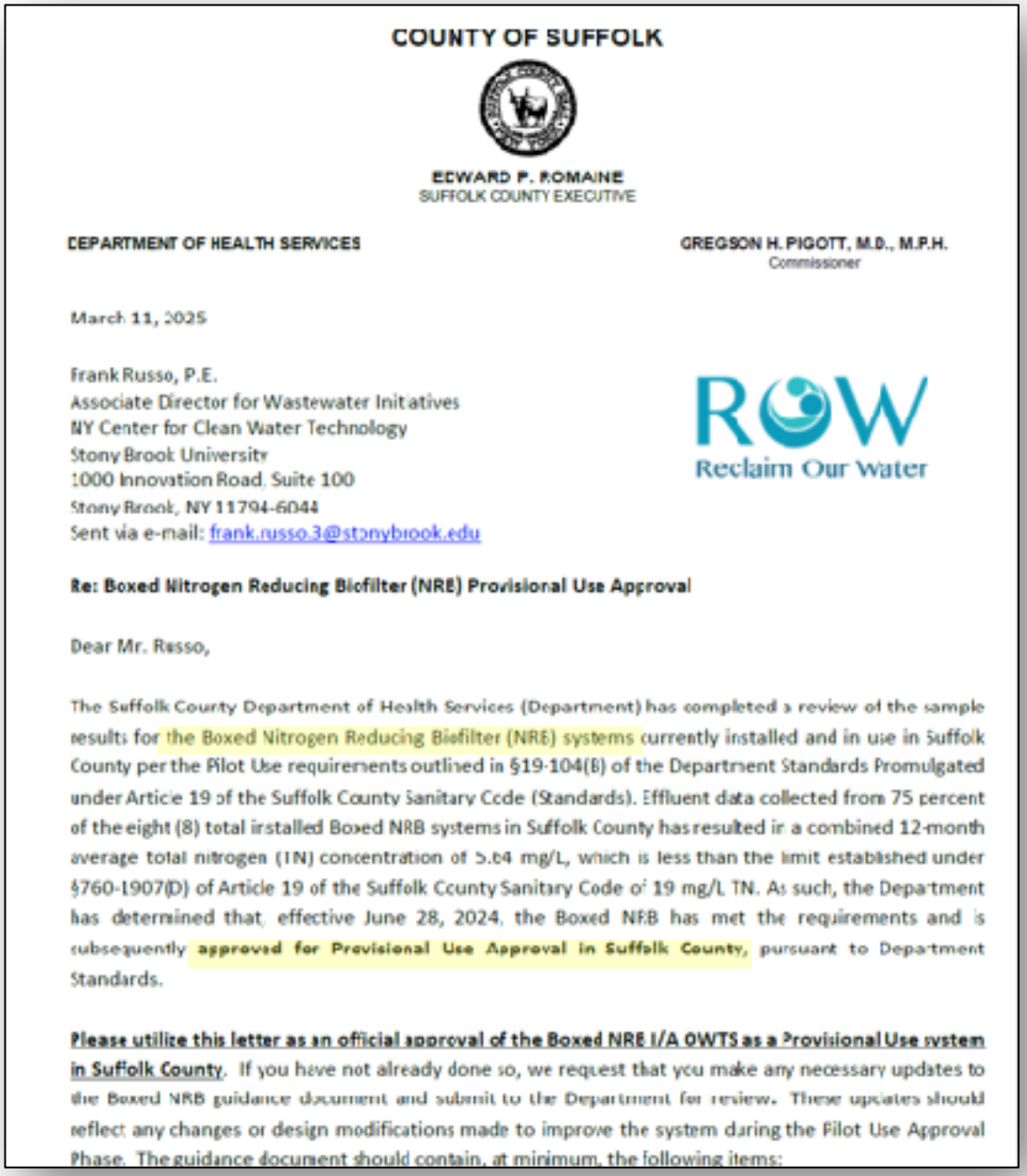
# NRBs remove 60 – 100% of 25 emerging contaminants

- All removal percentages exceed this of sewage treatment plants.
- Removal occurs via bacterial degradation within the oxic sand filter layer of the NRB; no other approved I/A system has that layer.
- No other I/A system has been assessed for the removal of these compounds.

| Compound | Use | Removal (%) |
|---|---|---|
| 1,4-dioxane | solvent | 60% |
| Acetaminophen | NSAID | 94 – 100 |
| Caffeine | stimulant | 99 – 100 |
| Paraxanthine | human metabolite of caffeine | 98 – 99 |
| DEET | mosquito repellant | 82 – 96 |
| Nicotine | stimulant | 92 – 97 |
| Cotinine | human metabolite of nicotine | 86 – 98 |
| Sulfamethoxazole | antibiotic | 85 – 97 |
| Diphenhydramine | antihistamine | 97 – 95 |
| Trimethoprim | antibiotic | 87 – 90 |
| Ciprofloxacin | antibiotic | 64 – 78 |
| Atenolol | beta blocker | 88 – 97 |
| Metoprolol | beta blocker | 85 – 90 |
| Diltiazem | calcium channel blocker | 76 – 90 |
| Carbamazepine | anticonvulsant | 51 -60 |
| Ketoprofen | NSAID | 68 – 74 |
| TCEP | flame retardant | 60 – 70 |
| Salbutamol | bronchiodialator | 50 – 78 |
| Ranitidine | anti-acid | 82 – 100 |
| Diclofenac | NSAID | 76 |
| Propranolol | beta blocker | 98 – 100 |
| Venlafaxine | antibiotic | 98 |
| Fluoxetine | antidepressant (SSRI) | 64 – 66 |
| Lamotrigine | anticonvulsant | 82 |

Venkatesan et al., 2021; Sci. Total Environ.
Clyde et al 2021, Water Research

- Two distinct Nitrogen Removing Biofilters have been provisionally approved for use in **Suffolk** County and **Nassau** County.
- Covered by **up to $50K** in tax-free grants.
- Installations offered by **Excav Services** at prices similar to commercial systems (e.g. Fuji Clean, HydroAction)



COUNTY OF SUFFOLK

EDWARD P. ROMAINE
SUFFOLK COUNTY EXECUTIVE

DEPARTMENT OF HEALTH SERVICES

GREGSON H. PIGOTT, M.D., M.P.H.
Commissioner

March 11, 2025

Frank Russo, P.E.
Associate Director for Wastewater Initatives
NY Center for Clean Water Technology
Stony Brook University
1000 Innovation Road, Suite 100
Stony Brook, NY 11794-6044
Sent via e-mail: frank.russo.3@stonybrook.edu

ROW
Reclaim Our Water

**Re: Boxed Nitrogen Reducing Biofilter (NRB) Provisional Use Approval**

Dear Mr. Russo,

The Suffolk County Department of Health Services (Department) has completed a review of the sample results for the Boxed Nitrogen Reducing Biofilter (NRB) systems currently installed and in use in Suffolk County per the Pilot Use requirements outlined in §19-104(B) of the Department Standards Promulgated under Article 19 of the Suffolk County Sanitary Code (Standards). Effluent data collected from 75 percent of the eight (8) total installed Boxed NRB systems in Suffolk County has resulted in a combined 12-month average total nitrogen (TN) concentration of 5.64 mg/L, which is less than the limit established under §760-1907(D) of Article 19 of the Suffolk County Sanitary Code of 19 mg/L TN. As such, the Department has determined that, effective June 28, 2024, the Boxed NRB has met the requirements and is subsequently **approved for Provisional Use Approval in Suffolk County,** pursuant to Department Standards.

**Please utilize this letter as an official approval of the Boxed NRB I/A OWTS as a Provisional Use system in Suffolk County**. If you have not already done so, we request that you make any necessary updates to the Boxed NRB guidance document and submit to the Department for review. These updates should reflect any changes or design modifications made to improve the system during the Pilot Use Approval Phase. The guidance document should contain, at minimum, the following items:

# Georgica Pond Watershed Manager – Tom Varley

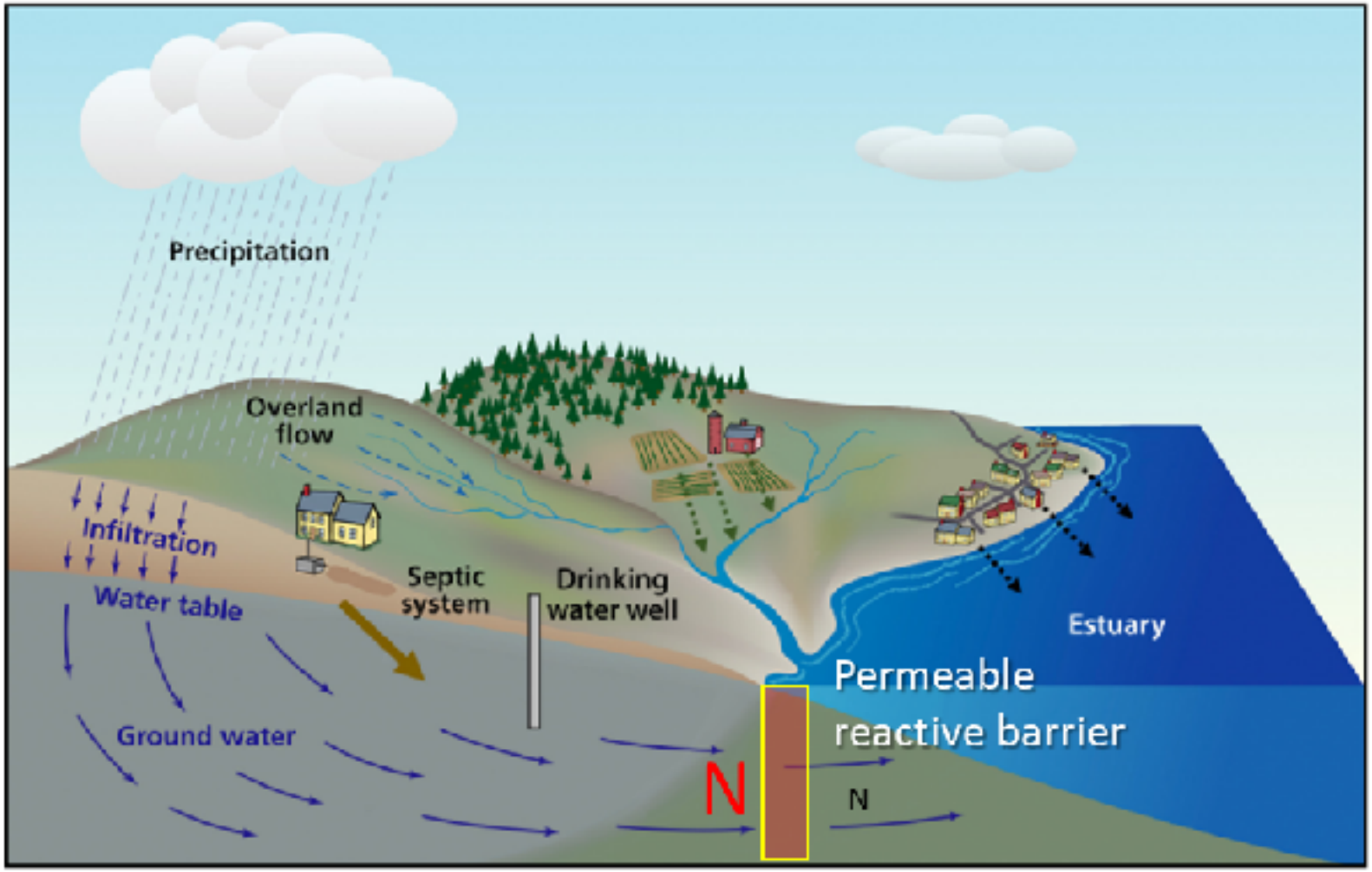
- 40 years experience in wastewater treatment specializing in operation & maintenance
- Certified Grade 4 Wastewater Operator in NY, NJ & CT
- Experience in groundwater remediation
- Working with Georgica Pond and Sagaponack Pond homeowners on septic upgrade.
- **Tom is here to help you seamlessly upgrade your septic systems**: System selection, system design, obtaining grants, installation, operation and maintenance.

Stony Brook University

*NYS Center for Clean water Technology*

PECONIC LAND TRUST

# Permeable reactive barriers

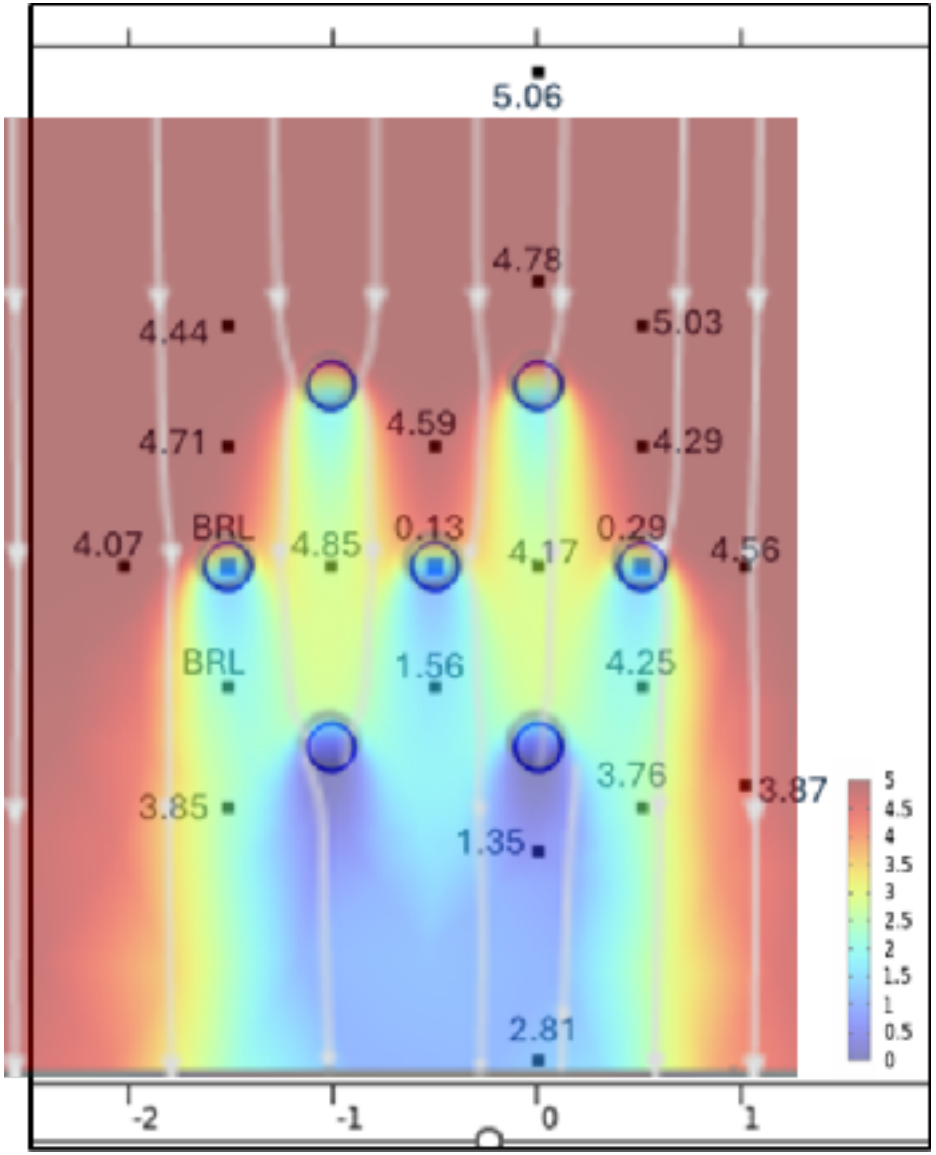



- It will take decades to upgrade hundreds of thousands septic systems on Long Island and for legacy contamination to flush out of the aquifer.
- PRBs allow for the removal of legacy N before entering ecosystems or well heads.

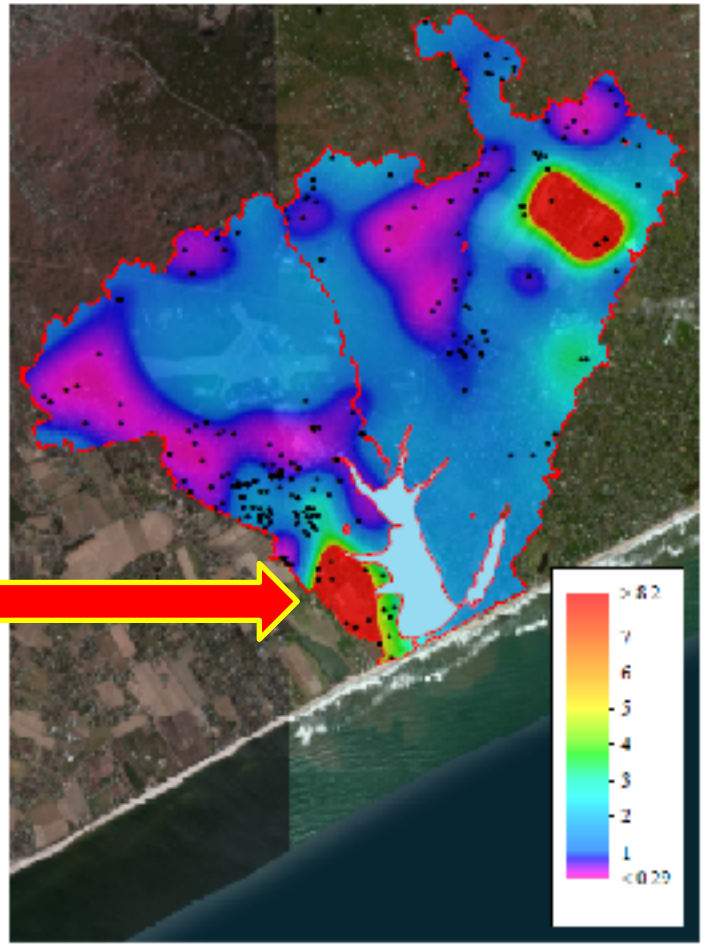
# Carbon array installation at Georgica Pond, June 2023

# Carbon Array

- Nitrate depleted in the center of woodchip columns
- Lower nitrate concentrations downstream
- Matches model simulation



# High nitrate plume entering Eel Cove



# Piezometer wells installed on Kagan and Yass properties at Eel Cove, Georgica Pond, installed May 2024


- Three sets of 3 piezometer well clusters in front yard (East), at periphery of farm (West) and in relic freshwater marsh (marsh)
- Each cluster includes 4 wells at approximate depth intervals of 5-10, 10-15, 15-20 and 20+ below ground
- Sampling campaigns June, July, September and October

# Nitrogen pollution at Eel Cove

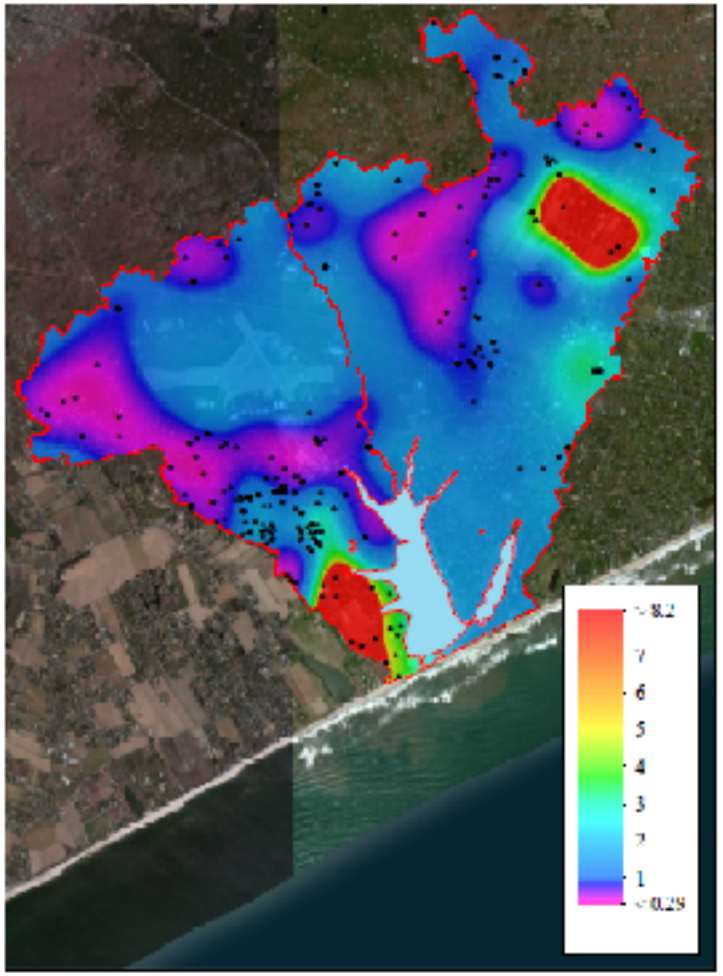
Consistently nitrate concentrations of 10-25 mg N $L^{-1}$ below 10 ft

Apparent absence of NOx in shallow wells in the marsh

# High nitrate plume entering Eel Cove

- These are the highest groundwater N levels ever measured in in East Hampton Town.

- CCWT will submit a grant application to the Town of East Hampton CPF fund for a PRB to remediate this N source.



# Transport and Bioaccumulation Per- and Polyfluoroalkyl Substance (PFAS) in an Aqueous Film Forming Foam (AFFF)-Impacted Estuary

Kevin W. Shaffer

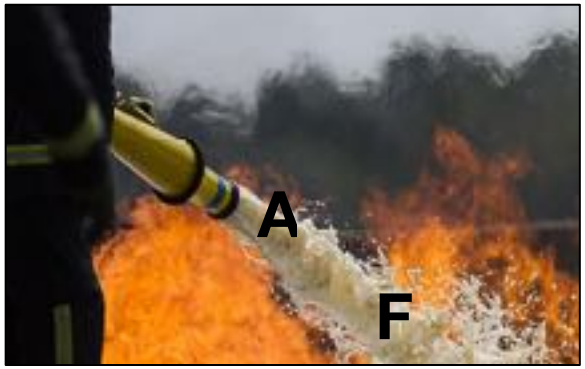
Master's Seminar

July 29, 2024

Photo: Doug Kuntz

# Per- and Polyfluoroalkyl Substances (PFAS)

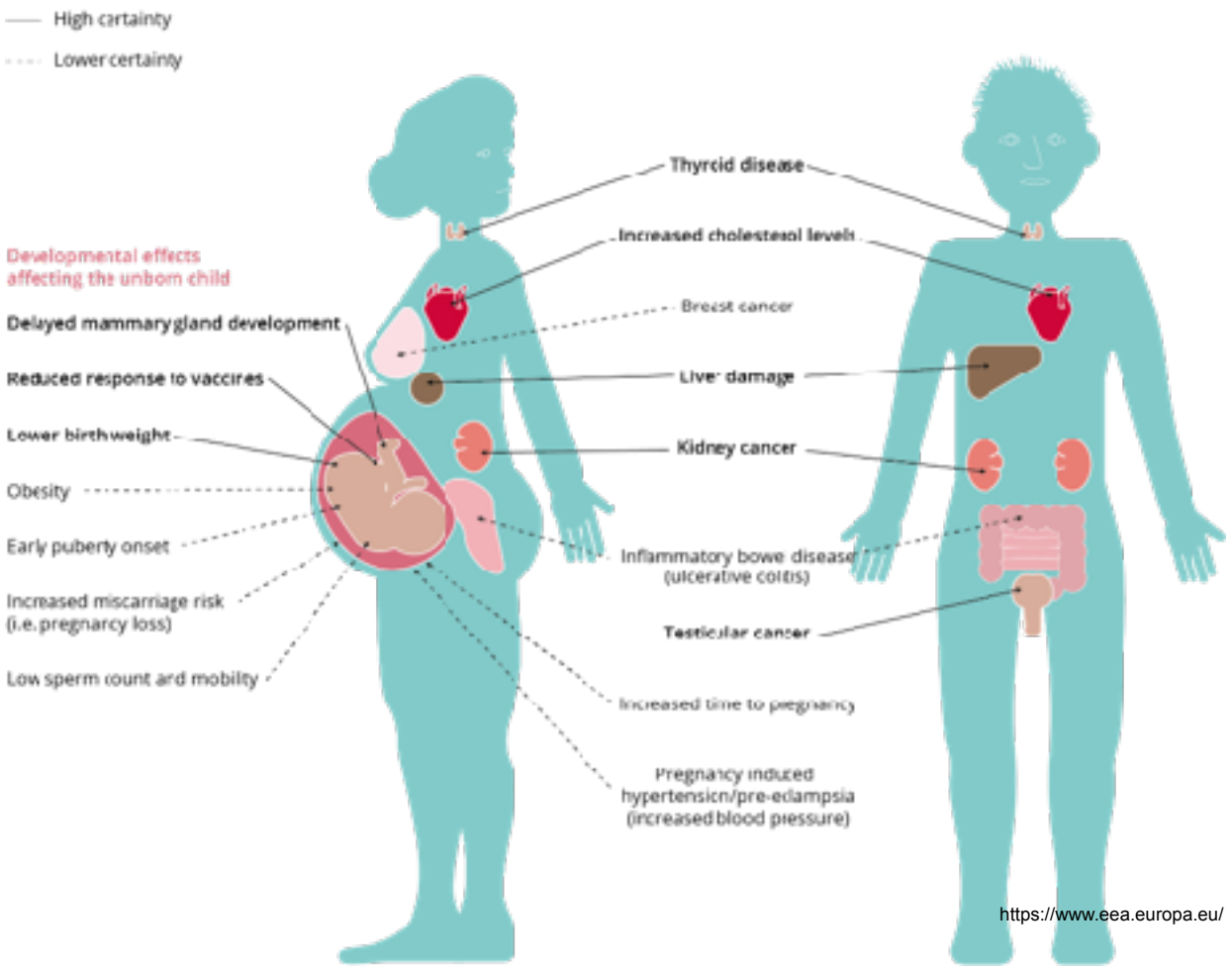
- Commercial and industrial uses
- Oil, water, and heat resistant
- Environmental release during production, disposal, AFFF
- Mobile in water and air
- Resistant to degradation





# PFAS Health Risks

- Toxic: adverse health effects
  (Sunderland et al., 2019; Wang et al., 2017)
- Perfluorooctanoic acid (PFOA): classified as a **possible human carcinogen** by International Agency for Research on Cancer (IARC)



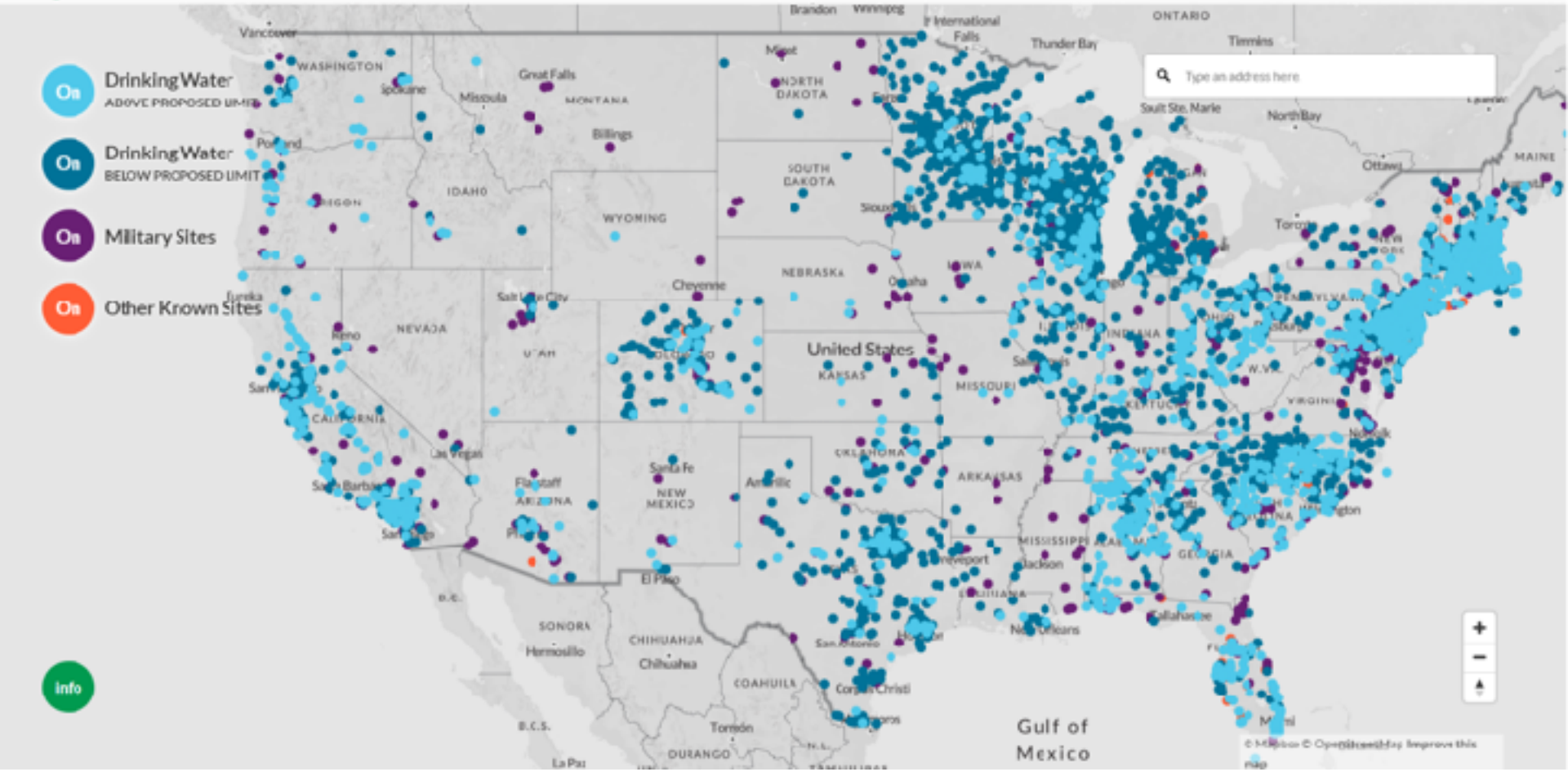
# New EPA PFAS Regulations

- In 2024, EPA announced the final National Primary Drinking Water Regulation establishing MCLs for six PFAS (4 -10 ng/L or parts per trillion)

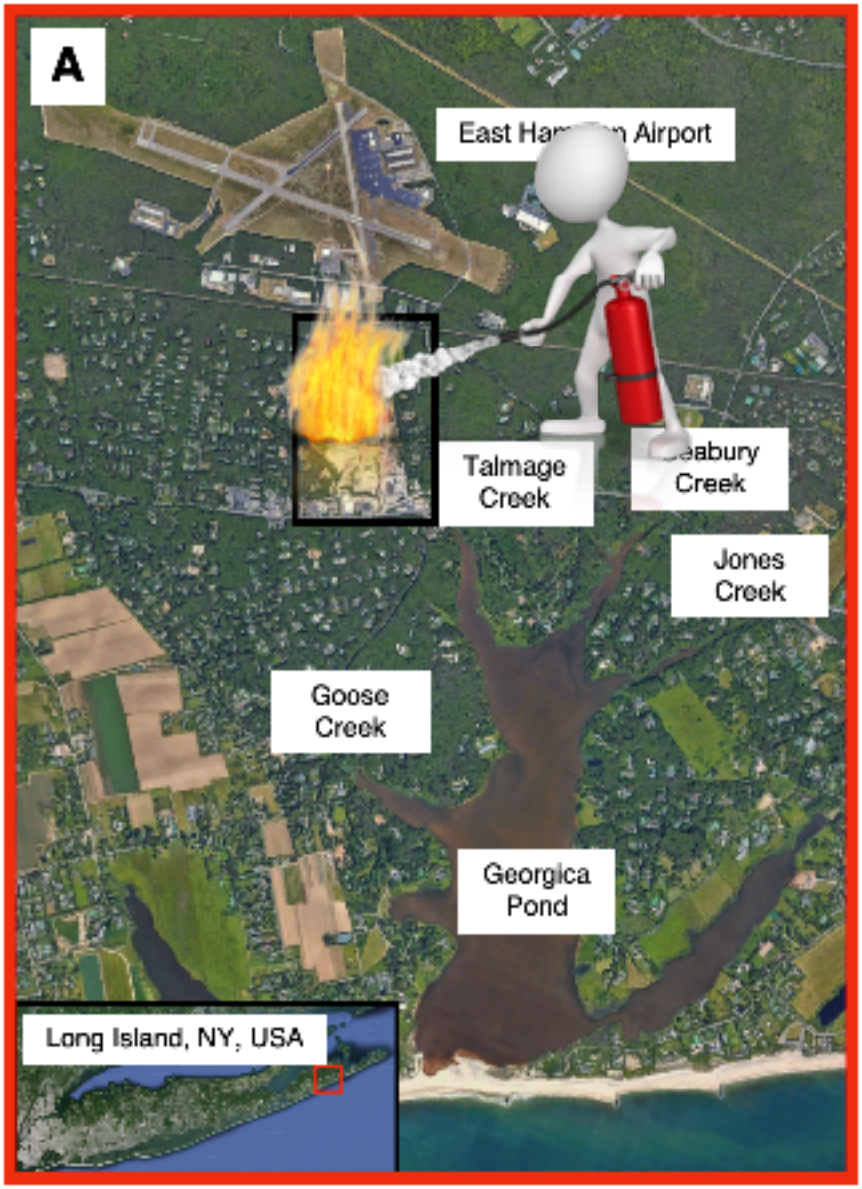
| EPA National Primary Drinking Water Standards | | | |
|---|---|---|---|
| PFAS | | Maximum Contaminant Level Goal | Maximum Contaminant Level |
| PFOA | | 0 | 4.0 ppt |
| PFOS | | 0 | 4.0 ppt |
| PFNA | | 10 ppt | 10 ppt |
| PFHxS | | 10 ppt | 10 ppt |
| GenX | | 10 ppt | 10 ppt |
| Mixture of 2 or more | PFNA | 1 (unitless) Hazard Index | 1 (unitless) Hazard Index |
| | PFHxS | | |
| | GenX | | |
| | PFBS | | |

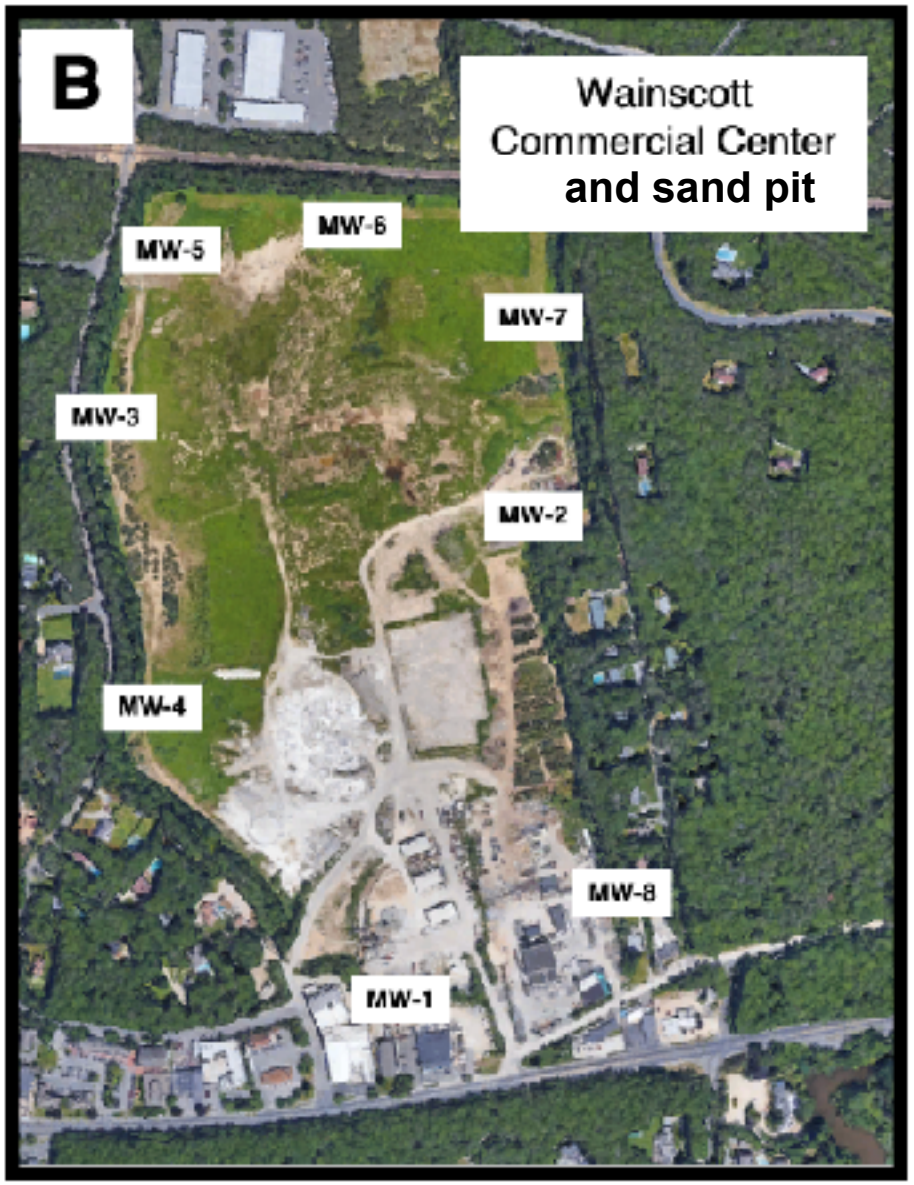
https://www.mass.gov/info-details/epa-maximum-contaminant-levels-mcls-for-pfas

# PFAS Contamination in the U.S. (May 21,2025)

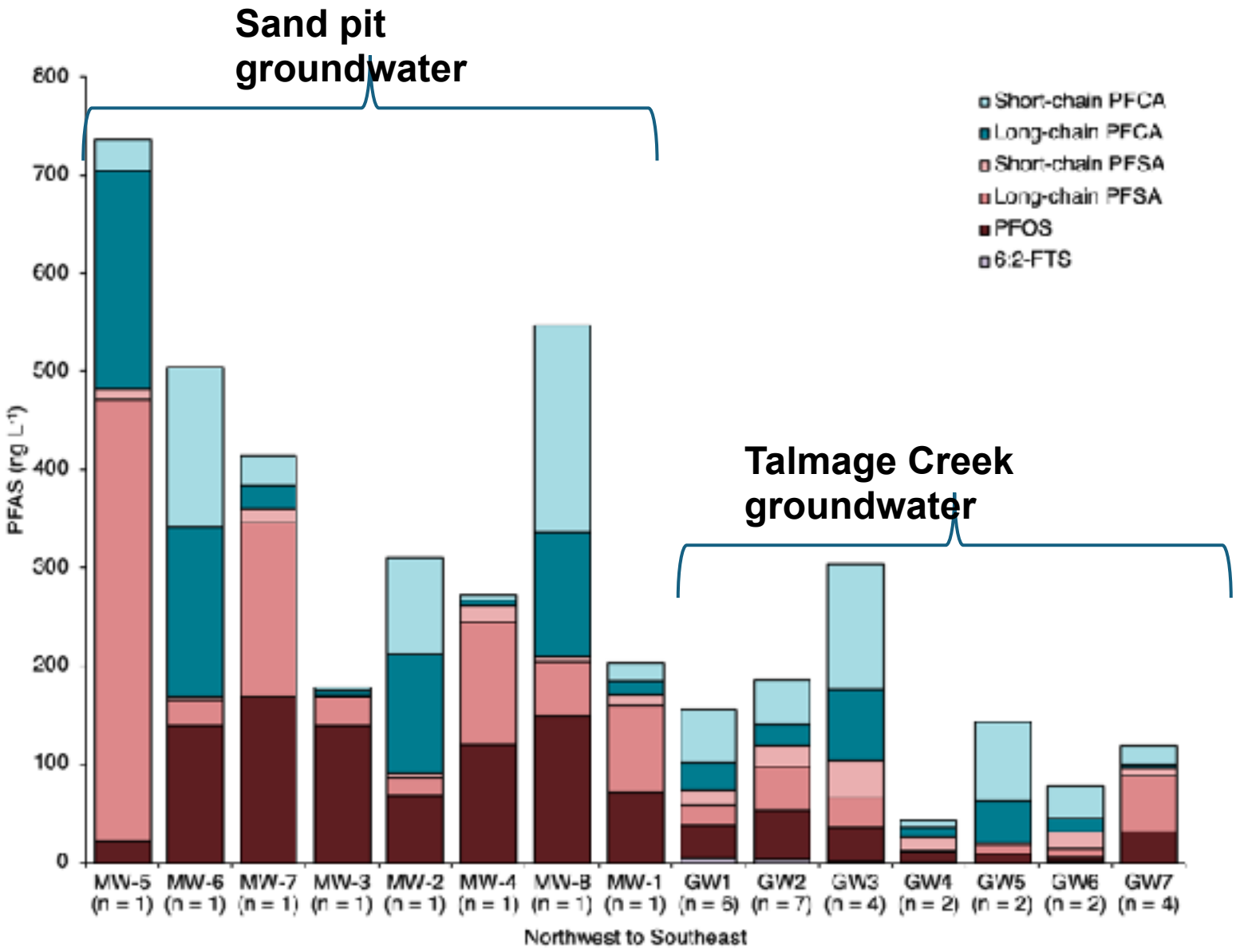


# Study Site: Georgica Pond Watershed

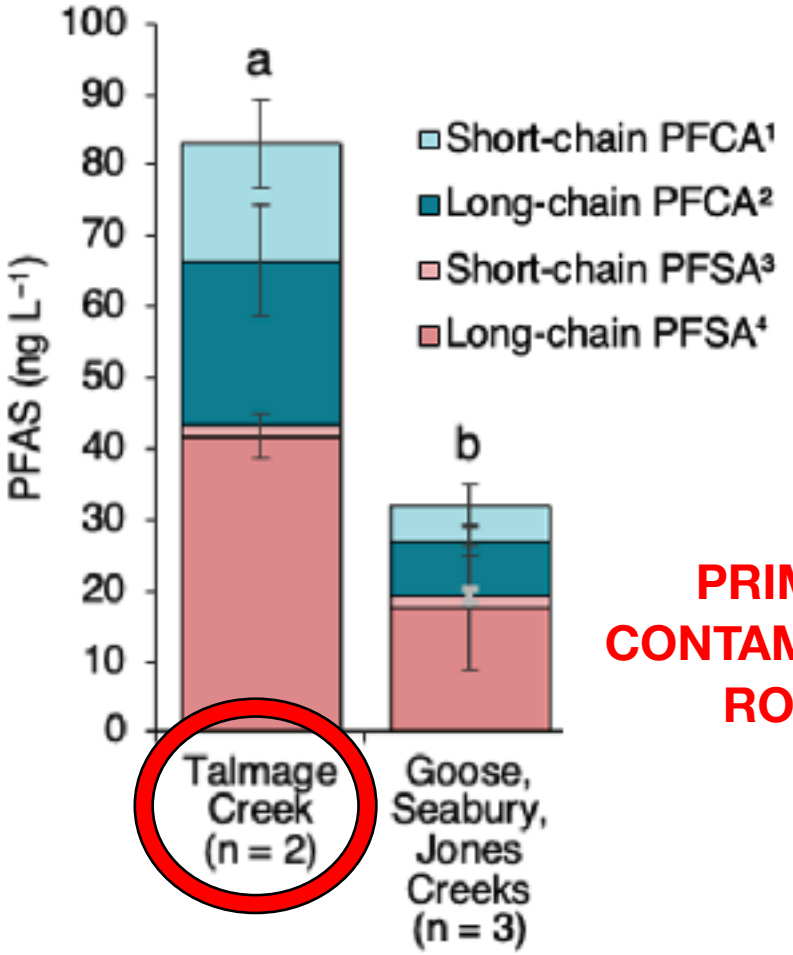


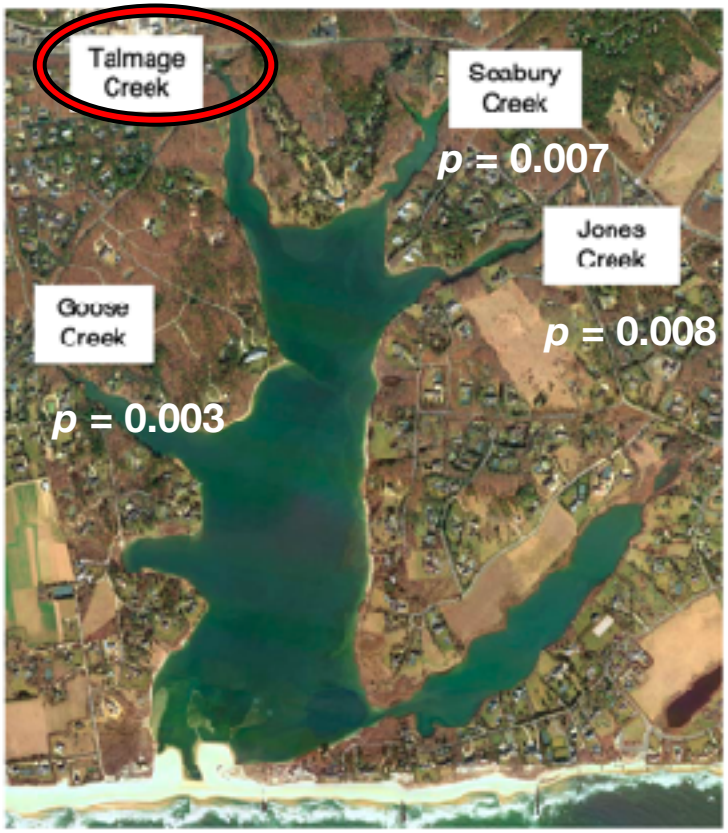
# PFAS Transport to Georgica Pond



# Route of PFAS to Georgica Pond: Tributary Comparison




**PRIMARY CONTAMINATION ROUTE**



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journal homepage: www.elsevier.com/locate/scitotenv

# Accumulation and trophic transfer of per- and polyfluoroalkyl substances (PFAS) in estuarine organisms determined via stable isotopes

Kevin W. Shaffer [a,b], Xiayan Ye [b,c], Cheng-Shiuan Lee [b,d], Oliver N. Shipley [a], Carrie A. McDonough [e], Arjun K. Venkatesan [f], Christopher J. Gobler [a,b,*]

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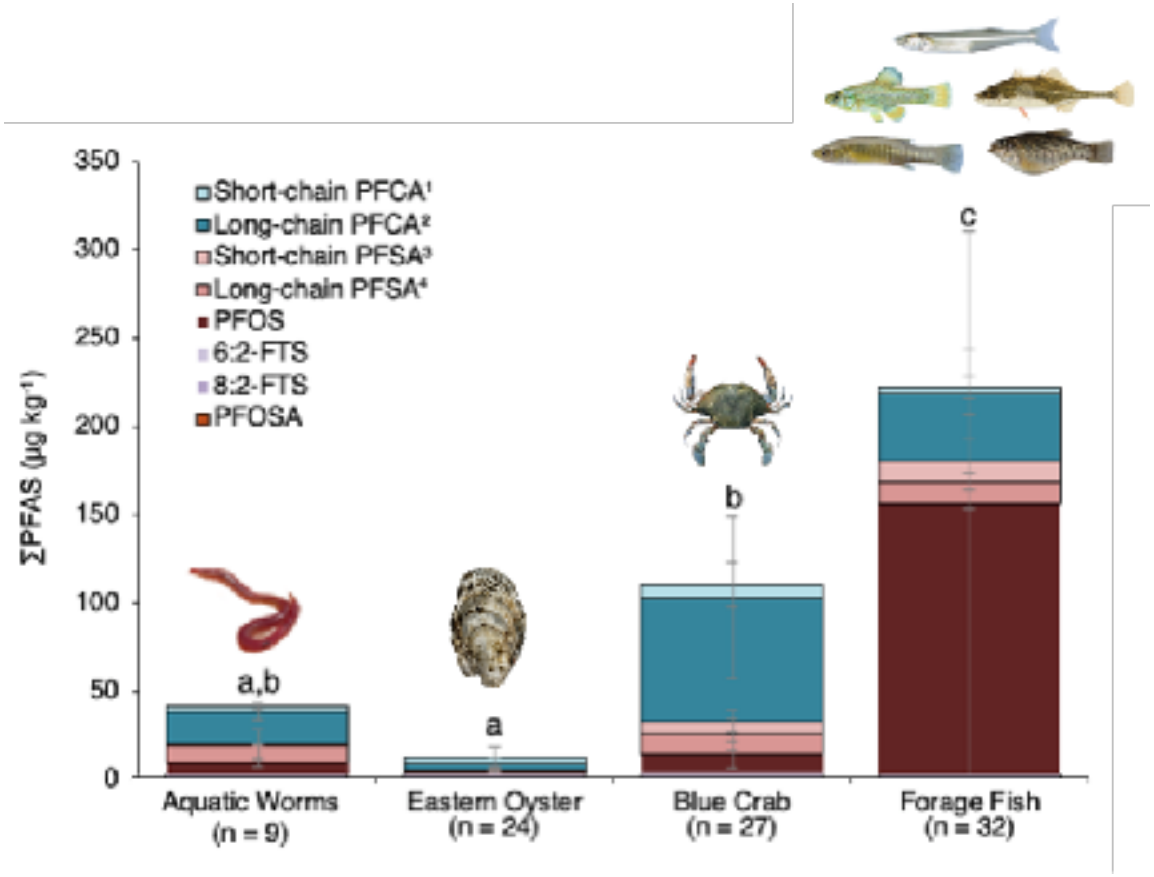
[b] New York State Center for Clean Water Technology, Stony Brook University, Stony Brook, NY, United States
[c] Lerner Research Institute, Cleveland Clinic, Cleveland, OH, United States
[d] Research Center for Environmental Changes, Academia Sinica, Taipei 115201, Taiwan
[e] Carnegie Mellon University, Department of Chemistry, Pittsburgh, PA, United States
[f] New Jersey Institute of Technology, Department of Civil and Environmental Engineering, Newark, NJ, United States

# Biota Comparison of Total Concentration

- Total PFAS in fish greater than all other biota

- Eastern Oysters $p < 0.001$
- Aquatic Worms $p = 0.003$
- Blue Crab $p = 0.032$

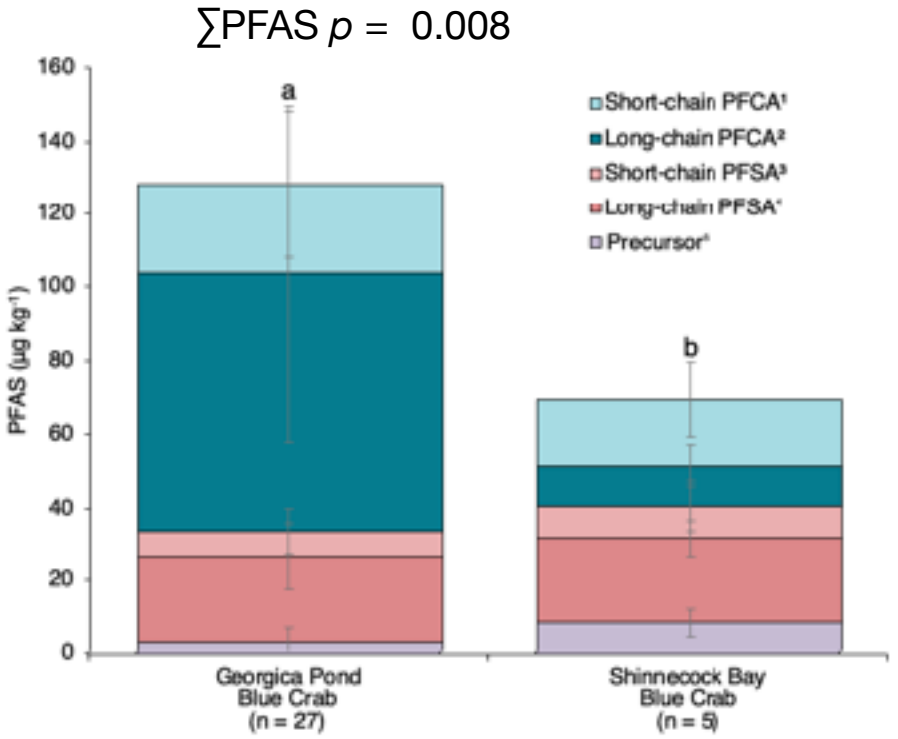
- Total PFAS in blue crab greater than Eastern oysters $p = 0.021$



# Blue Crab Comparison

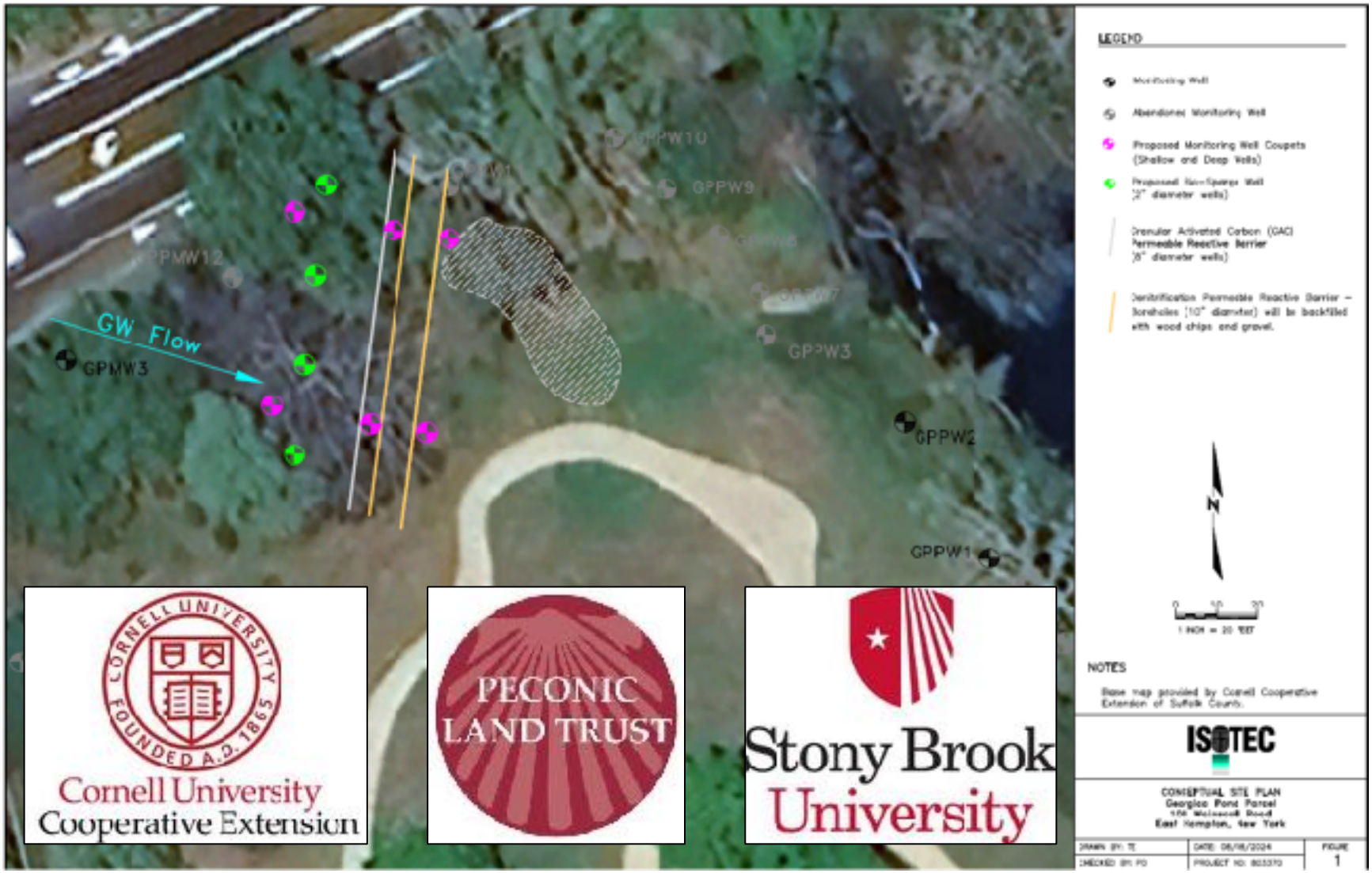
**Georgica Blue Crab**

- Long-chain PFCA dominated (PFOA)
- Concentrations twice that of Shinnecock Bay
- Reflects AFFF contamination



# New Talmage Creek permeable reactive barrier to remove PFAS and nitrogen grant from East Hampton CPF

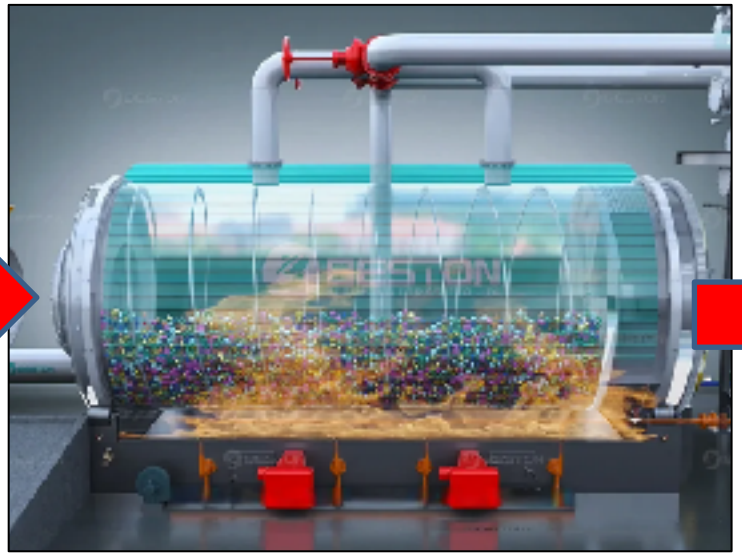
*-First ever project to remove PFAS from groundwater on Long Island*



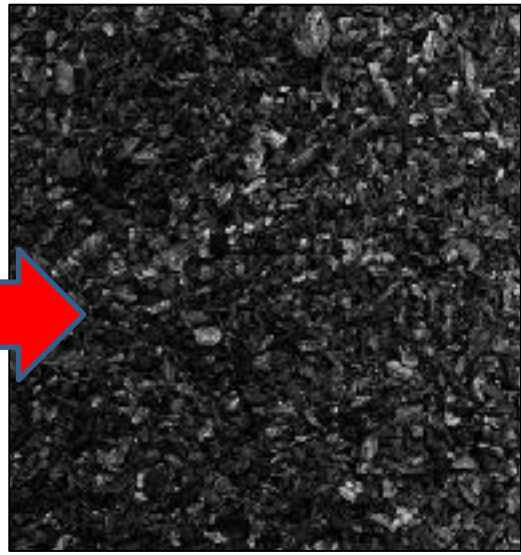
# Repurposing invasive species, waste material to clean water

Bamboo (invasive)

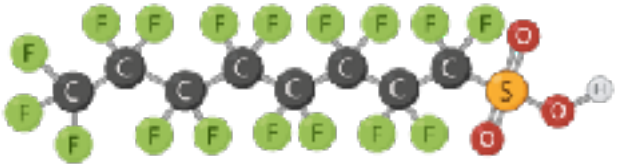
Pyrolysis (700°C, no $O_2$)



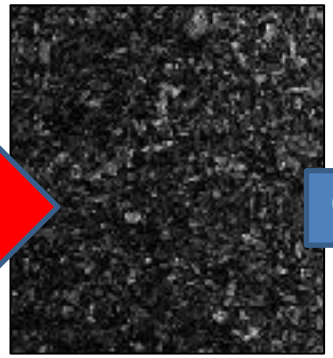
Biochar



Bamboo biochar barrier



PFAS-contaminated groundwater



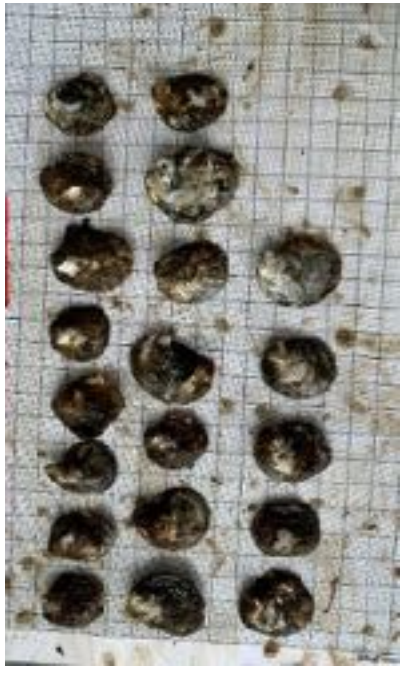
Clean groundwater

# *OYSTERS in Georgica Pond 2019 - 2025*

# Grow-out Experiments

- Initial experiments conducted to map oyster survivorship, growth, and disease across Georgica Pond
- Oysters placed in cages at 3 study sites (North, Central, South)
  - **Single-seed oyster seed deployed in 2019**
  - **Spat-on-shell deployed in 2021**

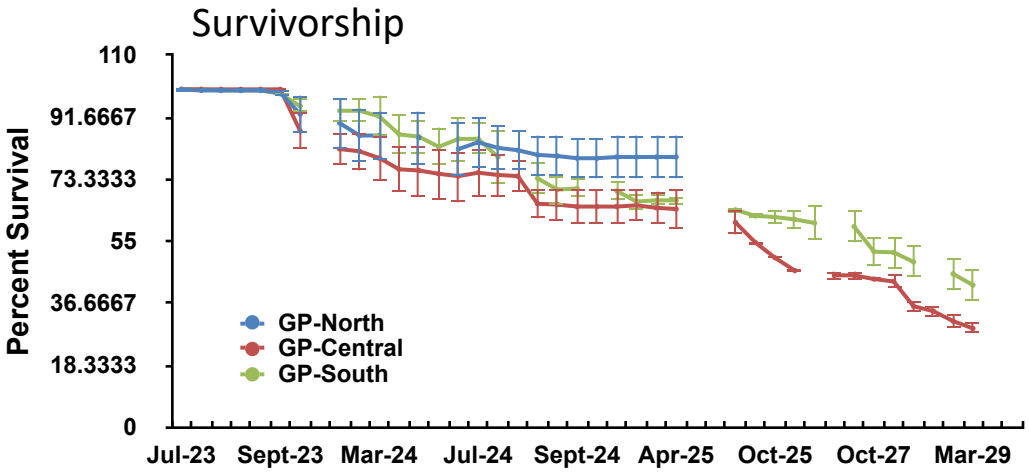
Single-set seed

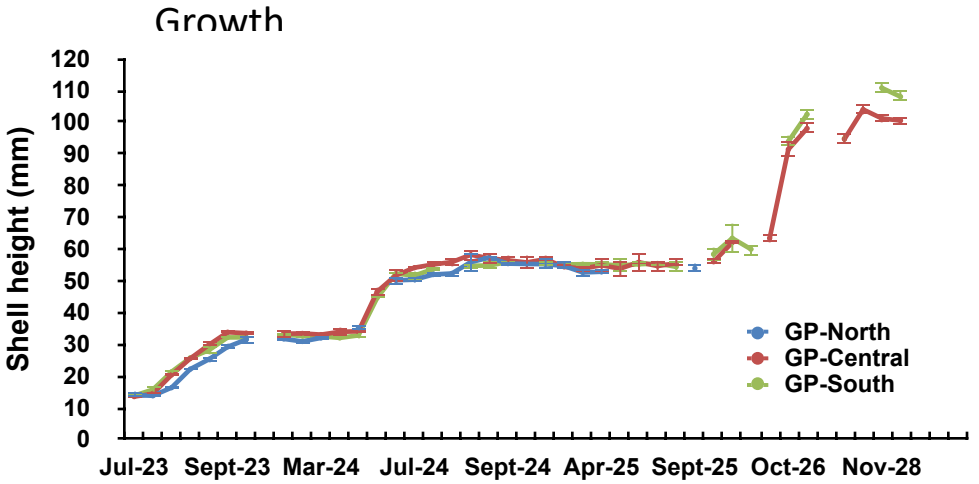


Spat-on-shell

## Cage experiments - Oyster seed

- High survivorship and growth of single-set oysters in cages for ***six years***!
- Six-year old oysters currently about **4-inches long!**



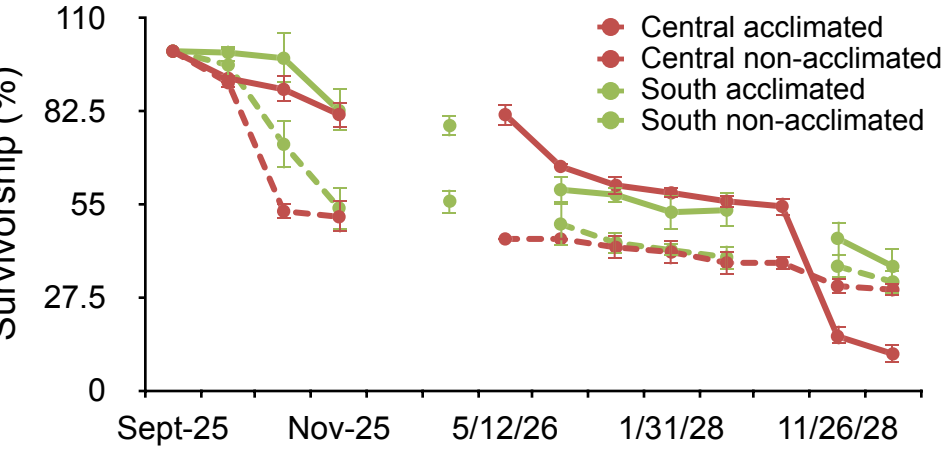

July 18, 2019

March 18, 2025

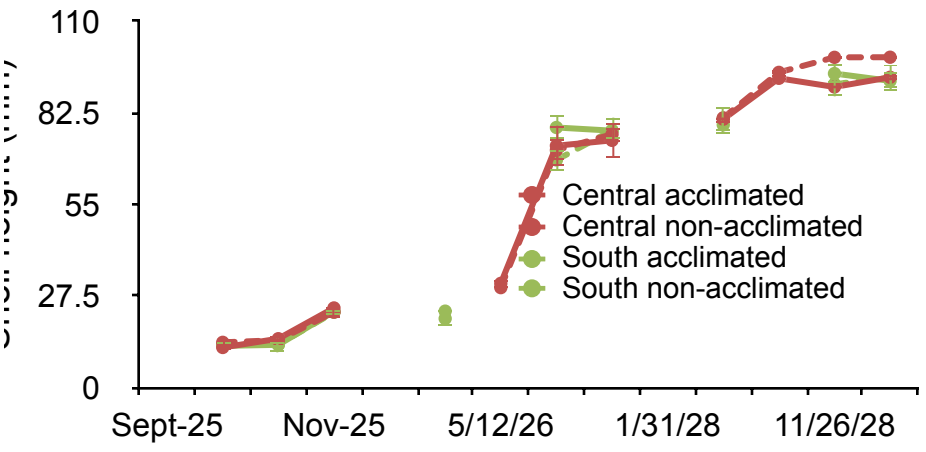
# Cage experiments – Spat-on-shell

- High survivorship and growth of spat-on-shell in cages for ***four years***!
- Higher initial survival when spat is acclimated to low salinity

Survivorship



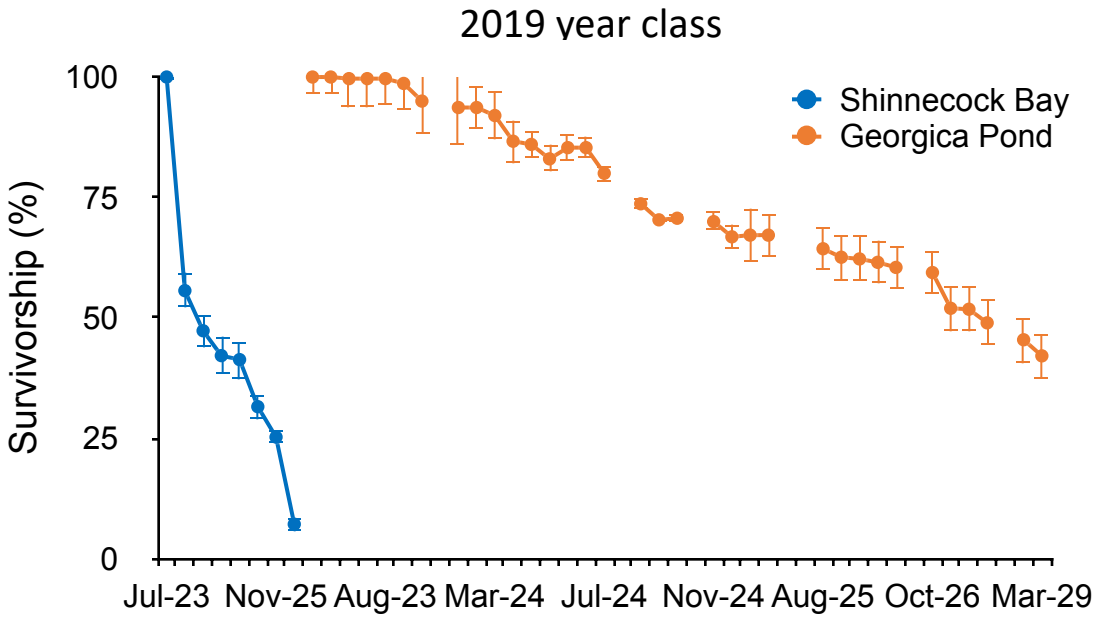

Growth

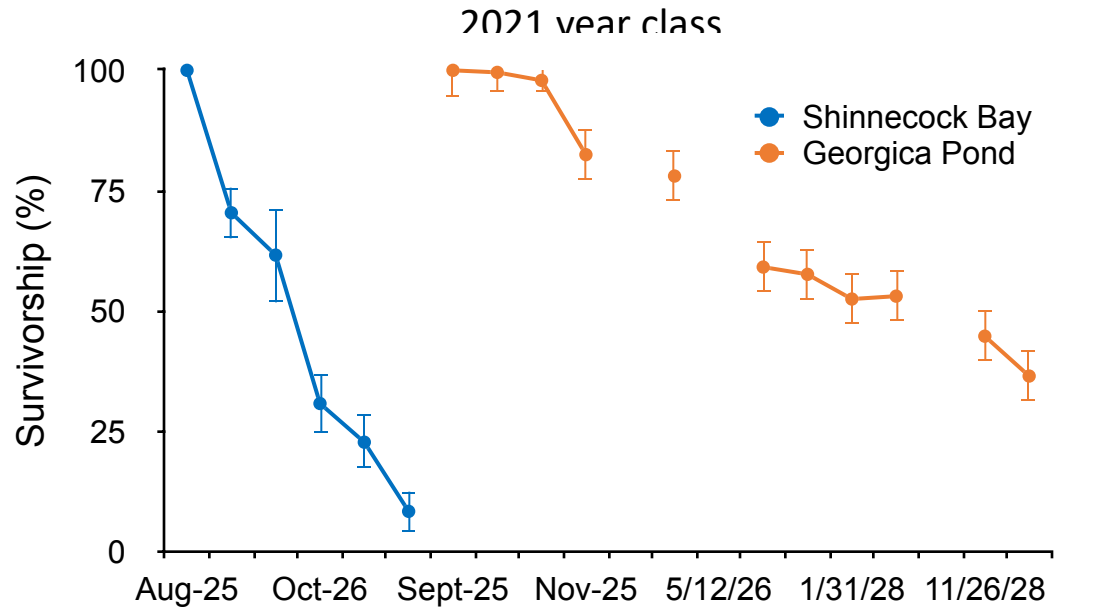





# High long-term survival of oysters in Georgica Pond

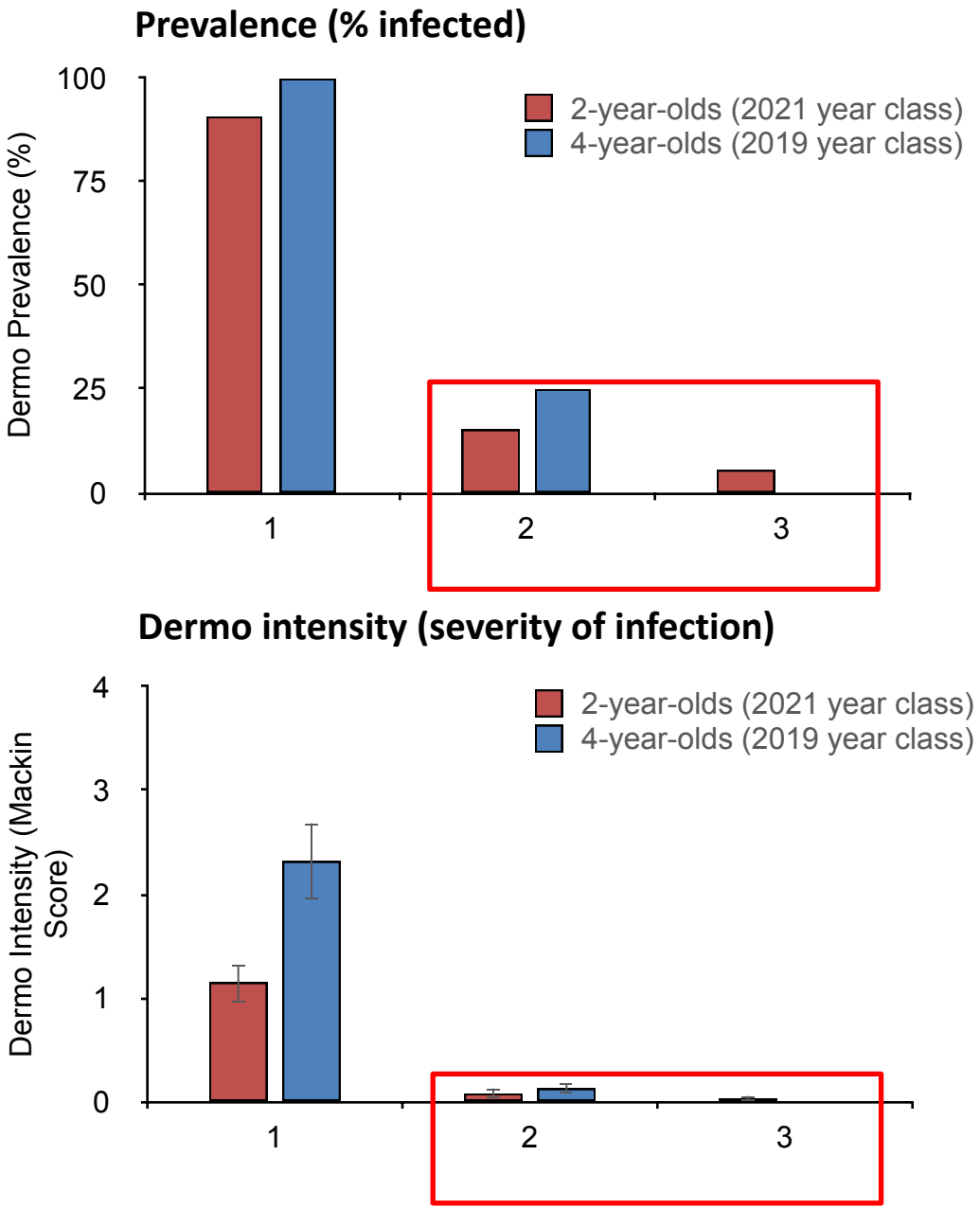
- Highest long-term survival ever measured on Long Island.
- Comparison here made to oysters deployed in **Shinnecock Bay of same year class; now all dead (vs 40% survival in Georgica Pond).**



# Low prevalence of the oyster disease Dermo in Georgica Pond

- Dermo testing conducted in early fall 2023
  - 2019 year class were 4 years old
  - 2021 year class were 2 years old
- **Lower prevalence and intensity of Dermo in Georgica Pond than Shinnecock Bay for both year classes**
- Low salinity is Georgica Pond creates a refuge from Dermo
- Dermo is a leading cause of mortality in older oysters in Shinnecock Bay and other coastal waters around Long Island



# Pilot Oyster Reefs

- Encouraging results from cage experiments
- Installed small test oyster reefs at two sites (central and south) in fall 2022
- Reefs constructed using shell bags containing oyster spat-on-shell

# Pilot Oyster Reefs

- Shell bags initially deployed to the two sites on November 2022.
- At each site, placed twelve ‘shell bags’ in two adjacent, parallel lines on top of a base of loose shell.
- Unlike the oyster spat deployed in cages in previous years, the spat on the shell bags are exposed to predators, like blue crabs .

# Pilot oyster reefs – results to data

- As of spring 2025, there are living oysters on shell bags at each reef site, including **three-year-old oysters** from the spat-on-shell initially deployed in 2022
  - 10 to 40 visible oysters per shell bags
  - 2+ year-old oysters: **55 mm average shell height**
- '**Predation scars**' observed on surface of bags.
- We believe **blue crabs predated on oyster spat on the outer surface of the bags**, while oyster spat within the shell matrix were protected from predation



# Conclusions and recommendations

- Best survival and lowest disease prevalence on Long Island.
- Blue crab predation is a threat to oyster restoration in Georgica Pond. The use of shell bags to build oyster reefs may help protect small spat from predators, providing a refuge from predation within the shell matrix.
- The ability of oyster larvae to survive and recruit in Georgica Pond is unknown; current research focused on this important life stage.
- The siting of future oyster reefs is important to ensure survival and growth of oysters, and to avoid user conflicts.
  - Our surveys have found suitable bottom for reef restoration in areas of central and south Georgica Pond
  - Recurring dredging in the southern part of Georgica Pond may limit oyster restoration opportunities in that area
  - The Friends of Georgica Pond, the East Hampton Trustees, and Gobler Lab researchers are working together to identify the most promising locations.

# Final conclusions:

- Georgica Pond has experienced algal blooms, toxic blue-green algae, low oxygen, and fish kills.
- Algal blooms are promoted by excessive nitrogen.
- Most of the nitrogen entering Georgica Pond comes from wastewater.
- Accelerating the removal of nitrogen from wastewater is the central long-term solution.
- PFOS chemicals have entered the pond from past industrial activities to the north but remediation is now underway.
- Legacy agricultural nitrogen is being investigated and will be remediated.
- Oysters are thriving in Georgica Pond and can be part of long-term remediation.

**Acknowledgements:**

Sincere gratitude for:
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