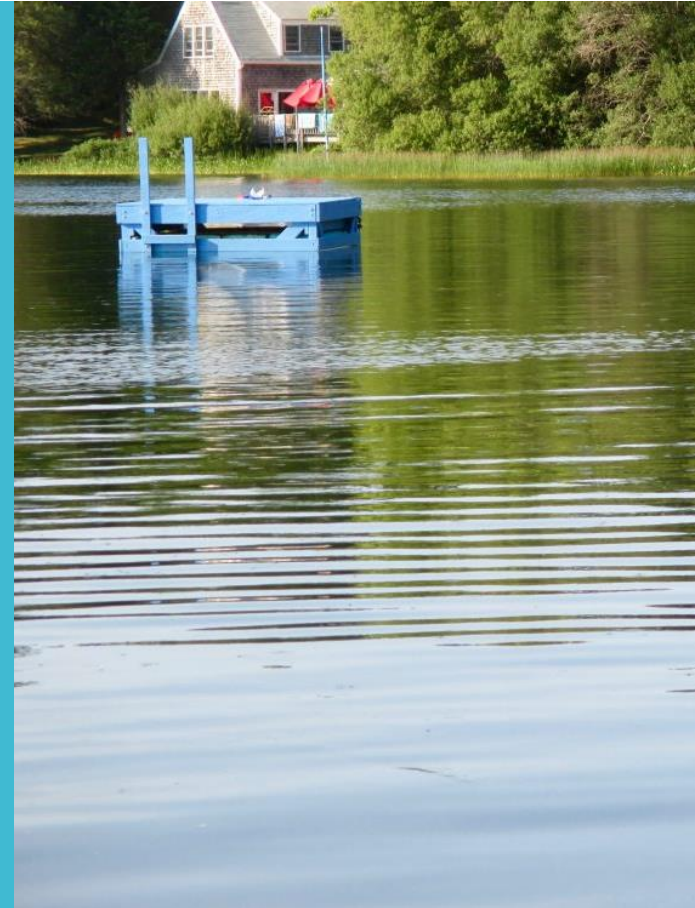


# Update: Water Quality & Habitat Conditions Town of Eastham



*Photo by Brian Tarcy,  
Cape Code Wave Magazine*



*EcoLogic*

Liz Moran Ph.D.  
EcoLogic LLC  
August 24, 2022

# Agenda

- Update Status of Inland Kettle Ponds
  - (Phosphorus Focus)
- Update Status of Salt Pond
  - (Nitrogen Focus)
- Discussion

# Partners and Context



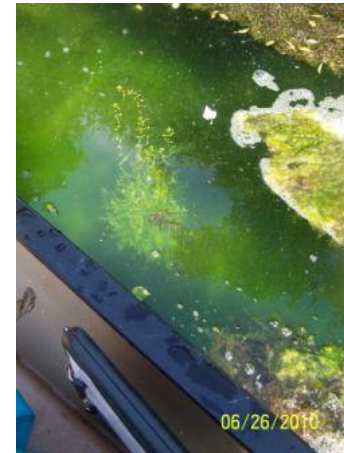
*Integrated Assessment of  
Wastewater and Water Management*

# Status Update: Inland Kettle Ponds

Summer, 2022

# 2011 Ponds Action Plan with GHD

- Evaluated current conditions and trends
  - Groundwater delineations
  - Water and nutrient budgets
- Identified alternatives for protection and remediation
- Defined criteria for prioritization
- Outlined path to implementation



# Kettle Ponds



# Phosphorus Levels are Key to Pond Health

Total Phosphorus	Attributes	Fisheries and Recreation
6 – 12 ppb	<ul style="list-style-type: none"> <li>• Clear water, well oxygenated</li> </ul>	<ul style="list-style-type: none"> <li>• Cold water fishery</li> </ul>
12 – 24 ppb	<ul style="list-style-type: none"> <li>• Shallow lakes may become anoxic, water moderately clear</li> </ul>	<ul style="list-style-type: none"> <li>• Transitional fishery</li> </ul>
24 – 96 ppb	<ul style="list-style-type: none"> <li>• Deep water anoxia</li> <li>• Diminished clarity</li> <li>• More plants</li> </ul>	<ul style="list-style-type: none"> <li>• Less suitable for contact recreation, warm water fishery</li> </ul>
96 – 192 ppb	<ul style="list-style-type: none"> <li>• Persistent algal blooms</li> <li>• Anoxia</li> </ul>	<ul style="list-style-type: none"> <li>• Unattractive for recreation</li> <li>• Harmful algal blooms</li> <li>• Fish kills possible</li> </ul>

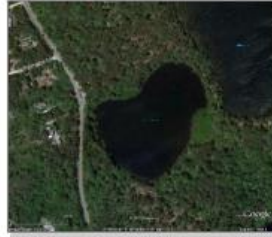


# Ecoregional Criteria for Pond Health: 2011 Assessment

	Bridge	Depot	Great	Herring	Jemima	Little Depot	Minister	Schoolhouse	Moll	Muddy*	Widow Harding
Dissolved Oxygen (>4 mg/L)	✓	✓	✗	✗	✓	✓	✓	✓	✓	✓	✓
Water Clarity (>2m)	✓	✓	✓	✗	✓	✗	✗	✓	✗	✗	✓
Phosphorus (<10 µg/L)	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗
Chlorophyll-a (<8 µg/L)	✓	✓	✗	✓	✓	✗	✗	✗	✓	✗	✓
<b>Count of “Healthy” Indicators (top score = 4)</b>	<b>3</b>	<b>3</b>	<b>1</b>	<b>1</b>	<b>3</b>	<b>1</b>	<b>1</b>	<b>2</b>	<b>2</b>	<b>1</b>	<b>3</b>

# Pond-Specific Fact Sheets

## Bridge Pond, Eastham MA



### Setting

Pond Size: 6.7 acres; Maximum Depth: 20 ft.

Watershed Size: 7.9 acres

Public Access: Herring Brook Road to walking trails in conservation area and Wiley Park.

Uses: Wildlife viewing; herring run; fishing. No boat launches or developed beaches.

Fish community: warm water

Data: PALS, Eichner (2009), EcoLogic 2011, SOLitude, Provincetown Center for Coastal Studies

### Current Conditions

- Stable water quality conditions, 2003-2021
- Hydrologically connected to Great Pond (inflow) and Herring Brook (outflow).
- Estimated 10.6 – 14.7 kg of annual phosphorus loading from Great Pond.

- Land use is park/conservation land around the pond, except for Herring Brook Road. No residences within 100 m of pond.
- Increase in DO minimum average compared to 2011
- Possible sediment release of phosphorus
- Most likely phosphorus sources: birds, precipitation, roads, Great Pond

### Outlook for Future

- Watershed likely to remain undeveloped

### Recommended Actions

#### Watershed Best Management Practices

- Manage Great Pond phosphorus concentrations
- Maintain vegetated shoreline
- Discourage large flocks of birds
- Control road runoff



Bridge Pond Water Quality Summary

Water Column	Parameter	Result <sup>1</sup>	"Healthy" Ponds Thresholds <sup>2</sup>
Upper Waters	Total Phosphorus	21.59 µg/l	≤10 µg/l
	Chlorophyll-a	15.14 µg/l	≤1.7 µg/l
	Secchi Disk Transparency	2.73 m	Not calculated
Lower Waters	Total Phosphorus ( <i>maximum average</i> )	44.98 µg/l	--
	Dissolved Oxygen ( <i>minimum average</i> )	2.54 mg/l	--

<sup>1</sup>Annual average results- PALS- Total phosphorus, chlorophyll-a, Secchi disk transparency, and dissolved oxygen, 2012-2021.

<sup>2</sup>Cape Cod Commission 2003, Table 5.

# Setting Priorities for Intervention

Criteria	1	2	3
<b>Regulatory Status</b>	Use Attainment	Threatened	303(d)- TMDL
<b>Projected Future</b>	Improving	Stable	Declining
<b>Ownership</b>	Private	Mix: private and public	Public
<b>Access</b>	None	Limited	Public beach or launch site
<b>Size</b>	Less than 5 acres	5 – 10 acres	Larger than 10 acres (a Great Pond)
<b>Prior Town investment in remediation</b>	Yes, within 5 years	Yes, within 10 years	None

# Alternative Screening

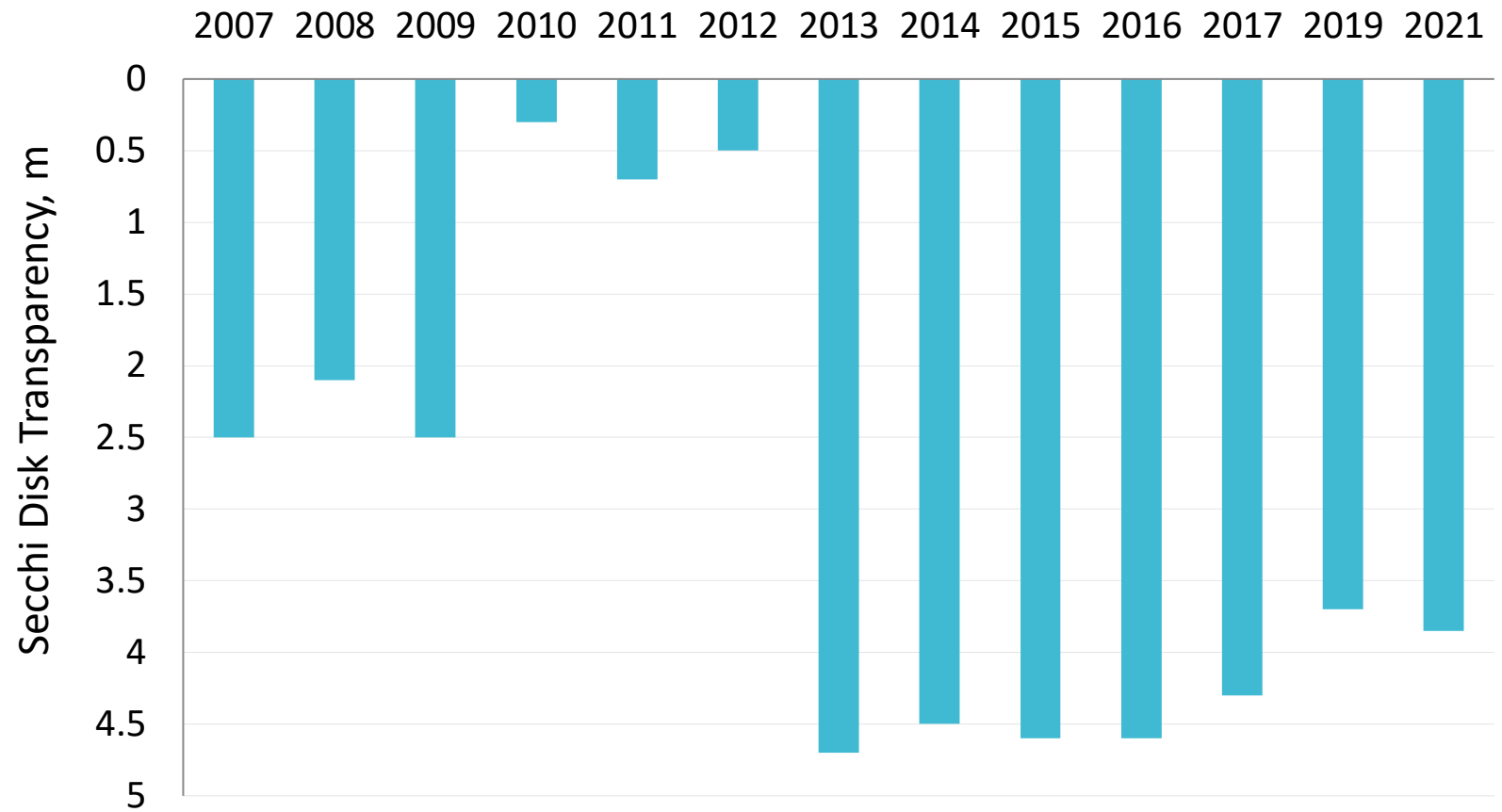
- Addresses the specific impairment
- Likelihood of success/track record on Cape Cod
- Duration of effectiveness (longevity)
- Relative cost, benefits, and risks
- Potential impacts on human & ecosystem health
- Outlook for permitting
- Community acceptance

# Priority Action: Alum Treatment Programs

	Treatment Area		Treatment Dose	
	Acres	% of Pond Sediment Area	g/m <sup>2</sup>	max, mg/L
Herring Pond (2012)	19.8	45.2%	75	5
Great Pond (2013)	27.7	25.1%	25	5

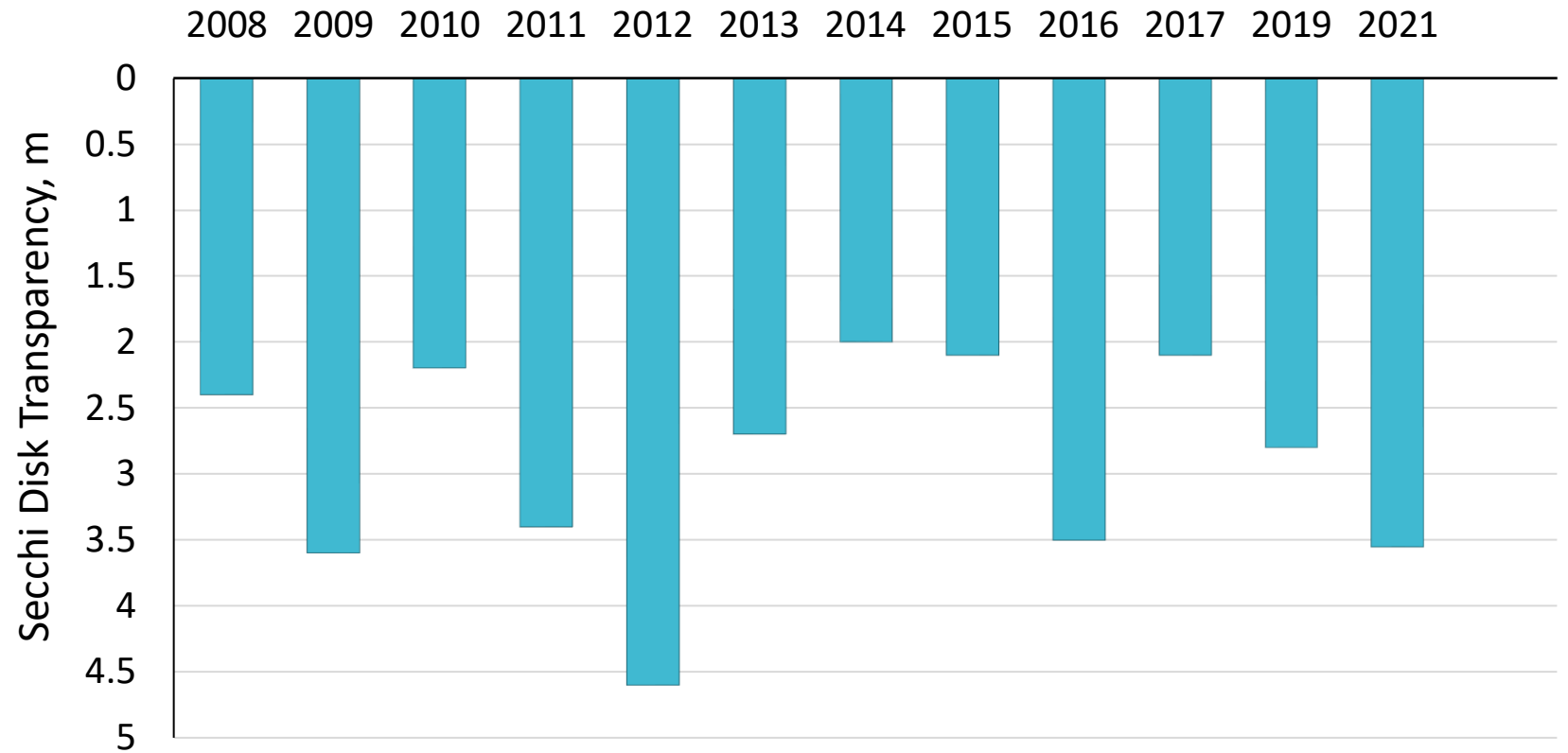
Herring Pond:  
response to  
alum  
treatment  
program in  
Fall 2012

# Herring Pond Water Clarity



Great Pond:  
response to  
alum  
treatment  
program in  
Fall 2013

Great Pond Water Clarity



# A Closer Look at the data...

Herring Pond	TP - upper (µg/L)	TP - lower (µg/L)	Minimum DO (mg/L)	Chlor-a (µg/L)	Secchi Disk (m)
2011-2012 (pre)	30.3	776.2	0.4	23.5	0.6
2013-2017 (post)	12.2	20.1	1.5	2.0	4.4
2018-2021	12.04	33.71	4.21	5.98	3.6
Great Pond	TP - upper (µg/L)	TP - lower (µg/L)	Minimum DO (mg/L)	Chlor-a (µg/L)	Secchi Disk (m)
2011-2013 (pre)	19.6	83.2	0.2	2.9	3.6
2014-2017 (post)	14.6	29.3	0.2	4.2	2.4
2018-2021	18.92	23.73	3.57	5.9	3.49

# Healthy Pond Criteria: 2018 - 2021

	Bridge	Depot	Great	Herring	Jemima	Little Depot	Minister	Schoolhouse	Moll
Dissolved Oxygen (>4 mg/L)	✓	✓	✓	✓	✓	✗	✓	✓	✓
Water Clarity (>2m)	✓	✓	✓	✓	✓	✗	✓	✗	✓
Phosphorus (<10 µg/L)	✗	✗	✗	✗	✗	✗	✗	✗	✗
Chlorophyll-a (<8 µg/L)	✓	✓	✓	✓	✓	✗	✓	✓	✓
<b>Count of “Healthy” Indicators (top score = 4)</b>	<b>3</b>	<b>3</b>	<b>3</b>	<b>3</b>	<b>3</b>	<b>0</b>	<b>3</b>	<b>2</b>	<b>3</b>

# Water Quality Trends

**2018**

Stable	Improving	Declining
Bridge	Herring	Depot
Great		Moll (HABs)
Jemima		Minister (macrophytes)
Little Depot		Schoolhouse (macrophytes)



**2021**

Stable	Improving	Declining
Depot		Bridge
Minister (macrophytes)		Jemima
Schoolhouse (macrophytes)		Little Depot
Great		Moll (HABs)
Herring *		

# Impaired Waters

2016 Impaired Waters		2018-2020 Impaired Waters	
Category 2: Unassessed	Herring Pond	Category 2: Unassessed	Herring Pond
	Depot Pond	Category 4c: Impairment not caused by pollutant, TMDL not required	Depot Pond: <ul style="list-style-type: none"> <li>Fish passage barrier</li> </ul>
Category 5: TMDL Required	Great Pond: <ul style="list-style-type: none"> <li>Elevated Chlorophyll-a, Total P</li> <li>Low Dissolved Oxygen</li> </ul>	Category 5: TMDL Required	Great Pond: <ul style="list-style-type: none"> <li>Elevated Chlorophyll-a, Total P</li> <li>Low Dissolved Oxygen</li> </ul>
	Moll Pond: <ul style="list-style-type: none"> <li>Harmful Algal Blooms</li> </ul>		Moll Pond: <ul style="list-style-type: none"> <li>Harmful Algal Blooms</li> </ul>

# Updated Criteria to Prioritize Remedial Measures

Criteria	1	2	3
<b>Algal Abundance</b>	Avg. Chlorophyll <8 µg/L	Avg. Chlorophyll 8 – 15 µg/L	Avg. Chlorophyll >15 µg/L
<b>Regulatory Status</b>	Use Attainment	Threatened	303(d)- TMDL
<b>Projected Future</b>	Improving	Stable	Declining
<b>Ownership</b>	Private	Mix: private and public	Public
<b>Access</b>	None	Limited	Public beach or launch site
<b>Size</b>	Less than 5 acres	5 – 10 acres	Larger than 10 acres (a Great Pond)
<b>Prior Town Investment in Remediation</b>	Yes, within 5 years	Yes, within 10 years	None

# Updated Prioritization

<b>Pond</b>	<b>2011</b>	<b>2018</b>	<b>2021</b>
<b>Bridge</b>	<b>Low</b>	<b>Low</b>	<b>Medium</b>
<b>Depot</b>	<b>Medium</b>	<b>Medium-High</b>	<b>Low</b>
Little Depot	Medium	Medium	Medium
Great	High	Medium-303(d)	Medium-303(d)
<b>Herring</b>	<b>High</b>	<b>Low</b>	<b>Medium</b>
Jemima	Medium	Medium	Medium
<b>Minister</b>	<b>High</b>	<b>High</b>	<b>Low</b>
<b>Schoolhouse</b>	<b>High</b>	<b>High</b>	<b>Low</b>
Moll	Low	Medium-303(d)	Medium-303(d)
Muddy (2015)	Medium	Medium	Medium
Widow Harding (2017)	Low	Low	Low

# Remedial Measures

Technique	Suitability	Consider For
Alum treatment program	Stratified ponds, excessive algae, internal P a major component of budget, iron-rich sediments	<ul style="list-style-type: none"><li>• Minister?</li><li>• Schoolhouse?</li><li>• Depot</li></ul>
Oxygenation/Aeration	Small ponds with transient DO depletion, excessive algae	<ul style="list-style-type: none"><li>• Little Depot</li><li>• Minister</li><li>• Schoolhouse</li></ul>
Watershed BMPs	Ponds affected by development	<ul style="list-style-type: none"><li>• All ponds</li></ul>
Dredging/Hydroraking (nearshore areas)	Ponds impaired by loss of depth, emergent vegetation	<ul style="list-style-type: none"><li>• Minister</li><li>• Schoolhouse</li></ul>

# Status Update: Minister/Schoolhouse Remedial Measures

# 2017 SŌLitude Program

- Plant survey (June 7, 2017) - 17 species, all native
- Water quality survey (2 locations, upper waters of deep basins)- consistent with previous findings
- Detected stands of invasive *Phragmites*

# 2018 SŌLitude Program

- Continued monitoring to understand nutrient dynamics
  - Water quality monitoring, both basins, 2 depths
  - Macrophyte survey later in the season
- Treated shoreline *Phragmites*
- Tested bottom sediments for forms and concentration of phosphorus
- Estimated macrophyte rooting depth

# 2018 SŌLitude Findings

- Narrow littoral zone supports nuisance levels of native macrophytes, interfering with recreational access
- Elevated chlorophyll-a concentrations diminish aesthetic appeal
- Relatively shallow organic layer overlies sandy bottom; macrophyte rooting depth restricted to upper 4 – 6 inches
- Sediments contain low to moderate concentrations of available P

# 2020 SŌLitude Program

- Hydroraking and aeration done in 2020 in both basins

# 2021 SŌLitude Program

- Water quality monitoring (both basin, two depths)
- Sediments tested for phosphorus

# Sediment Phosphorus and Chemical Forms

Pond	Total P (mg/kg dry)	Iron-bound P (mg/kg dry)
Minister (2018)- deep	989	185
Schoolhouse (2018)- deep	2,202	408
Minister (2021)- deep	1,270	86
Schoolhouse (2021)- deep	1,250	138
Great (2013)	14,717	20
Herring (2012)	74,233	789

# SŌLitude Recommendations

- Current Actions:
  - Hydroraking to address excessive macrophytes
  - Aeration to address oxygen depletion
  - Continued surveillance and treatment of *Phragmites*
- Future Phases:
  - Expand hydroraking program
  - Possible alum treatment program to address sediment phosphorus flux (sediment testing completed)

# Schoolhouse-Ministers Pond: Nature-Based Stormwater Management



The screenshot shows a video player with a title card that reads "Town of Eastham Schoolhouse Minister's Pond Stormwater Project". The video content shows a pond with a fence in the foreground and trees in the background. Below the video player, the title "Schoolhouse Minister's Pond Road Runoff Project 8/17/22" is displayed, along with a "NOT YET RATED" badge, a "1 day ago" timestamp, and a "Town of Eastham" profile with a "Follow" button. At the bottom of the player, there are icons for play, heart, comment, and share, along with "Download" and "Share" buttons. To the right of the video player, there is a "More from Town of Eastham" section with a toggle for "Autoplay next video" and two video thumbnails: "Schoolhouse Mini..." and "Nauset Marsh Stu...".

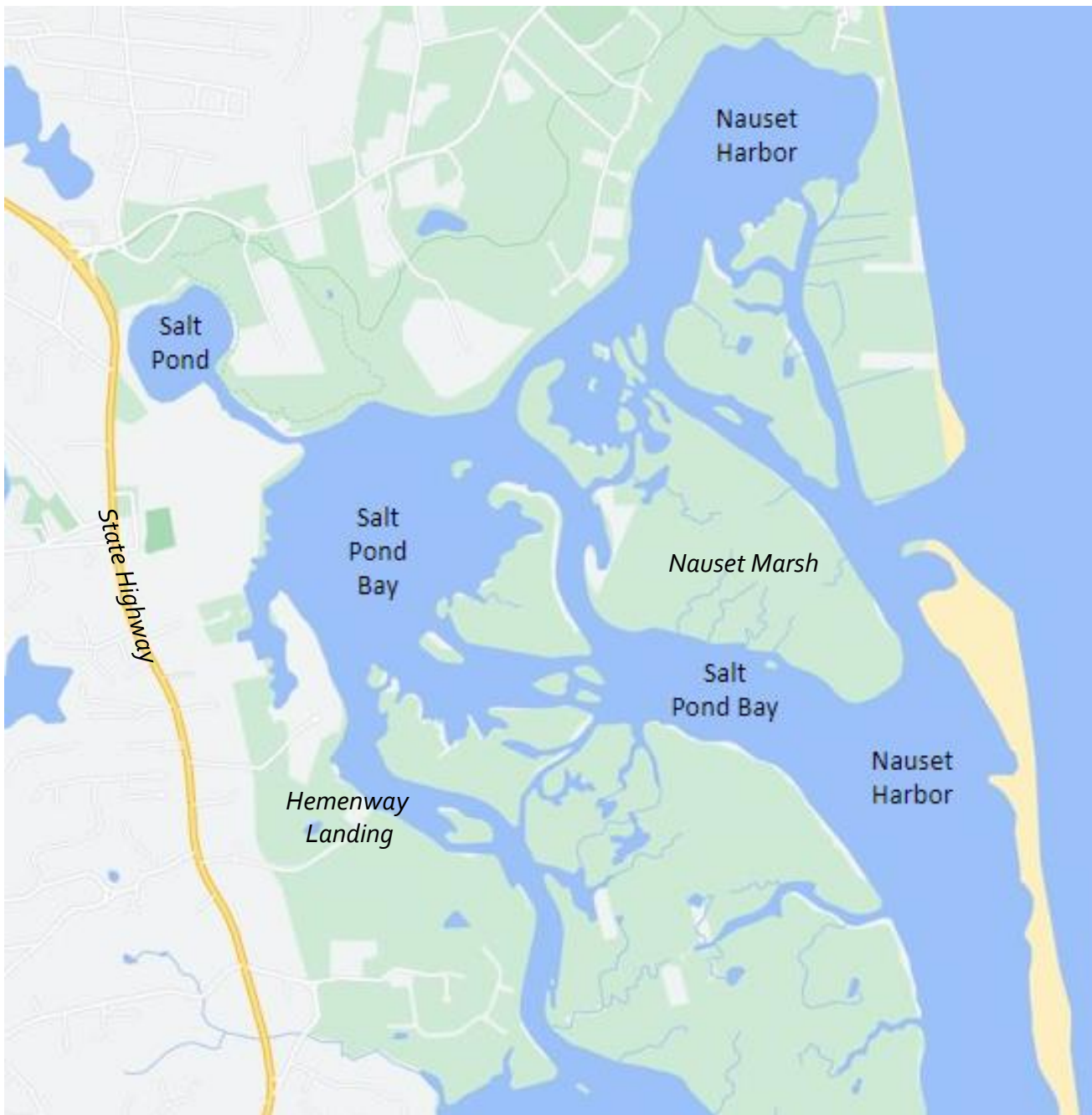
<https://vimeo.com/741967644>

# Status Update: Salt Pond

# Nitrogen TMDL for Nauset Estuary

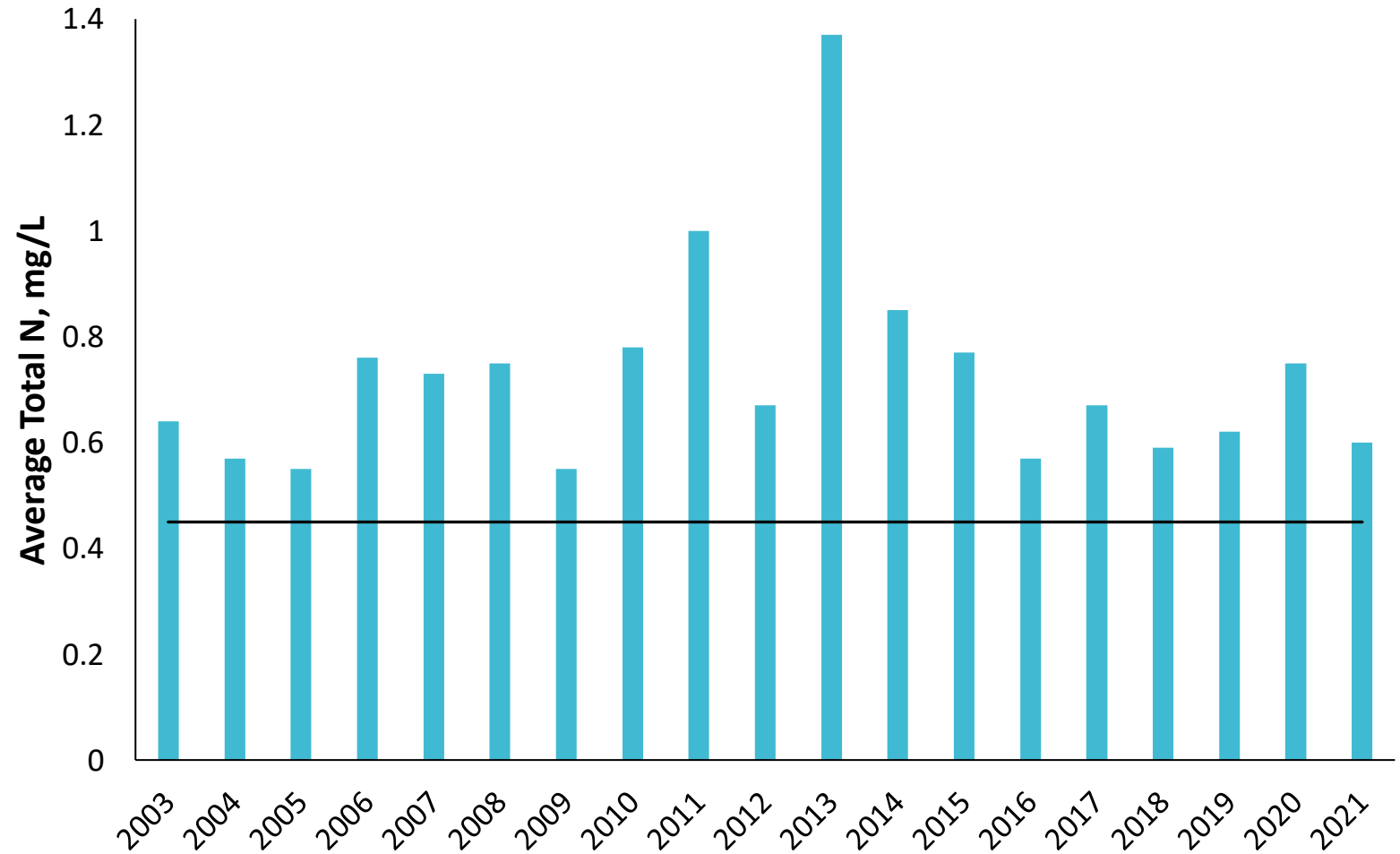
- Restoration goal: eelgrass bed expansion
- Eelgrass present when Total N less than 0.45 mg/L
- MEP model estimated the current N load, the N load to achieve 0.45 mg/L, and allocated load reductions across sources (Total Maximum Daily Load (TMDL))
- Salt Pond in Eastham is among the sentinel monitoring stations for Nauset (Site 038)

# Nauset Estuary and Salt Pond

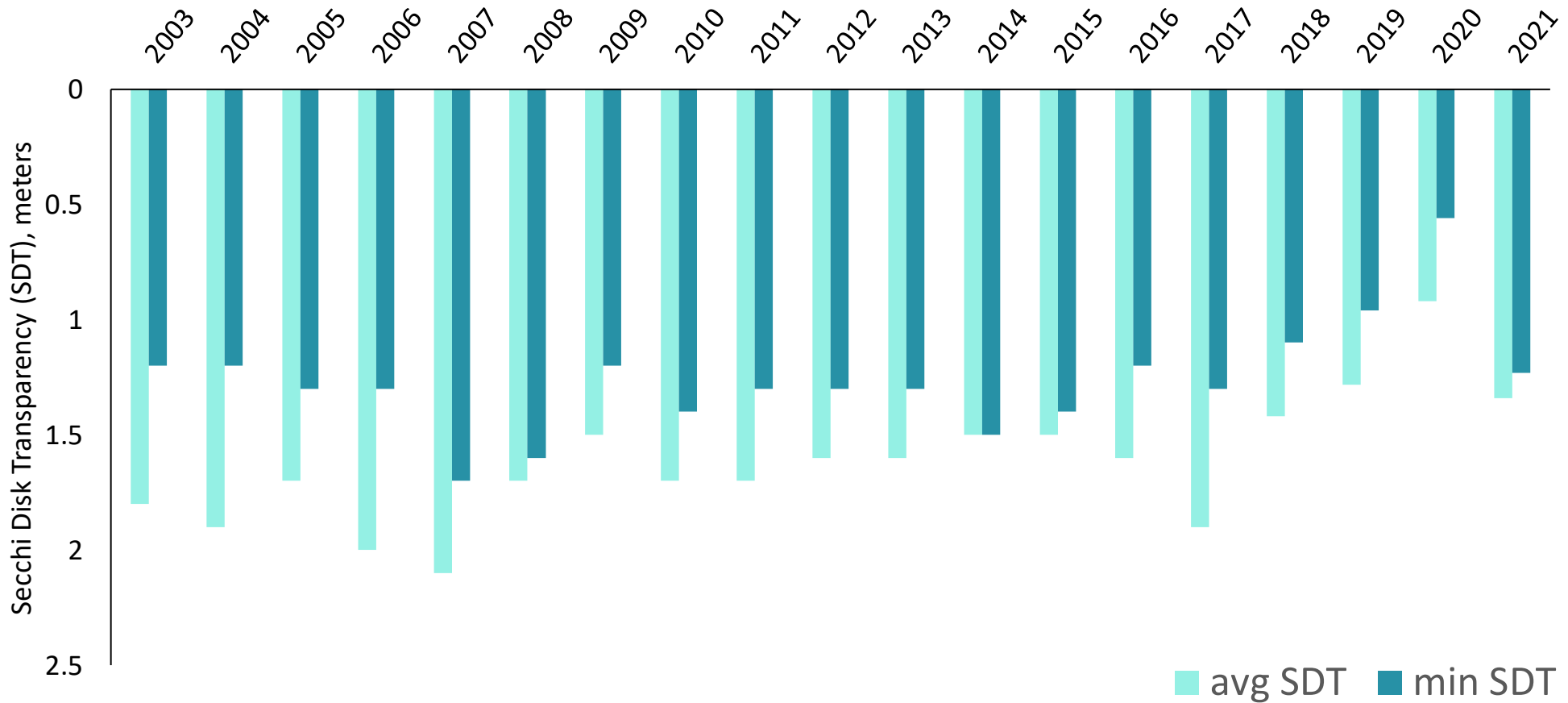


TMDL  
Nitrogen  
Target:  
0.45 mg/L

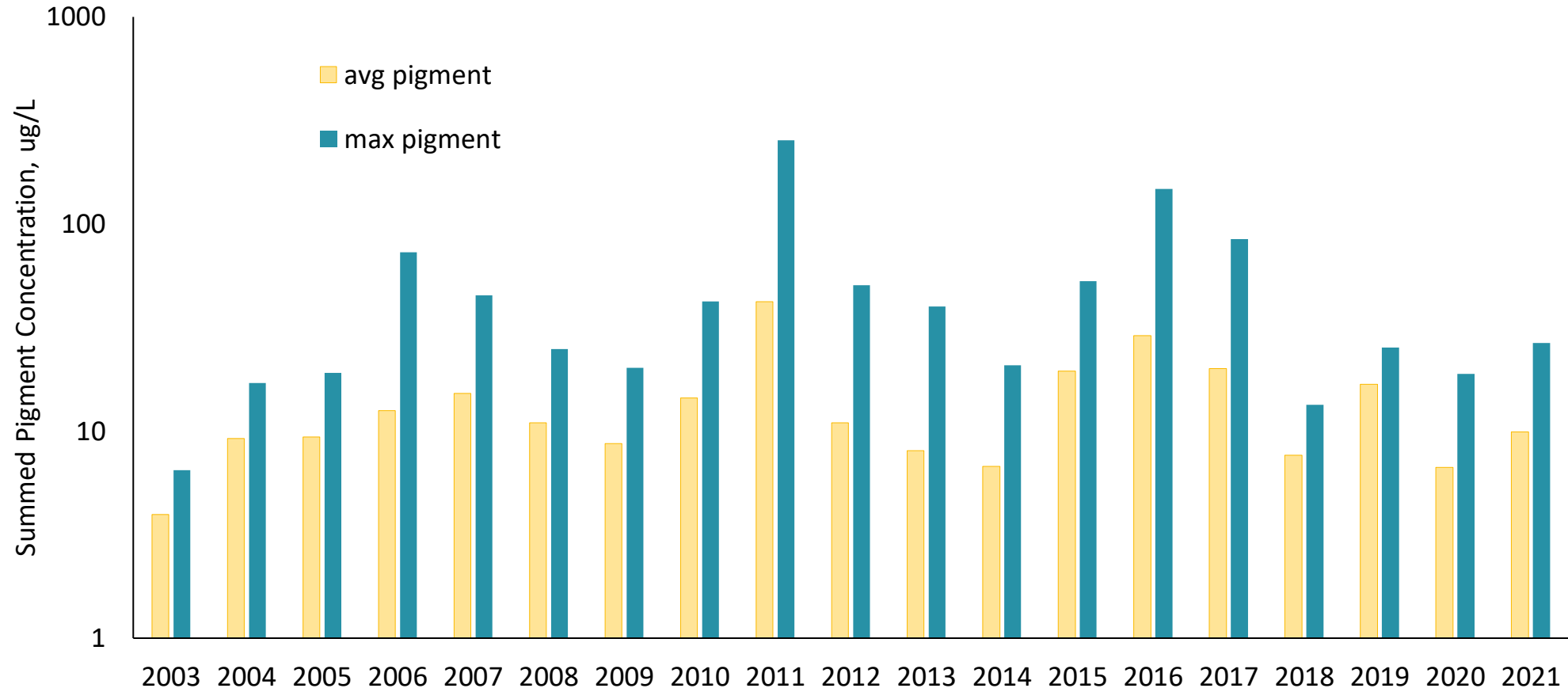
**Salt Pond: Total N Status**  
*Average Compared to Target*



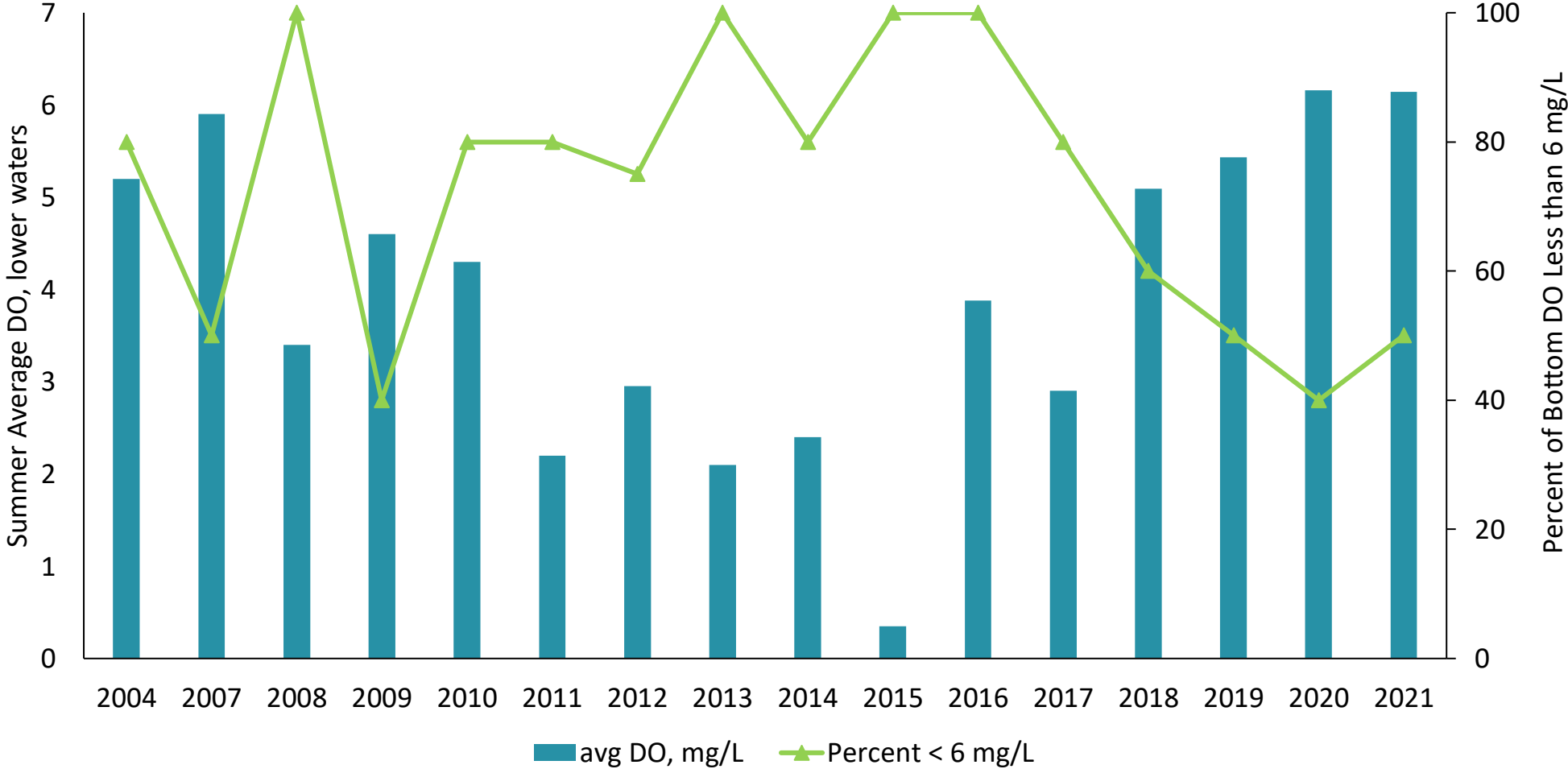
# Salt Pond: Water Quality Status



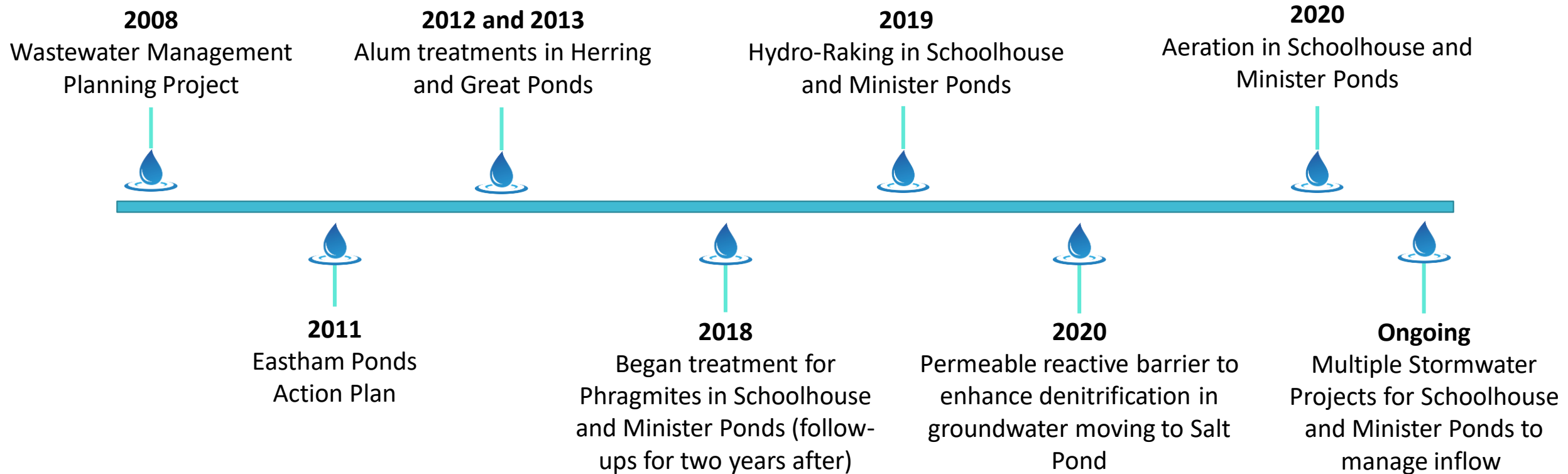
# Salt Pond: Algal Pigment Status



# Salt Pond: Deep Water Dissolved Oxygen Status



# Elements of the Wastewater Management Planning Project



# Discussion

