Overview Nutrient Management Plan & Harbor Water Quality

Nutrient Management Plan

- Purpose & Elements
- Monitoring Requirements/Parameters
- Permit and NMP Thresholds
- Baseline Comparisons/ Overview of Operational Results

Harbor

- Water Quality TMDL Regulation
- Harbor Dye Test
- Shellfishing & Aquaculture Impacts of Outfall Pipe

Nutrient Management Plan 2001

Purpose & Elements

- Monitor changes in the Eel River System & Review Baseline to Current Conditions
  - Groundwater
  - Surface water
  - Biological
- Protect the Eel River from nutrient impacts (land-use and WWTF impacts)
- Base Management Plan
  - Improving Water Quality
  - Source Best Management Practices
  - Land Acquisitions to protect watershed

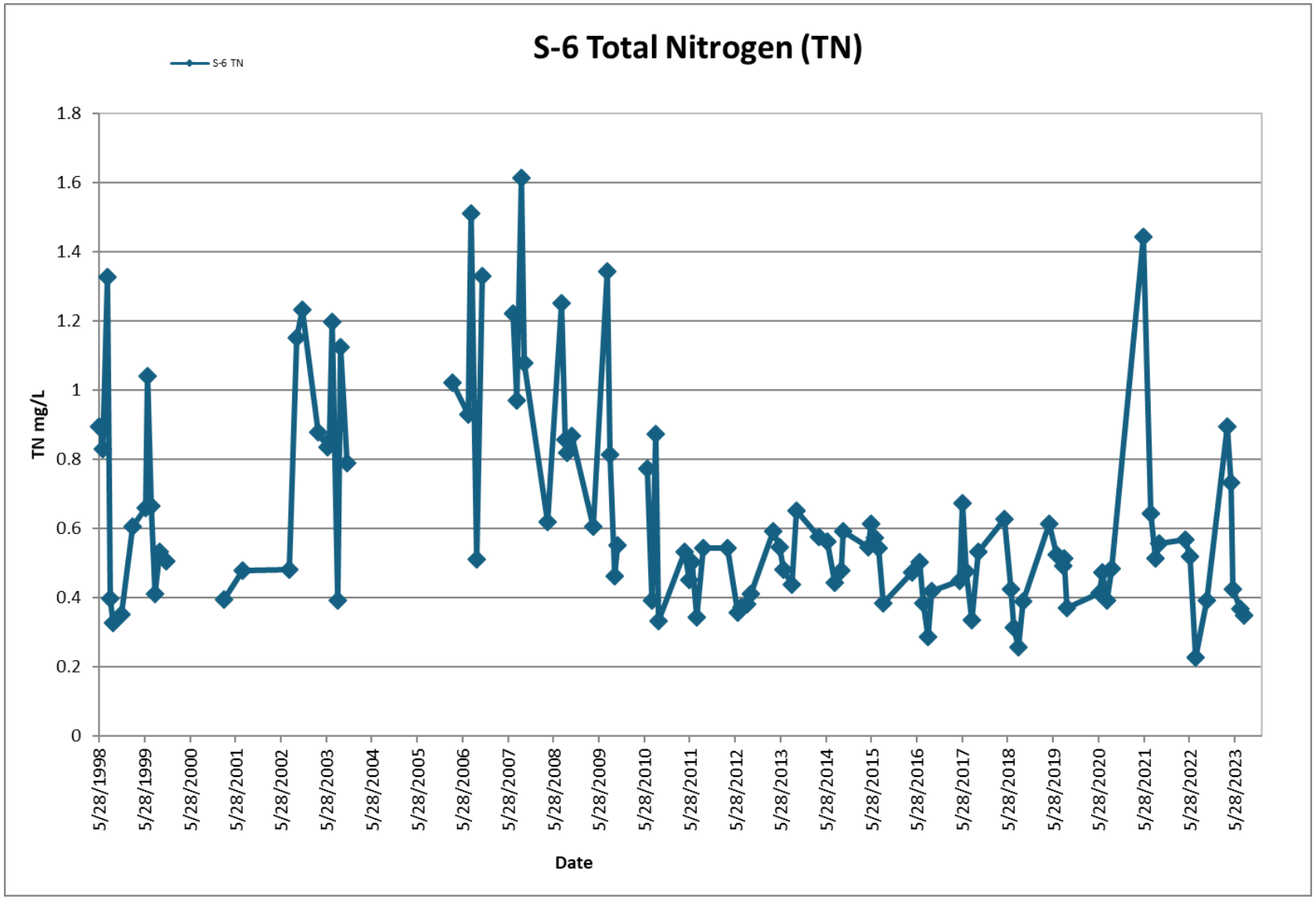
Open Space >450 acres protected during NMP

Invasive Removal @ Headwaters for Wetland Protection (ongoing)

Pinnacle Bog Restoration Project 21ac restore 51ac land (ongoing)

Eel River Headwaters Restoration Project

Nitrogen Decrease following Eel River Restoration & Dam Removal

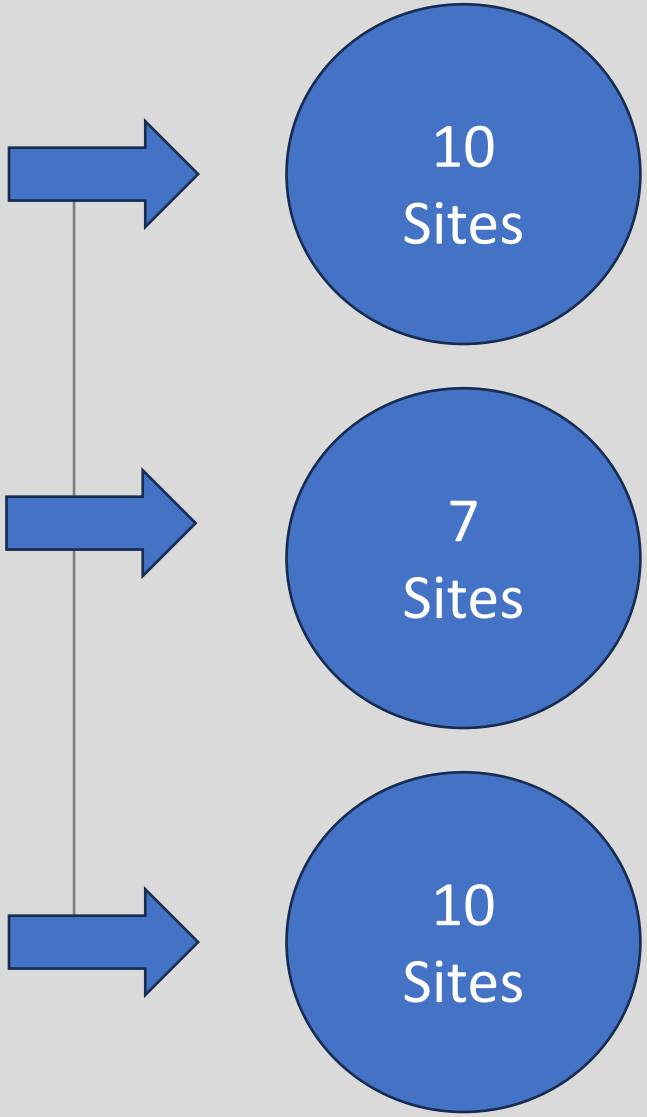


Monitoring

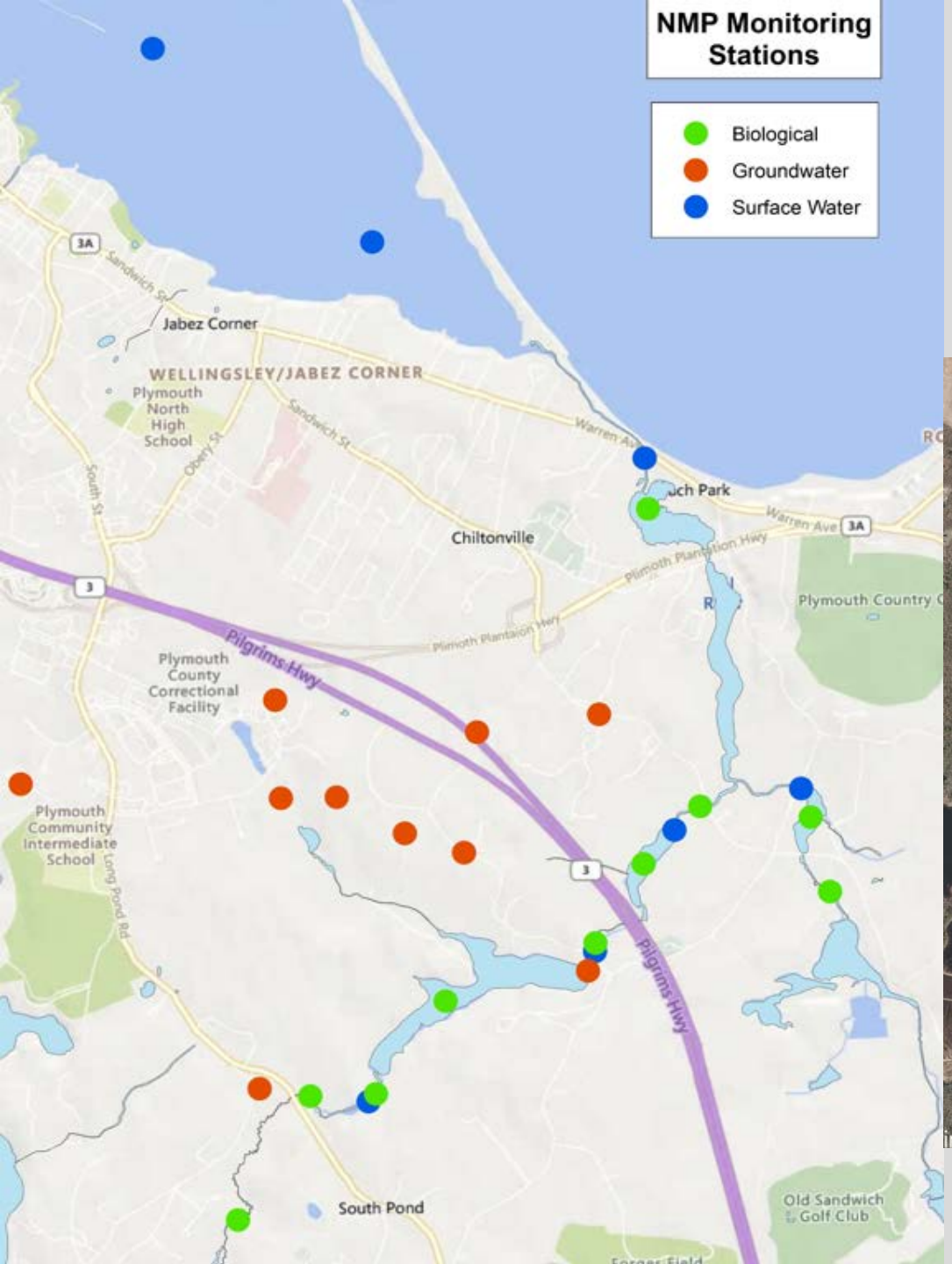
- Baseline /Interim Monitoring 1998-May 2002
- Operational Monitoring May 2002- current

Monitoring Requirements for NMP

- **Groundwater** monitoring wells (in addition to permit wells) **(2x/yr)**
- **Surface water** monitoring in the Eel River **(5x/yr)** and Plymouth Harbor **(2x/yr)**
- **Biological** Monitoring in the Eel River and Impoundments conducted by SMAST
  - Macroinvertebrate **(1x/yr)**
  - Periphyton **(2x/yr)**
  - Phytoplankton and Clarity **(2x/yr)**

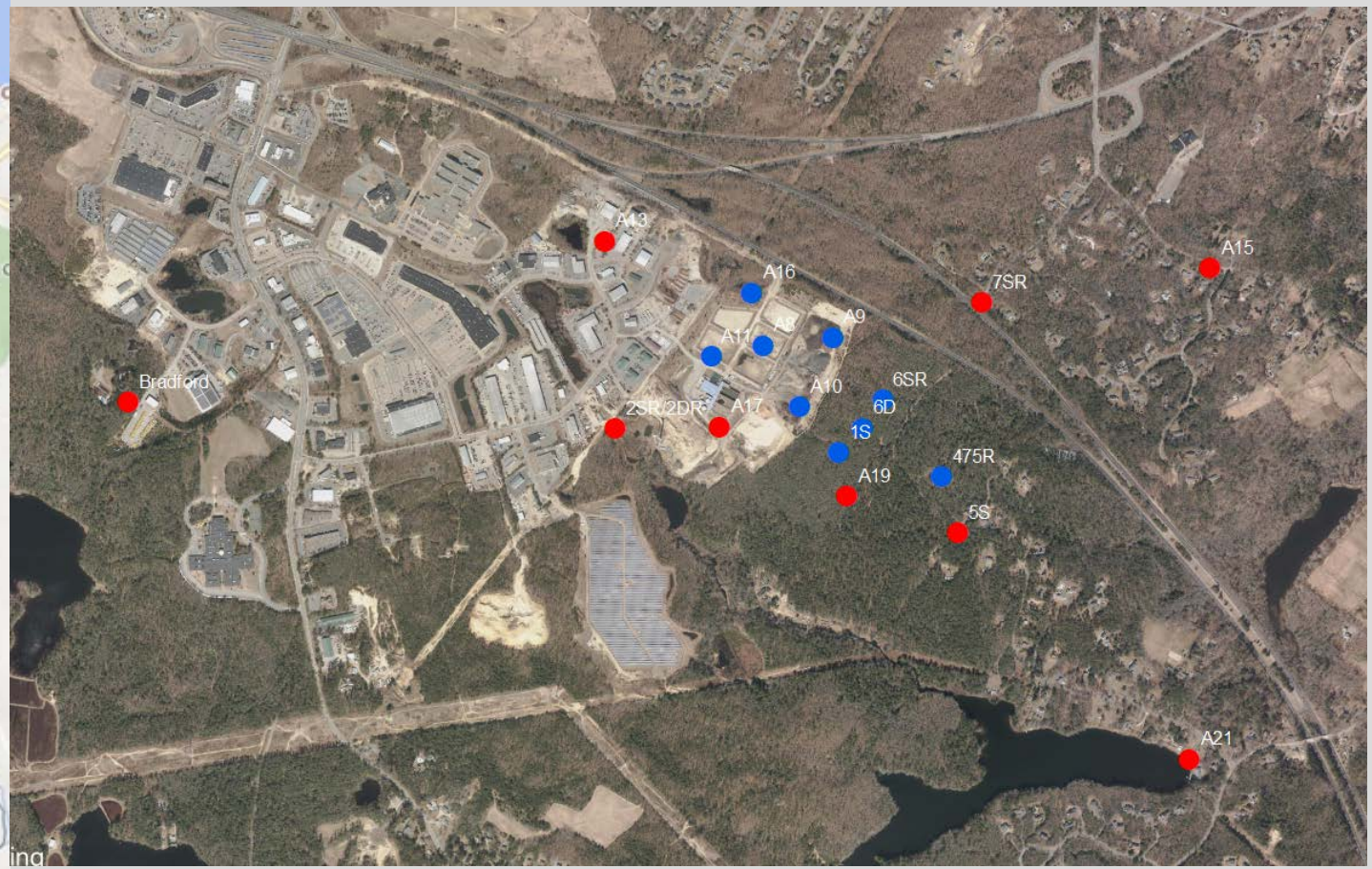


WWTF Monitoring Wells



Legend

- NMP Wells
- InnerOuter Wells



Monitored Parameters

Groundwater Monitoring

- Total Nitrogen (TKN, NO2, NO3)
- Ortho and Total Phosphorus
- Boron, Chloride, TDS
- VOC
- Water Levels

*Compare WWTF Monitored wells with NMP wells

Surface Water Monitoring

- Total Nitrogen (TKN, NO2, NO3)
- Ortho and Total Phosphorus
- Boron, Chloride, TDS
- Chlorophyll-a
- Biological Data Contracted - SMAST
  - Macroinvertebrate
  - Periphyton, Plankton, Macrophytes

Baselines and comparisons

Groundwater Permit Compliance Total Phosphorus Limits

Table 6

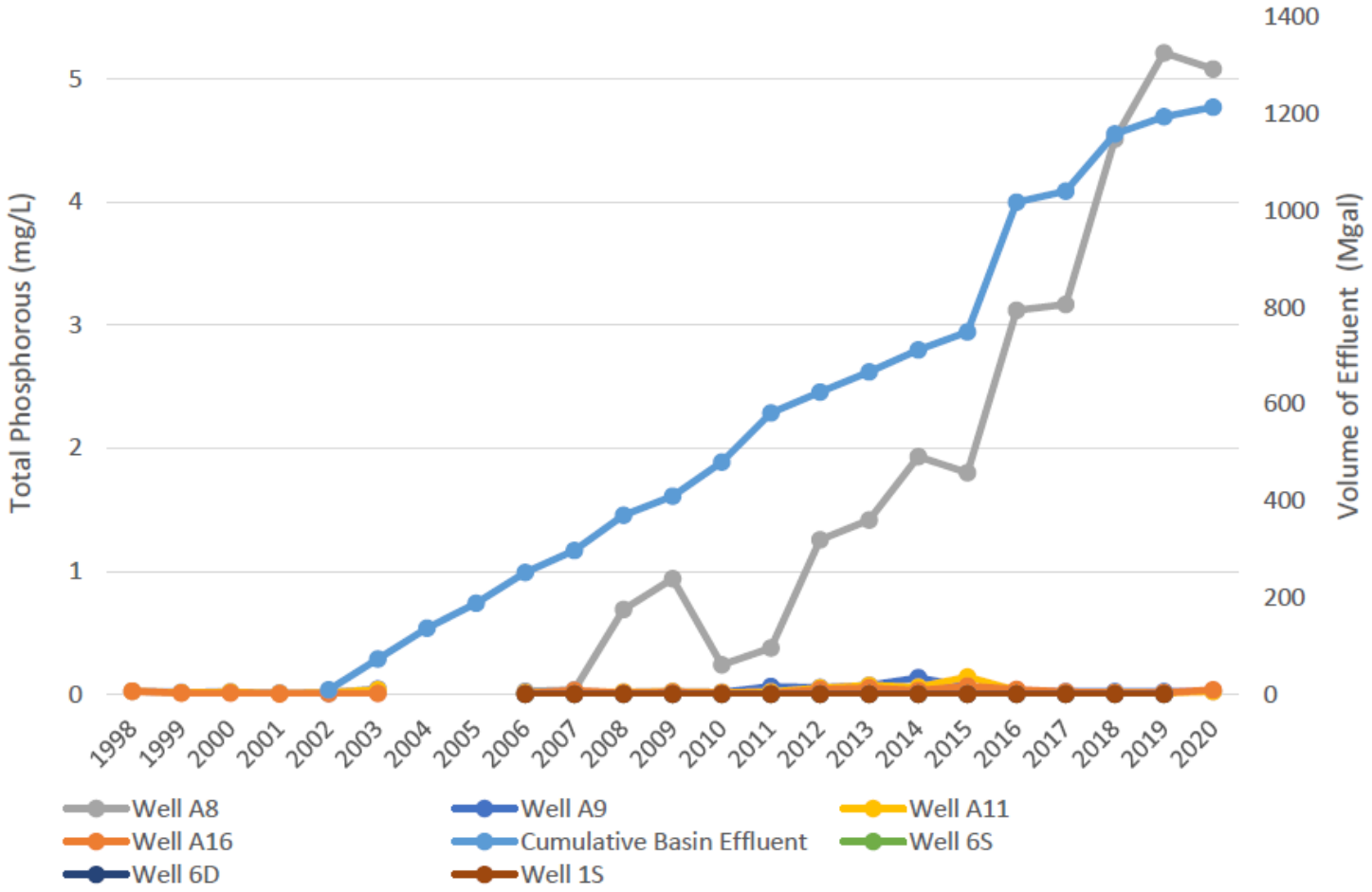
Groundwater Permit Compliance

Monitoring Group	*Wells*	*Permit Limit*
Adjacent Wells near WWTF site "inner wells"	A9, A10, A11, & A16	Any well >0.2mg/L of total phosphorus for either 3 consecutive months or 4 out of 6 consecutive months
Down-gradient Wells from WWTF site "outer wells"	1S,6SR,6D & USGS 475	Any well total phosphorus increase of >100% over established background concentrations for either 3 consecutive months or 4 out of 6 consecutive months. (Using all baseline data the average background concentration for these four outer wells is 0.07mg/L. The NMP Section 7.3 states 0.084mg/L through July 2001. Therefore an increase of 100% over the established background is 0.14mg/L)

TN, Boron, pH – monitor for groundwater inner/outer wells.

NMP Wells – Monitored and compared with baseline as well as inner/outer wells, surface water and biological and utilize thresholds

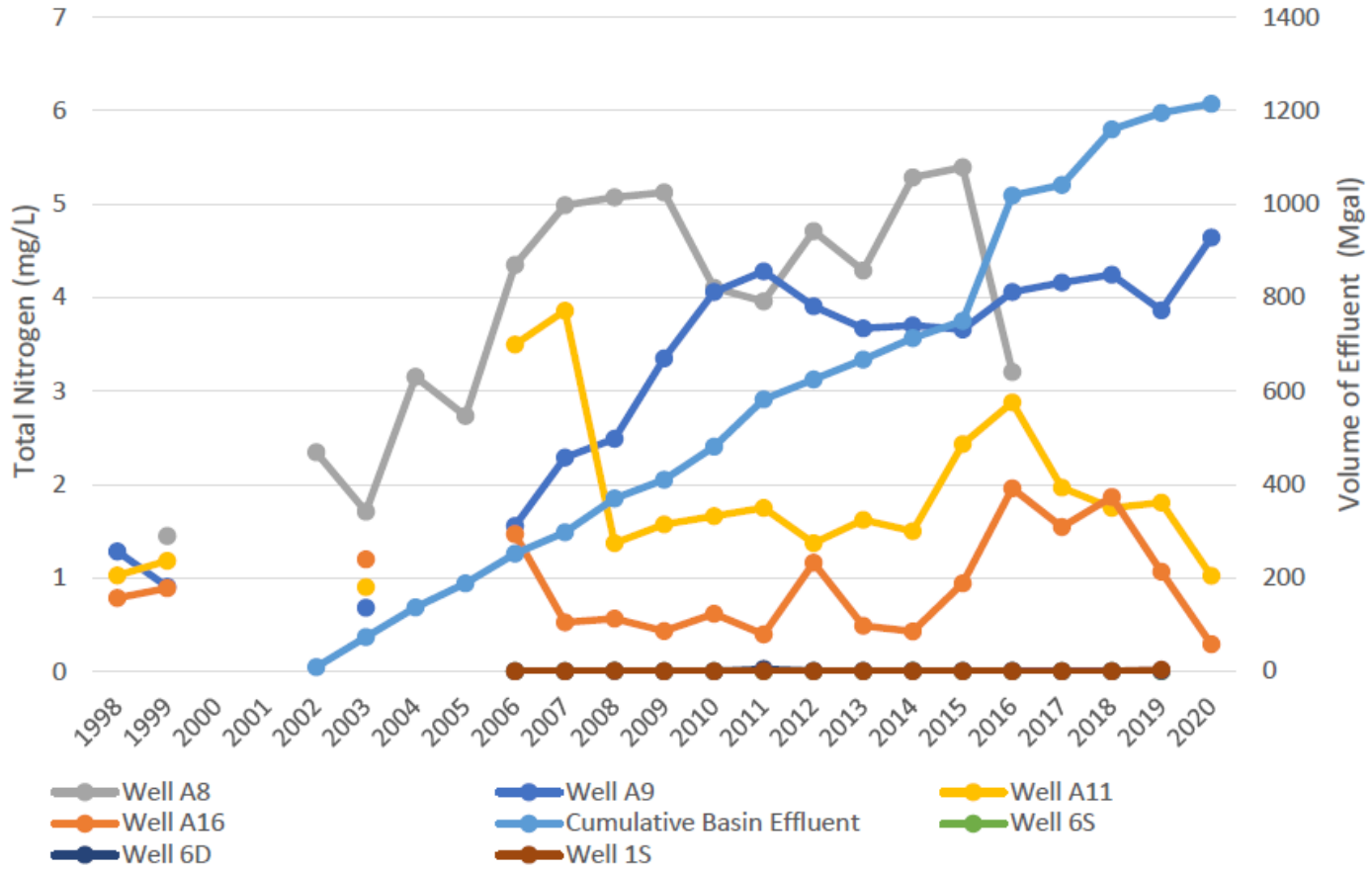
- Correlation between phosphorus concentrations at Well A8 (directly below beds) and the cumulative volume of effluent infiltrated on site.
- Groundwater at Well A8 appeared to increase significantly roughly around 2011, when approximately 600 million gallons had been released into sand beds since operation began in 2002.



Groundwater Sampling Phosphorus Data Analysis

Phosphorus concentrations – HW SLIDE

- Elevated nitrogen concentrations at groundwater wells close to the sand beds (Well A8, Well A9, Well 11, Well 16).
- Minimal correlation between nitrogen concentrations observed in the groundwater wells and the cumulative volume of effluent infiltrated on site.



Groundwater Sampling Nitrogen Data Analysis

Nitrogen concentrations – HW SLIDE

NMP Baselines and comparisons

Chemical Indicators for Surface Waters as Described in the NMP 2001

Table 2

Indicator	Relevance	Expected Change	Comparison Level	Evaluation	Action
Monitor					
Boron	Indicator of wastewater plume	Increase with no harm	Average baseline conditions	None	None
Monitor and Evaluate					
Total Nitrogen	Required nutrient for aquatic growth	Increase with no harm	Average Baseline Conditions	Check change in ecological indicators	See Recommended Actions
pH	Large changes may cause ecological shift	No change expected			
Monitor and Act					
Total Phosphorus	Limiting nutrient for aquatic growth	No increase expected	Concentrations exceed baseline average & 95% exceedance level ** for 2 months in one season	See Action	See Recommended Actions
Ecological Indicators					
Secchi Depth/ Turbidity	Measure of water clarity		Secchi depth <5% exceedance level for 2 months in one season	Evaluate parameters to determine whether several indicators have changed systematically together.	See Recommended Actions
Chlorophyll-a	Measure of algal abundance		Concentrations >95% exceedance level for 2 months in one season		
Macroinvertebrates (SC/CF ratio)	Indicates the dominant food source available		+/- 50% change in ratio over baseline		
Macrophytes (spatial	Habitat		+/- 25% change		

NMP Baselines and comparisons

Recommended Actions from NMP 2001

Table 3

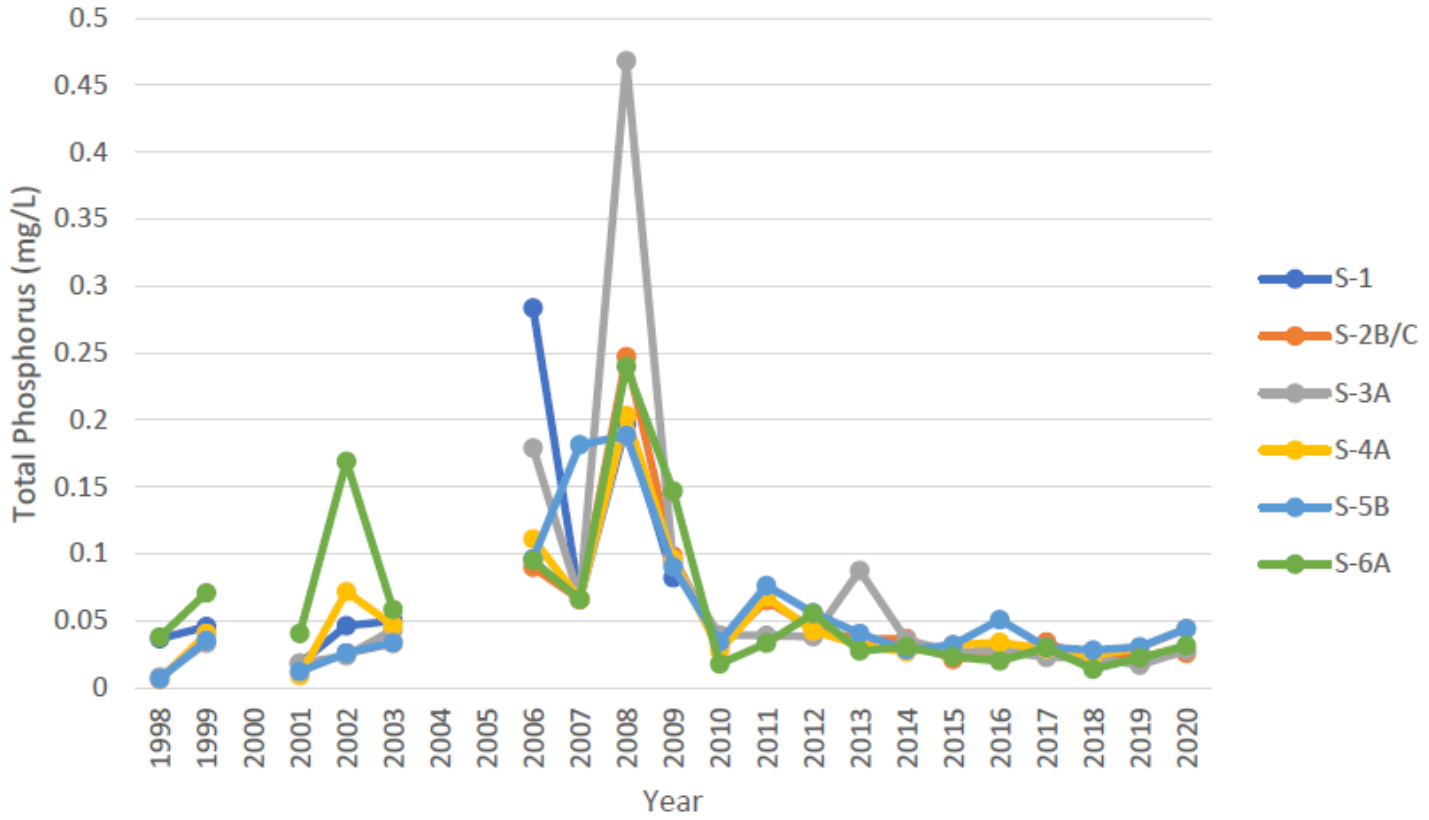
Indicator	Source	Available Actions
Total Phosphorus	WWTF	• Change Plant Operations • Upgrade plant to include phosphorus removal • Relocate discharge to Site 101
	Pinehills Development	Inform Pinehills Management of change
	Watershed	See Nutrient Management Plan – Possible Actions include: • Reduce P load from cranberry bogs and hatcheries • Identify and remediate failed septic systems • Limit use of fertilizers • Implement BMPs to reduce surface runoff
Total Nitrogen	WWTF	• Change Plant Operations • Upgrade nitrogen removal at plant • Relocate to Site 101
	Pinehills Development	Inform Pinehills Management of change
	Watershed	See NMP. Possible actions include: • Upgrade septic's to include nitrogen removal • Limit Use of fertilizers • Implement BMPs to reduce surface runoff
pH	WWTF	Upgrade pH adjustment at plant

NMP Surface Water Comparisons Exceedance Level/Baselines

Location	Parameter	*95 % Exceedance Baseline*	*Calculated Baseline (Pre-Operational)*	Operational Average thru 2022	2022 Average	Operational Average thru 2023	2023 Average	Operational Average thru 2024	2024 Average	
S-2	Total Nitrogen (TN) mg/L	*0.936*	*0.900*	0.556	0.413	0.561	0.664	0.569	0.711	
S-3	Total Nitrogen (TN) mg/L	*0.982*	*0.570*	0.626	0.516	0.629	0.697	0.636	0.766	
S-4	Total Nitrogen (TN) mg/L	*0.64*	*0.240*	0.604	0.441	0.639	1.267	0.643	0.735	
S-5	Total Nitrogen (TN) mg/L	*0.743*	*0.418*	0.601	0.664	0.600	0.589	0.608	0.770	
S-6	Total Nitrogen (TN) mg/L	*1.048*	*0.639*	0.642	0.427	0.637	0.553	0.644	0.760	
S-2	Total Phosphorus (TP) mg/L	*0.048*	*0.019 (NMP)* *0.131 (Re-calc)*	0.034	0.046	0.034	0.031	0.034	0.044	
S-3	Total Phosphorus (TP) mg/L	*0.073*	*0.025*	0.038	0.036	0.038	0.038	0.039	0.062	*June had high TP, otherwise 0.03
S-4	Total Phosphorus (TP) mg/L	*0.07*	*0.032*	0.040	0.031	**Excluded 2023 due to sig outliers	*0.14	0.041	0.0466	
S-5	Total Phosphorus (TP) mg/L	*0.075*	*0.027*	0.044	0.052	0.045	0.051	0.047	0.0924	*June had high TP, otherwise 0.05
S-6	Total Phosphorus (TP) mg/L	*0.084*	*0.054*	0.040	0.027	0.040	0.030	0.040	0.0468	*June had high TP, otherwise 0.02

S-4 Howland Pond outside of WWTF Impact

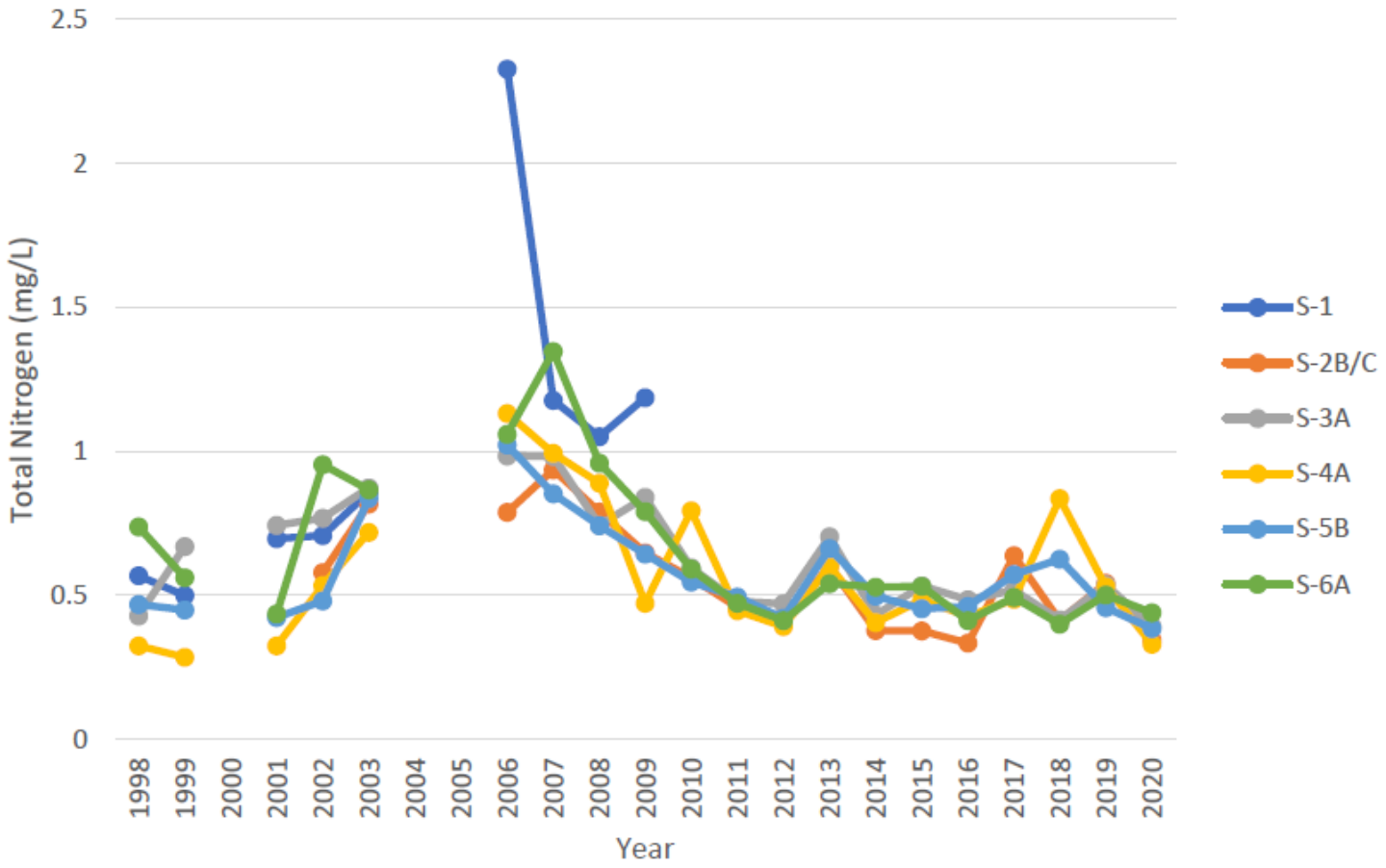
- The spike in 2006 is thought to be caused by the wetland clearing violation that occurred along Warren Wells Brook in 2006.
- The spike in 2008 is thought to be caused by algal blooms that were present when testing.
- Since 2010 phosphorus concentrations have remained around 0.04-0.06mg/L.



Surface Water Sampling Phosphorus Data Analysis

Phosphorus concentrations – HW SLIDE

- The spike in 2006 is thought to be caused by the wetland clearing violation that occurred along Warren Wells Brook in 2006.
- Nitrogen concentrations have remained somewhat constant, around 0.5mg/L from 2012-2020

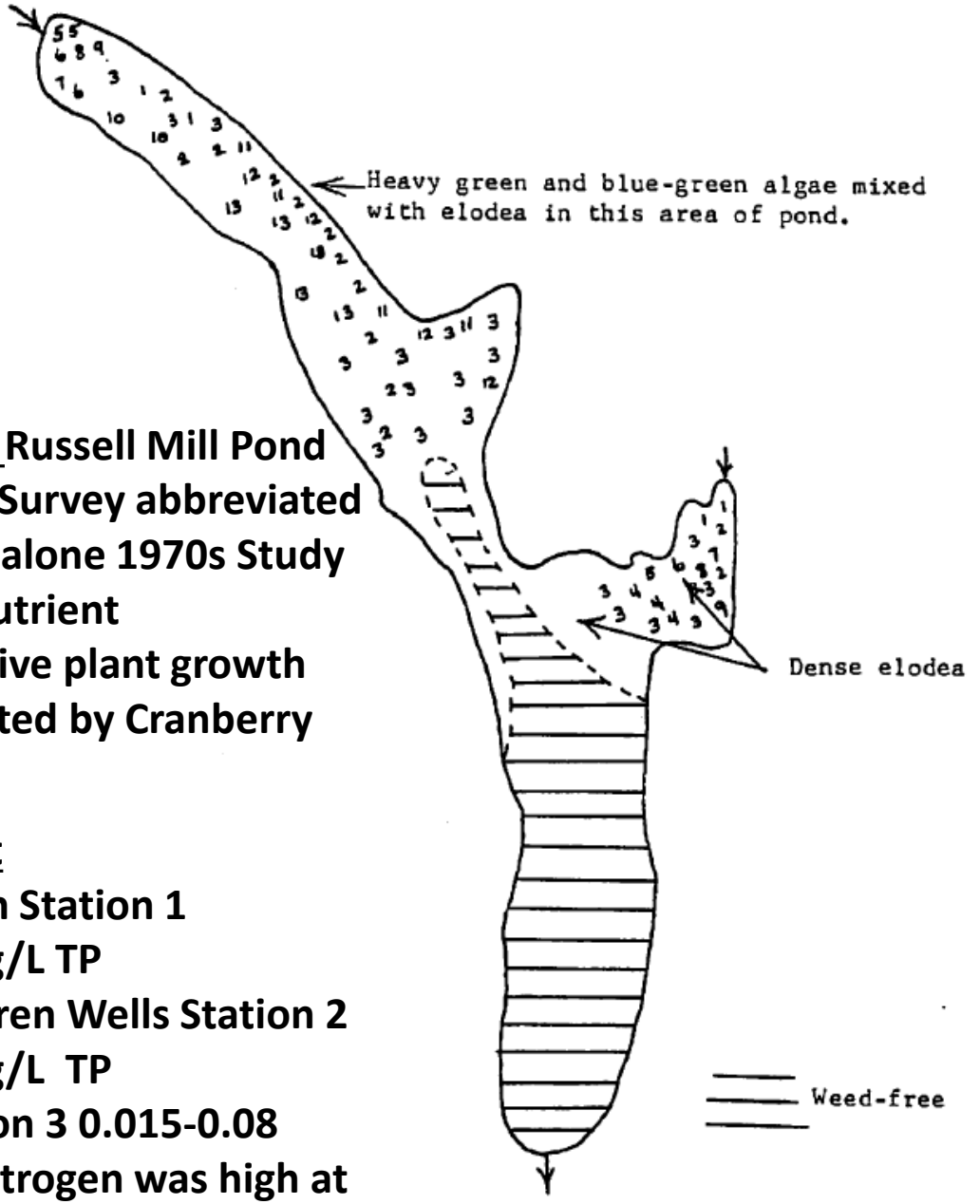


Surface Water Sampling Nitrogen Data Analysis

Nitrogen concentrations

Russell Mill Pond Water Quality Prior to Plant Operation

- 1970's Baseline Survey classified Russell Mill Pond as nutrient rich with heavy blue-green algae in northern section of pond
- Nutrient Management Plan 2001 indicates the highest levels of Total Phosphorus were in Russell Mill Pond, Upstream of Russell Mill Pond and downstream of Warren Wells Brook prior to entering Russell Mill Pond.



<u>1970's Studies -</u> Russell Mill Pond Vol 5 –Baseline Survey abbreviated version & Standalone 1970s Study

- **Eutrophic (nutrient rich/productive plant growth heavily affected by Cranberry Bog**

<u>1970's Nutrient</u>

- **u/s northern Station 1**
- **0.08-0.14mg/L TP**
- **Output Warren Wells Station 2 0.02-0.09mg/L TP**
- **Outlet Station 3 0.015-0.08 mg/L TP *Nitrogen was high at or above 1mg/L**

WWTF Impacts to Eel River

Groundwater Wells

- Inner/Outer Wells not near exceedance for WWTF for TP
- To date no increase in TP in inner/outer wells nor NMP Wells correlated to WWTF
- To date no correlation of TN increases from WWTF. 1S/6S decreased in 2024

Eel River

- Surface water data has seasonal and/or occasional fluctuations based on watershed/climatic not WWTF
- Surface water nutrient data under exceedance levels/triggers and at/below or near baseline conditions
- Biological Data not impacted by WWTF
- Headwaters Site S-6 significant reduction in TN since Restoration and Dam Removal

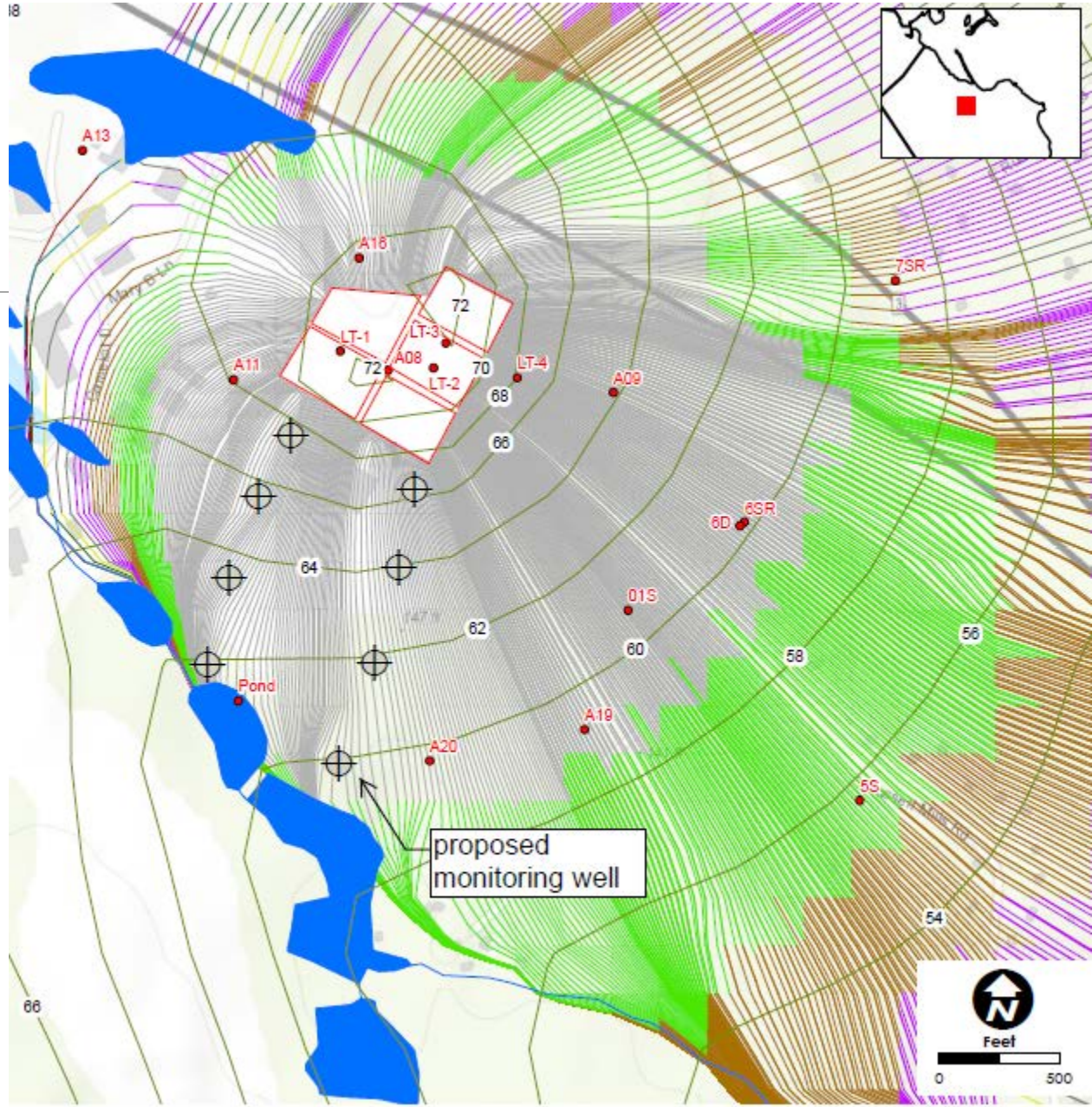
Mitigation Measures

CURRENT (TO REMAIN IN PLACE)

- Nutrient Management Plan and Eel River Watershed Monitoring Program
  - Consistent monitoring of groundwater, surface waters, and biological indicators.
  - Annual report summarizing data.
  - WWTF Monthly Monitoring – Wells/Influent/Effluent reported to DEP

PROPOSED

- Eight additional monitoring well to better assess the potential for phosphorus migration to Warren Wells Brook.
- Proposed Tertiary Treatment Implementation at WWTF
- *Possible Permeable Reactive Barriers at WWTF or in Eel River for Nitrogen and Phosphorus*
- Replacement or relocation of private septic as necessary.



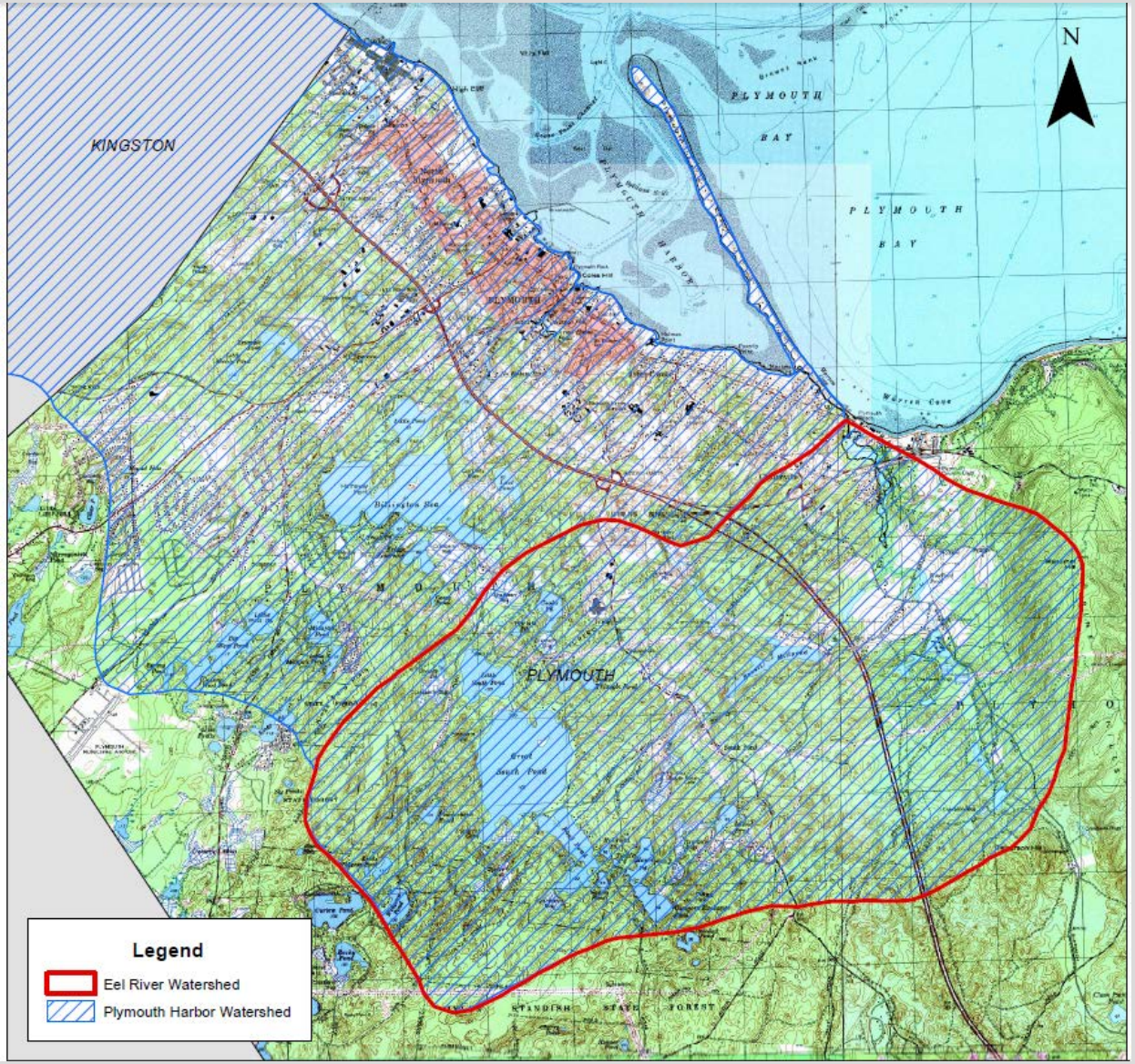
Plymouth Harbor

Plymouth Harbor

- **Total Maximum Daily Load**
- **Outfall Pipe – Dye Study**
- **Outfall Pipe – Shellfish / Aquaculture Impacts**

Total Maximum Daily Load – forthcoming regulation by DEP

- Draft Plymouth-Kingston-Duxbury Embayment System Modeling completed 2011
- DEP concerns regarding embayment system and nitrogen loading
- WWTF outfall pipe highest load for Town of Plymouth
- Under review and nearing regulatory implementation by DEP
- **2022 DEP initiated implementation of Denitrification Systems for Private Septic's in the entire Plymouth Harbor Watershed. This was put on hold in 2023 and only implemented on Cape Cod. Potentially forthcoming.**



Aquaculture and Wastewater Treatment

- June 2018 FDA conducted a hydrographic dye study. At that time the 3 bays system produced approximately $8M in oyster landings.
- MA DMF is required to meet National Shellfish Sanitation Program (NSSP) requirements when classifying growing areas.
- MA is a member of the Interstate Shellfish Sanitation Conference (ISSC)
- Review and analysis of the dye study results, and FDA recommendations resulted in: Expanded prohibited zone around outfall pipe and other waters downgraded to conditionally approved. Area along PLB closed.
- No European market – requires shellfish to be from Approved areas only.
- Concerns: Potential impacts from WWTF to other communities and their aquaculture programs.

MarineFisheries
Commonwealth of Massachusetts

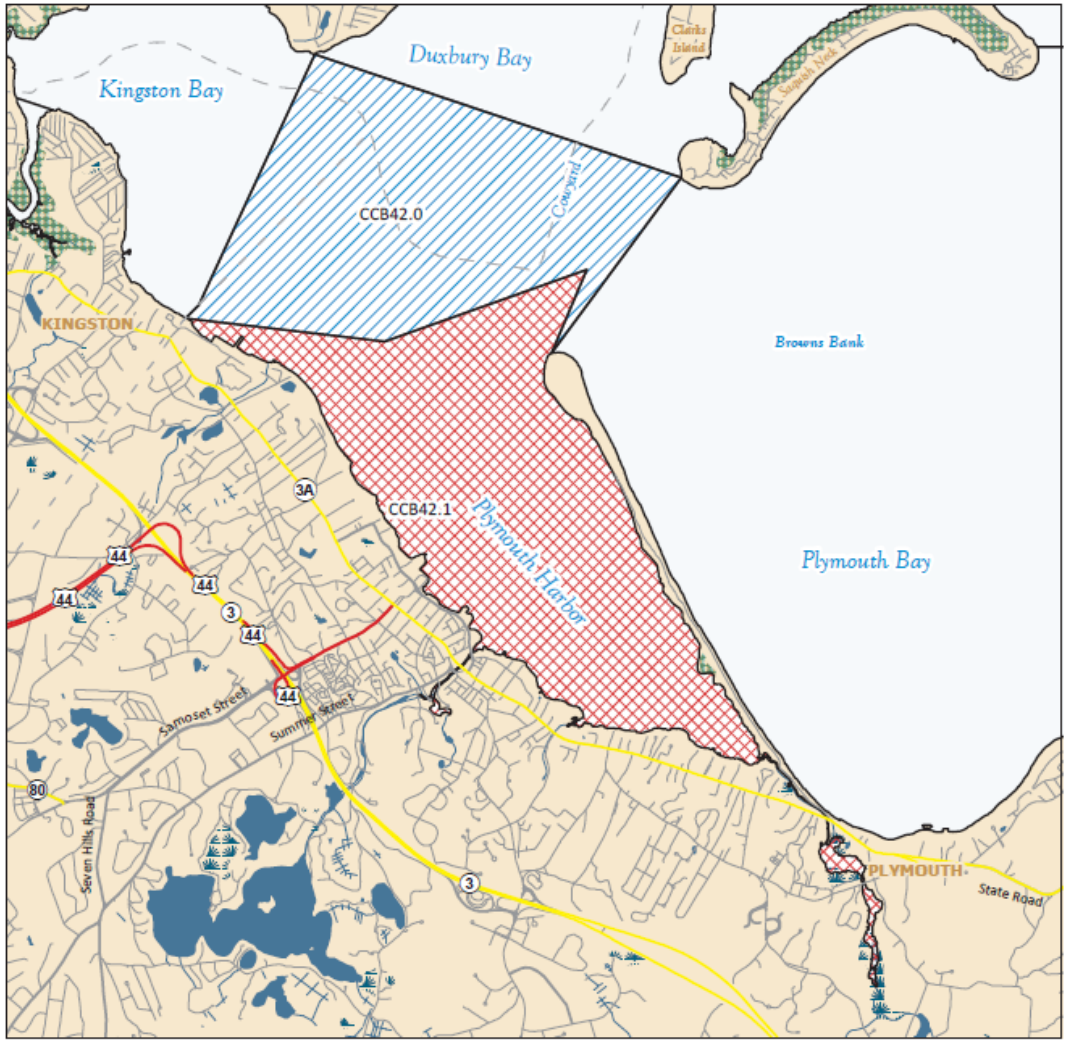
Massachusetts
Division of Marine Fisheries
SHELLFISH SANITATION AND MANAGEMENT

Growing Area Code: CCB42
Area Name: PLYMOUTH HARBOR
Area Town(s): Duxbury, Kingston, Plymouth

Shellfish Area Classification

- Approved
- Conditionally Approved
- Restricted
- Conditionally Restricted
- Prohibited

Produced: 5/21/2021



This map depicts the MarineFisheries' sanitary classification of shellfish growing waters in accordance with the National Shellfish Sanitation Program. It does not indicate the current status, either "open" or "closed" to harvesting due to shellfish management or public health reasons. Always confirm the status with local authorities and/or MarineFisheries. Information on this map may be out-dated or otherwise incorrect, and should not be relied upon for legal purposes.

Marsh/Wetland · Saltmarsh · Pond/Lake/Reservoir
Town Boundaries · Stream/Ditch/Canal

NORTH 0 0.5 1 miles

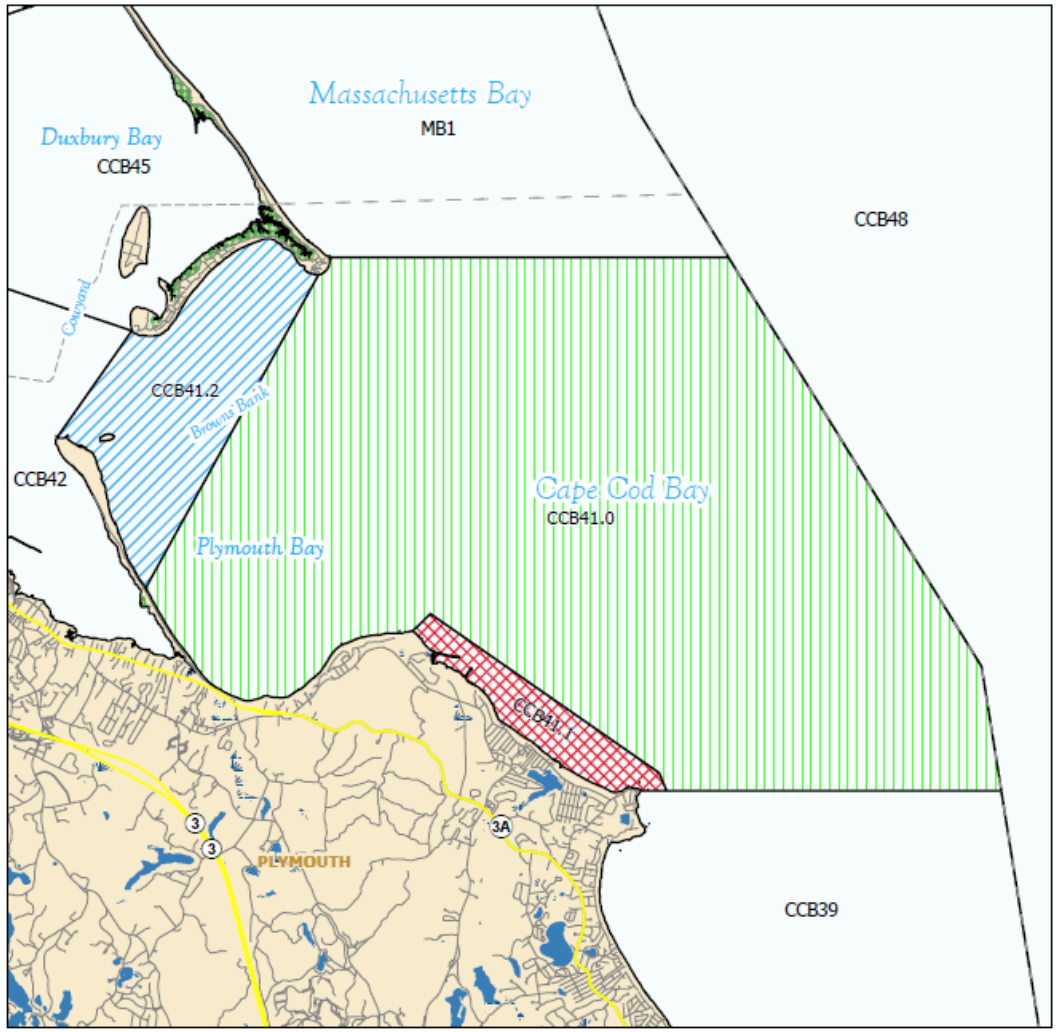
Massachusetts
Division of Marine Fisheries
SHELLFISH SANITATION AND MANAGEMENT

Growing Area Code: CCB41
Area Name: Plymouth North Coastal
Area Town(s): Plymouth

Shellfish Area Classification

- Approved
- Conditionally Approved
- Restricted
- Conditionally Restricted
- Prohibited

Produced: 10/10/2024



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