

Upper Bay Monitoring Initiatives and Water Quality Improvements

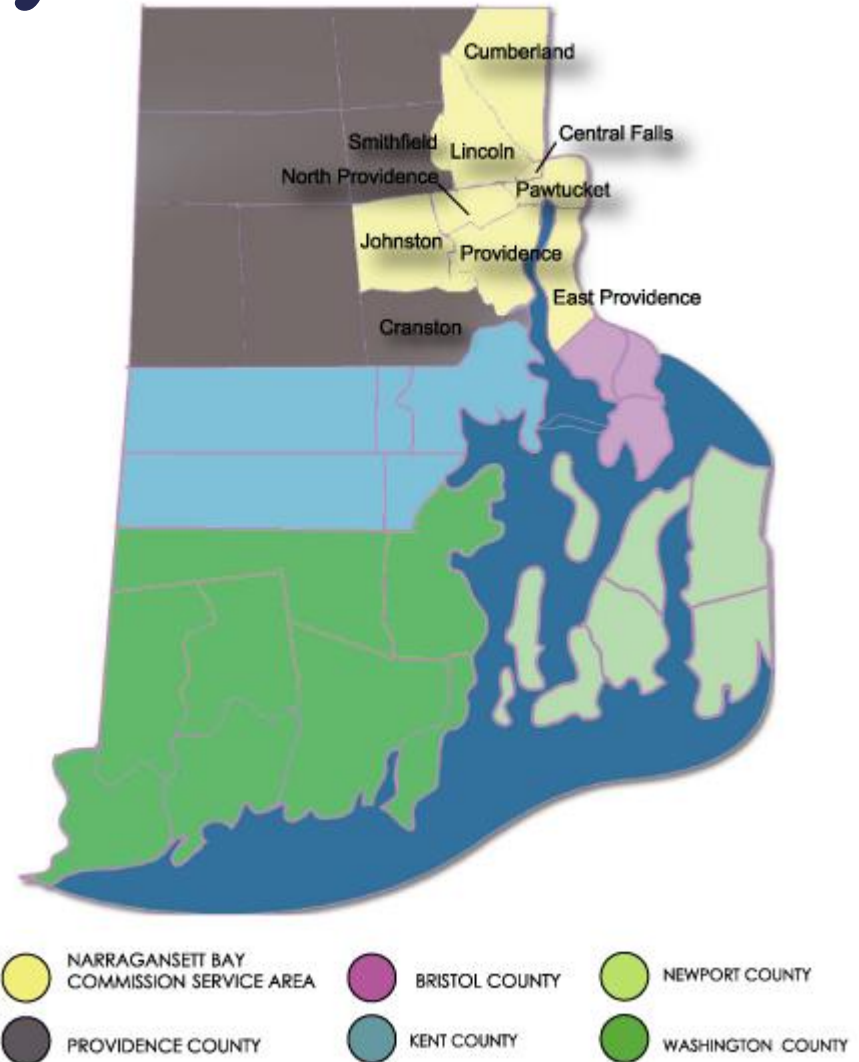
Eliza Moore
Senior Environmental Scientist
Narragansett Bay Commission

June 5, 2019



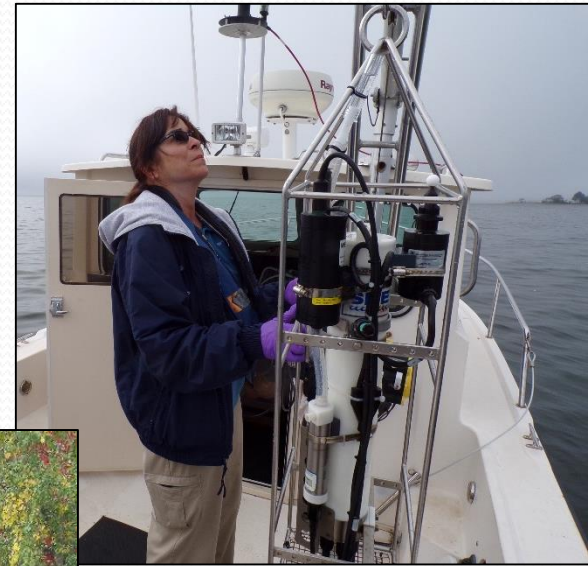
Narragansett Bay Commission

- Quasi-state agency
- Oversees the two largest wastewater treatment facilities (WWTFs) in Rhode Island:
 - Bucklin Point - East Providence
 - Field's Point - Providence
- Service area: 10 municipalities
- 360,000+ people served including 8,000+ commercial and industrial customers



Environmental Monitoring

- Receiving Waters –
 - Seekonk River and Providence River estuaries
 - Freshwater Rivers
 - Woonasquatucket
 - West
 - Moshassuck
 - Blackstone



NBC Monitoring Initiatives

- Sampling
 - Bacteria
 - Fecal coliform and enterococci
 - Nutrients
 - Nitrogen forms, orthophosphate, silicate, chlorophyll *a*, TSS
 - Phytoplankton
- Water Clarity
 - Secchi depth, turbidity, and PAR (photosynthetically-active radiation)
- Vertical Profiles
 - Temperature, salinity, pH, fluorescence, dissolved oxygen, PAR
- Fixed Site Monitoring
 - Temperature, salinity, pH, chlorophyll *a*, dissolved oxygen, turbidity
- Surface Mapping
 - Temperature, salinity, pH, chlorophyll *a*, dissolved oxygen
- Benthic Video

Environmental Monitoring



- Provide data for researchers and regulators
 - Better understand water quality in the region
 - Ensure regulations are based on **sound science**

Data Sharing



Narragansett Bay Commission

SNAPSHOT of Upper Narragansett Bay

WATER QUALITY INITIATIVES BUOYS LEARN MORE LINKS

Water Quality Initiatives

[Fixed Water Quality Monitoring](#)

The NBC maintains two of the ten real-time water quality stations in Narragansett Bay. Sensors at Phillipsdale Landing and Bullocks Reach record temperature, salinity, dissolved oxygen, pH, chlorophyll a, and water clarity.



[Water Quality Profiles](#)

The NBC collects water quality profiles of the water column at six locations throughout the Upper Bay. The parameters collected including depth, temperature, salinity, dissolved oxygen, pH, and chlorophyll a.



[Surface Mapping](#)

The NBC employs state-of-the-art equipment to automatically map surface water quality while their

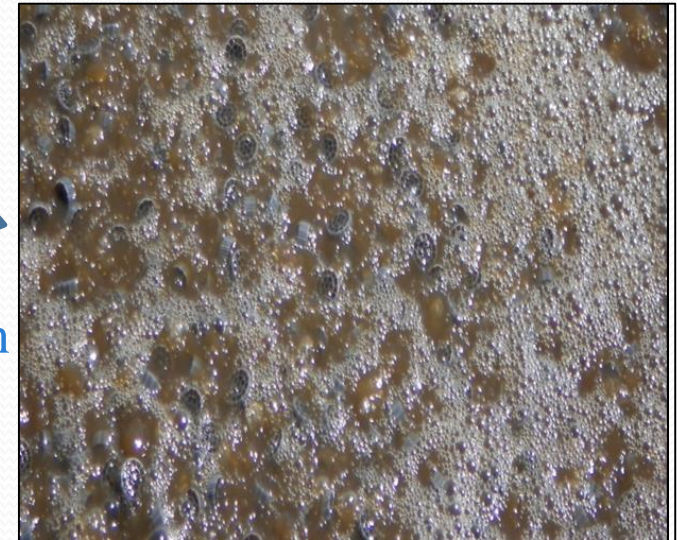
Snapshot Website:

<http://snapshot.narrabay.com/>

Environmental Monitoring

- Measure improvements to water quality following wastewater treatment investments.

Nitrogen Reduction



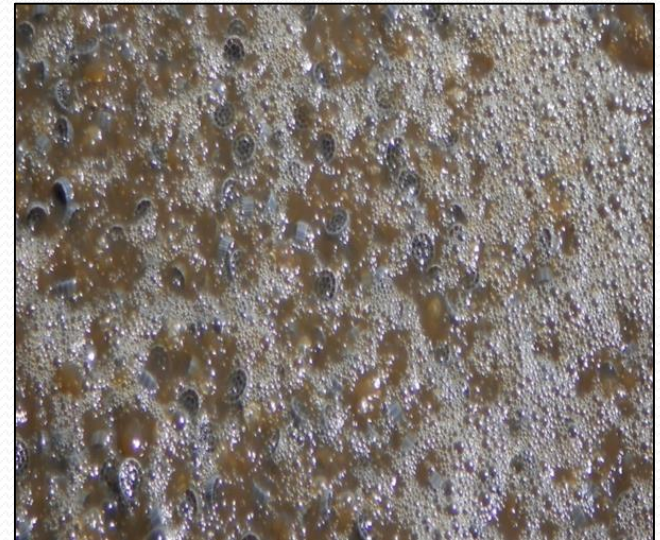
CSO Abatement



Nitrogen Reduction Upgrades

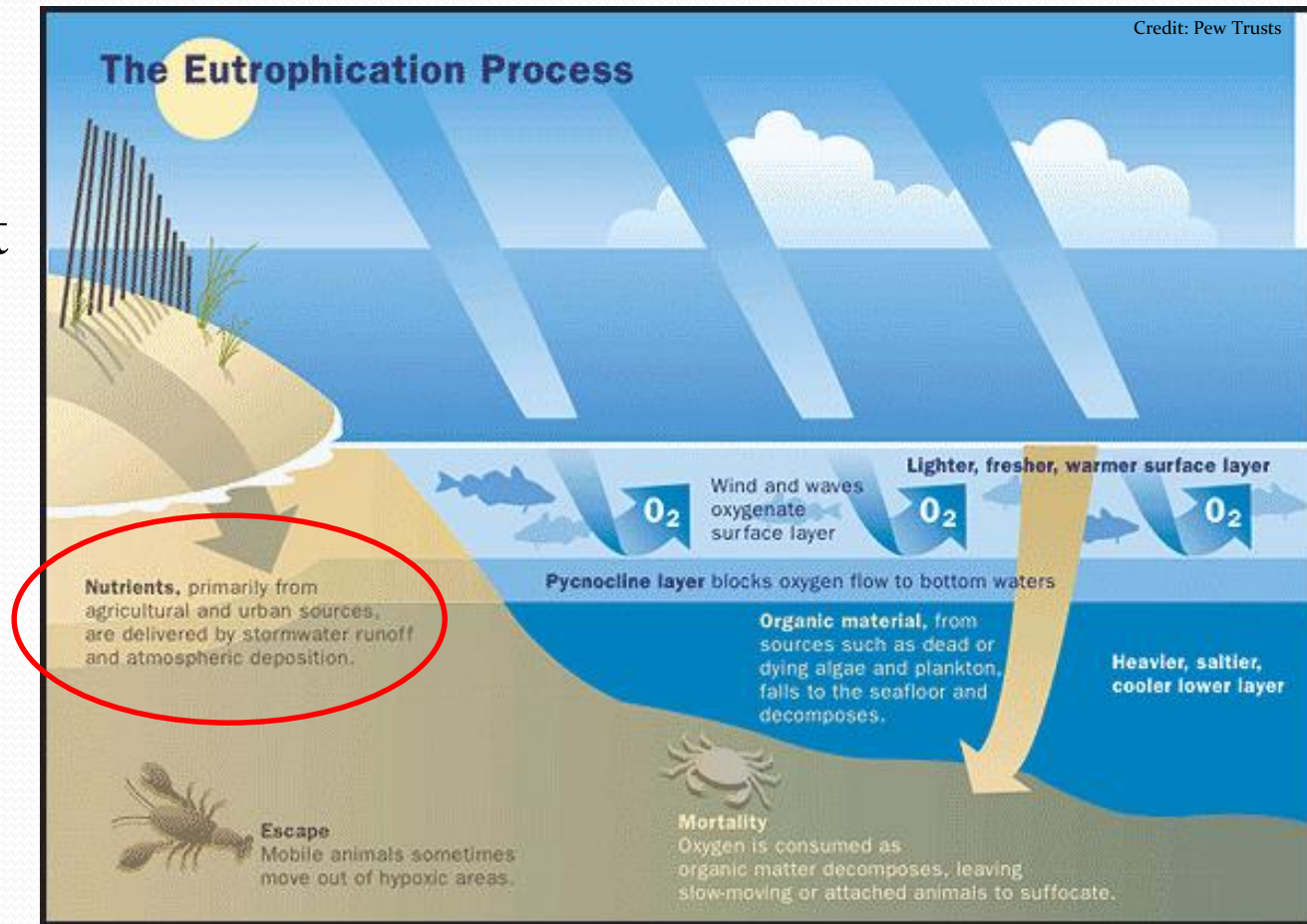
- Completed in 2014
- Biological Nutrient Removal (BNR)
 - Integrated Fixed-film Activated Sludge (Field's Point)
 - Four-stage Bardenpho (Bucklin Point)
- Optimize **nitrification** and **denitrification** by microorganisms

Upgrade cost ~ \$43 million



Nutrient Reduction

- Reduce eutrophication of Narragansett Bay
 - Excess nutrients contribute to low oxygen



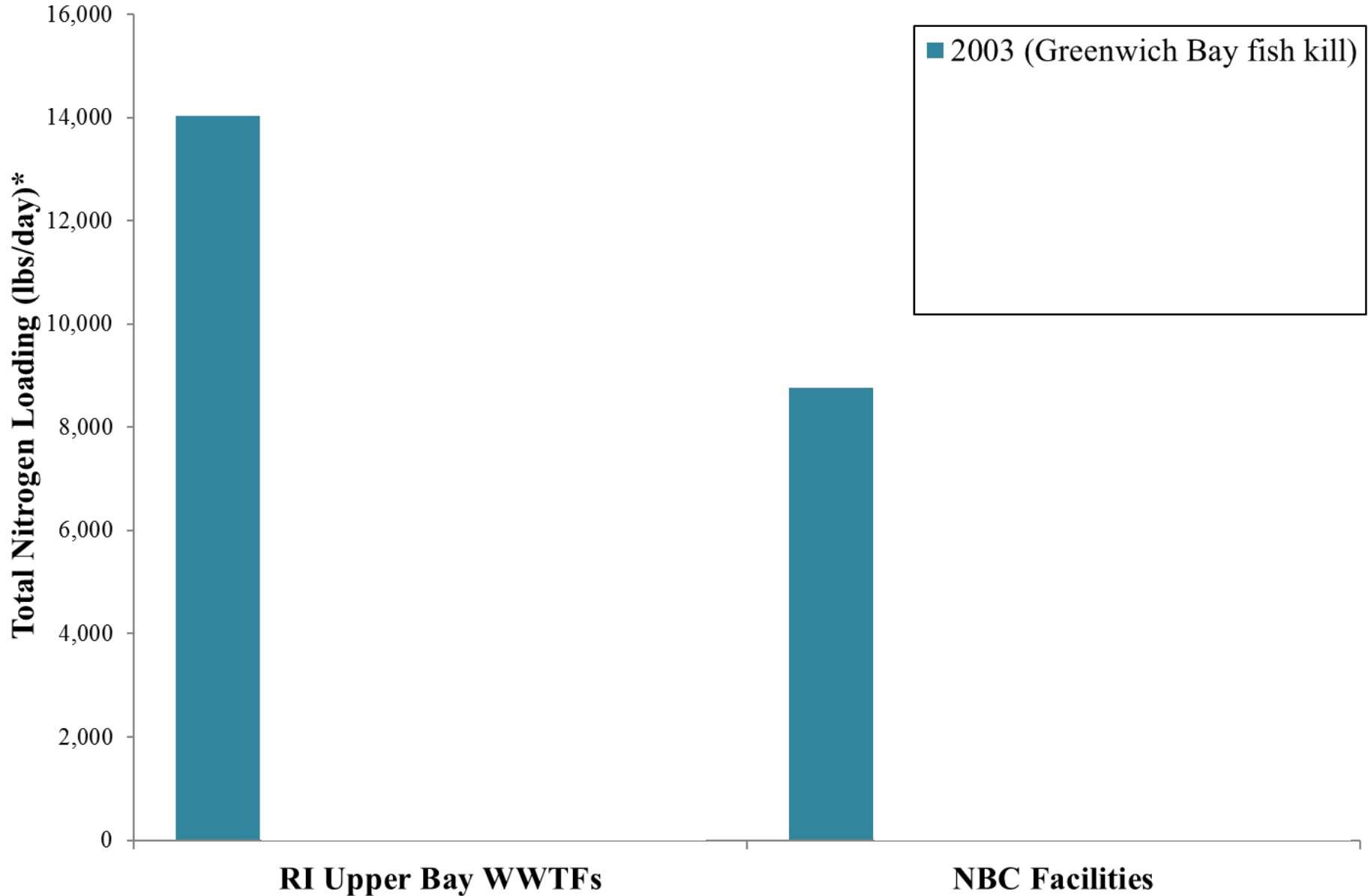
2003 Fish Kill

- Greenwich Bay, August 20th, 2003
- ~One million small menhaden, other fishes, and shellfish dead due to lack of oxygen
- The cause?
 - A perfect storm of weather conditions and excess nutrients
- Lawmakers targeted wastewater treatment facilities to reduce nutrients loadings to the Bay by 50% (May - Oct)



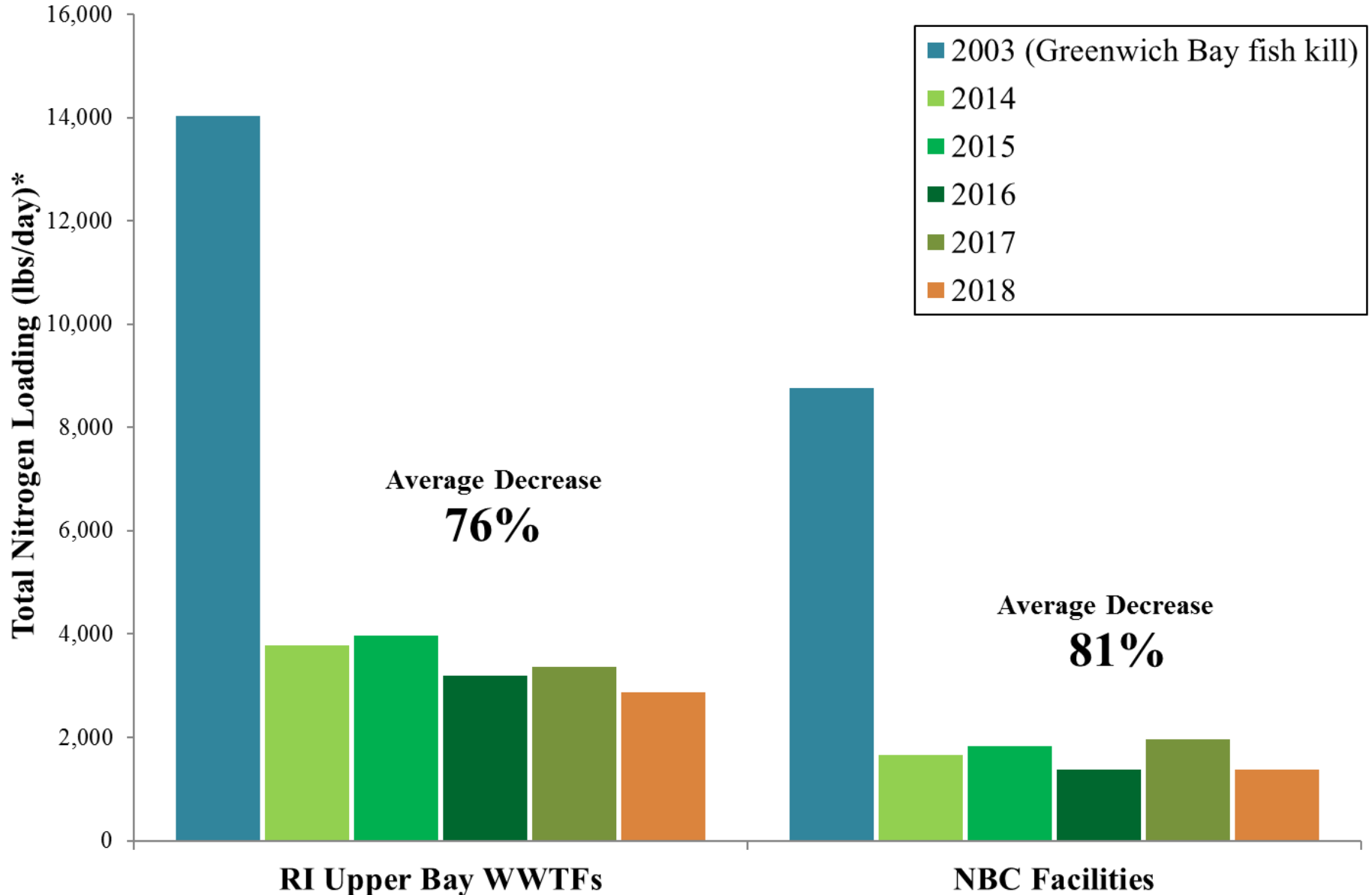
Photo Credit: The Providence Journal

Average Seasonal (May - October) Total Nitrogen Loading



*Loading calculations based upon TN monthly average concentration and monthly average flow

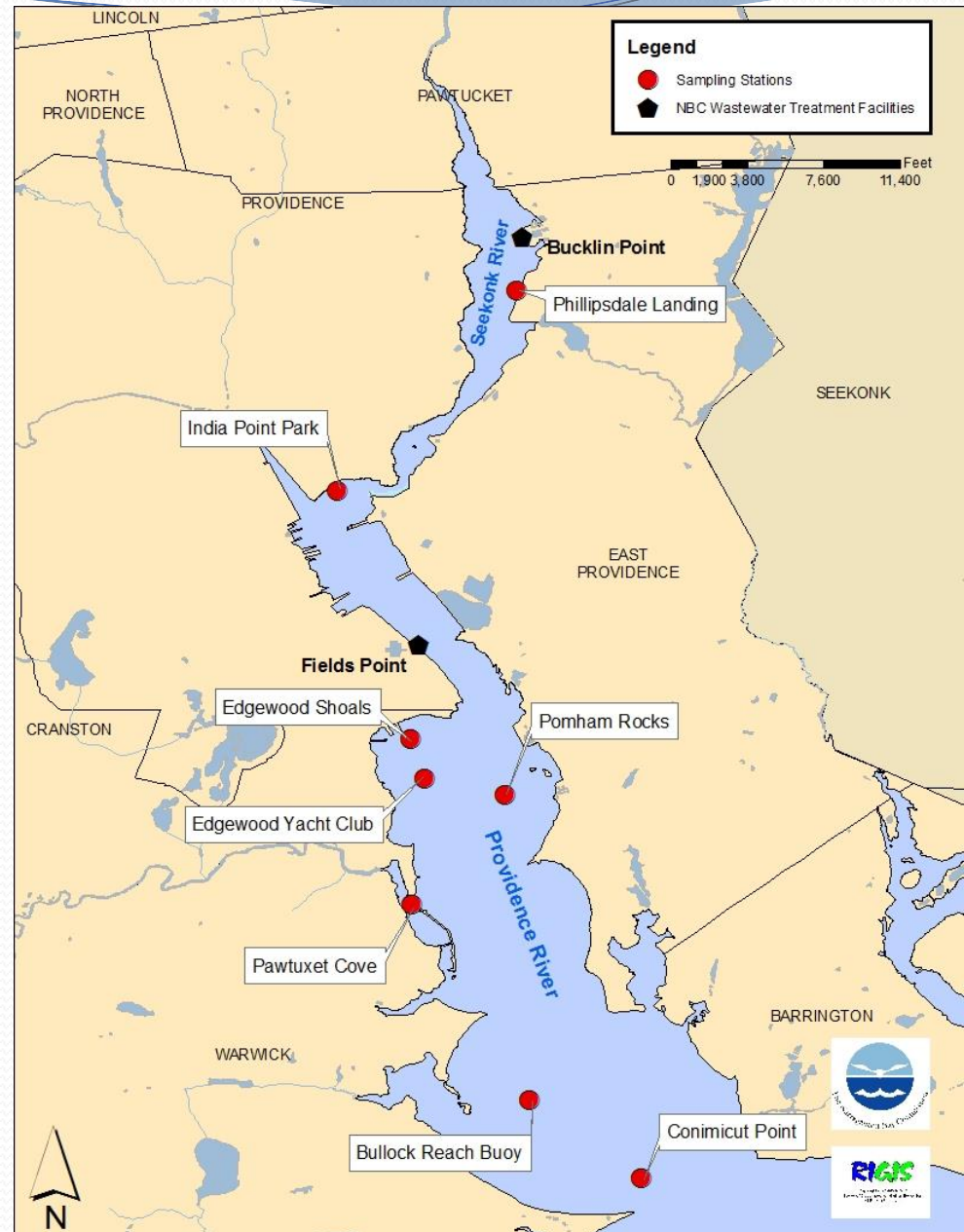
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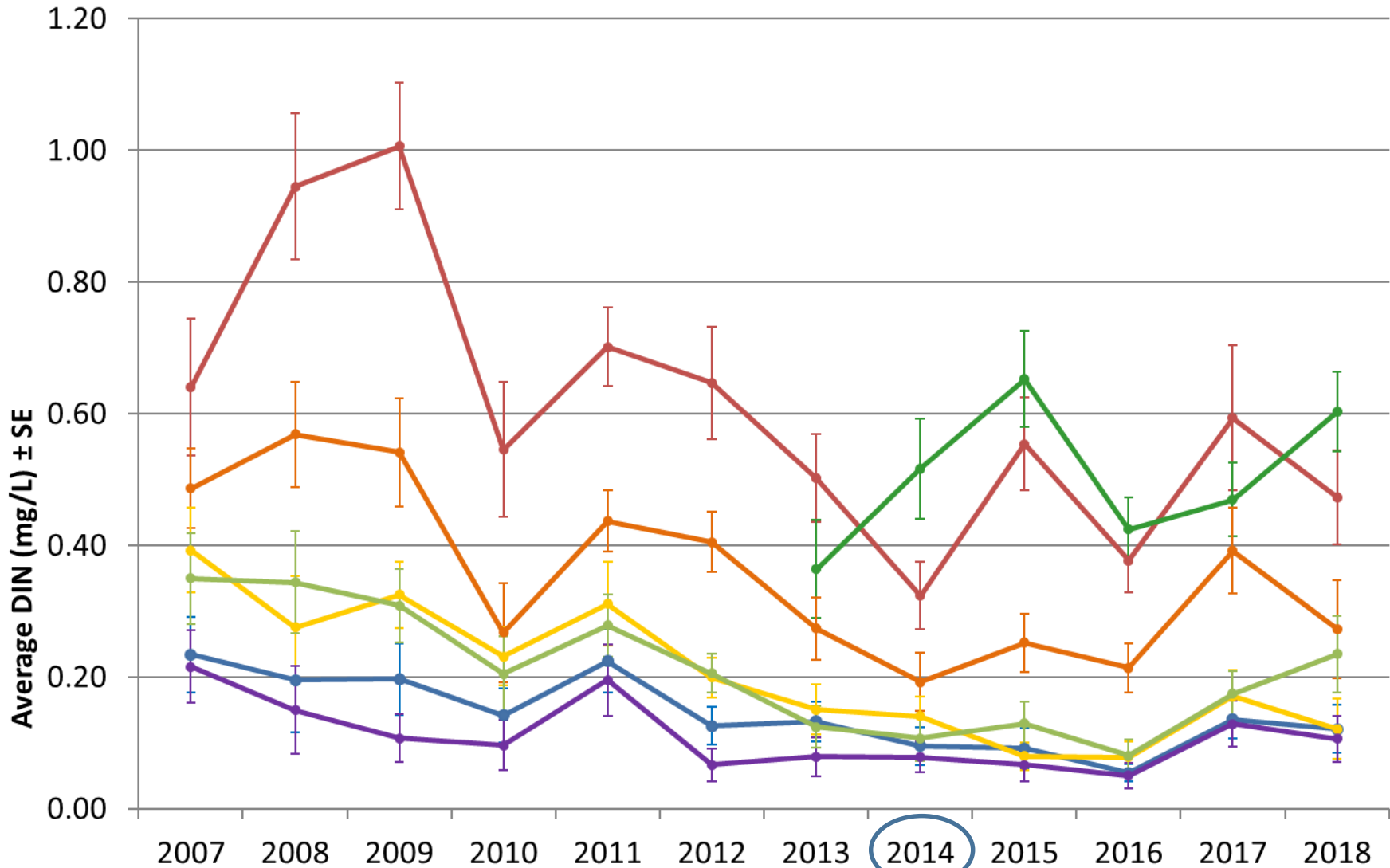
Nutrients Monitoring

- Bay Monitoring – 8 sites
 - 2x per month
- Nitrogen
 - total
 - ammonia, nitrate, nitrite (Dissolved Inorganic Nitrogen)
- Orthophosphate, silicate, chlorophyll *a*, TSS



Seasonal (May-Oct) Dissolved Inorganic Nitrogen, Precipitation, and Hypoxia Frequency

- Phillipsdale Landing
- Pawtuxet Cove
- India Point Park
- Bullock Reach Buoy
- Edgewood Yacht Club
- Conimicut Point
- Pomham Rocks

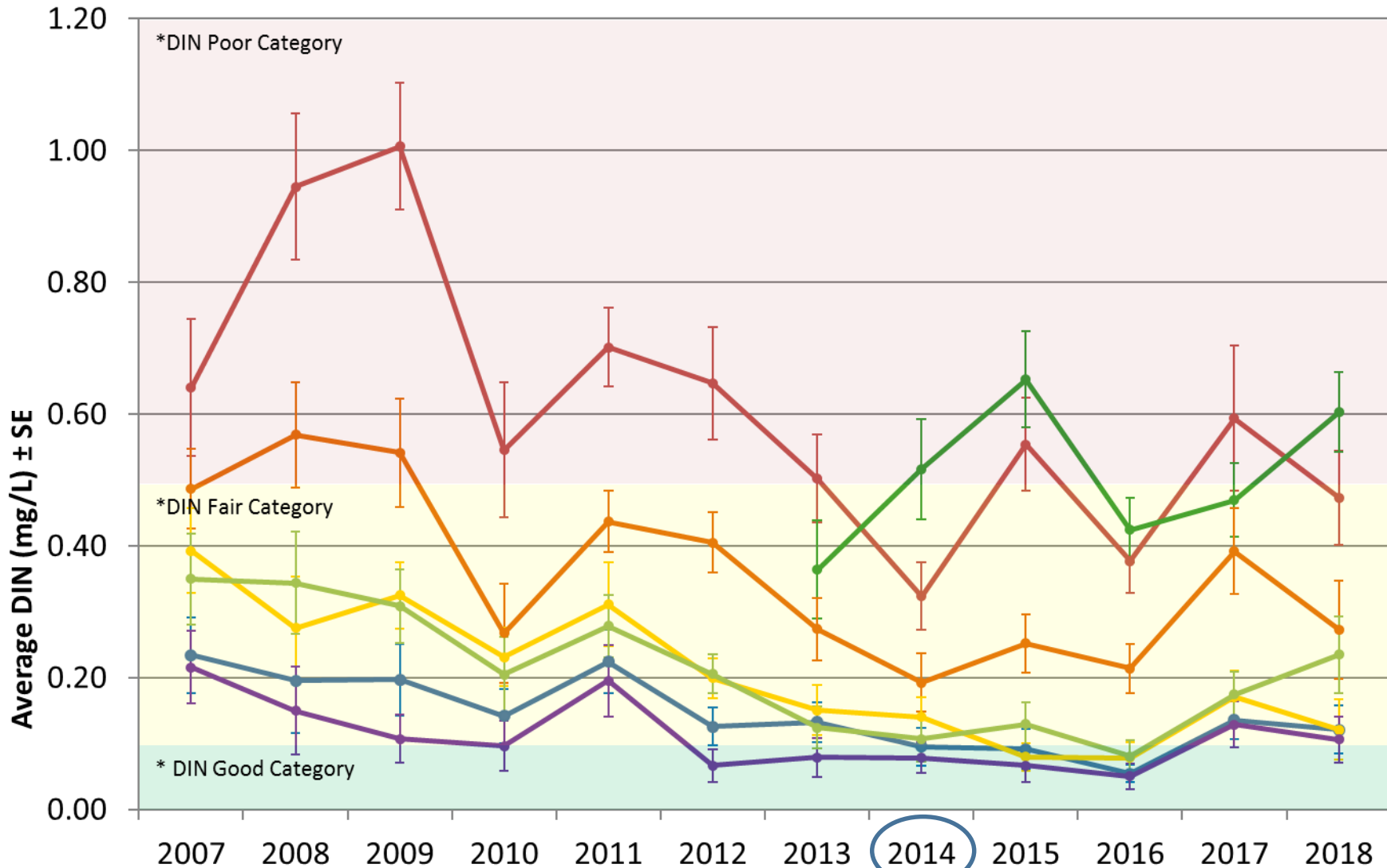


2014

NBC nutrient upgrades complete

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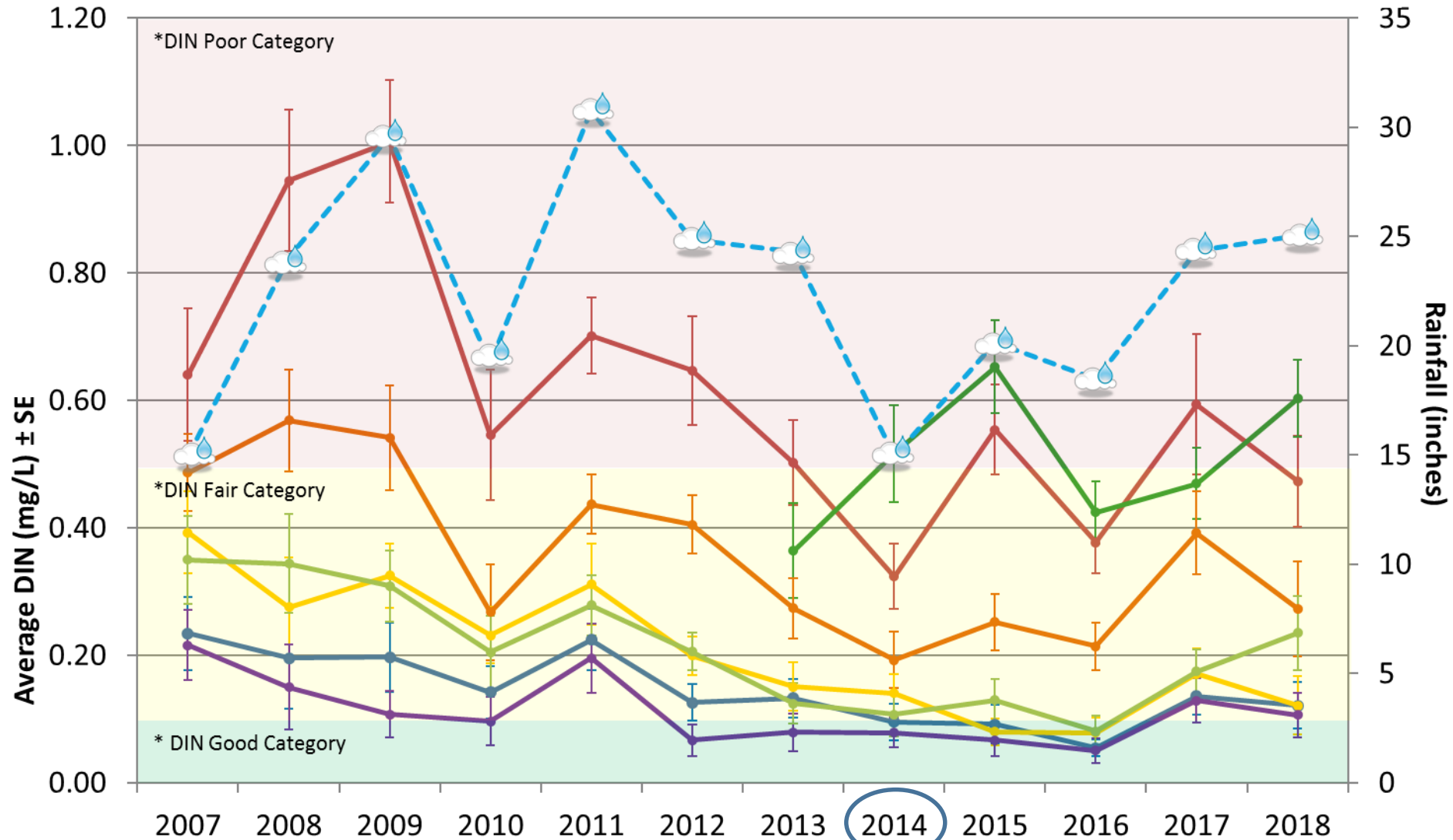


*Categories from National Coastal Condition Report

NBC nutrient upgrades complete

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- Total Rain (in)



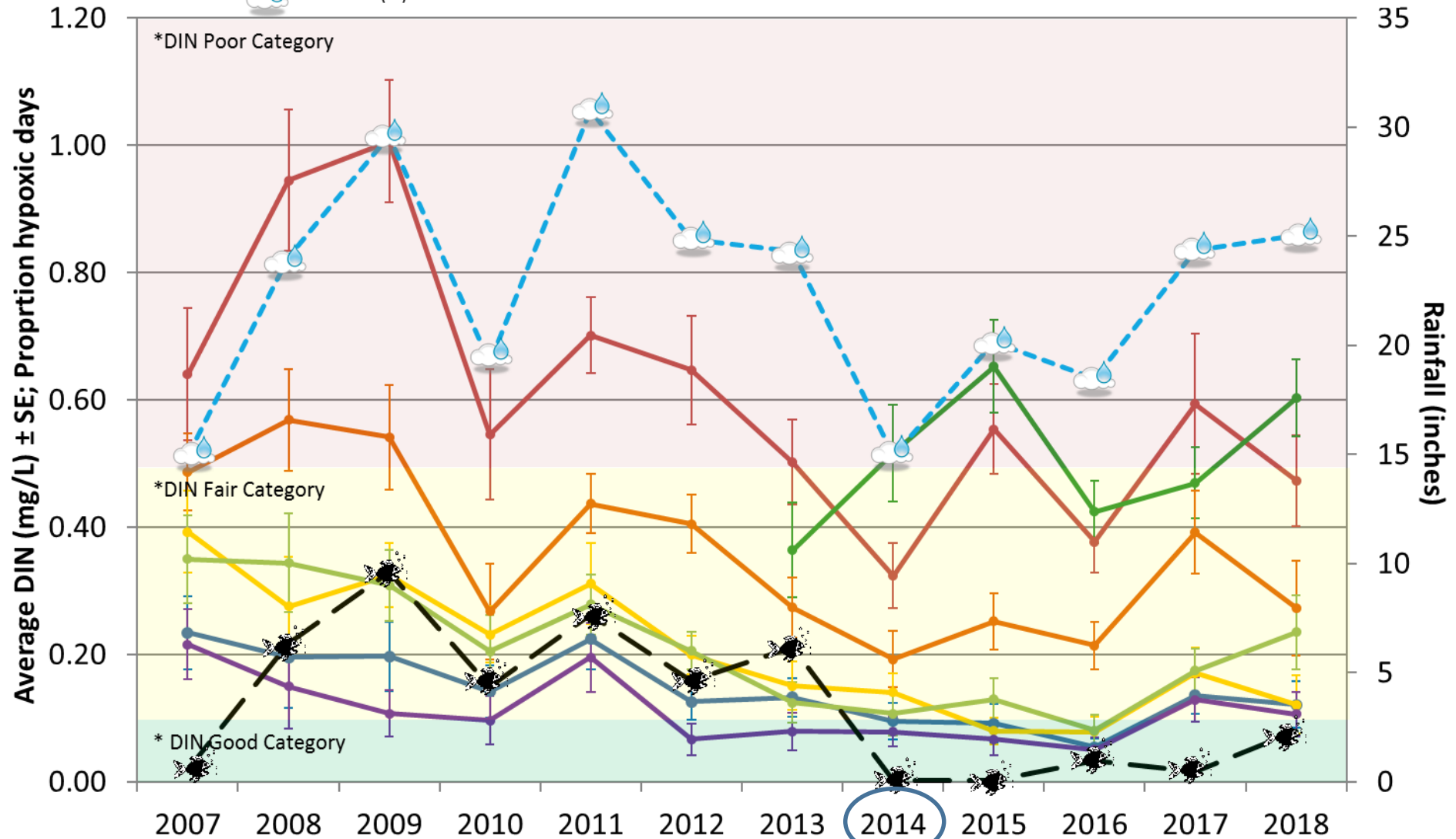
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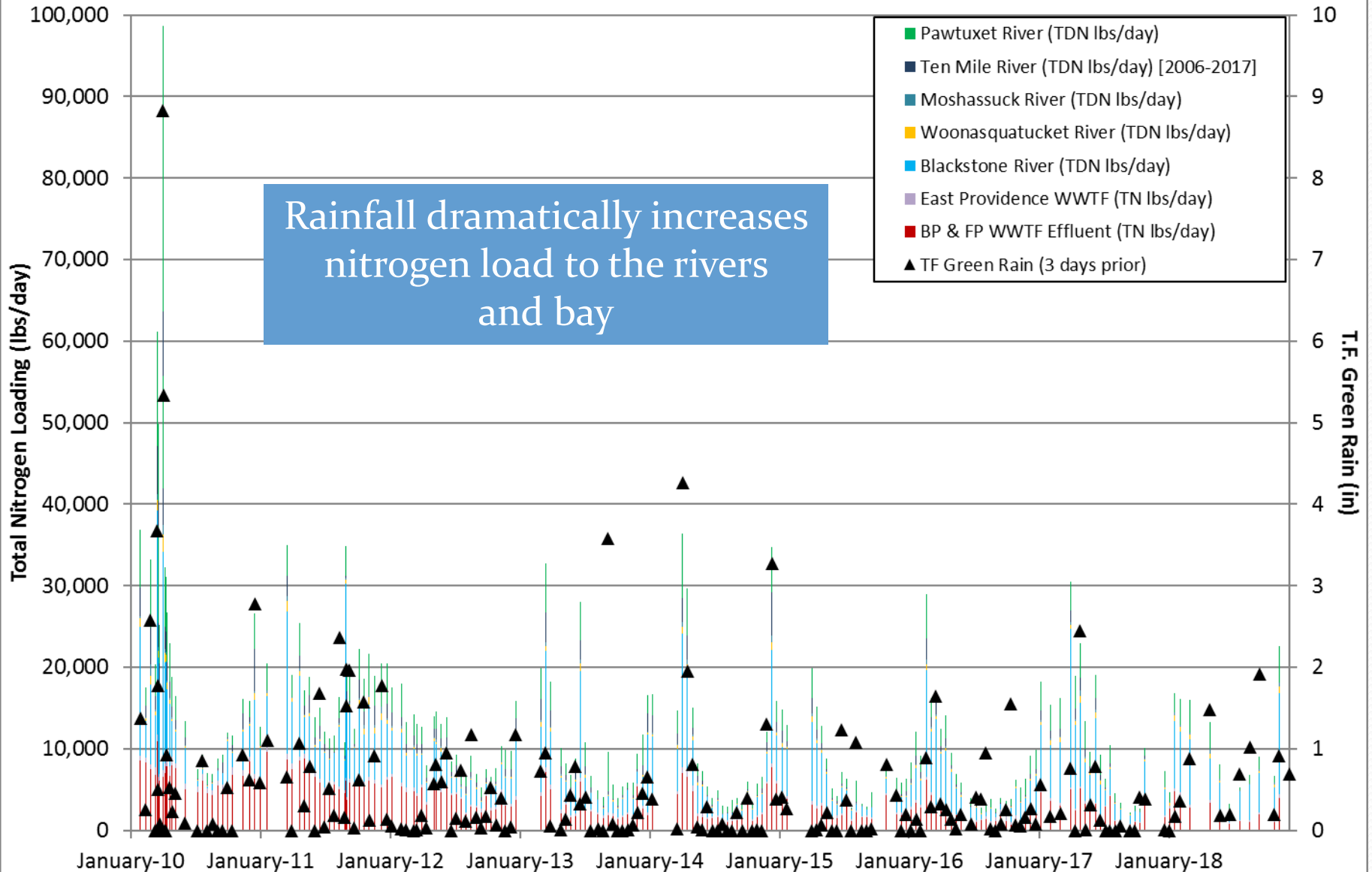
- Pawtuxet Cove
- Bullock Reach Buoy
- Conimicut Point
- % 24-hr periods with DO \leq 2.9 mg/L at BR Bottom



*Categories from National Coastal Condition Report

NBC nutrient upgrades complete

Nitrogen Loading to the Upper Bay from River and WWTF Sources

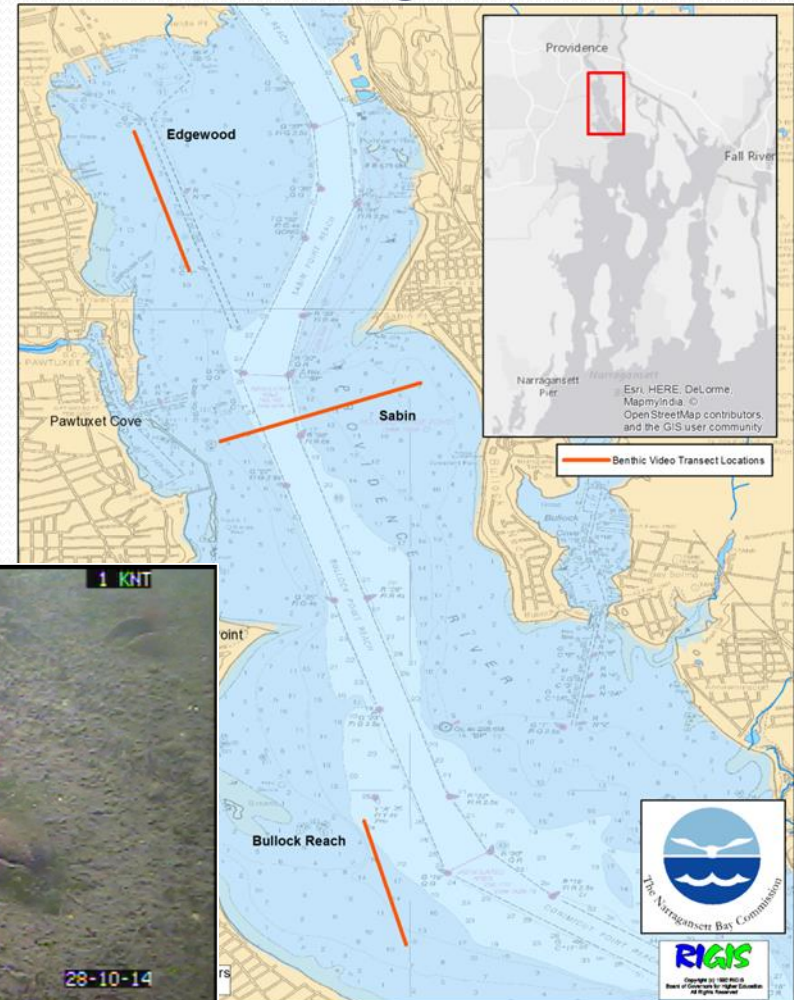
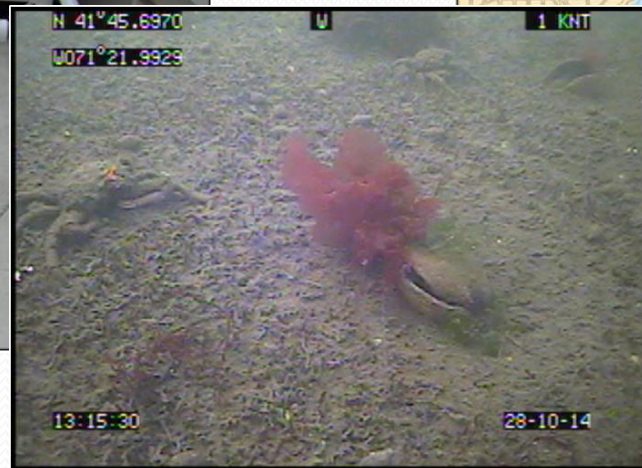


The “Grand Experiment”

- What does a 50% reduction in WWTF nitrogen actually do to the ecosystem?
 - Does it reduce **DIN** concentrations in the Bay?
 - Evidence of decrease since 50% reduction achieved (2012) and NBC upgrades completed (2014)
 - Decrease confounded by decrease in seasonal rainfall
 - Does it reduce **hypoxia** events?
 - Some evidence building, but monitoring must continue through more rainy years
- Does it change the **ecology** of the bay?

Benthic Video Monitoring

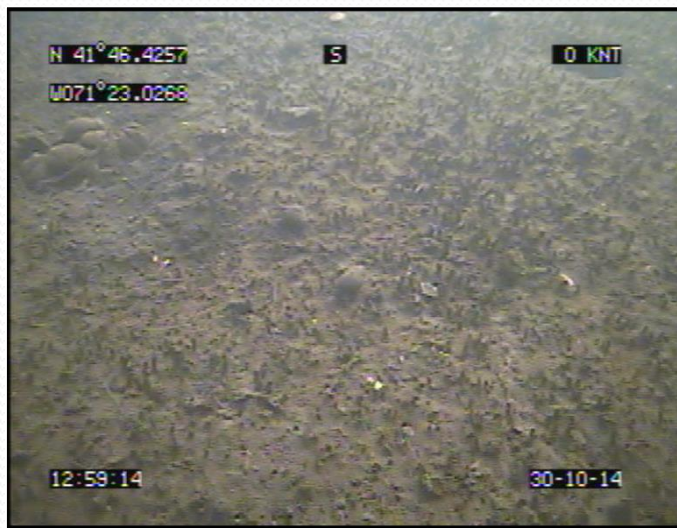
- Observations of the benthos – started in 2014
- ~Quarterly surveys



Benthic Video Monitoring

- Observable impacts of nitrogen reduction
 - Amphipod tube mats – high organic loading, but improving water quality – decrease as organic load decreases
 - Deep burrows – evidence of large-bodied infauna, adequate dissolved oxygen

Amphipod tube mats – indicative of excess organic matter, adequate DO levels



Tunneling megafauna – adequate DO levels

Providence River Benthic Life



Benthic Video Monitoring

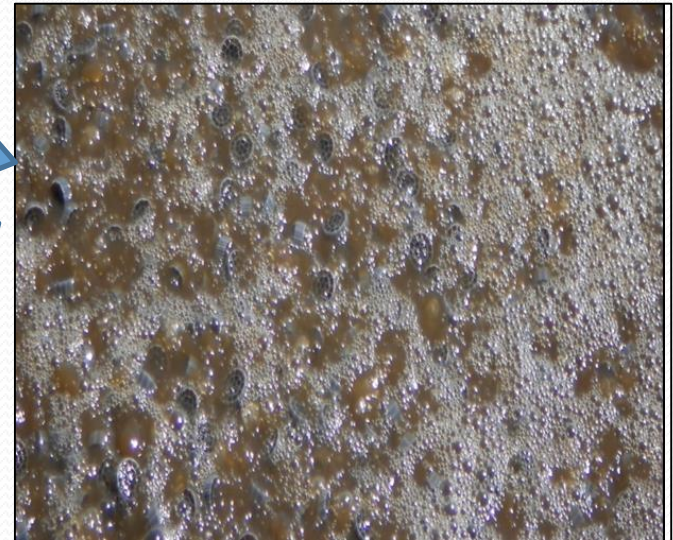
- The Providence River is alive!
- Data analysis methods being refined
 - Anecdotally – Fewer amphipod tube mat areas in recent videos – sign of improving conditions
- Habitat dominated by mudflat
 - Normal for northeast estuary
 - Potential for artificial reef installation to encourage oyster colonization? Increased structure?



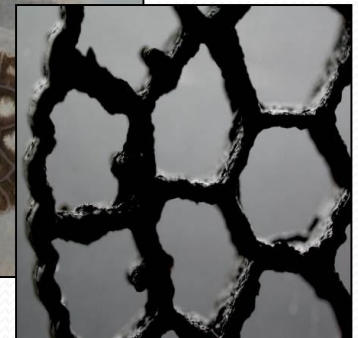
Environmental Monitoring

- Measure improvements to water quality following WWTF investments.

Nitrogen Reduction

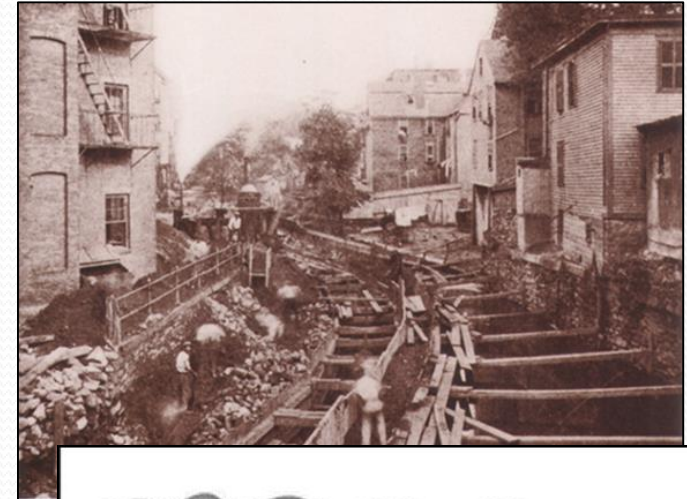


CSO Abatement



Combined Sewer System

- Late 1870s
 - 65 sewer outfalls directly into urban rivers and harbor
- 1901
 - Field's Point Chemical Precipitation Plant
- Today
 - 65 original outfalls remain – residential, industrial, and stormwater flows may discharge untreated during heavy storm events.



Combined Sewer System

- Combined sewer overflows are:
 - Violation of the Clean Water Act
 - Public health and environmental problem
- 2.2 Billion gallons per year
- **NBC Combined Sewer Overflow (CSO) Abatement Project**
 - Goal: reduce CSO flows 98%



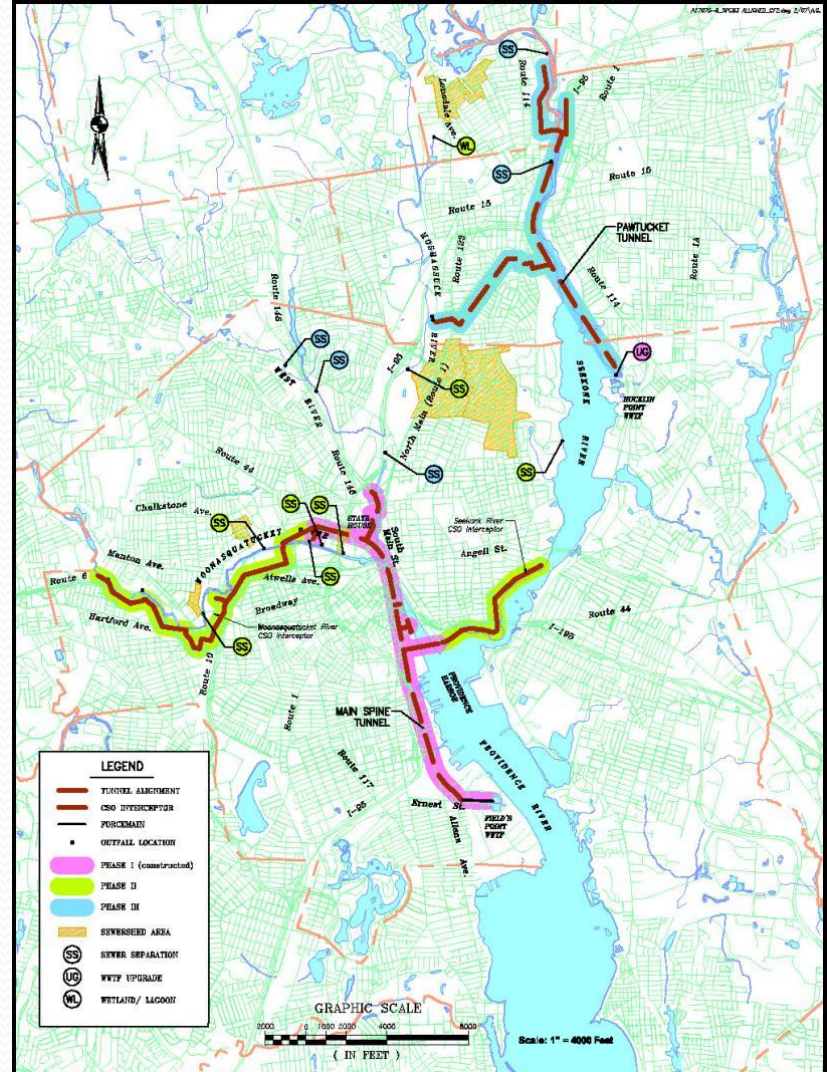
Three Phases - ~\$1.3 Billion

Three Phases over 40 years!

PHASE I (2001 – Nov 2008)

PHASE II (2010 – May 2015)

PHASE III (2017 – 2041)



Three Phases - ~\$1.3 Billion

PHASE I (2001 – Oct 2008)

- 26-ft diameter deep-rock tunnel
- 3+ mile long, 300 ft. below ground
- ~65 MG capacity
- Collects flow from 12 CSOs in Field's Point district
- Flow receives advanced secondary treatment at Field's Point

Actual Cost: ~\$359 million

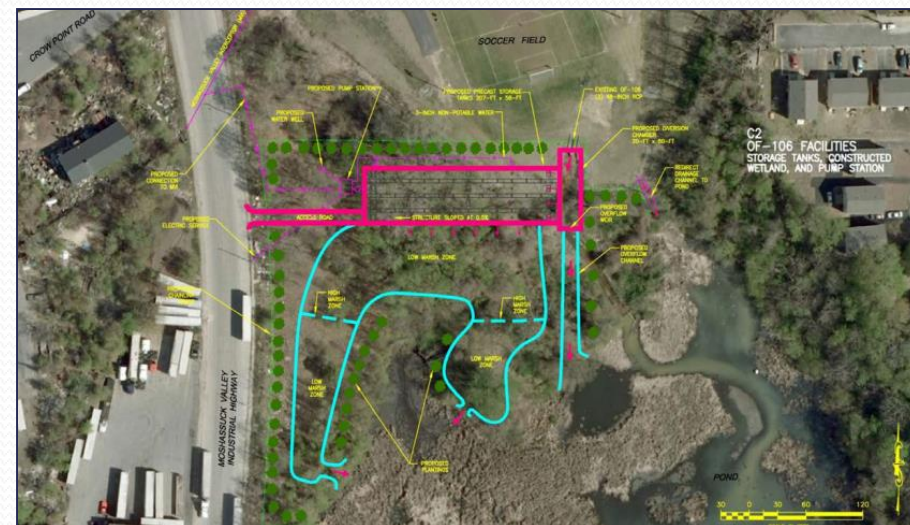
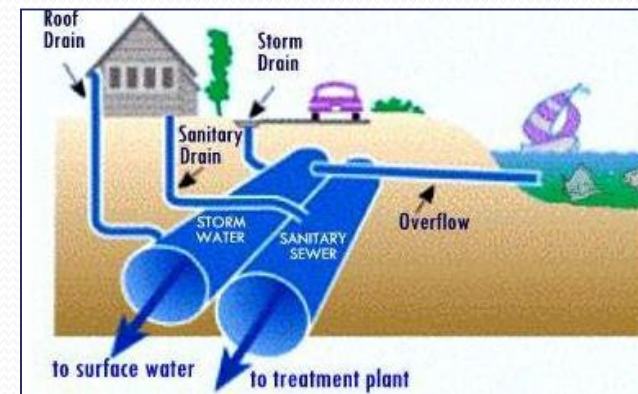


Three Phases - ~\$1.3 Billion

PHASE II (2010 – May 2015)

- Additional interceptors to bring flow to Field's Point Tunnel
- Two sewer-separation projects
- Constructed wetlands facility (Central Falls)

Actual Cost: ~\$197 million



Three Phases - ~\$1.3 Billion

PHASE III (2017 – 2041)

- Bucklin Point District Tunnel

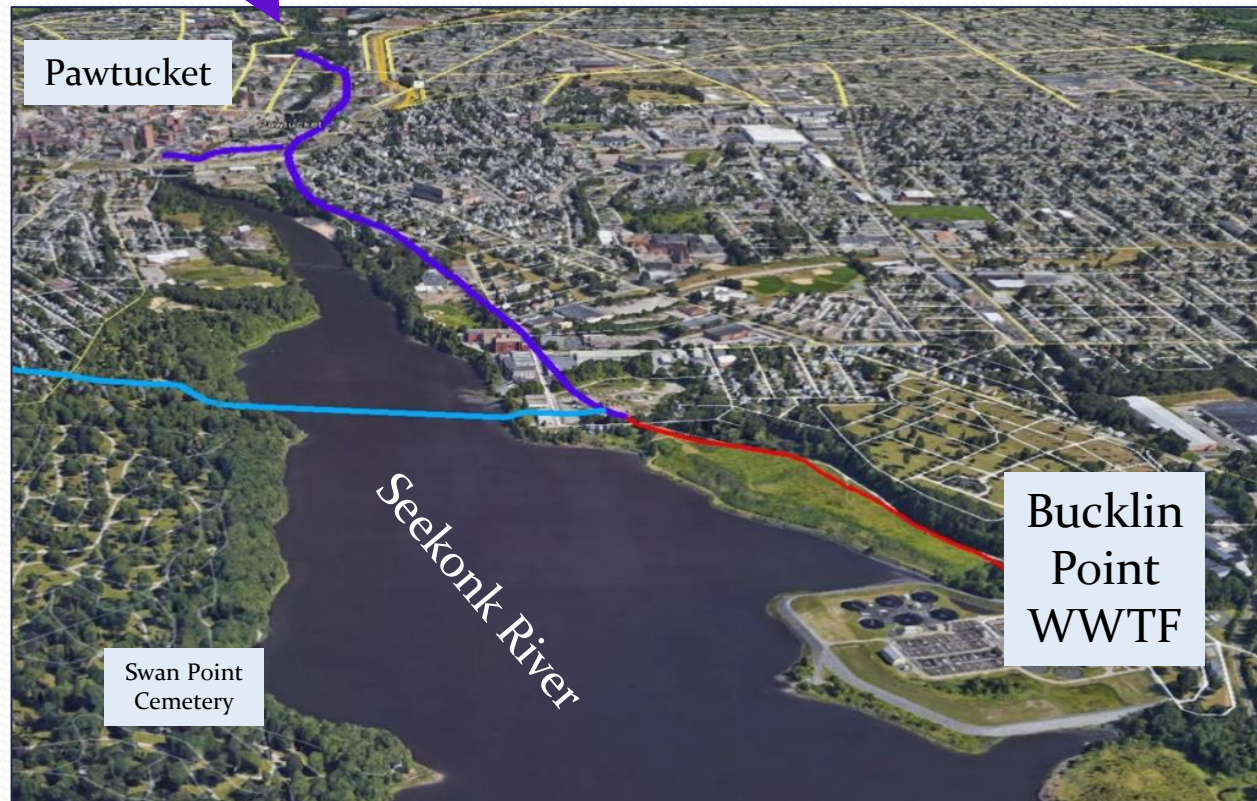
- 2.3 miles

- Green Stormwater Infrastructure

**Projected Cost
> \$750 million**

- Long timeline to spread out the cost

Graphic: Stantek/PARE



CSO Abatement Phase I

- 10.5 years, >10.9 billion gallons
 - ~1 billion gallons/year
 - ~50% reduction in overflow!
- Captured flow received full advanced secondary treatment

www.narrabay.com



Pollutants Captured by Tunnel

- 2015 – 2018 estimates
- **~1.3 billion gallons** per year, captured and treated at Field's Point
- Millions of pounds of pollutants removed over the ~11 year life of the tunnel!

Pollutant	Average Concentration CSO Tunnel Effluent	Total Pounds Removed by Capture and Treatment (per year)
Total Suspended Solids	57 mg/L	613,504
Biochemical Oxygen Demand	30 mg/L	326,334
Total Nitrogen	7 mg/L	61,797
Aluminum	561 µg/L	6,011
Cadmium	0.17 µg/L	2
Chromium	4 µg/L	35
Copper	20 µg/L	212
Iron	2,010 µg/L	20,718
Lead	27 µg/L	290
Nickel	12 µg/L	46
Silver	0.33 µg/L	3
Zinc	77 µg/L	650

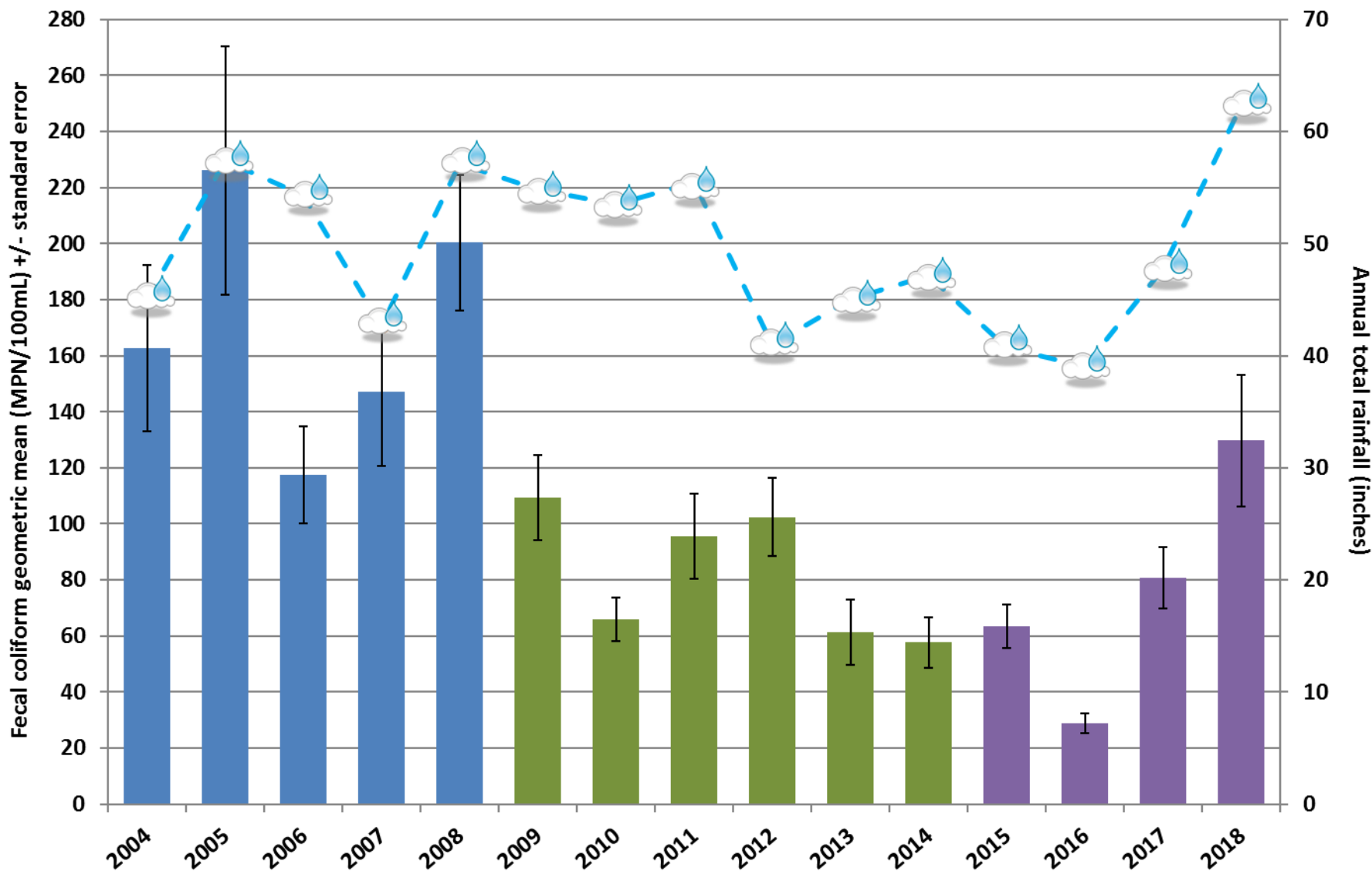
Bay Bacteria Monitoring



- 20 monitoring stations in Seekonk and Providence Rivers
 - Fecal coliform
 - Enterococci at subset of stations
- 2x per month in all weather

Providence River Annual Wet Weather Fecal Coliform Geometric Mean

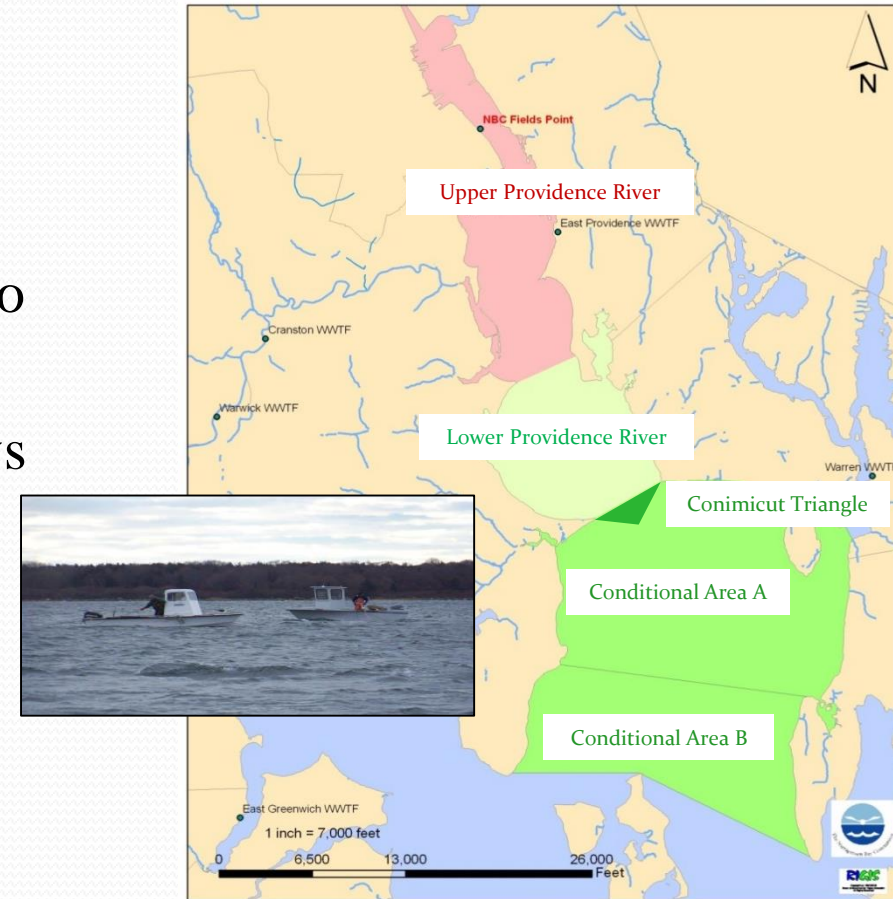
■ Pre-Phase I
 ■ Post-Phase I
 ■ Post-Phase II
 Annual Rainfall Total (Inches)



*Nov & Dec 2008 actually Post-Phase I

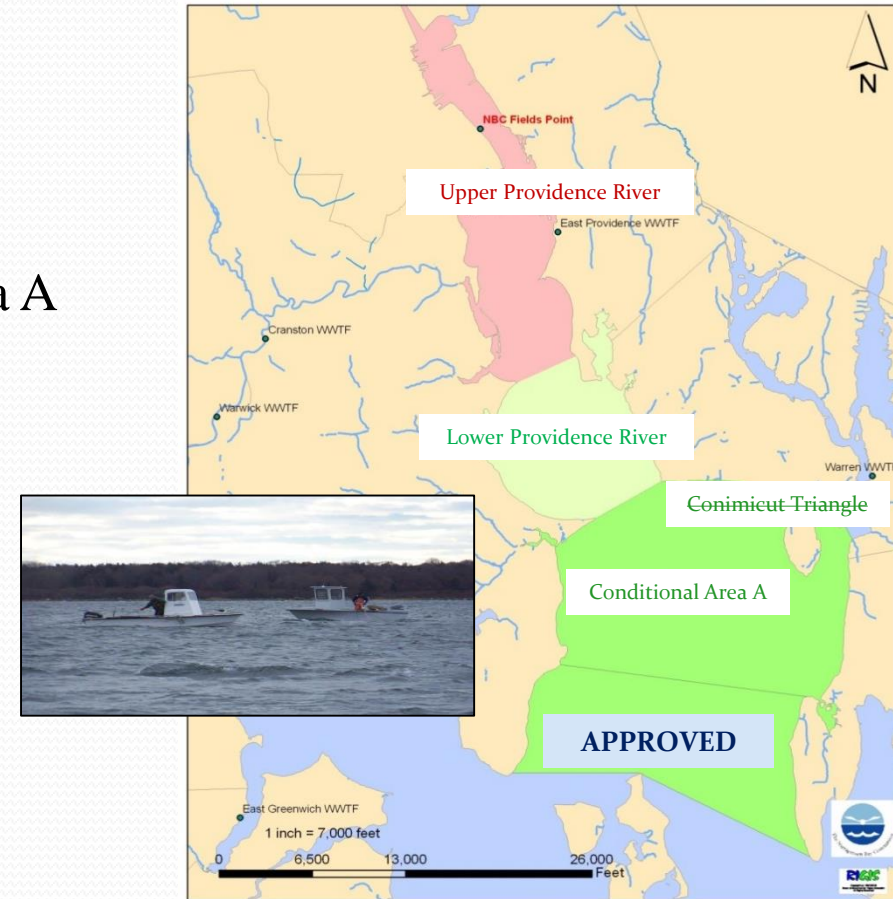
Shellfishing Impact Realized

- 2011 - Closure limits increased:
 - Cond. Area A: ≥ 0.8 inches of rainfall
 - Cond. Area B: ≥ 1.5 inches of rainfall
- RIDEM attributes closure changes to **success of Phase I CSO Project**
- 36% increase in number of acre-days Conditional Areas were open (2013 vs 2004; Watershed Counts 2014)
- In 2012....
 - 45% of the quahog harvest came from Areas A & B (54% in 2014!)
 - Totaling 17.5 million clams, \$2.48 million (J. Mercer, RIDEM)



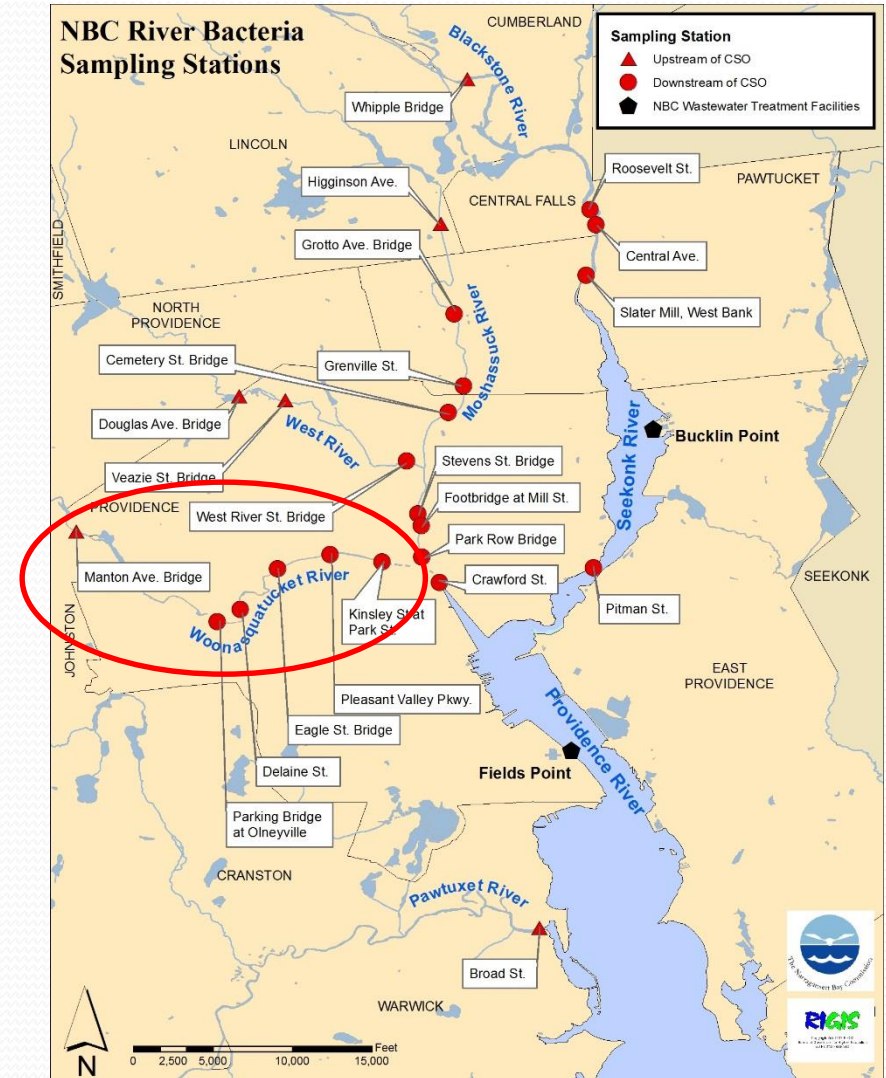
Shellfishing Impact Realized

- 2017
 - Conditional Area B – APPROVED
 - 3,712 acres
 - Conimicut Triangle merged with Area A
 - Conditional Area A – Increased rain limit from 0.8 inches to 1.2 inches
 - Projected increases in shellfishing –
 - 85 days (Conimicut Triangle)
 - 35 days (Area A)
- RIDEM attributes closure changes to **success of Phase I & II**



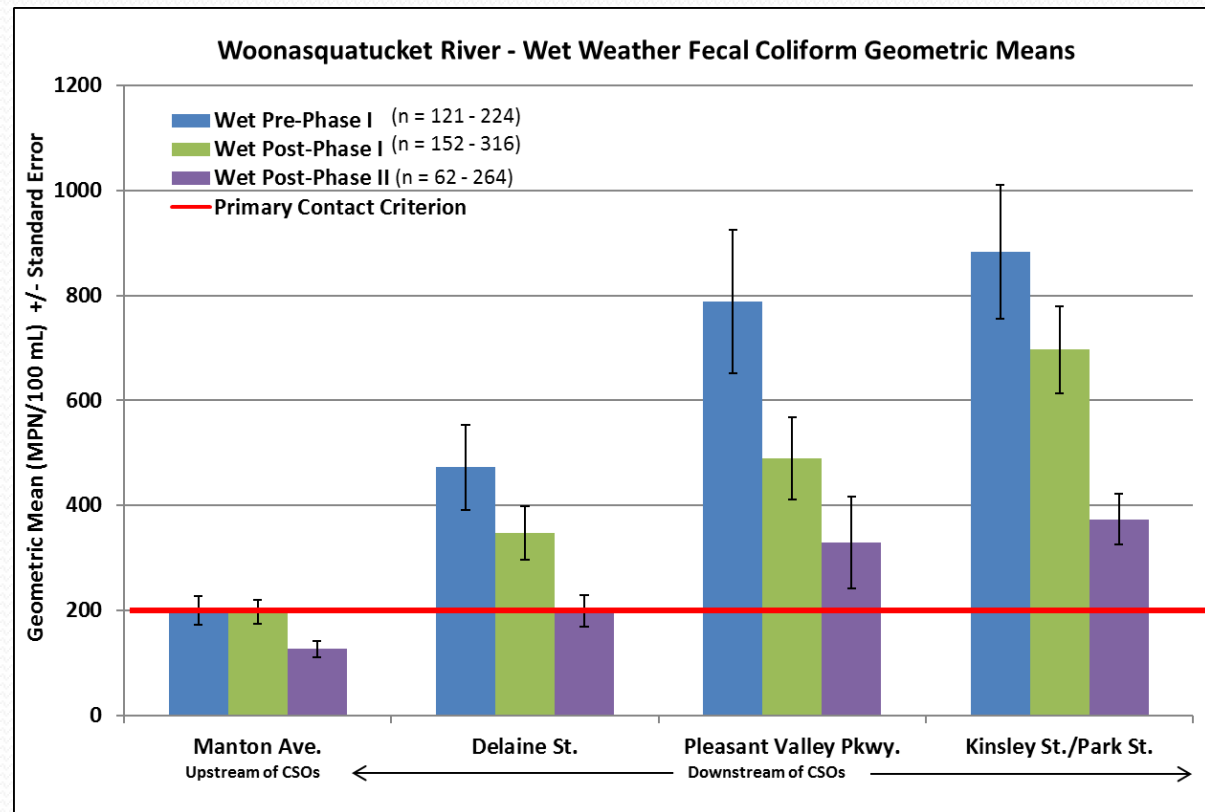
Urban River Bacteria Sampling

- Required by DEM RIPDES Permits (CSO Nine Minimum Controls Program)
 - Data collected weekly
 - Resampled if elevated
 - Monitor up/downstream of CSOs
 - One station on Pawtuxet River (no CSOs)
- Let's look at an example – Woonasquackett River



Urban River Bacteria

- Woonasquatucket River
 - Bacteria counts increase down river
 - Reduction in overall counts with each Phase
 - Counts still elevated...

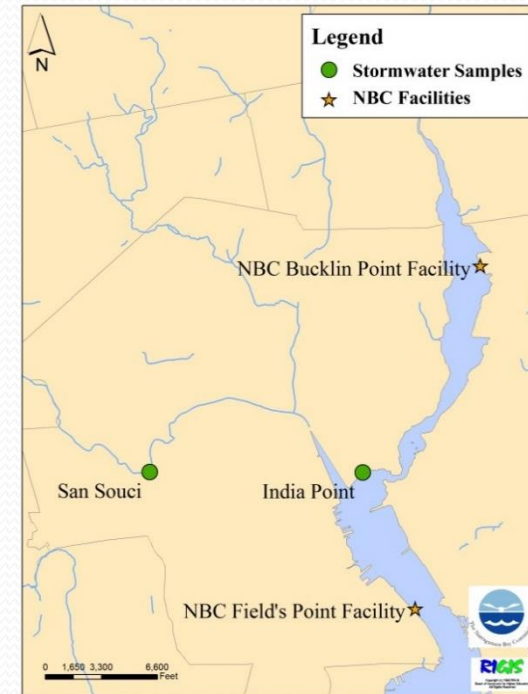


Stormwater

Average of Stormwater Samples

Constituent	Units	India Point	San Souci Dr.
Fecal Coliform	MPN/100 mL	>252,654	31,984
Enterococcus	MPN/100 mL	>2,420	>2,420
Total Suspended Solids	mg/L	124.00	83.33
Total Nitrogen	mg/L	3.70	<0.54
Total Kjeldahl Nitrogen	mg/L	2.49	<0.54
Nitrite + Nitrate	mg/L	1.21	<0.1
Ammonia	mg/L	1.39	<0.11
Total Aluminum	µg/L	1,184	724
Total Arsenic	µg/L	1.54	<0.5
Total Cadmium	µg/L	0.27	<2.5
Total Chromium	µg/L	5.88	<10
Total Copper	µg/L	122.36	13.55
Total Iron	µg/L	1,828	1,188
Total Lead	µg/L	158.12	38.78
Total Nickel	µg/L	<10	<10
Total Zinc	µg/L	255.68	59.88

- Two stormwater outfalls sampled
 - August 22, 2013 – *0.49 inches*
 - September 30, 2015 – *2.02 inches*
- Fecal coliform:
 - Range: 9,300 to >24,000,000 MPN/100 mL
- All enterococci samples:
 - >2,420 MPN/100 mL



Stormwater can be a substantial source of pollutants!

Summary

- Water quality is improving, but there is still work to do.
- NBC is investing heavily in improved treatment processes – nutrient removal and CSO abatement
- CSO Abatement Project – Phase I and II
 - CSO volume and bacteria loads reduced substantially
 - Increased shellfishing areas and open days
- Phase III will be complete in 2041
 - CSOs will still overflow occasionally (~4x per year)
- Separate stormwater is still a major source of bacteria and pollutants
- The NBC will continue to monitor water quality:
 - To build understanding of water quality issues
 - To support sound science-based regulation



Thank you



- Environmental Monitoring staff
 - [John Motta](#) – Manager
- Data Analysis
 - [Christine Comeau](#) – Env. Scientist
 - [Molly Welsh](#) – Env. Scientist
 - [Karen Cortes](#) – Asst. Env. Monitoring Manager
- [Tom Uva](#) – Environmental Science & Compliance Director
- [Jim Kelly](#) – Technical Analysis & Compliance Manager
- [Kim Kirwan](#) – Environmental Coordinator