Narragansett Bay Commission: Stormwater Mitigation, CSO Abatement & Water Quality Monitoring Programs

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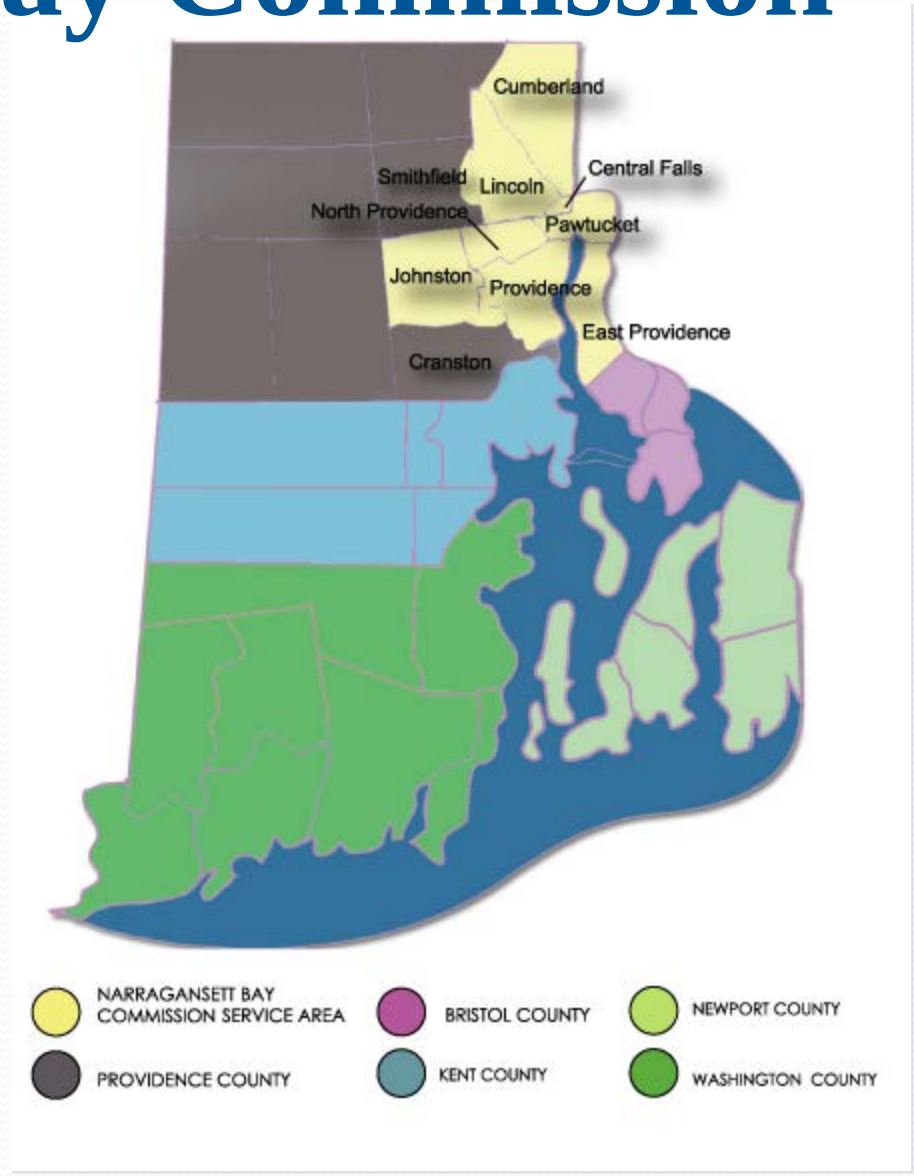
Environmental Scientists
Narragansett Bay Commission

Narragansett Bay Commission

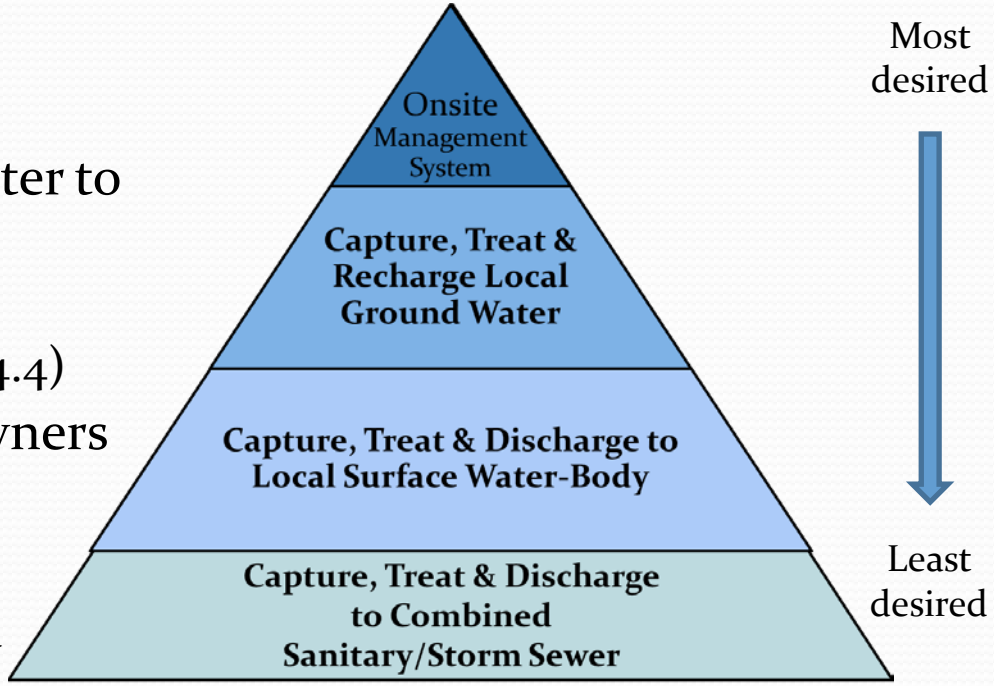
- Narragansett Bay Commission (NBC) is a quasi-state agency which oversees the two largest WWTFs in Rhode Island:
  - Bucklin Point in East Providence
  - Field's Point in Providence
- Service area: 10 municipalities
- 360,000 people served including 8,000 commercial and industrial customers

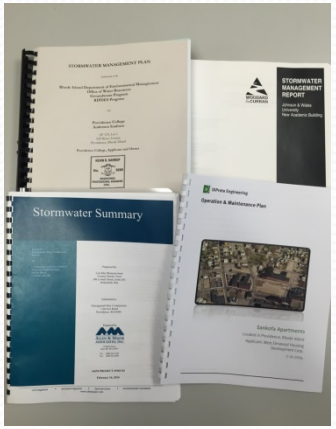


NBC Stormwater Mitigation Program

NBC Stormwater Mitigation Program

- NBC formalized their Stormwater Mitigation Program in 2003
- Prohibits the discharge of stormwater to NBC system, unless it's the only reasonable means available
  (See NBC Rules & Regulations Article 4.4)
- Requires commercial/industrial owners & builders to evaluate stormwater
- Stormwater Mitigation Plan is mandatory to obtain Stormwater & Sewer Connection Permits





NBC Stormwater Mitigation Program

Stormwater Mitigation Plan Requirements:

- Determine how much stormwater is generated onsite
- Investigate measures to eliminate or reduce stormwater flows
- Examine on-site flow infiltration, retention & reuse options
- Explore Low Impact Design (LID) methods
- Institute Best Management Practices (BMPs)
- Consider options to redirect stormwater to storm system or natural waterways if LID options not possible


NARRAGANSETT BAY COMMISSION
STORMWATER CONNECTION PERMIT

NBC Stormwater Mitigation Program

- 128 Stormwater Management Plans approved since 2003
- 2 year storm: 15,251,674 Gallons removed from the combined system
- 3 month storm event (basis for NBC CSO Project): 7,621,646 Gallons abated from the combined system
- Program Eliminated the Equivalent to ~10% of CSO Tunnel Capacity from Field's Point collection system

Stormwater Flows Abated

Permitted Year	Approved Stormwater Projects	Gallons of Stormwater Mitigated	
		3 Month Storm Event (1.65 inches)	2 Year Storm Event (3.3 inches)
2003	8	415,900	839,800
2004	11	647,154	1,294,318
2005	10	1,062,576	2,126,351
2006	9	517,375	1,034,750
2007	16	1,089,332	2,177,905
2008	13	790,865	1,580,989
2009	9	486,852	973,847
2010	10	258,719	517,438
2011	6	489,519	979,038
2012	13	772,336	1,544,672
2013	8	159,149	318,828
2014	5	182,047	364,094
2015	10	749,822	1,499,644
Total Stormwater Projects & Stormwater Flow Mitigated	**128**	**7,621,646**	**15,251,674**

(updated through October 2015)

For permit applications visit: http://www.narrabay.com/ProgramsAndProjects/NBC%20Sewer%20Connection%20Permit%20Program%20Overview.aspx

NBC Stormwater Mitigation Program

- Award winning program - regionally & nationally recognized for excellence
- Annually recognizes local businesses – NBC Environmental Merit Award for Stormwater Management
- River clean-up program & grants

NBC CSO Abatement Program

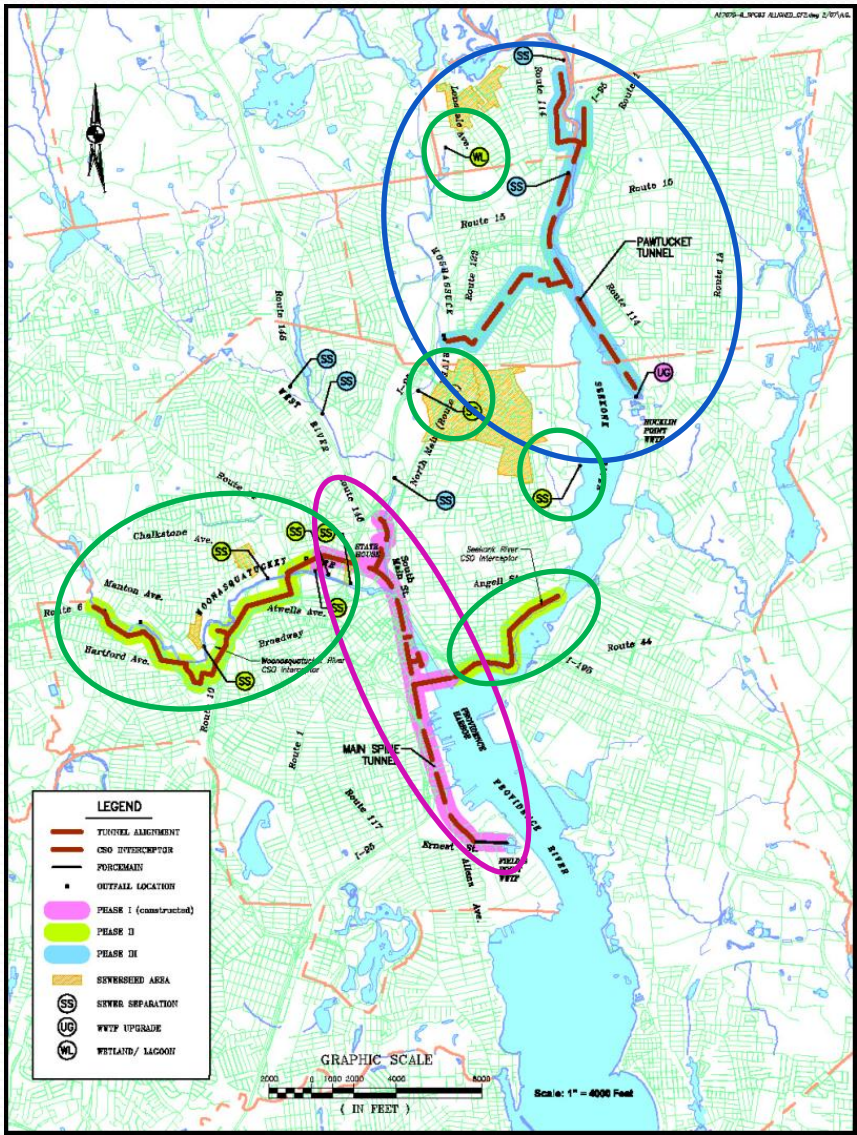
CSO Abatement Program: 3 Phases - ~$1.2 Billion

Three Phases over 20 years

- Design storm: 3-month - 1.6” of rain in 6 hrs

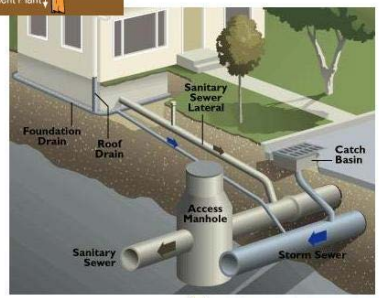
PHASE I (2001 – Nov 2008)

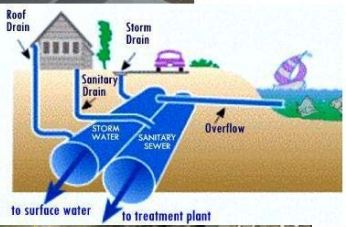
- 26 ft diameter deep rock tunnel
- 3+ mile long, 300 ft. below ground
- 62 MG design capacity (actual ~65 MG)
- 7 drop shafts to divert flow to tunnel
- Diversion structures at 8 CSOs
- Relief structures at 2 interceptors
- Collects sewer/stormwater from 12 CSOs in FP area
- **Actual Cost: ~$359 million**



Phase II of CSO Abatement

- Focused to improve water quality of Urban Rivers
- Woonasquatucket & Seekonk interceptors constructed to transport flow to the CSO tunnel
- Two sewer separations –
  - Construct new storm sewers via conventional open-cut trenching methods
  - Extensive utility impacts
    - $3.6 million for gas main replacement
    - $4.25 million for water main replacement
- Constructed wetlands facility in Central Falls
  - 0.32 MG of storage
  - Pumped to sanitary sewer after rain event
  - Overflows to wetlands when tanks are full
- Flows intercepted end of 2014
- Whole project completed 2015
- Projected costs: **$213 million**





Phase III of CSO Abatement

- 1998 Conceptual Design Report Amendment included:
  - Pawtucket Tunnel-13,000 feet long, 26 feet diameter
  - 3 Near surface interceptors in Central Falls & Pawtucket
  - Sewer separation at 4 CSOs
- 2014 review of 1998 plan, affordability & water quality conditions
- 1998 plan was best approach, but needed to lengthen the schedule to be financially sustainable
  - 2016-2023: CSO Tunnel, drop shafts & pump station, GI study
  - 2024-2028: Pawtucket & Central Falls interceptors, GI creation
  - 2029-2033: CSO Adit/CSO Storage Tank, GI installation
  - 2034-2038: Interceptor for 2 CSOs, GI construction & sewer sep.
- Estimated cost: **$815 million**
- Final report to RIDEM on June, 2015

The Providence Journal

NARRAGANSETT BAY

Narragansett Bay Commission Chairman Vincent J. Mesolella said, "Sometimes we have to make difficult decisions." He voted to approve the sewer project. THE PROVIDENCE JOURNAL/SANDOR BODO

Commission member Richard H. Burroughs voted against approving the project, saying, "Aspirations for water quality ... are beyond what engineering and prudent finance can deliver." THE PROVIDENCE JOURNAL/SANDOR BODO

Final, $815M phase of sewer project OK'd

But not before Bay commission debates cleaner waters vs. affordability

By Alex Kuffner
Journal Staff Writer

PROVIDENCE – The biggest public works project in Rhode Island history is getting bigger.

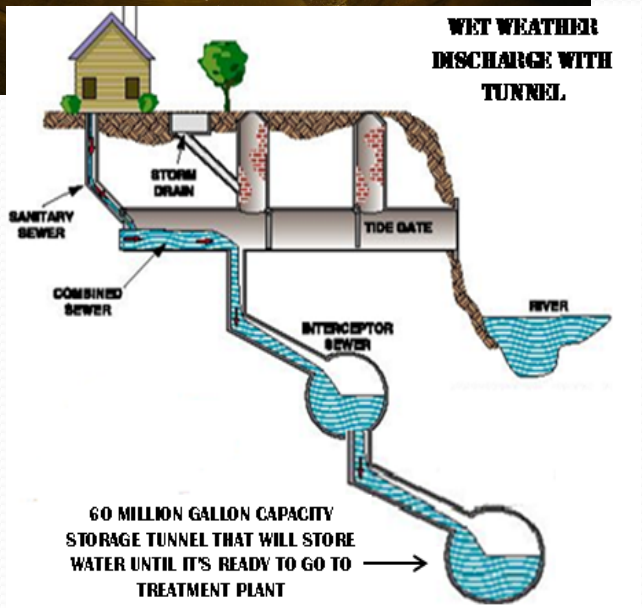
On Tuesday, the Board of Commissioners of the Narragansett Bay Commission voted to move ahead with an $815-million project that will become the third phase of a decades-long plan to contain and treat contaminated storm water that inundates century-old sewer systems in Providence, Pawtucket and Central Falls and

SEE PROJECT, A6

Inspectors inside the 3-mile tunnel that was built beneath Providence in the first phase of the project that was completed in 2008. COURTESY OF THE NARRAGANSETT BAY COMMISSION

CSO Phase I Water Quality Improvements

CSO Abatement Tunnel: Phase I



Expected benefits:

- Reduce annual CSO volume by 39%
- Reduce fecal coliform bacteria load by 40%
- Reduce TSS by 30%
- Reduce BOD by 31%
- Reduce the acre-days of shellfish closure in northern half of Upper Narragansett Bay by 47% and 77% in southern half

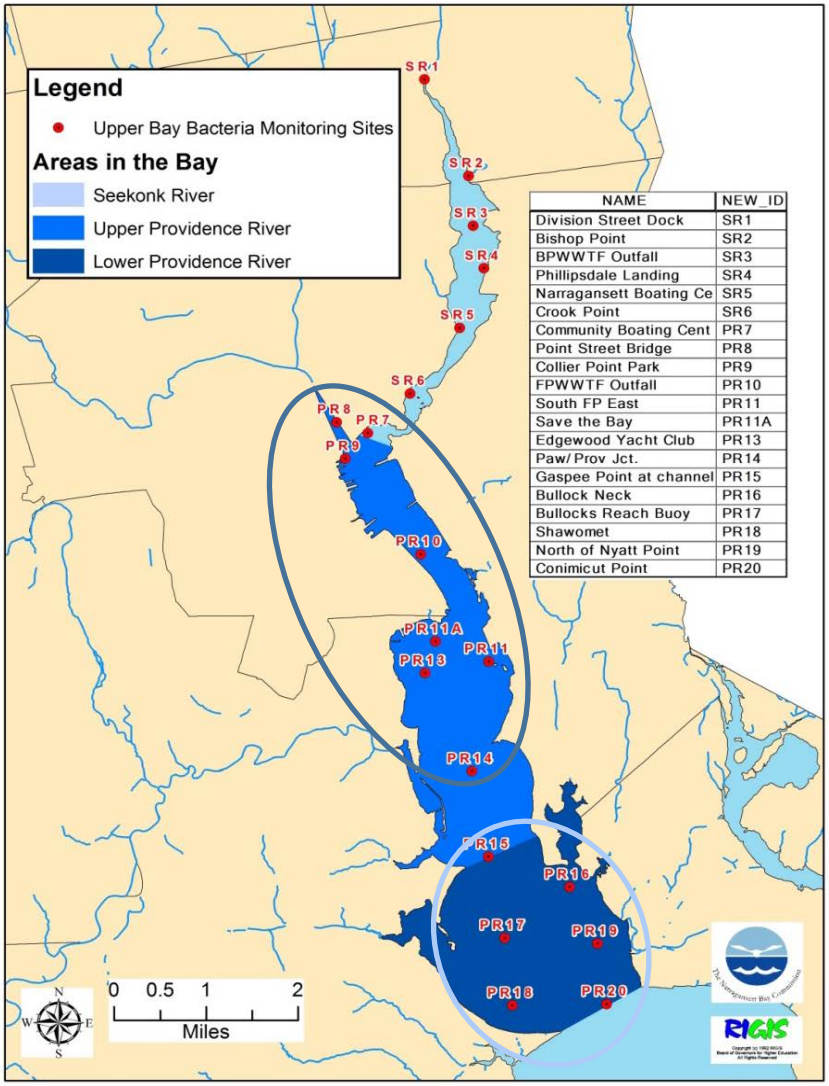
Combined system with the 65 million gallon CSO Tunnel, which captures & stores stormwater until it can be treated at the WWTF.

Pollutants Removed Due To Tunnel

- **Tunnel captured 6.6 billion gallons** of CSO flow over past 6+ years (through 10/29/15)
- Flow is pumped to FP WWTF & receives full secondary & tertiary treatment
- **~1.1 billion gallons/yr** captured
  - 50% of the CSO volume captured and treated annually (based on design model)
  - 50% Bacteria Load Reduction!!!
- Millions of pounds of pollutants prevented from being discharged
  - >2.5 Million Pounds TSS
  - >1.6 Million Pounds BOD
  - ~260,000 Pounds Nitrogen
  - >83,000 Pounds of Metals

Contaminant	Average Concentration CSO Tunnel Effluent		Total Pounds Removed by Capture in Tunnel & Treatment at Field's Point
Total Volume Captured in Tunnel	6,634,000,000 gallons		
Total Suspended Solids	52.18	mg/L	2,580,929
Biochemical Oxygen Demand	32.15	mg/L	1,654,025
Total Nitrogen	8.50	mg/L	260,722
Cyanide	6.29	µg/L	268
Aluminum	240	µg/L	12,566
Cadmium	1.27	µg/L	66
Chromium	5.67	µg/L	272
Copper	11.52	µg/L	535
Iron	1,432	µg/L	67,632
Lead	9.38	µg/L	471
Nickel	17.48	µg/L	298
Silver	2.02	µg/L	107
Zinc	31	µg/L	1,281

Upper Bay Bacteria Monitoring



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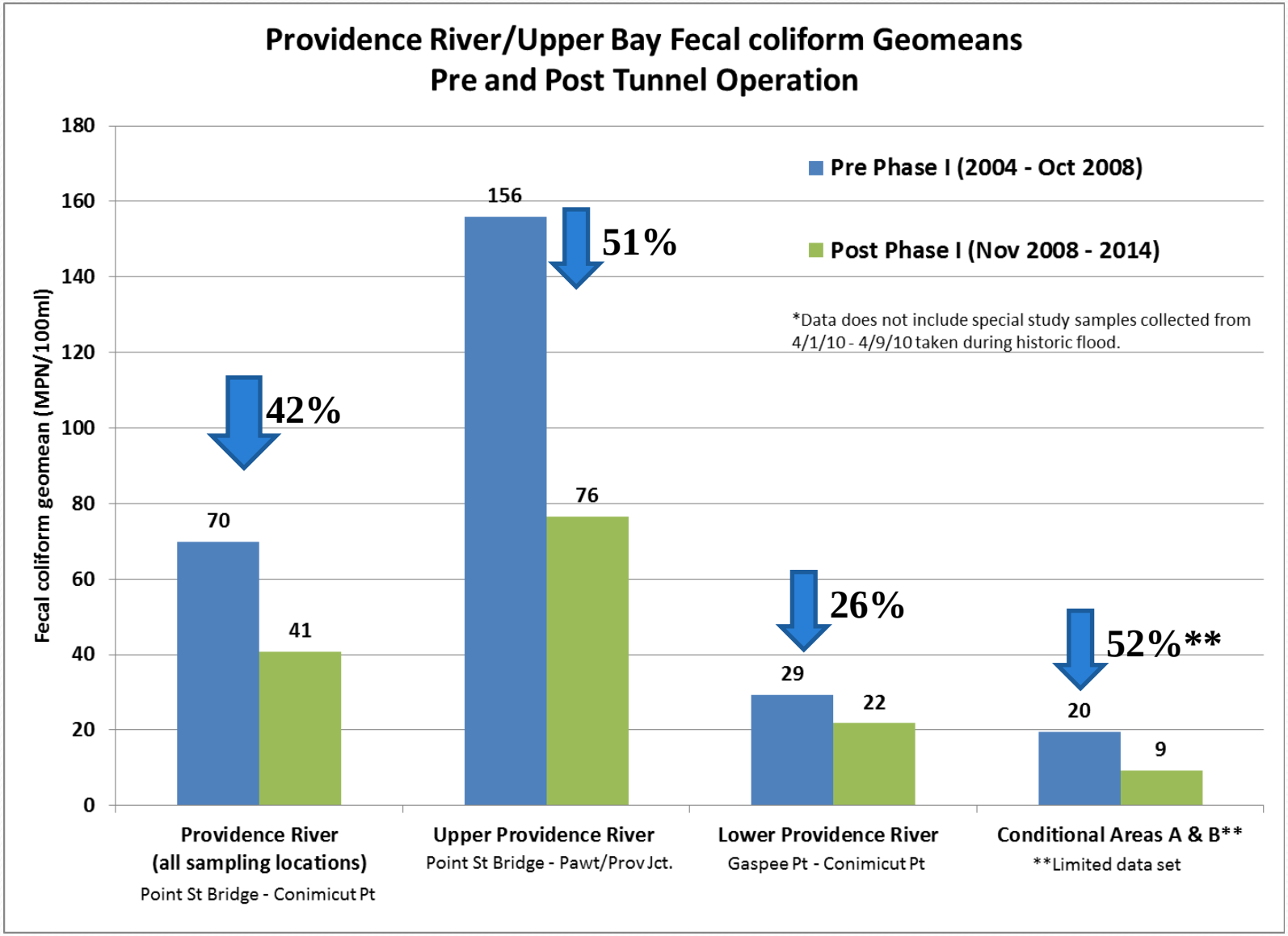
Division Street Dock	SR1
Bishop Point	SR2
BPWWTF Outfall	SR3
Phillipsdale Landing	SR4
Narragansett Boating Ce	SR5
Crook Point	SR6
Community Boating Cent	PR7
Point Street Bridge	PR8
Collier Point Park	PR9
FPWWTF Outfall	PR10
South FP East	PR11
Save the Bay	PR11A
Edgewood Yacht Club	PR13
Paw/ Prov Jct.	PR14
Gaspee Point at channel	PR15
Bullock Neck	PR16
Bullocks Reach Buoy	PR17
Shawomet	PR18
North of Nyatt Point	PR19
Conimicut Point	PR20

- 20 monitoring stations in Seekonk & Providence Rivers
- Twice a month throughout year for fecal coliform bacteria
- Pre-Phase I (2004 – Oct 2008)
- Post-Phase I (Nov 2008 – 2014)
- Extra sampling conducted during March 2010 storms were excluded from analysis (April 1 – 9, 2010)
- Wet day – rainfall 3 days prior >0.1 inches
- Dry day - rainfall 3 days prior <0.1 inches
- Water Quality Determination
  - May – October
  - Geomean < 50 MPN/100 mL
  - Not more than 10% samples > 400 MPN/100 mL

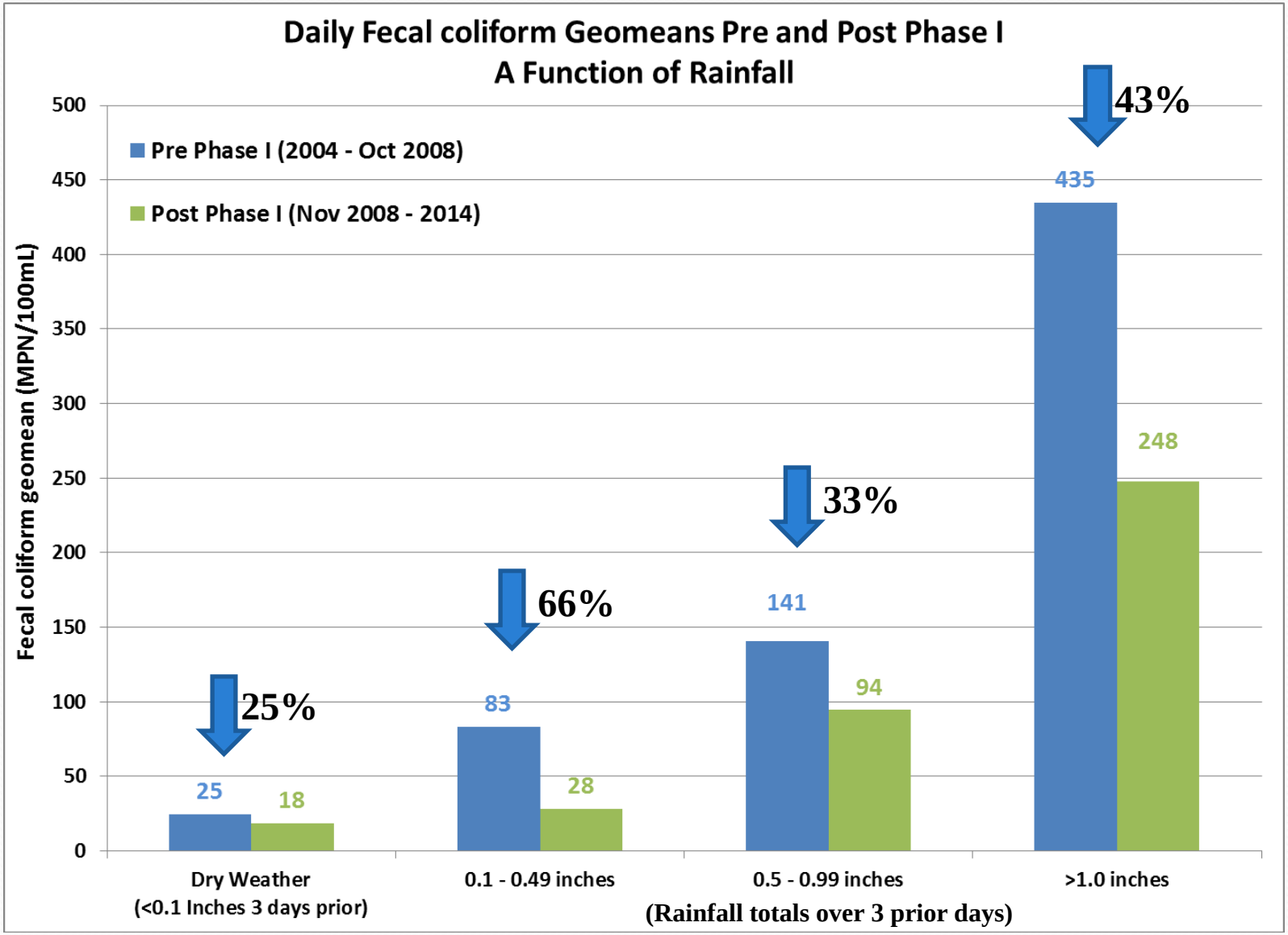
Upper Bay Bacteria Data Analysis

Providence River – All Weather



Upper Bay Bacteria Data Analysis

Providence River – Wet Weather

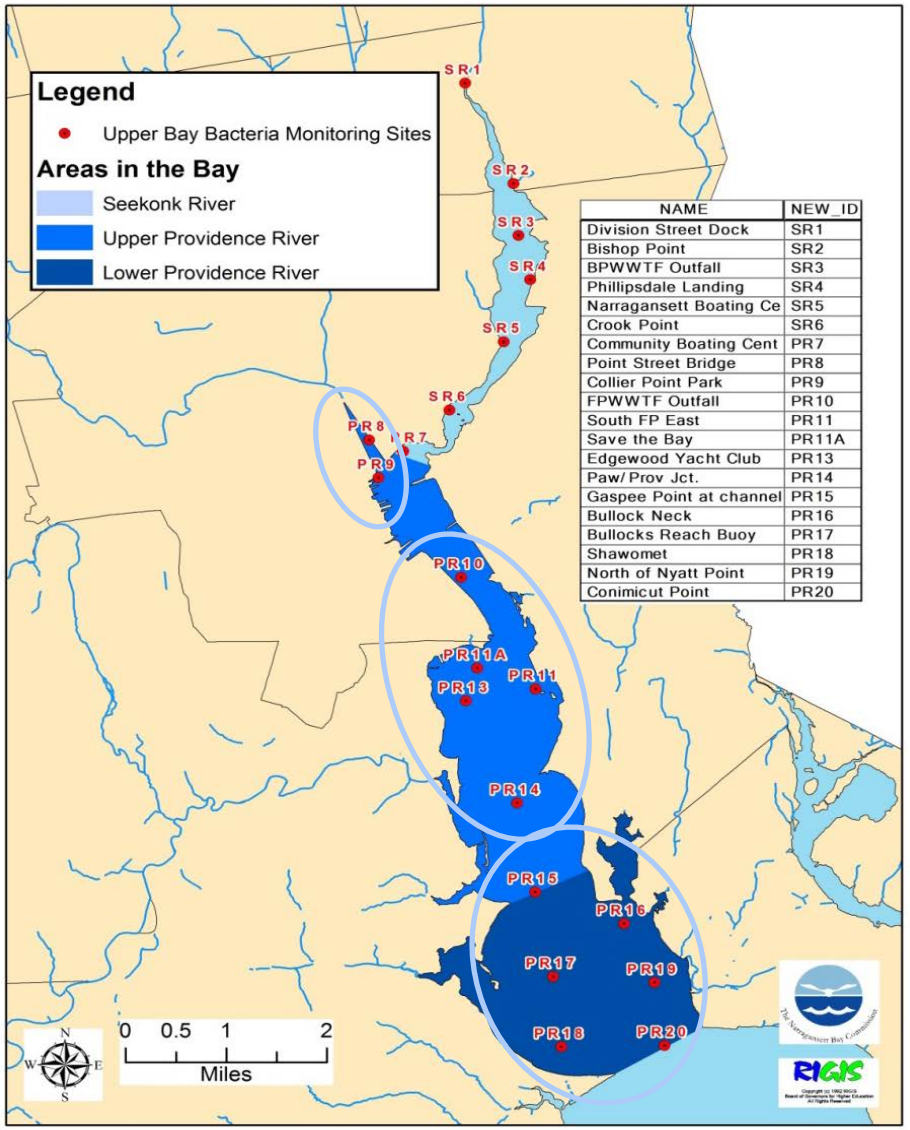


Upper Bay Bacteria Data Analysis

Meeting Water Quality Standards?

Providence River Post Phase I

- Upper Providence River did not meet WQ Standards
- Mid Providence River:
  - Met more frequently after Phase I
  - 2014: ALL stations met for first time!
- Lower Providence River:
  - Met both criteria most years, improved post Phase I
  - 65% of years met pre Phase I
  - 87% of years met post Phase I



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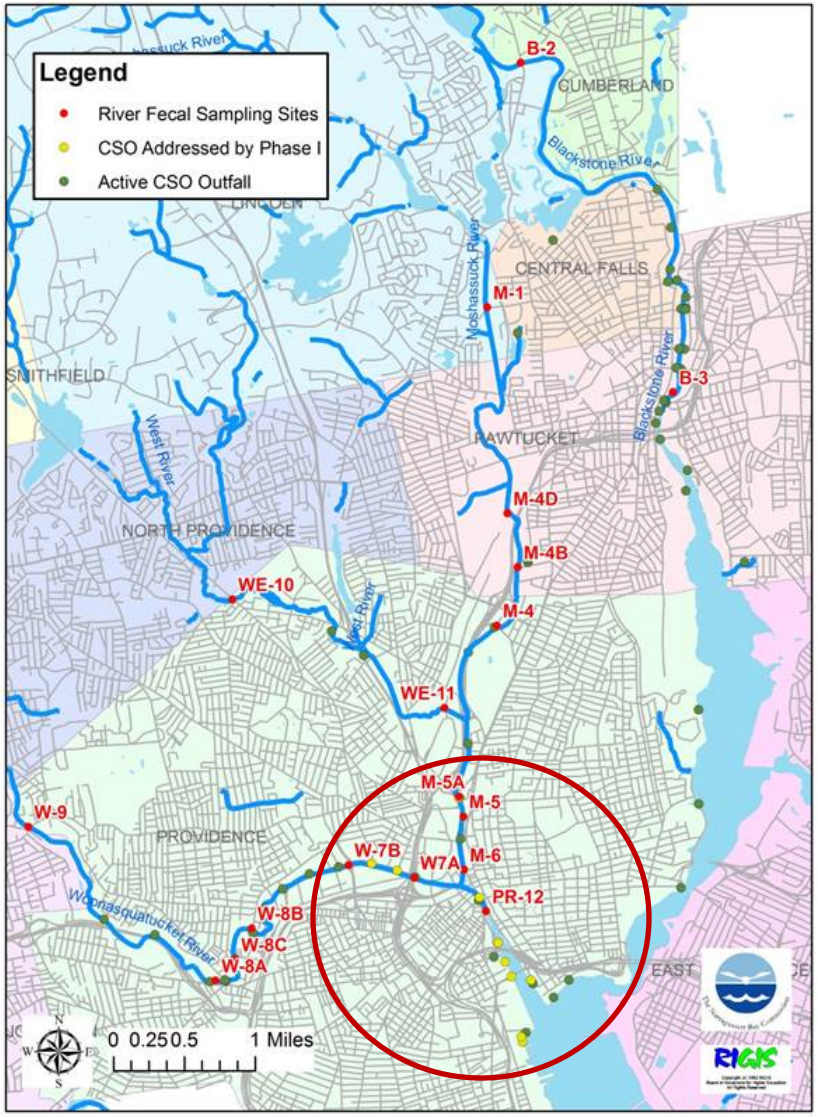
Has Phase I Improved Upper Bay Shellfisheries?

- Regulations changed in 2011:
  - Cond. Area A closed with 0.8 inches of rainfall
  - Cond. Area B closed with 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 in 2013 compared to 2004 (Watershed Counts 2014)
- This is important because, in 2012….
  - 45% of the quahog harvest came from Areas A & B (54% in 2014!)
  - Totaling 17.5 million clams
  - Equaling $2.48 million (Data from J. Mercer, RIDEM)
- DEM reevaluating the criteria now that Phase II is complete

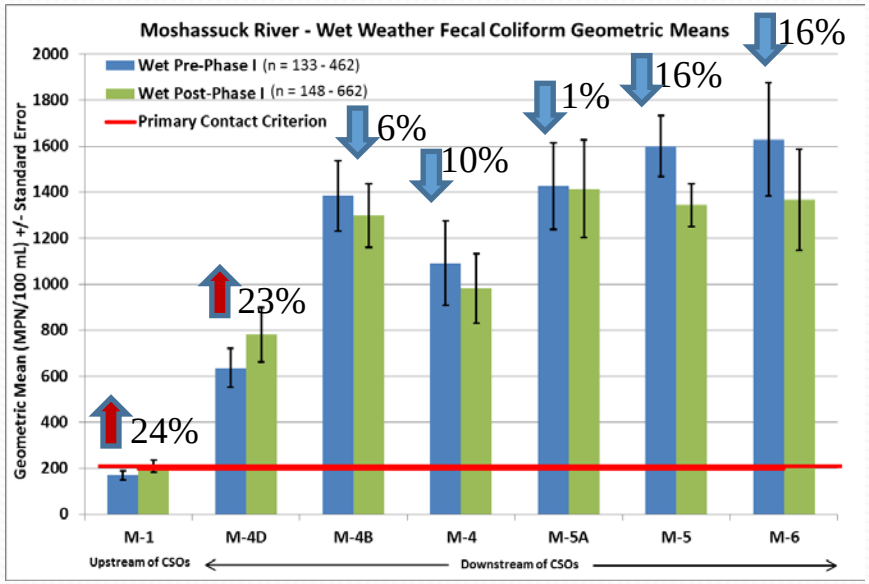
Urban River Bacteria Sampling

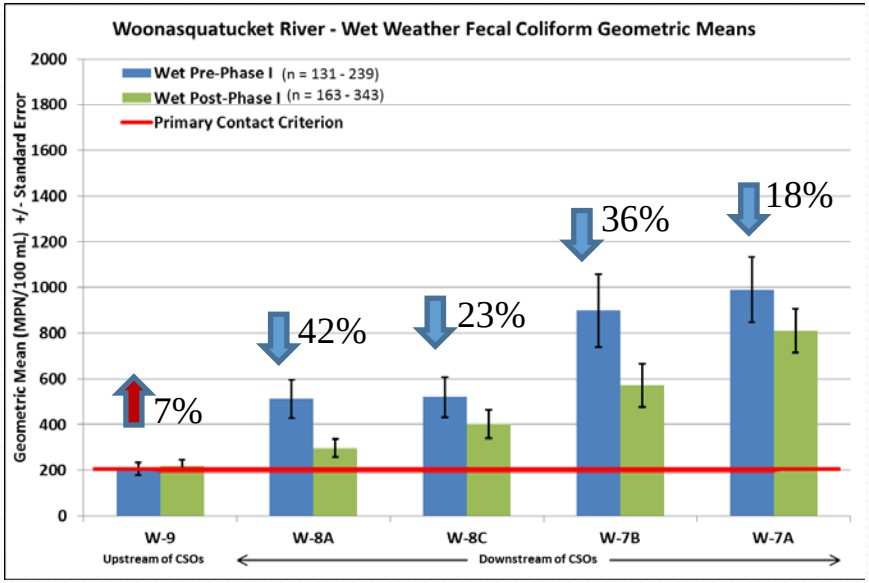
- Required by DEM RIPDES Permits (CSO 9 Minimum Controls Program)
  - Data collected weekly Monday & Tuesday (Thursday if results elevated)
  - Monitor Up/Downstream of CSOs
  - 1 station on Pawtuxet River as baseline
- Includes data from 2004 – 2014
- Pre-Phase I (2004 – Oct 2008)
- Post-Phase I (Nov 2008 – 2014)
- Wet day – rainfall 3 days prior >0.1 inches
- Dry day – rainfall 3 days prior <0.1 inches
- Water Quality Determination
  - May – October
  - Geomean < 200 MPN/100 mL
  - Not more than 10% samples > 400 MPN/100 mL

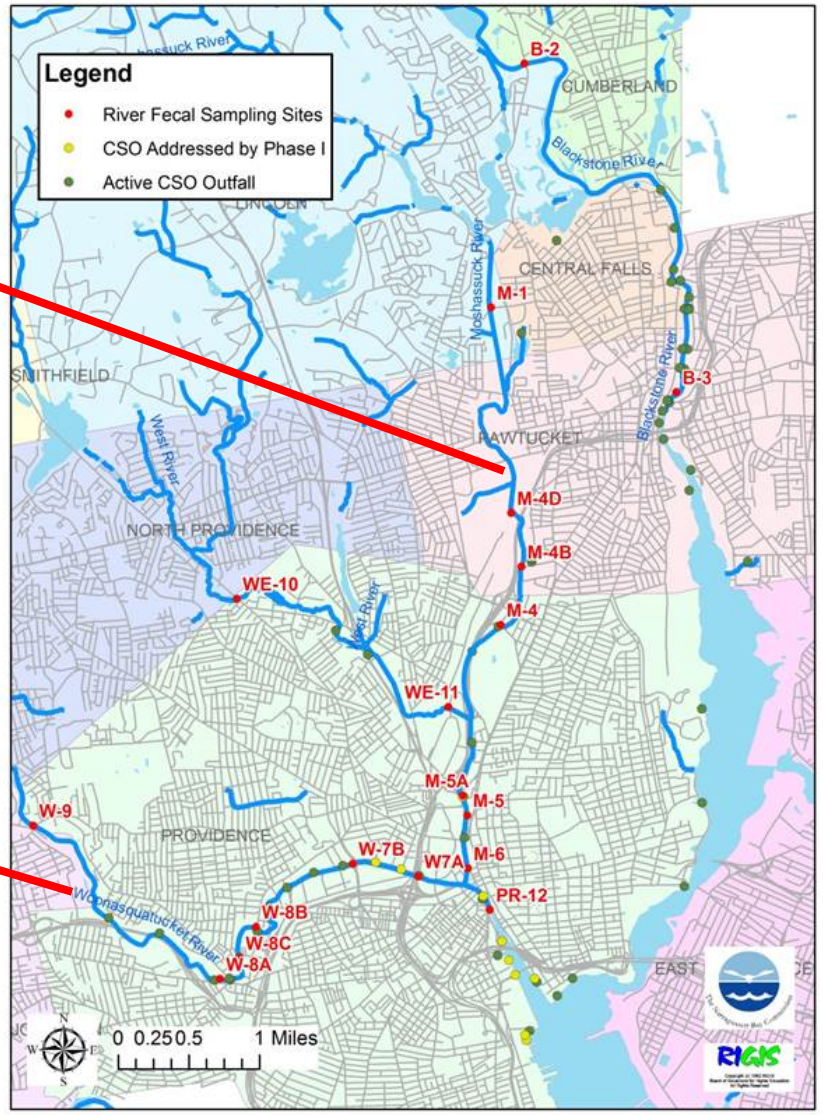


Urban River Bacteria Data Analysis

Wet Weather Results Pre vs Post Phase I Tunnel







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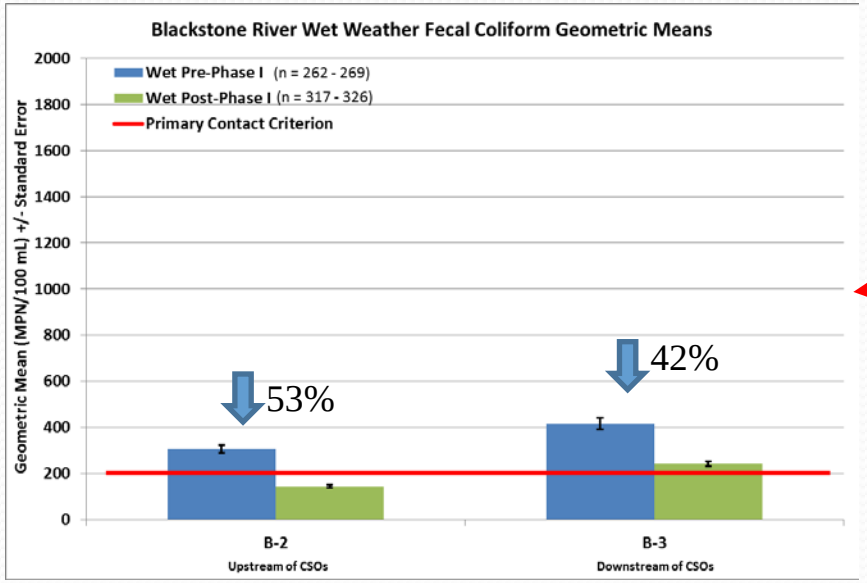
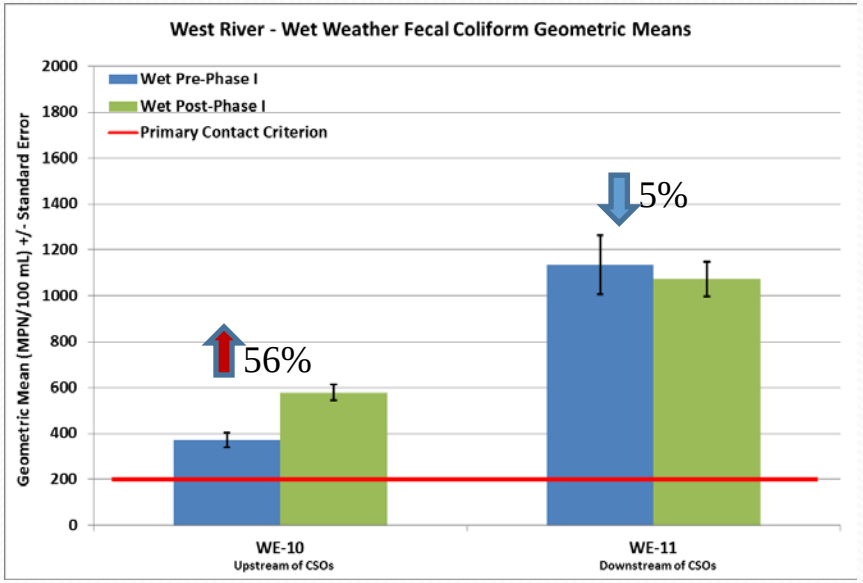
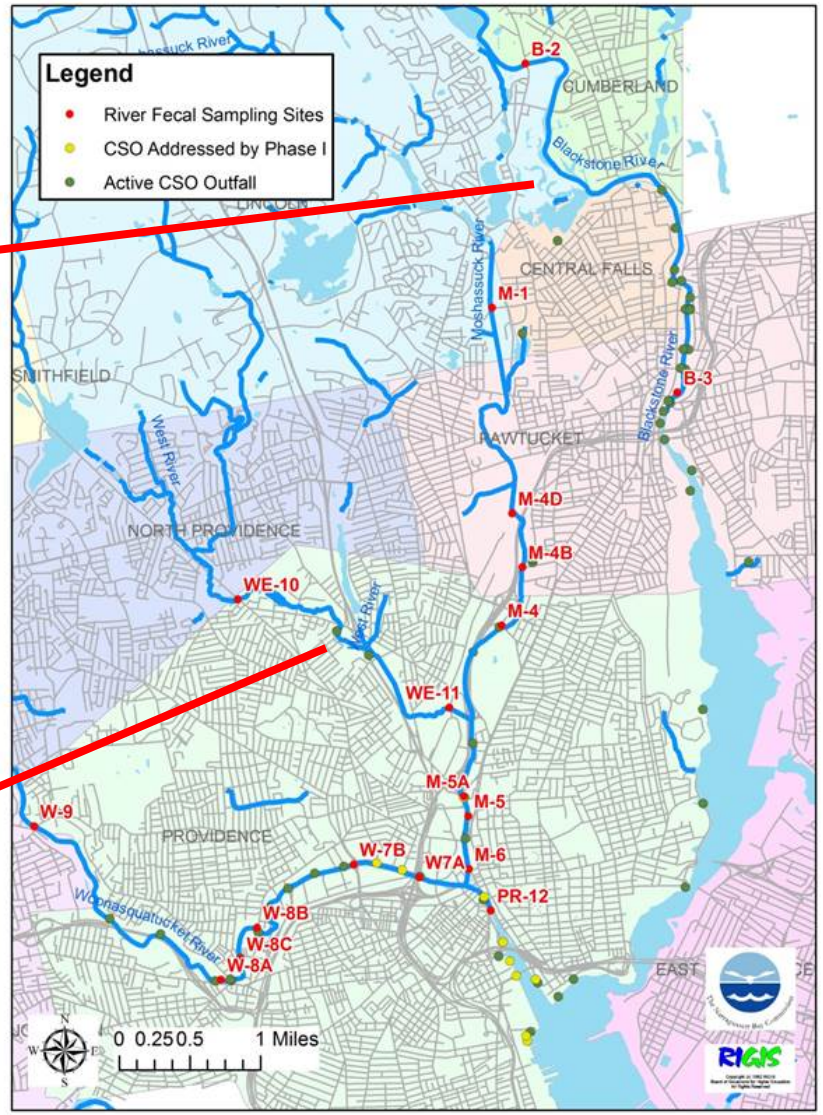
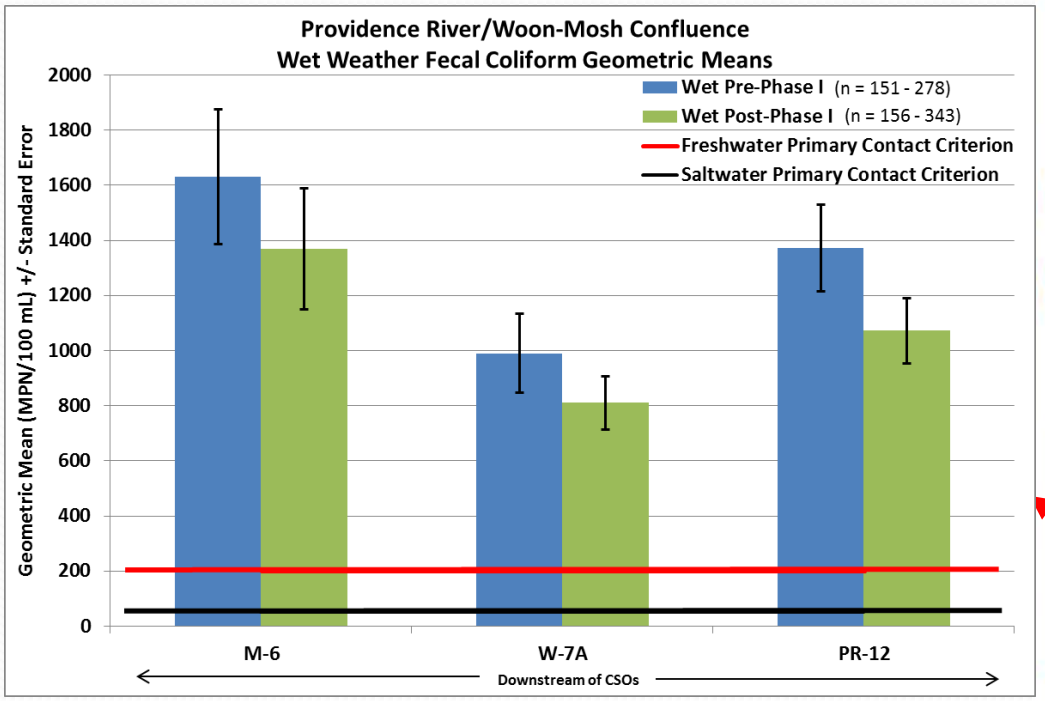




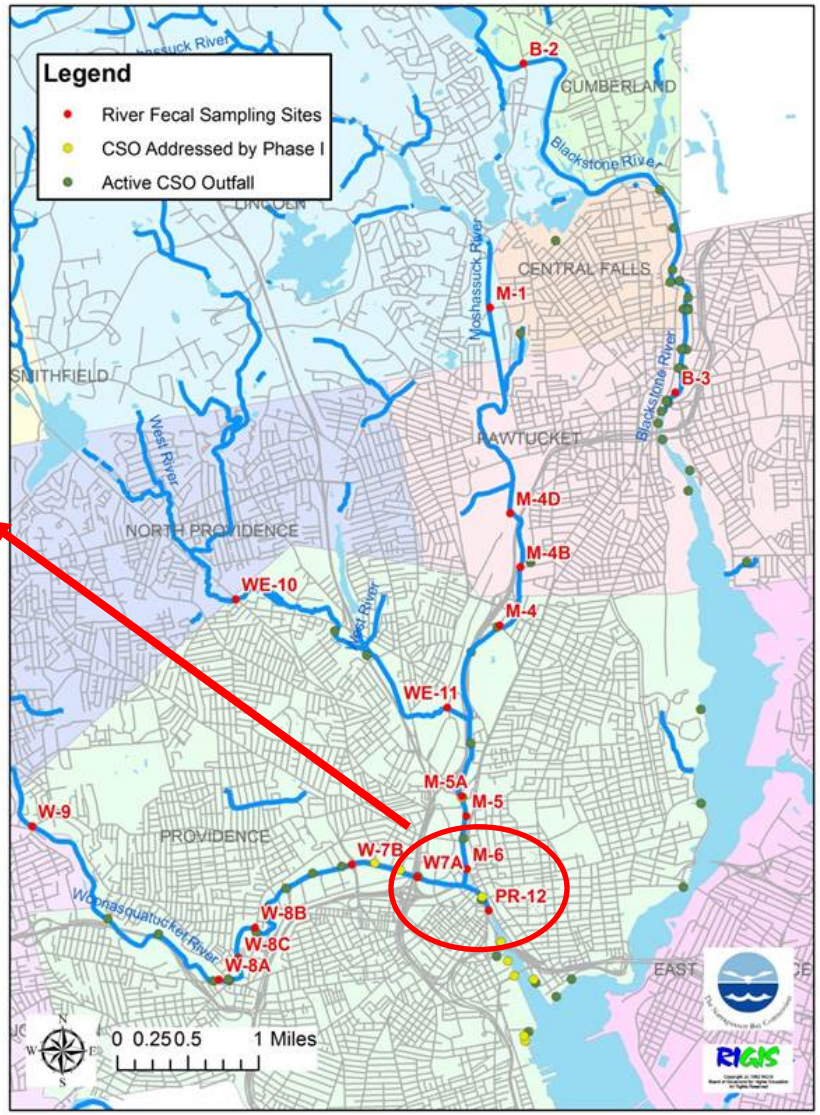


Urban River Bacteria Data Analysis

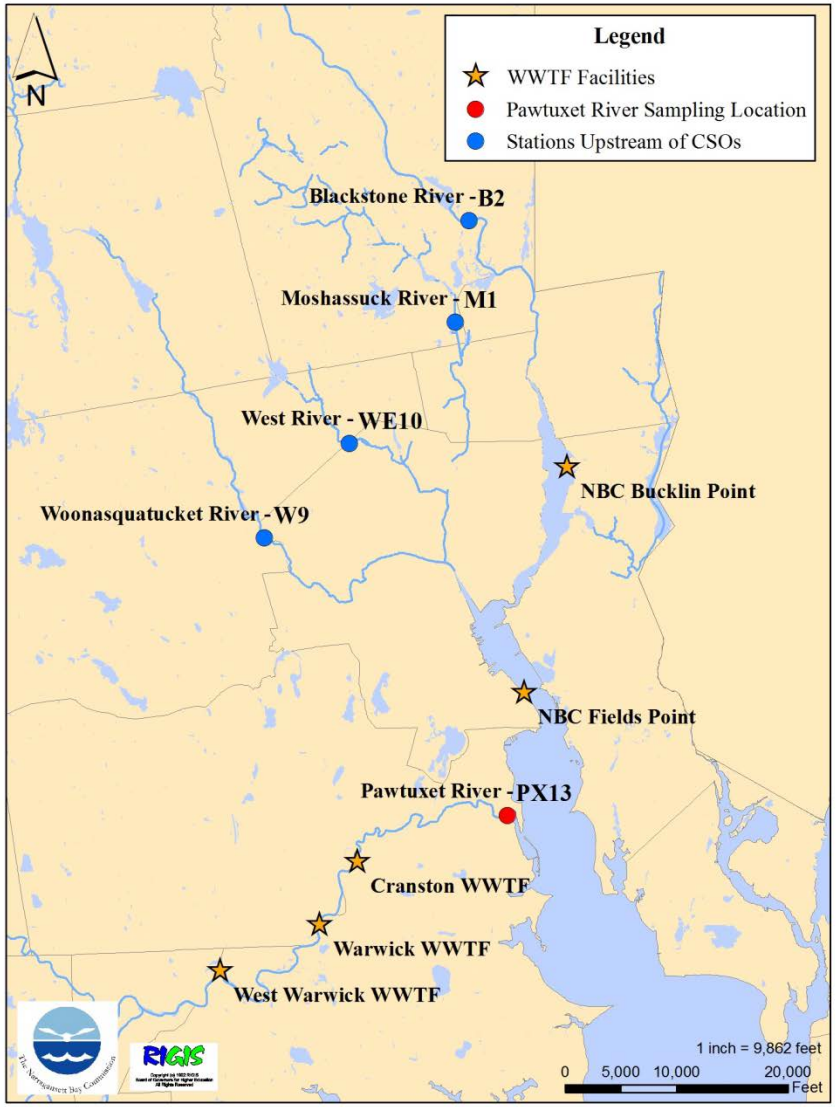
Wet Weather Results Pre vs Post Phase I Tunnel

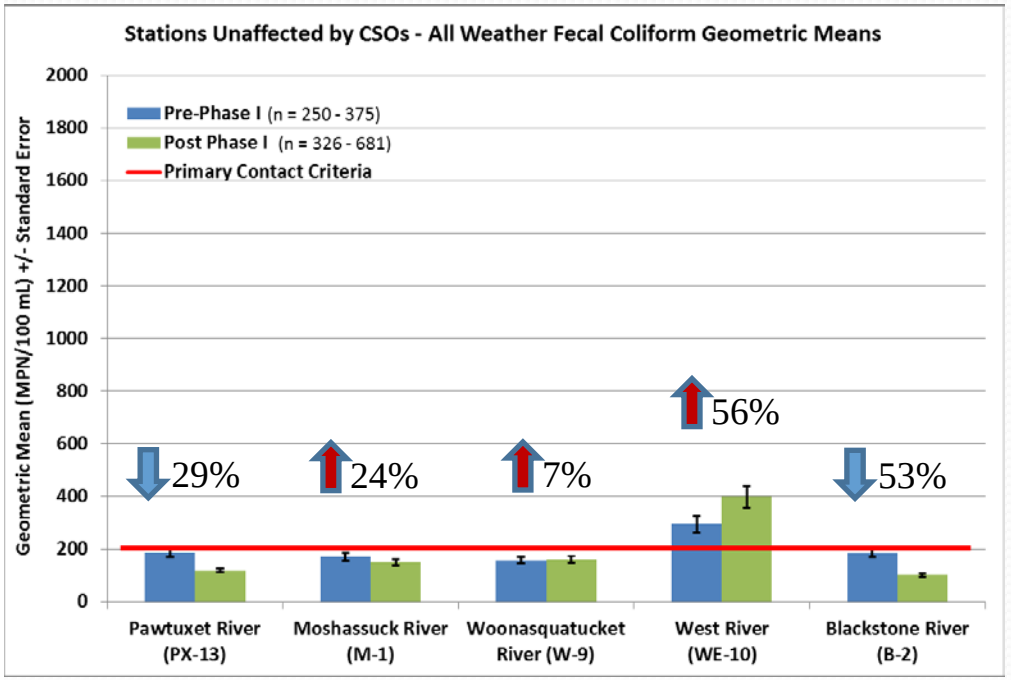


- Moshassuck River mouth ⇩16%
- Woonasquatucket River mouth ⇩18%
- Providence River headwaters ⇩22%



Monitoring Stations Upstream of NBC CSOs





- NBC monitors stations upstream of CSOs
- Also samples Pawtuxet River (no CSOs on this river)
- **NBC Data shows frequent water quality violations at all stations**

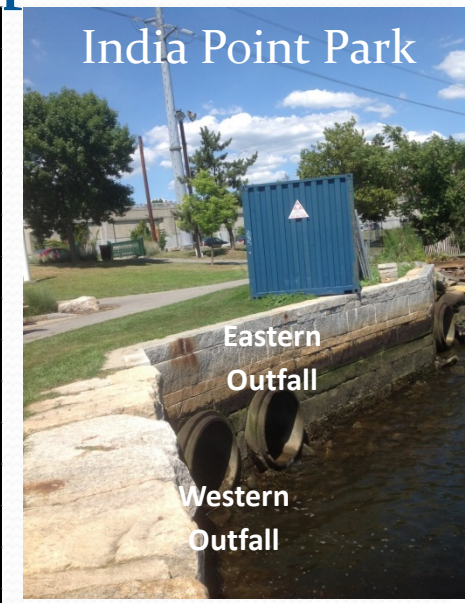
Urban River Bacteria Data Analysis

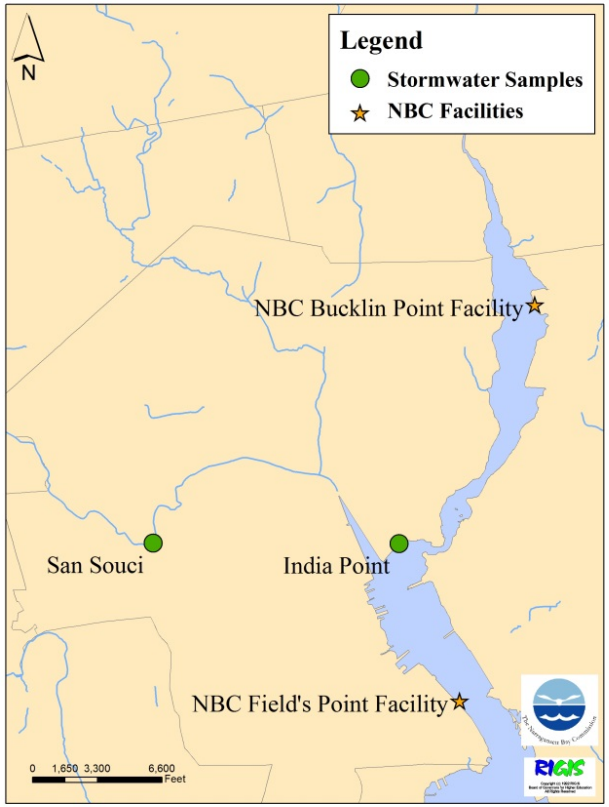
Meeting Water Quality Standards?

- **No stations met water quality criteria in all weather conditions (Wet and Dry)**
- Some stations met criteria using only dry weather results, but only in some years
  - Woonasquatucket River station met standards upstream of CSOs in 2008 & 2014
  - Blackstone River station met upstream of CSOs in all years but 2004, 2011 & 2012
  - Blackstone River station met downstream of CSOs in 2012 & 2014
  - Pawtuxet River station met in 2008 & 2009
- **Stations unaffected by CSOs are not always meeting criteria…**other pollution sources upstream of CSOs need to be addressed

Stormwater Impairments

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
Dissolved Aluminum	µg/L	63.29	395.3
Dissolved Cadmium	µg/L	0.10	0.09
Dissolved Chromium	µg/L	3.01	3.05
Dissolved Copper	µg/L	55.67	8.68
Dissolved Iron	µg/L	182.95	505.17
Dissolved Lead	µg/L	31.66	43.07
Dissolved Nickel	µg/L	2.08	1.14
Dissolved Silver	µg/L	<0.02	<0.02
Dissolved Zinc	µg/L	116.93	53.02
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 outfall sampled
  - August 22, 2013 – 0.49 inches
  - September 30, 2015 – 2.02 inches (not first flush)
- Fecal coliform:
  - Range: 9,300 to > 24,000,000 MPN/100 mL
  - Exceeded primary contact criteria
- All *Enterococci* samples: >2,420 MPN/100 mL

Phase I Summary

Phase I CSO Tunnel Project has:

- Captured ~1.1 Billion Gallons/Year of CSO flow
- Reduced CSO volume and bacteria loads by ~50%
- Prevented millions of pounds of pollutants from discharging to our rivers and Narragansett Bay
- Assisted in reducing beach closures
- Allowed DEM to relax Shellfishing Closure standards

- NBC Received Water Environment Federation's National Water Quality Improvement Award
- But, monitoring stations unaffected by CSOs are not meeting standards
- **NBC CSO Abatement Program WILL NOT meet water quality standards:**
  - ✓ CSO System will still overflow ~ 4 times per year
  - ✓ Other Sources of Bacterial Pollution Needs to be addressed

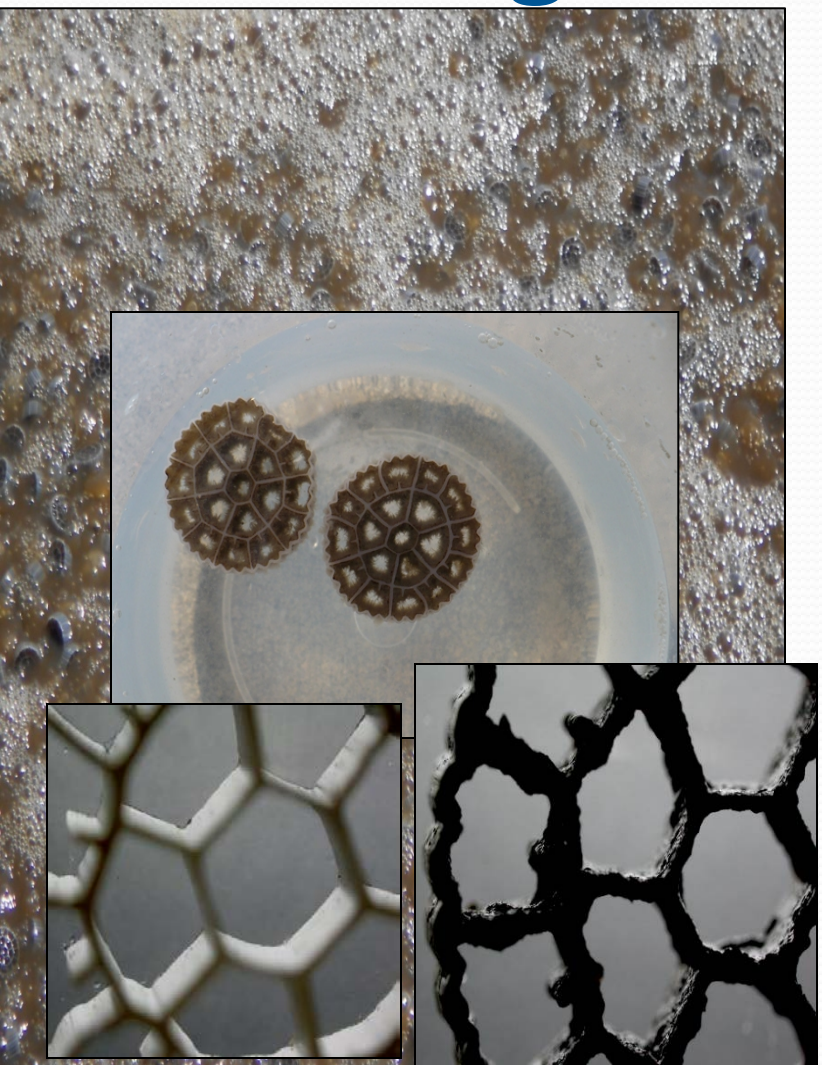
NBC Facility Nutrient Reductions

Bucklin Point
Biological Nutrient Removal

- Upgrade to meet seasonal 8.5 mg/L TN in 2005/2006 **- $8.3M** (out of total $59M plant upgrades)
- Upgrade to meet 5 mg/L complete in 2014, permit in effect on July 15th, 2014
- 2014 seasonal average = 4.0 mg/L
  - 2015 May – September = 4.2 mg/L
- Reduced 2,319 lbs TN/day vs. 2003

Nitrogen Upgrade Cost
~$13 Million

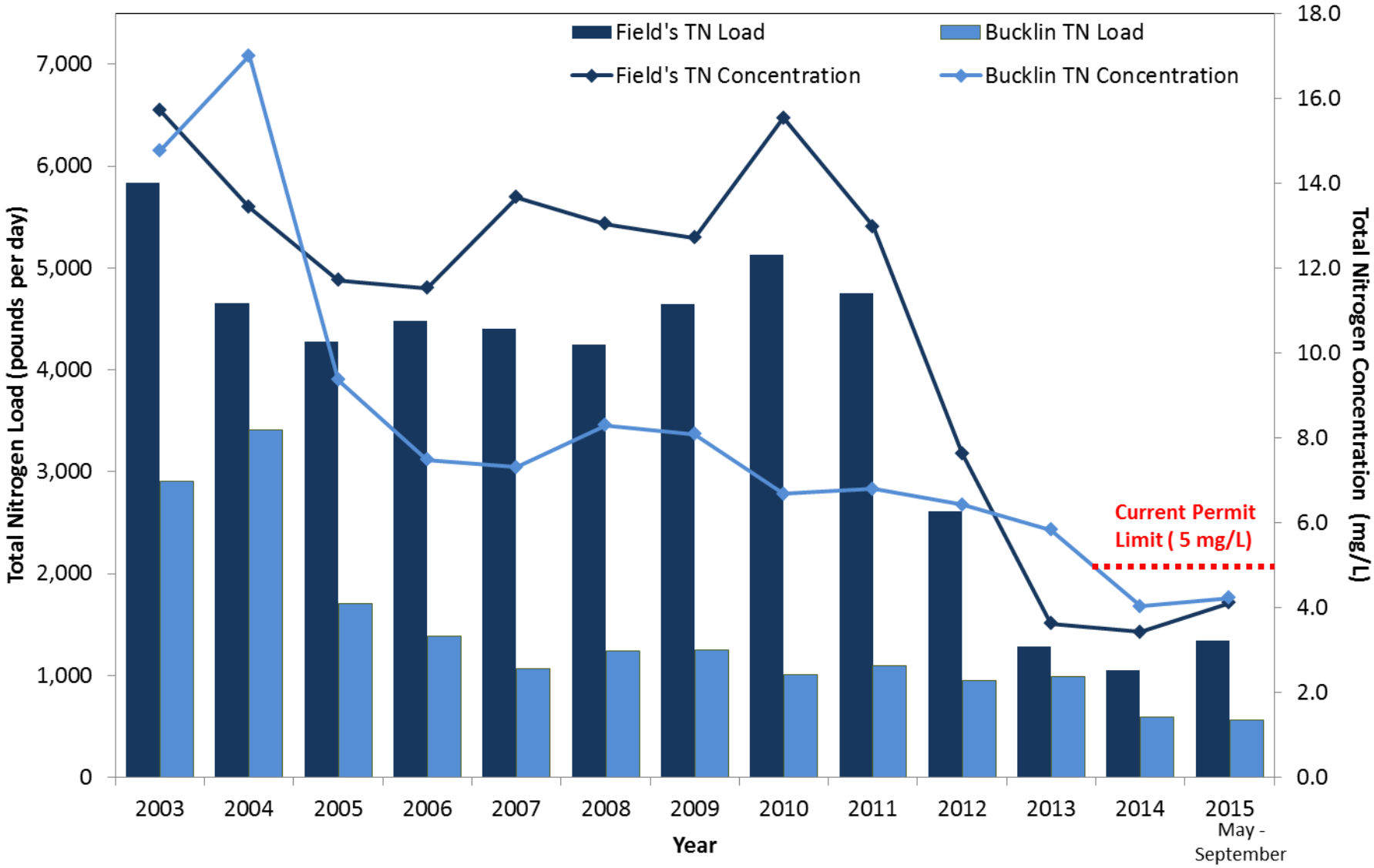
Field's Point
Biological Nutrient Removal



- Integrated Fixed Film Activated Sludge (IFAS) –
  Largest in the world achieving such a low effluent limit!
- Construction completed in 2013 –
  5 mg/L Permit limits in effect on May 1, 2014
- 2014 seasonal average = 3.4 mg/L
  - 2015 May – September = 4.1 mg/L
- Reduced 4,782 lbs TN/day vs. 2003

Nitrogen Upgrade Cost
~$31 million

Field's Point and Bucklin Point
Seasonal (May - Oct) Average Effluent Total Nitrogen



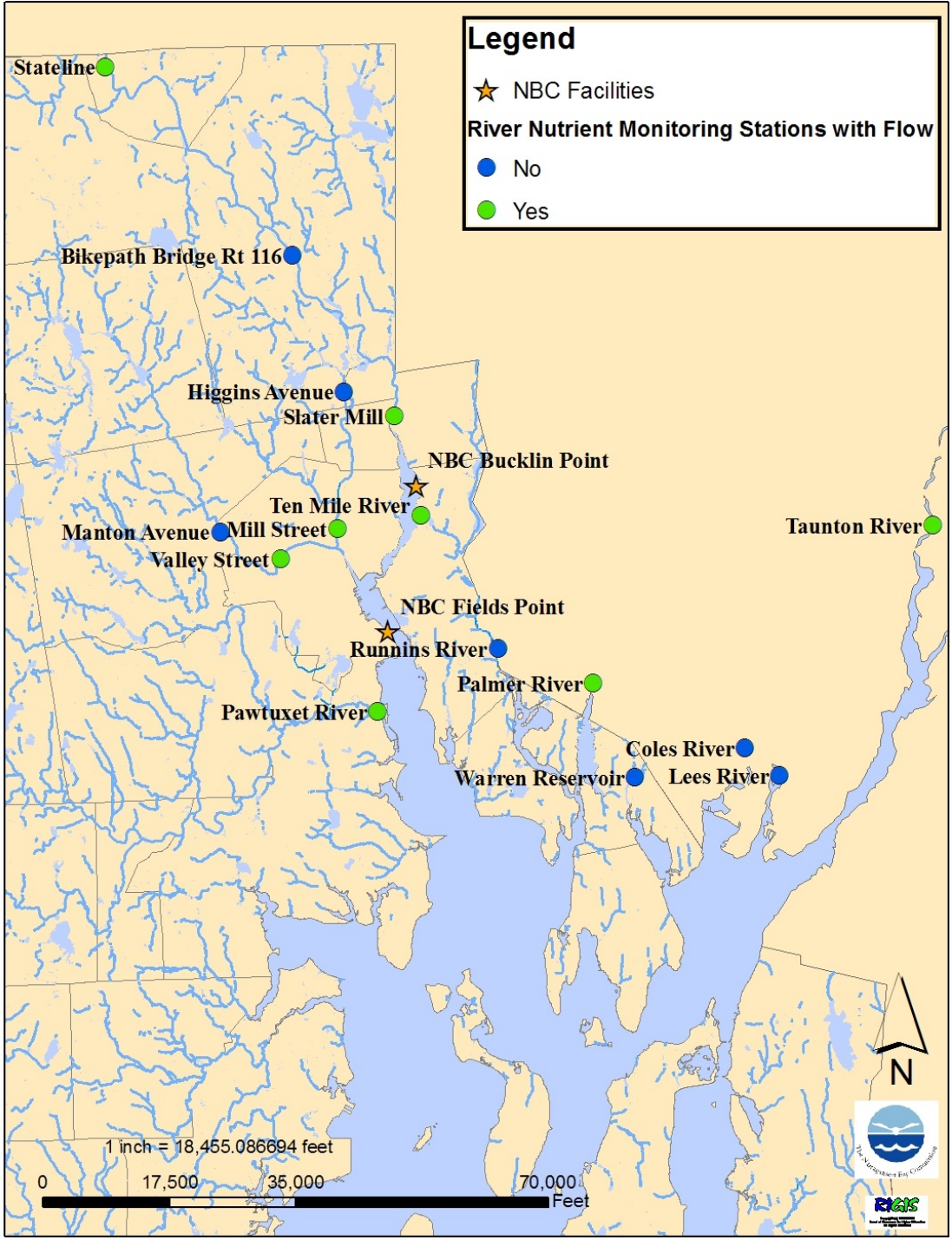
NBC Receiving Water Nutrient Monitoring

NBC Nutrient Monitoring

- NBC monitoring program one of the most extensive in the region
- Provides data & sound science needed to address regulatory mandates, protect ratepayers
- Nutrients are monitored in the upper bay and tributary rivers, including major rivers at the state border

River Nutrient Stations

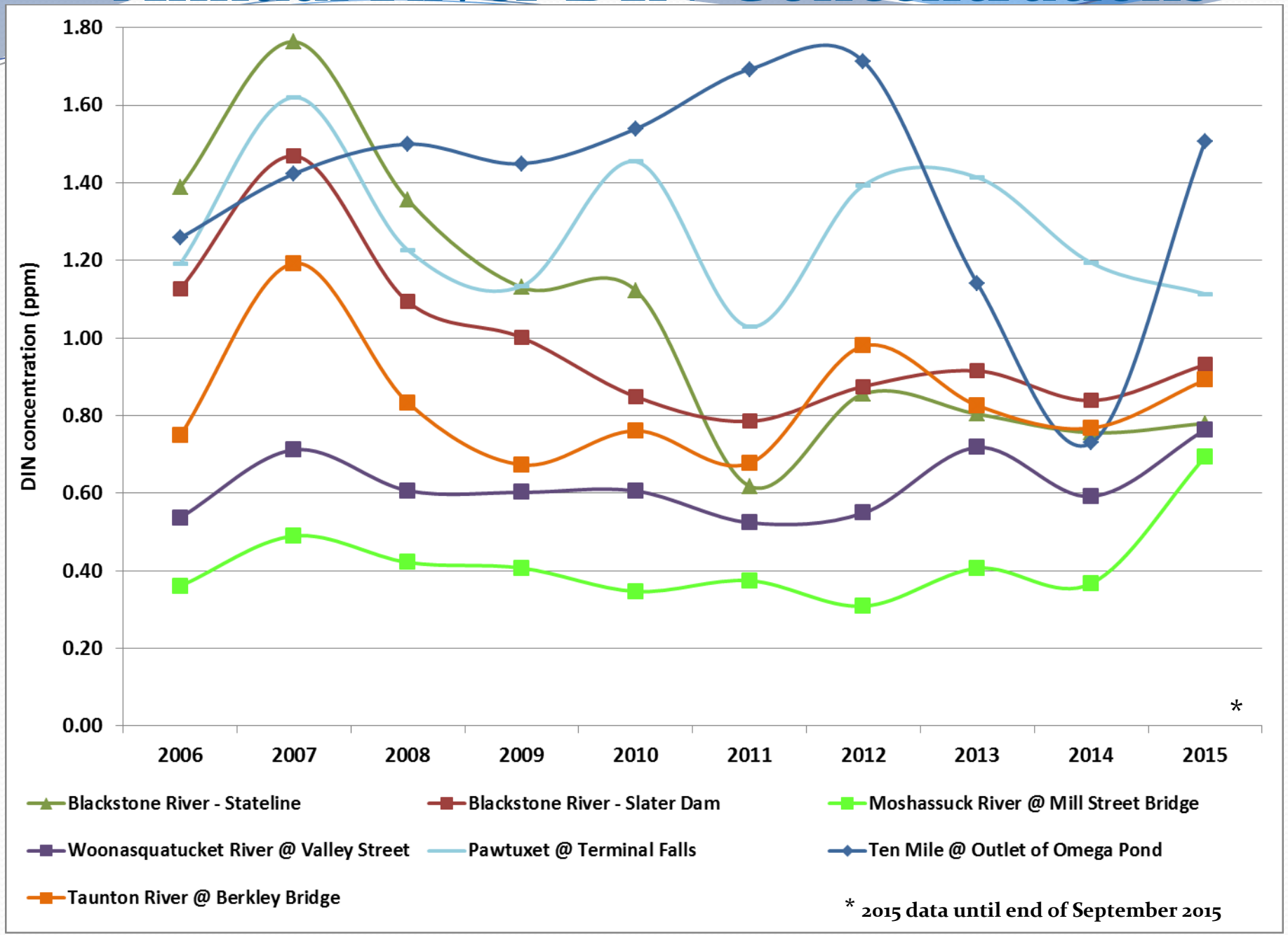
- Measured bi-monthly at 15 sites in RI & MA
- Total N loading – USGS river flow data
- Rivers with flow data:
  - Blackstone River
  - Moshassuck River
  - Woonasquatucket River
  - Pawtuxet River
  - Taunton River
  - Ten Mile River
  - Palmer River*

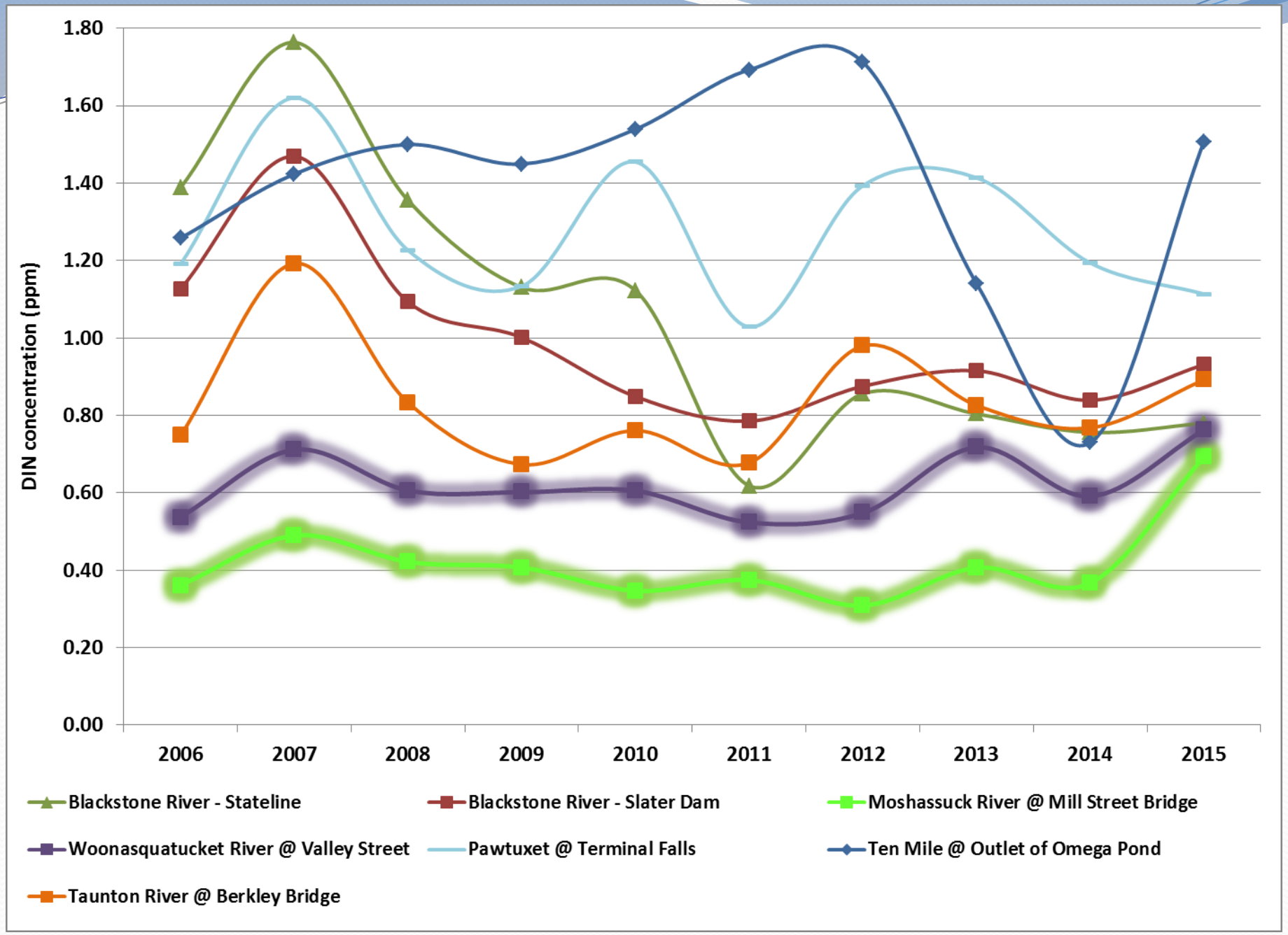


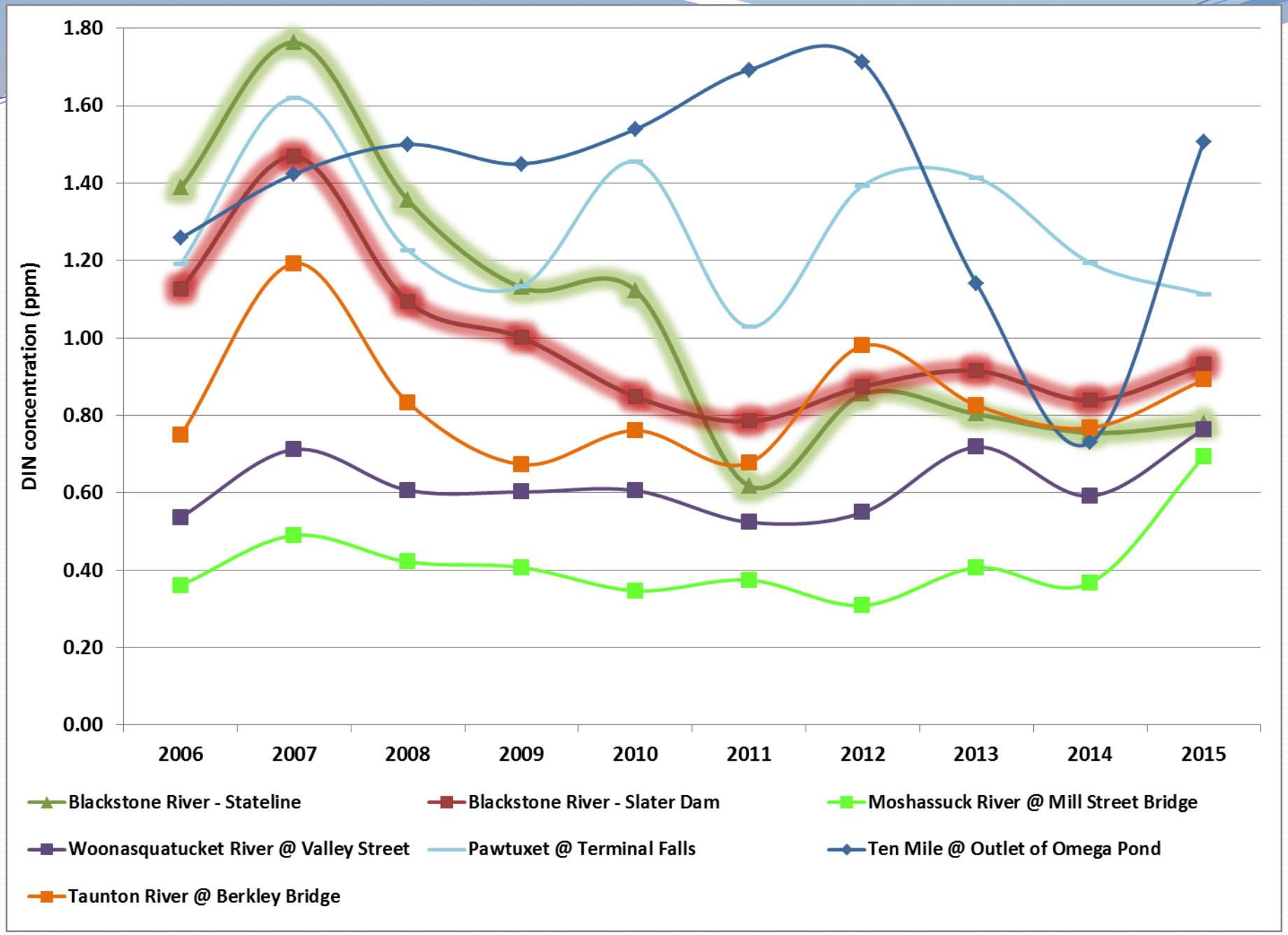
River Nutrients

- Nutrient suite analyzed includes:
  - Nitrite/nitrate (NO_2NO_3)
  - Nitrite (NO_2)
  - Total Dissolved Nitrogen (TDN)
  - Ammonia (NH_3)
  - Orthophosphate
  - Silicate
  - Total Suspended Solids (TSS)
- Dissolved Inorganic Nitrogen (DIN)
- DIN is calculated value
  - Sum of NO_2NO_3, NH_3
- Most biologically available form of N

Annual River DIN Concentrations




DIN concentration (ppm)
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
Blackstone River - Stateline
Blackstone River - Slater Dam
Moshassuck River @ Mill Street Bridge
Woonasquatucket River @ Valley Street
Pawtuxet @ Terminal Falls
Ten Mile @ Outlet of Omega Pond
Taunton River @ Berkley Bridge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1.80
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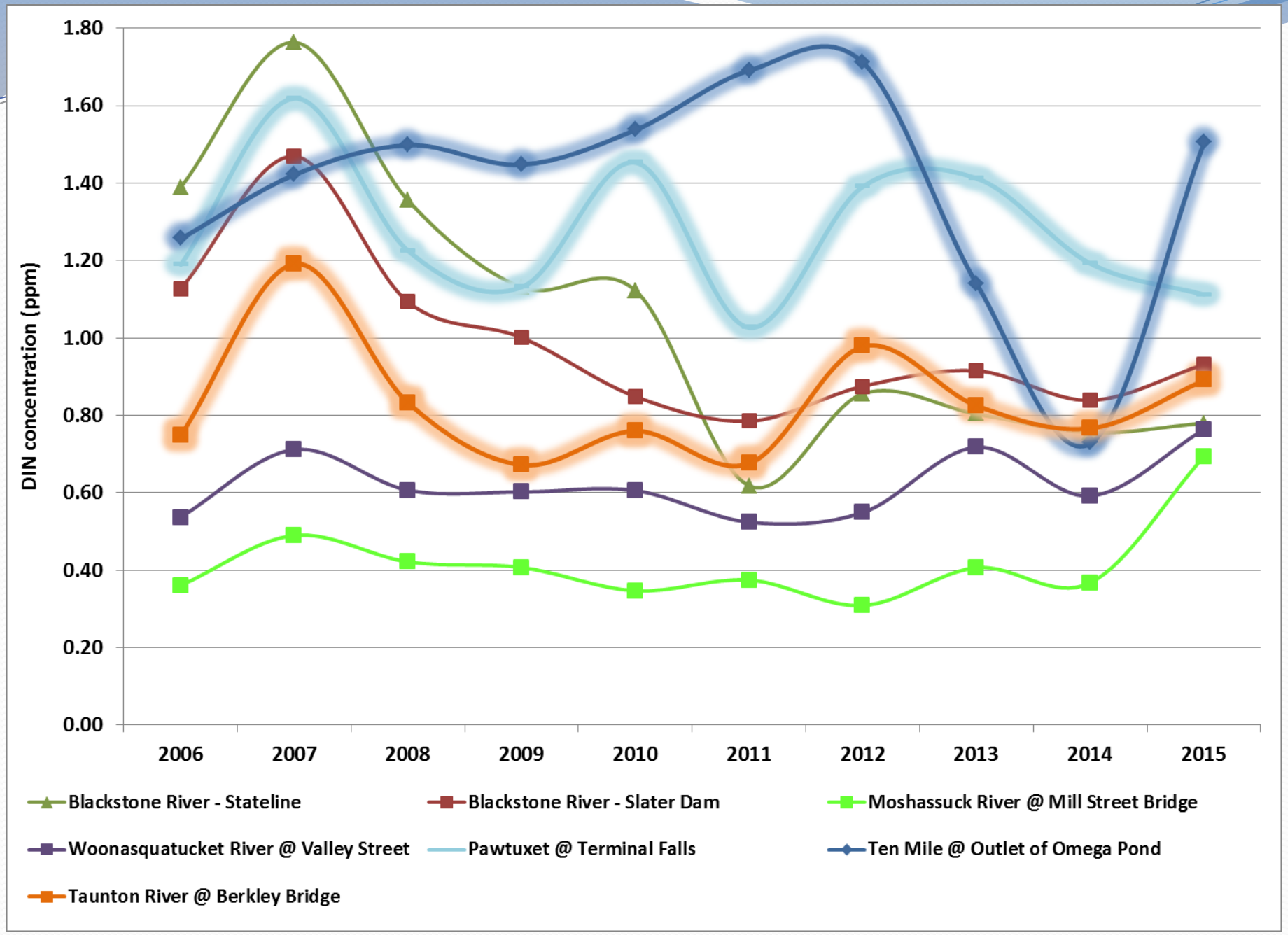
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1.60
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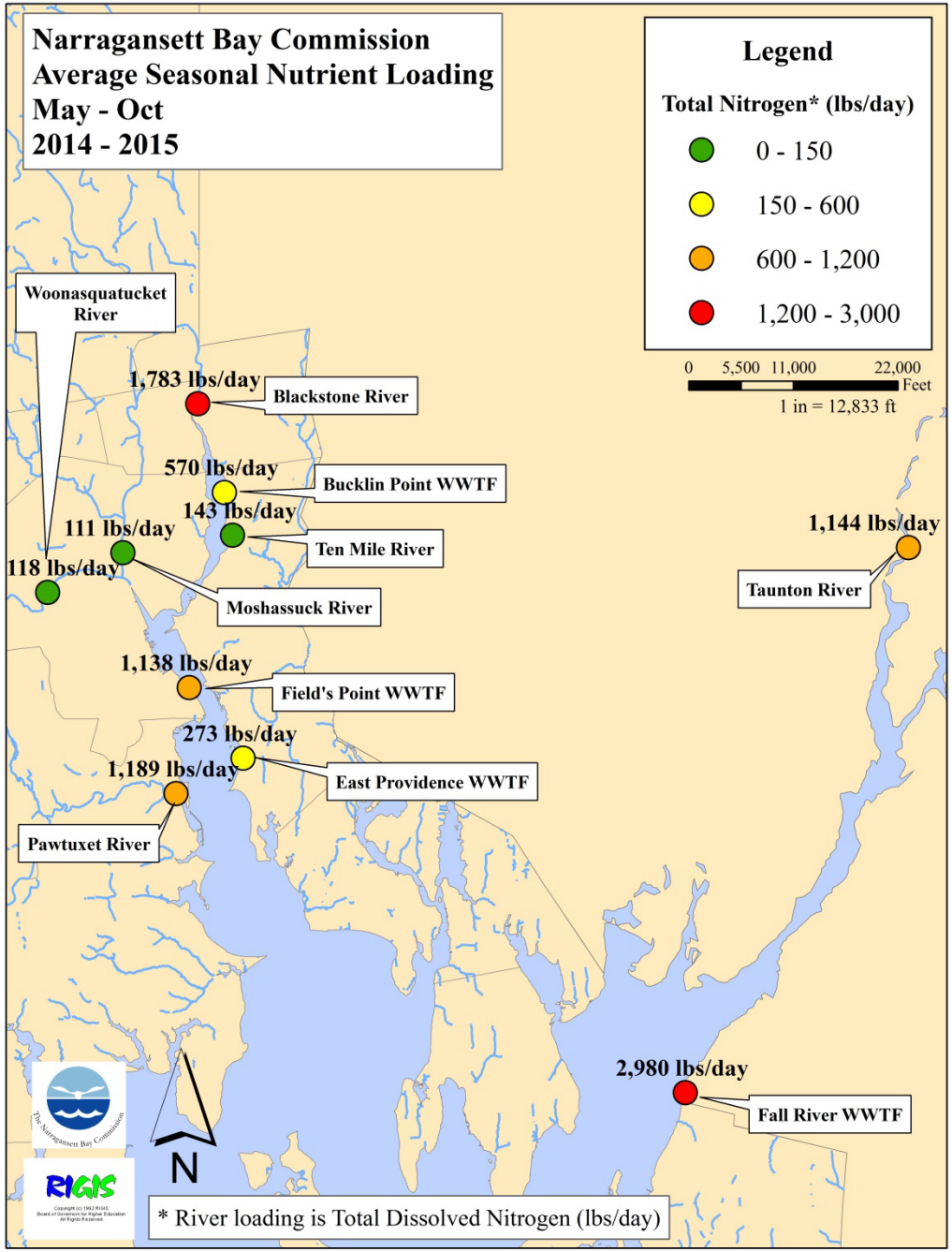


Total Nitrogen/TDN Loading from Upper Bay Rivers and WWTFs

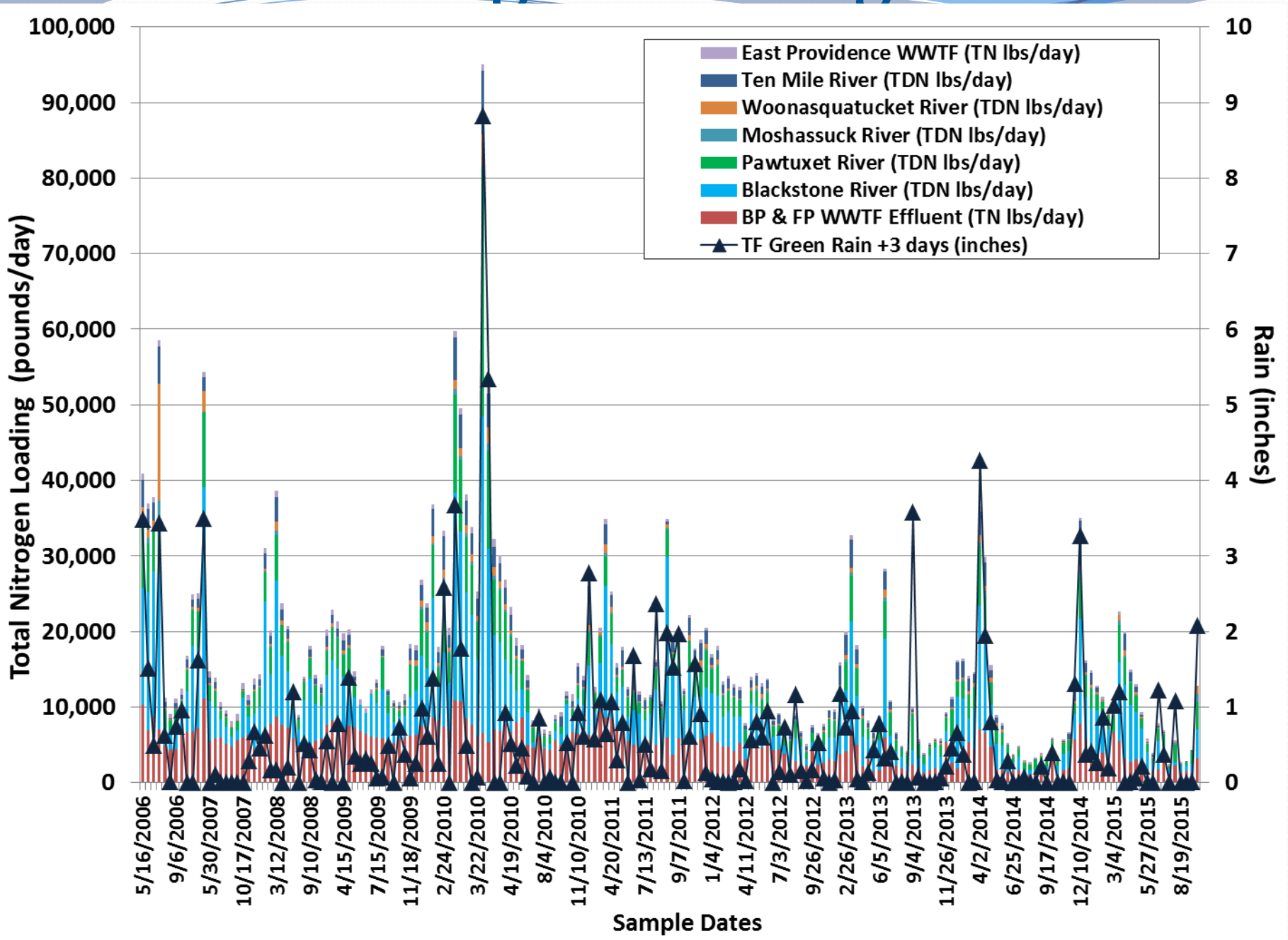
	2006-2013 Average Values	2014 - 2015 Average Values
Source	Pounds	Pounds
Bucklin Point	1,188	570
Field's Point	3,986	1,138
Blackstone River	4,424	1,783
Moshassuck River	175	111
Woonasquatucket River	426	118
Pawtuxet River	2,247	1,189
Ten Mile River	816	143
East Providence WWTP*	517	265
Taunton River	2,723	1,144
Fall River WWTP*	3,227	2,980
Other Sources TOTAL**	844	997
Total Contribution	20,573	10,438

*Data for East Providence and Fall River is for May - September

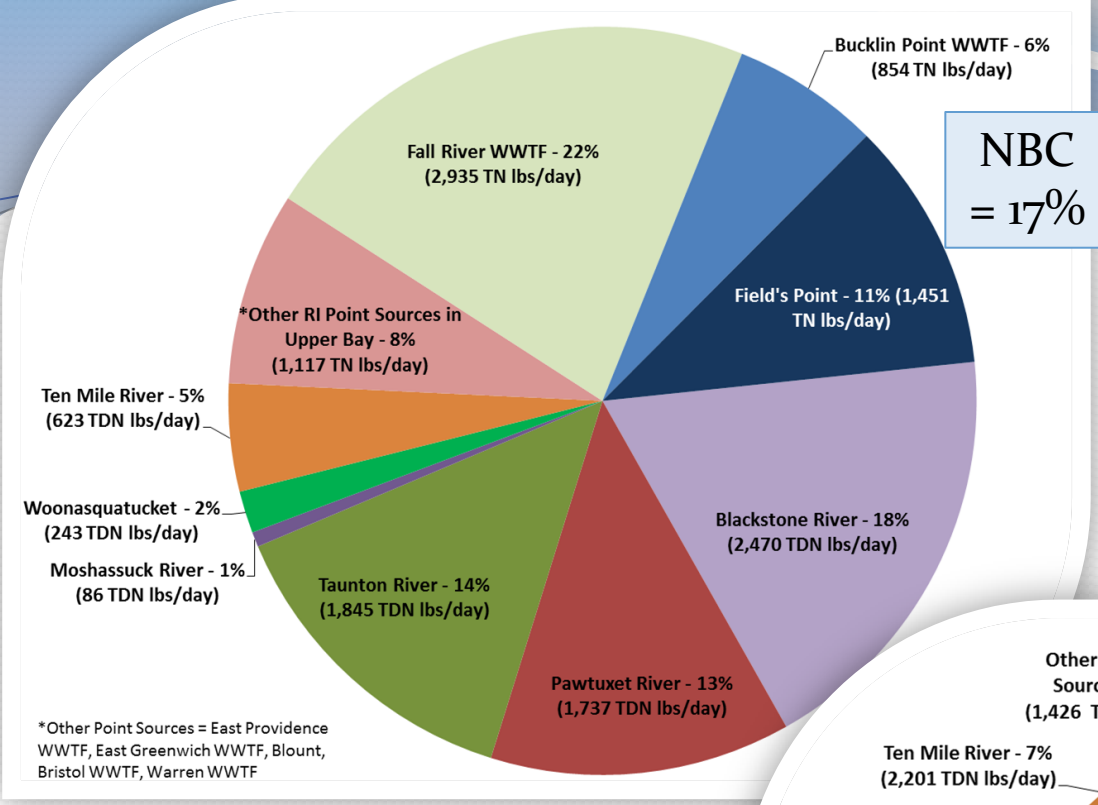
**"Other Sources" includes the East Greenwich, Bristol, and Warren WWTP.

Decrease of 49.3% since 2006

Total Nitrogen Loading & Rain



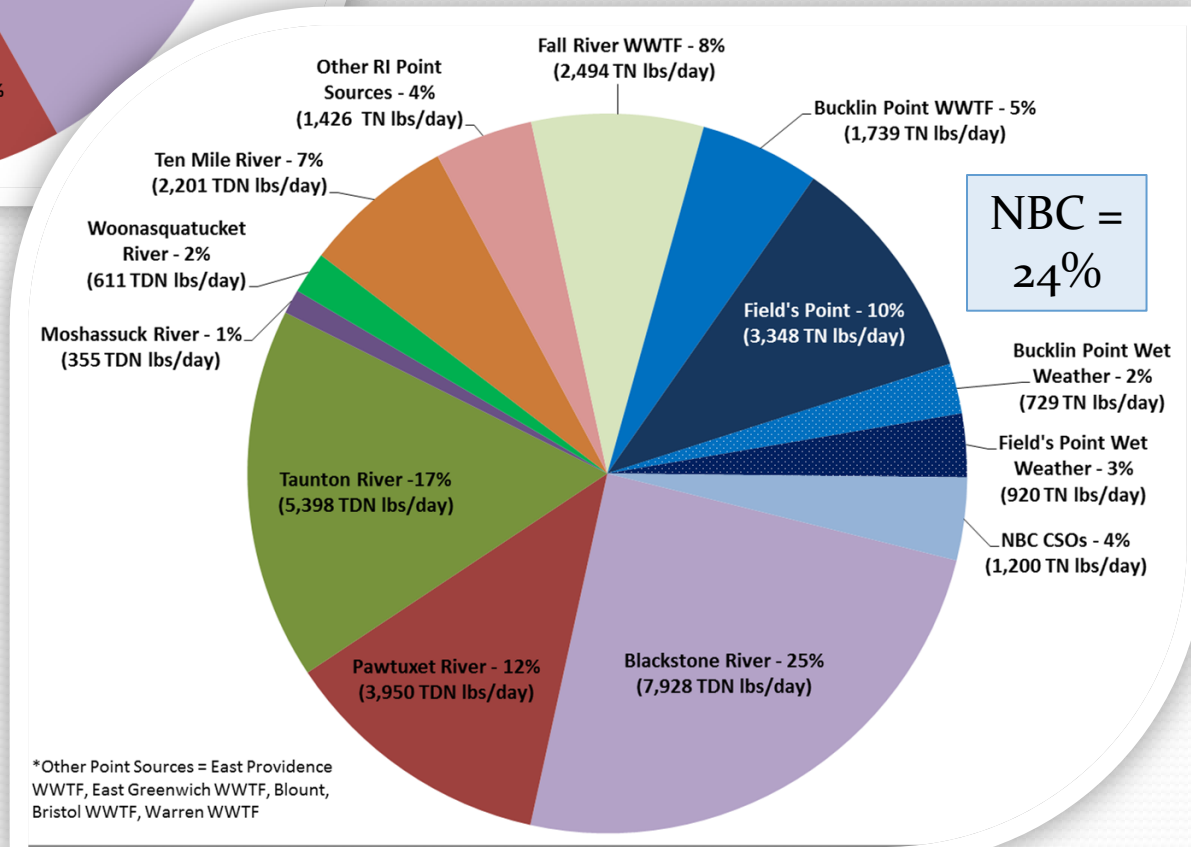
2013 – 2014 Annual Average Loads



NBC = 17%

DRY Weather Days

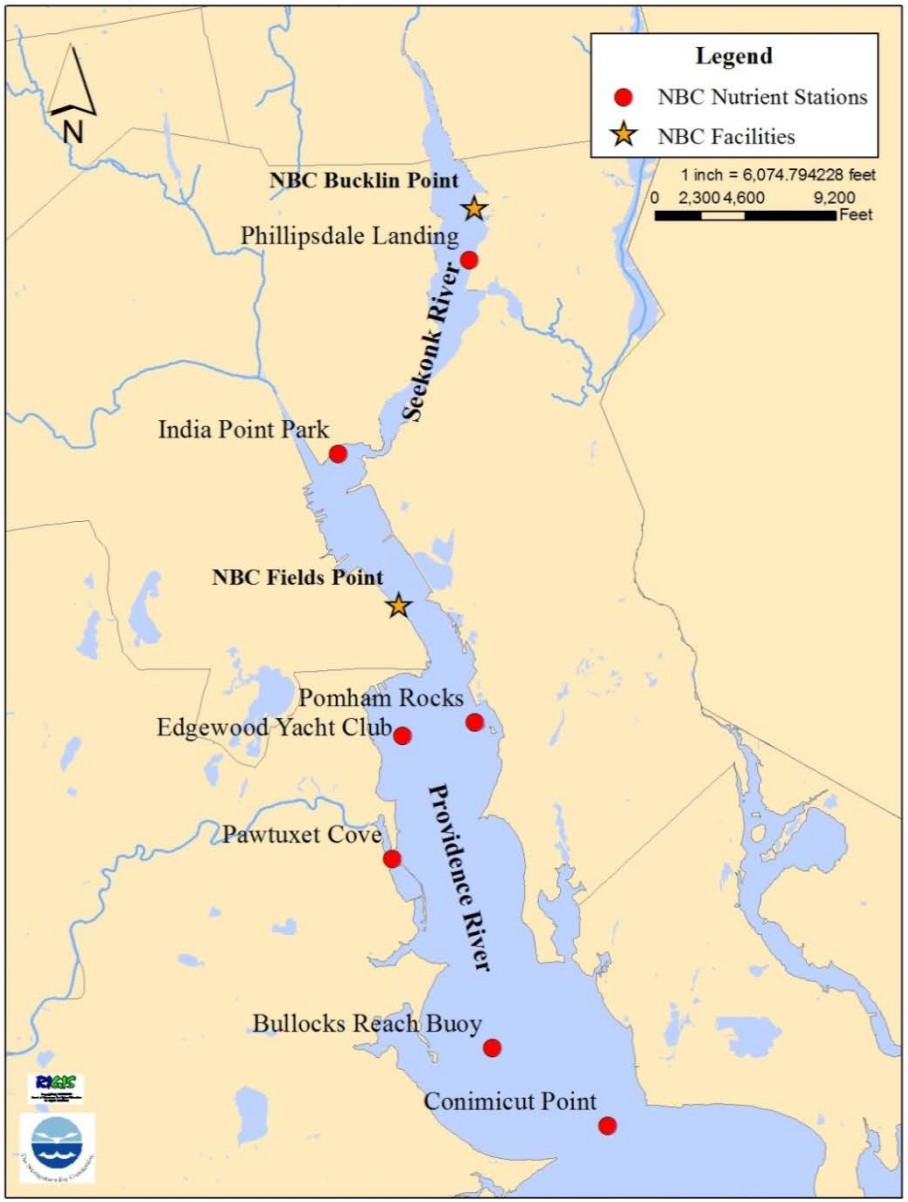
<0.1 inch of rain over prev. 3d



NBC = 24%

WET Weather Days

NBC Bay Sampling Locations



- Since 2007
- Nutrients measured bi-monthly
- 7 stations - Surface & bottom
- Collect at various stages of the tidal cycle throughout the year
- Nutrient suite includes:
  - Nitrite/nitrate
  - Nitrite
  - Total Nitrogen
  - Total Dissolved Nitrogen
  - Ammonia
  - Orthophosphate
  - Silicate
  - Chlorophyll a
  - Total Suspended Solids
- Determine impact of NBC's BNR systems & inform stakeholders

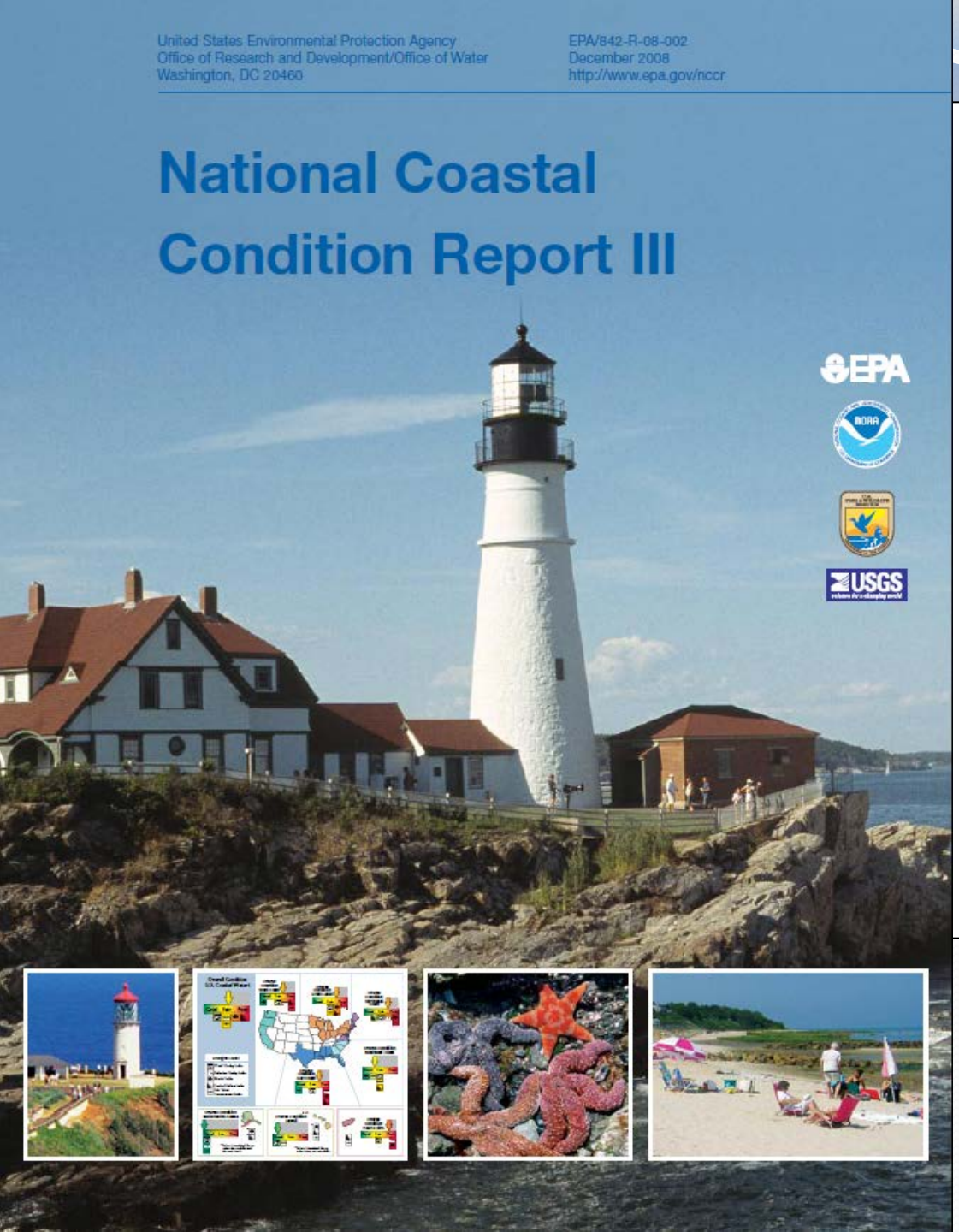


Table 1-2. Criteria for Assessing Dissolved Inorganic Nitrogen (DIN)

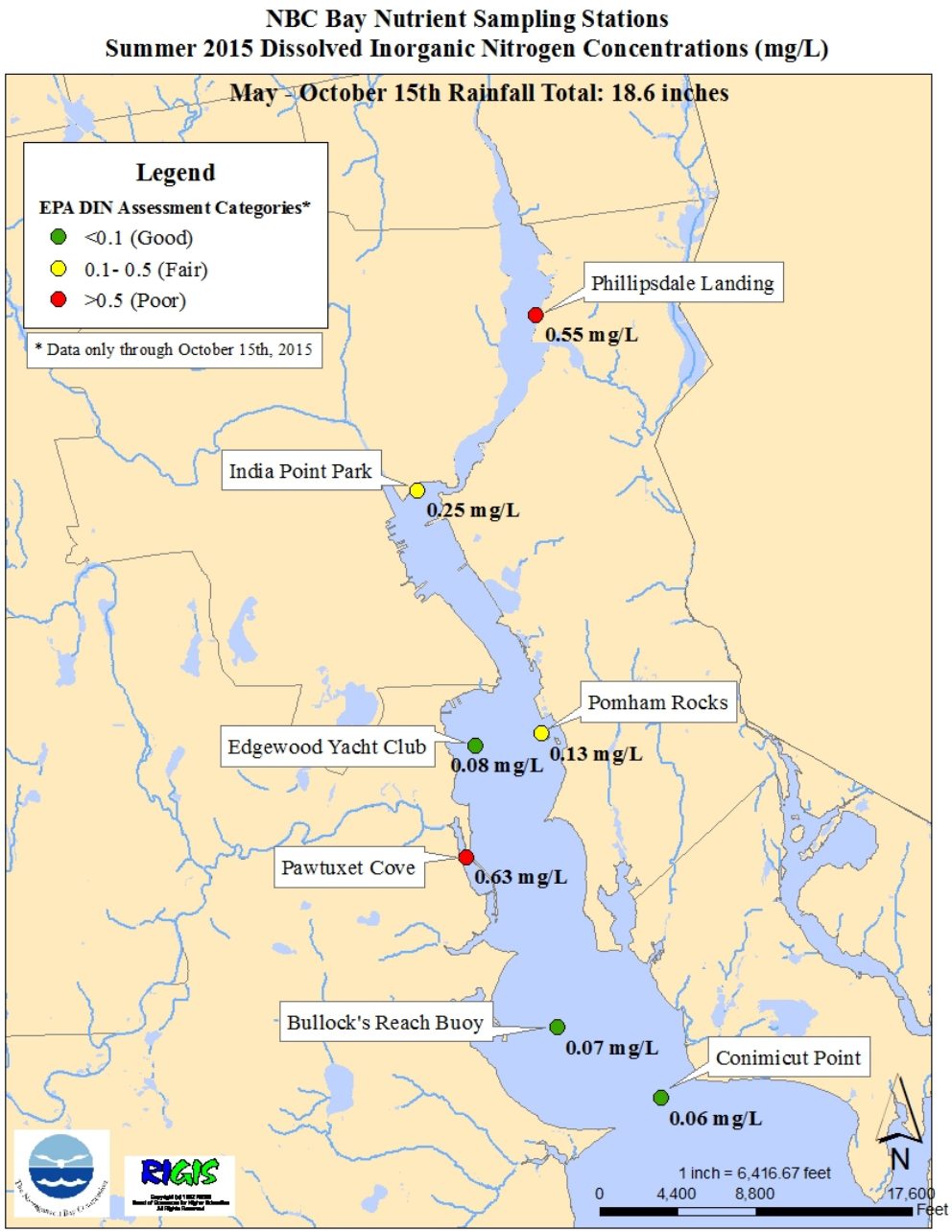
Area	Good	Fair	Poor
Northeast, Southeast, and Gulf Coast sites	< 0.1 mg/L	0.1–0.5 mg/L	> 0.5 mg/L
West Coast and Alaska sites	< 0.5 mg/L	0.5–1.0 mg/L	> 1 mg/L
Hawaii, Puerto Rico, and Florida Bay sites	< 0.05 mg/L	0.05–0.1 mg/L	> 0.1 mg/L
Regions	Less than 10% of the coastal area is in poor condition, and more than 50% of the coastal area is in good condition.	10% to 25% of the coastal area is in poor condition, or more than 50% of the coastal area is in combined poor and fair condition.	More than 25% of the coastal area is in poor condition.

Nitrogen TMDL not yet developed for Narragansett Bay

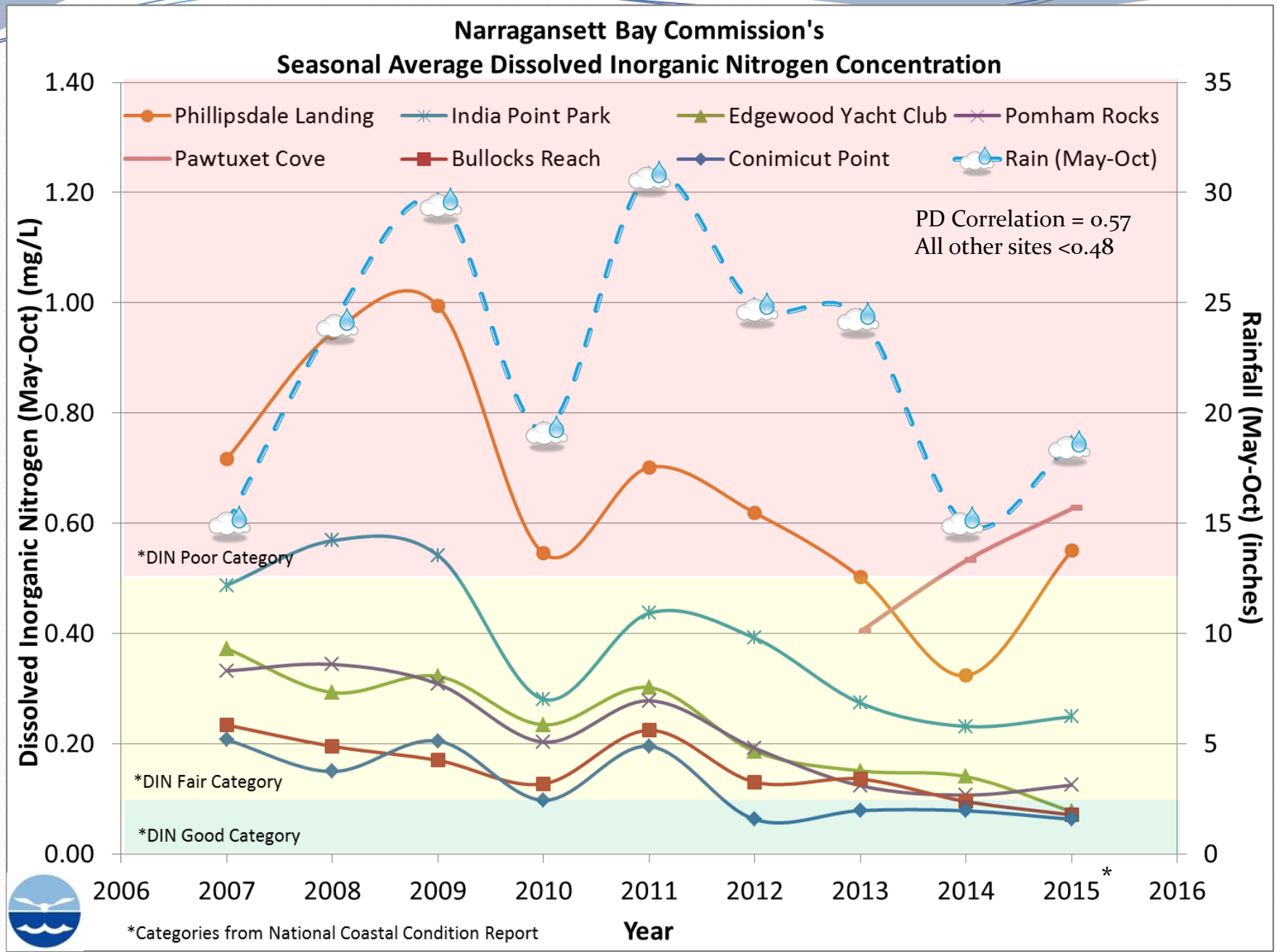
2015 Surface DIN

May – October 15, 2015
Rainfall Total: 18.58 inches

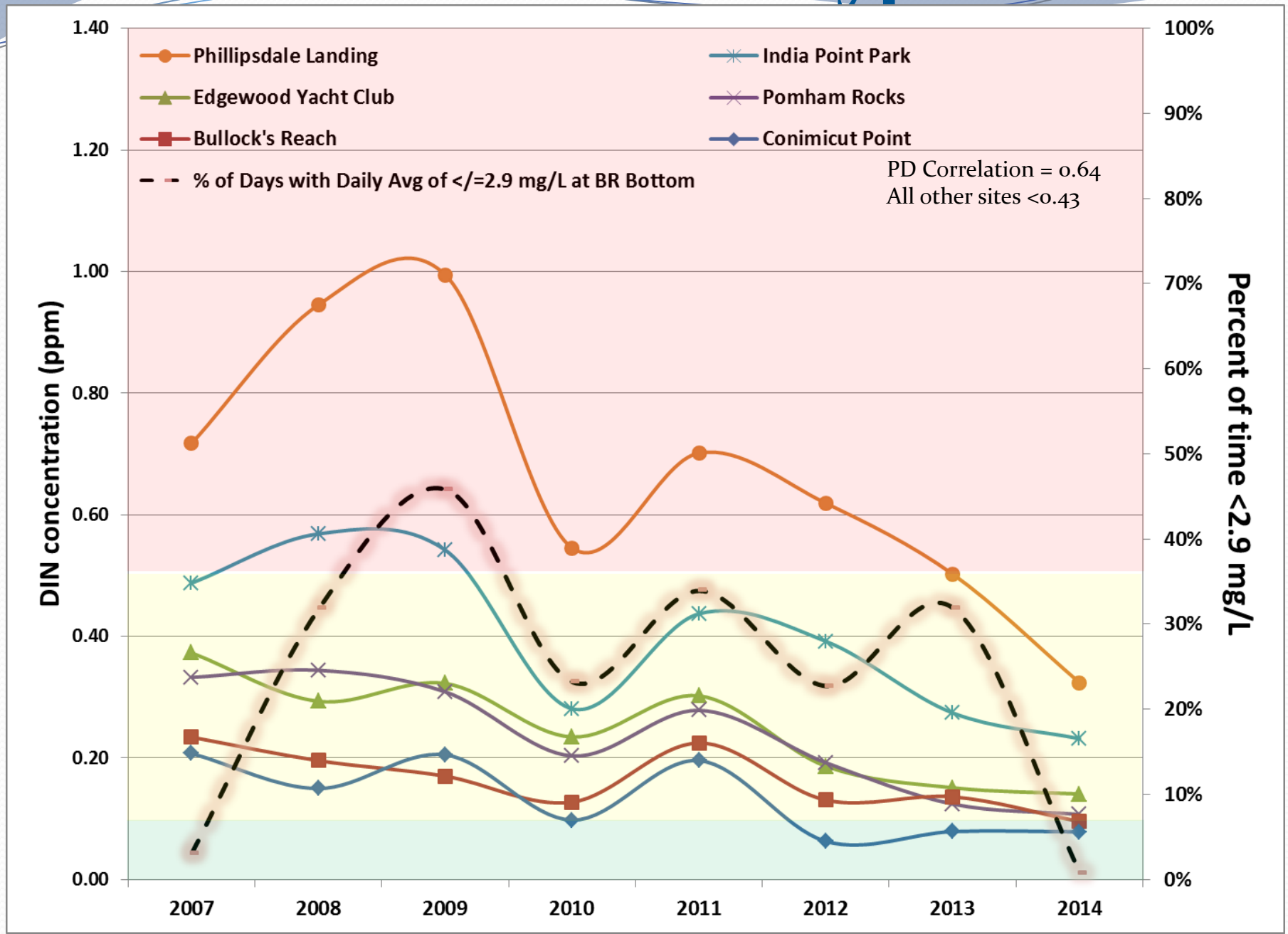
DIN (mg/L) Good <0.1 Fair 0.1-0.5 Poor >0.5 **Station**	**DIN (mg/L)**	**EPA CCR Category**
Phillipsdale Landing	0.55	
India Point Park	0.25	
Edgewood Yacht Club	0.08	
Pomham Rocks	0.13	
Pawtuxet Cove	0.63	
Bullock's Reach	0.07	
Conimicut Point	0.06	



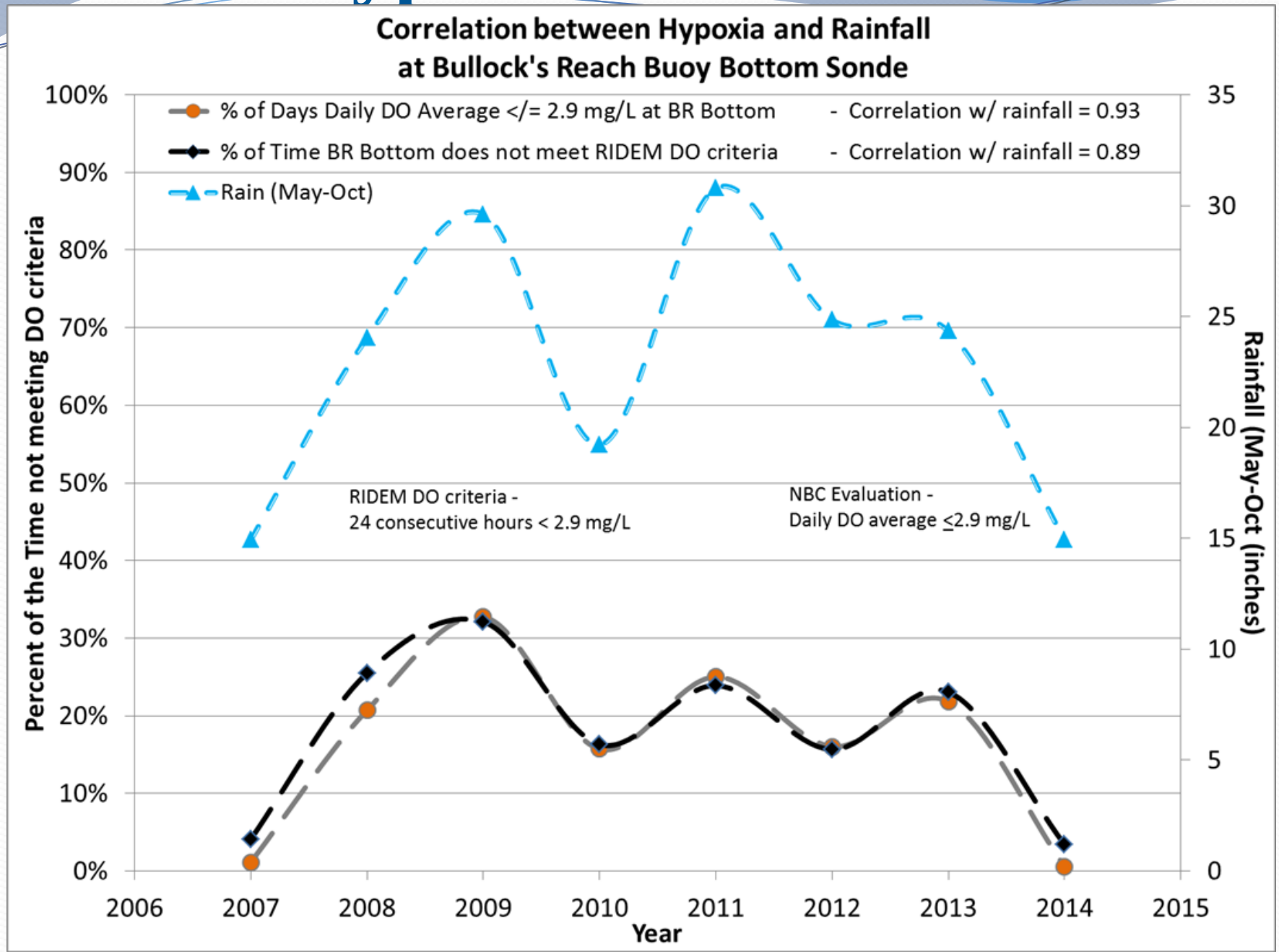
Surface DIN & Rainfall



Surface DIN & Hypoxia



Hypoxia & Rainfall



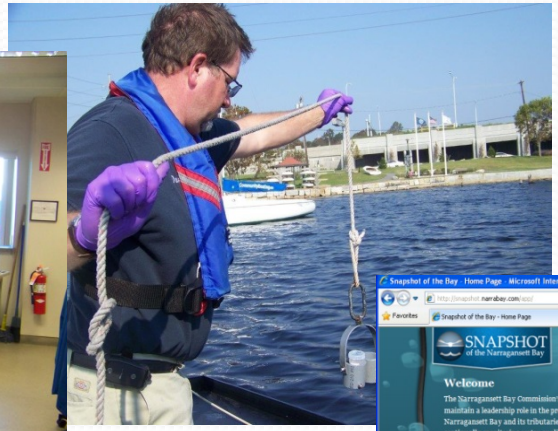
Summary

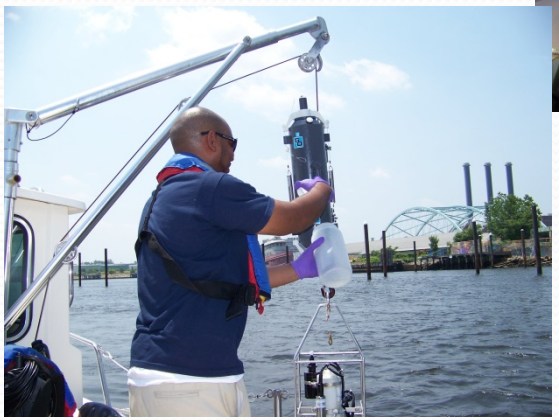
- River DIN – some decrease depending on river
  - Moshassuck and Woonasquatucket low concentrations
  - Blackstone River – Stateline decreased since UBWPAD online
  - Ten Mile and Pawtuxet – high concentrations
  - Taunton – About the same as Blackstone
- TDN/TN loading contribution has decreased by about 50%
  - Contribution of N from Rivers increases in wet weather
- Bay DIN - decreasing over time with 3 NBC stations now showing average results in the “good” category
- Hypoxia and DIN not correlated
- DIN and rainfall not correlated
- Hypoxia and rainfall - strong correlation
- Rainfall increases point source and non-point source loads
- Rainfall contributes to stratification

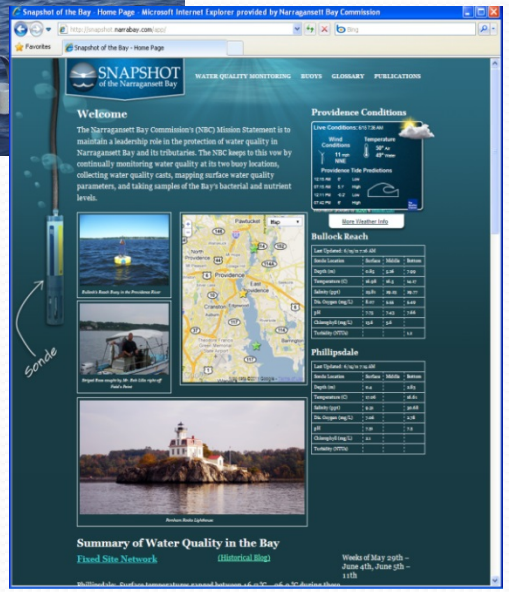
Any Questions?

Special Thanks to:

- *Tom Uva, John Zuba, John Motta, Jim Kelly, Eliza Moore, Steve Lallo, Kimberly Kirwan & Catherine Oliver*
- *NBC Monitoring, Lab & ESTA Staff*







Data and Presentations are available on NBC Website at http://snapshot.narrabay.com