Water Quality Monitoring Program of the Lower Narrow River
by the Narrow River Preservation Association
Final Report – 2014 & 2015 Monitoring Program
Cooperative Agreement No. FI4AC00J04 USFWS

Introduction

In 2014, the Narrow River Preservation Association (NRPA) initiated a two-year water quality program as identified in The Nature Conservancy (TNC) and U.S. Fish and Wildlife Service (USFWS) Cooperative Agreement No. FI4AC00J04. For more than two decades NRPA has had a River Watch program that monitors the water quality at fourteen locations spanning the entire length of the Narrow River (also known as Pettaquamscutt Estuary). Since the start of the program, elevated bacteria levels have been regularly observed at Mumford Brook and Mettatuxet Brook. Since 2001, elevated bacteria levels have also been observed at Middlebridge.

The focus of this program is to conduct supplemental water quality monitoring in the waters and streams of the John H. Chaffee National Wildlife Refuge that reside within the towns of South Kingstown and Narragansett, Rhode Island to support Saltmarsh and Estuarine resiliency and restoration actions planned by TNC and USFWS.

Project Overview and Work conducted during 2014 and 2015:

A) Project Team: NRPA hired a University of Rhode Island (URI) graduate student, Courtney Schmidt, and a URI Coastal Fellow, Eric Peterson, to carry out the field program. Courtney worked in the 2014 season and developed graphs of the 2014 data that was available. Eric worked in the 2015 season and developed graphs of the combined 2014-2015 data, including all the nutrient data, which only became available in early 2016. NRPA Board Members, Dr. Veronica Berounsky and Annette DeSilva provided project oversight.

B) Site Selection: In early May 2014, Veronica Berounsky, Annette DeSilva, and Courtney Schmidt evaluated potential monitoring locations along the southern portion of the Narrow River. Locations of interest included streams and brooks that feed into the River and Pettaquamscutt Cove. The waters in the areas of Middlebridge and Mettatuxet were also of interest.

Thirteen sites were selected for monitoring. The sites included two existing Narrow River monitoring locations as well as 11 new sites. The sites were selected with input from USFWS, town officials, RI Department of Environmental Management (RIDEM), and NRPA. Public and safe access to each site was a priority in the selection. All sites can be monitored from the shore. Table 1 provides a list of the selected sites. In Figure 1 the monitoring sites are indicated by dots on a map of the Narrow River. In Figure 2, the monitoring sites are overlaid (stars) on the image of the Narrow River. The large star on the left side of the image represents two stations in the southwestern part of the Cove (NR12 and NR27). Five of the sites were freshwater streams: Mettatuxet Road, Mettatuxet Brook, Bike Path Culvert, Mumford Brook, and Crooked Brook. One site was a small freshwater pond fed by small streams (and perhaps groundwater): Garrison Trail. Five sites were seawater and located near Middlebridge. Two sites were seawater and located at the edge of Pettaquamscutt Cove, Starr Drive (east side) and Kimberly Drive (west side). Streams were near these sites but were too small to sample.

Table 1: Monitoring Location Sites

LOCATION
NR 11 - Mettatuxet Brook
NR 12 - Mumford Brook
NR 17 - Mettatuxet Road
NR 18 - SE Middlebridge
NR 19 - NE Middlebridge
NR 20 - NW Middlebridge
NR 21 - SW Middlebridge
NR 22 - mid Middlebridge
NR 23 - Garrison Trail
NR 24 - Starr Drive
NR 25 - Crooked Brook
NR 26 - Kimberly Drive
NR 27 - Bike Path Culvert

Figure 1: The map below shows the sampling locations. Middlebridge has five different sampling locations, which are at the southeast, northeast, southwest, and northwest corners of the bridge, and at the center of the bridge.

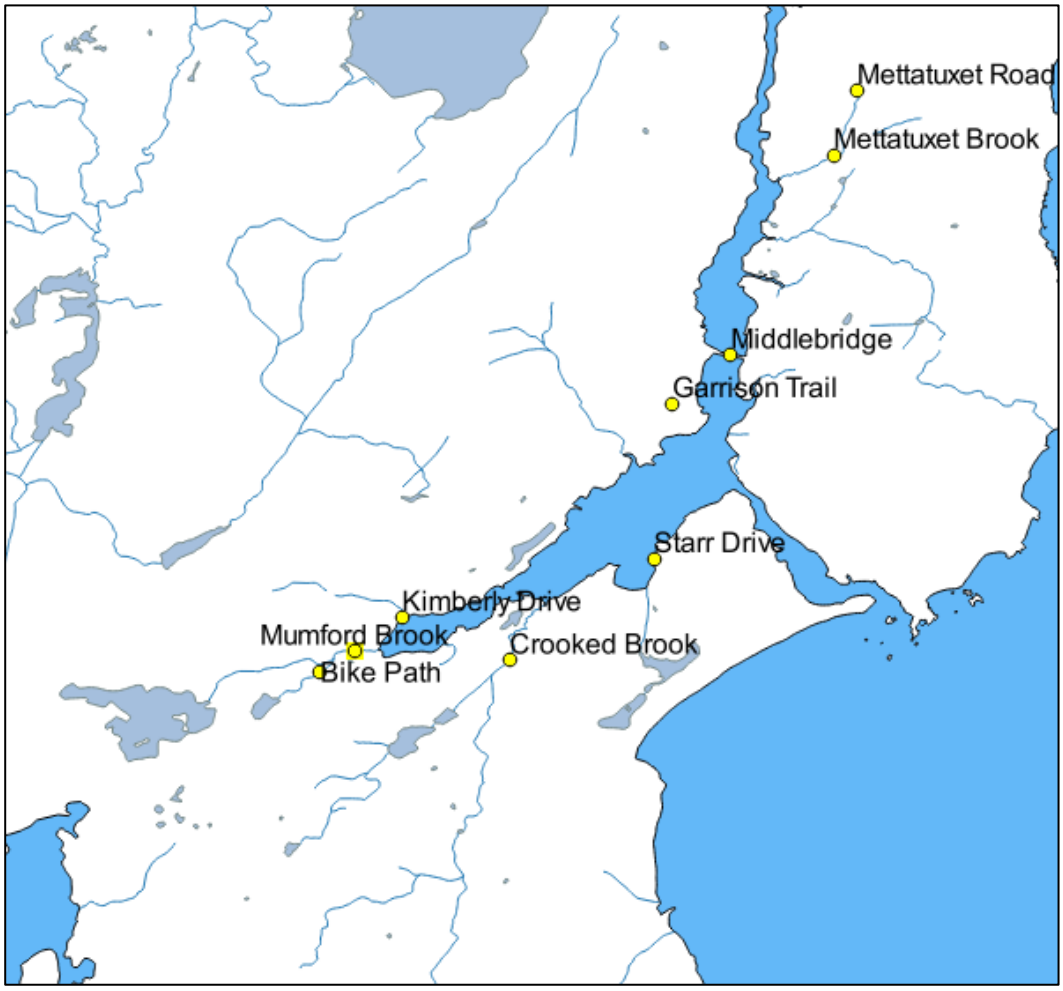


Figure 2: Monitoring areas overlayed on Narrow River Image

C) Field Work:

- The monitoring season began in mid-May and ran through mid-October in 2014 and 2015.
- Water samples were collected approximately every two weeks on 11 occasions during the monitoring season. On each sampling date, the collected samples were placed in a cooler and then transported to the University of Rhode Island's Watershed Watch (WW) Laboratory within 18 hours.
- In addition to water collections, additional parameters were measured bi-weekly using a YSI probe. Parameters include:
  - Dissolved Oxygen
  - Salinity
  - Temperature
- Weather, wind, and tide observations were recorded on each sampling date.

D) Equipment used:

- 2014: YSI Probe Model 85 with 20 m cable and with an oxygen permeable membrane covering an electrolytic cell.
- 2015: YSI Probe Model Pro 2030 with 20 m cable and with an oxygen permeable membrane covering an electrolytic cell.
- Pole and bucket samplers for select sites where an extended reach was necessary to collect a water sample.
- Cooler for transporting samples from River sites to the URI Watershed Watch Offices.

E) Analysis of Samples: The URI WW laboratory analyzed water samples for bacteria and nutrients. URI Watershed Watch ensures the quality of the data through their Quality Assurance Project Plans or QAPPs, which are approved by both RIDEM and USEPA. The QAPPs document how, what, where, and why the monitoring occurs both in their RI Health certified laboratories and in the field. Details about URI's WW services and protocols are available at http://www.uri.edu/ce/wq/ww/index.htm. The WW personnel compile the bacteria and nutrient data and provide the data in Excel format.

Bacteria:
At the URI WW laboratory, the sample was used to culture bacteria in test tubes to calculate the most probable number of enterococci and fecal coliform bacteria. In Rhode Island, the swimming standard is based on enterococci while the shell fishing standard is based on fecal coliform bacteria. WW basic bacteria capacity is for total coliforms and E.coli with Colilert-18 incubated at 35 C; Fecal coliform with Colilert-18 incubated at 44.5 C, and enterococci with Enterolert incubated at 41 C.

Nutrients:
The concentration of total nitrogen, total phosphorus, nitrate+nitrite, ammonia, and dissolved (ortho) phosphorus was measured in each water sample at the URI WW laboratory. Samples were analyzed on an Astoria-Pacific International (API) segmented, continuous flow, nutrient autoanalyzer, the "Astoria Analyzer", using standards in the same matrix (salt water samples have salt water standards, if samples are digested standards are too). External standards and matrix spikes were analyzed with each set of samples. Unfiltered samples, standards and proficiency test samples for total nitrogen and total phosphorus were digested using a potassium persulfate, boric acid and sodium hydroxide digest and analyzed within 24 hours of digest. Samples for ortho-phosphate, nitrate + nitrite nitrogen and ammonia-nitrogen were filtered through 0.45 um glass fiber filter and are kept frozen until the day of analysis

Project Data:

The 2014 and 2015 Narrow River sampling data is attached as Excel files.

These include:

- <measurements.xlsx> = YSI and observation data
- <bacteria.xlsx> = All bacteria data: fecal coliform and enterococci
- <nutrients.xlsx> = All nutrient data: Total Nitrogen, Ammonia, Nitrate + Nitrite, Total Phosphorus, and Dissolved Phosphorus

The excel files include worksheets with all of the data collected as well as charts with plots of the data. Select charts have been included in the following pages of this report.

Data Plots:

A series of charts are presented below. They are organized in three parts: 1) measurement data taken with the YSI probe, 2) bacteria data, and 3) nutrient data.

Measurement Data:

Figure 3a: 2014 Temperature Data

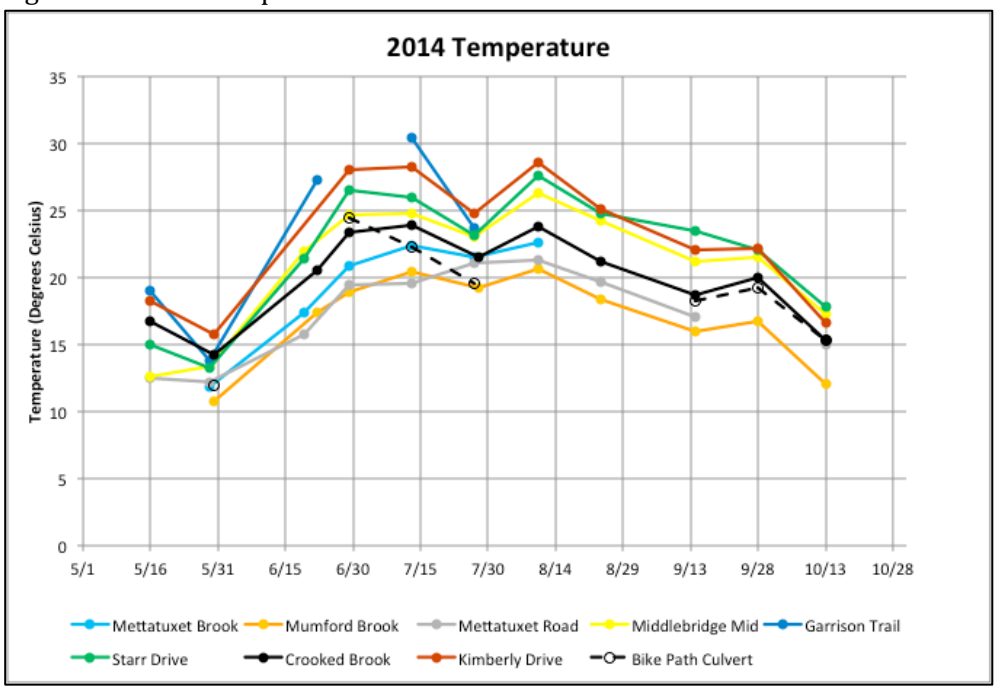


Figure 3b: 2015 Temperature Data

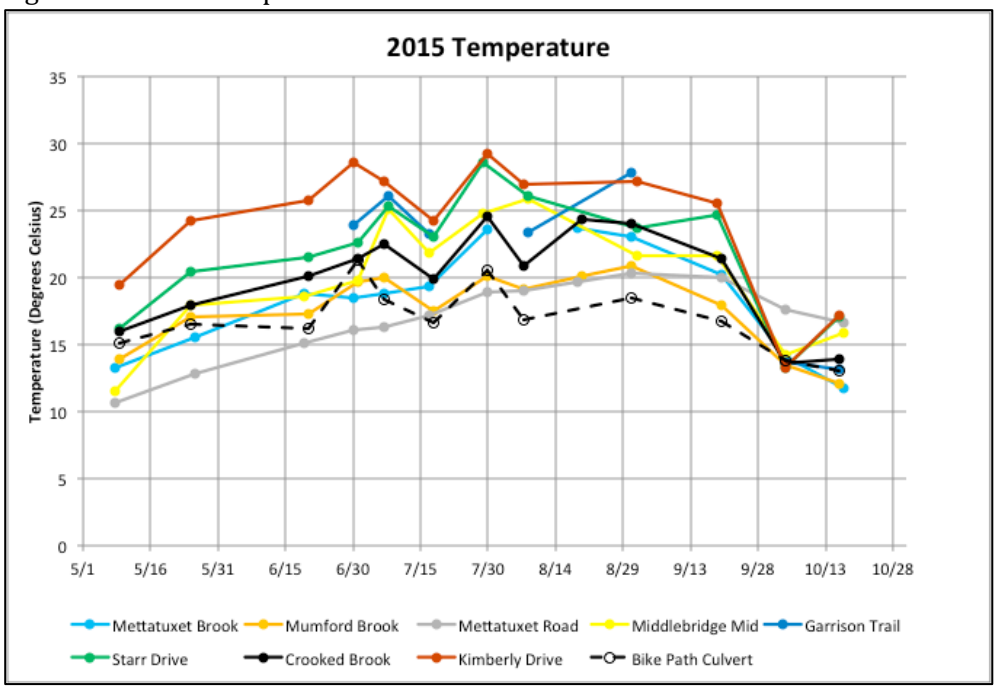


Figure 4a: 2014 Salinity Data

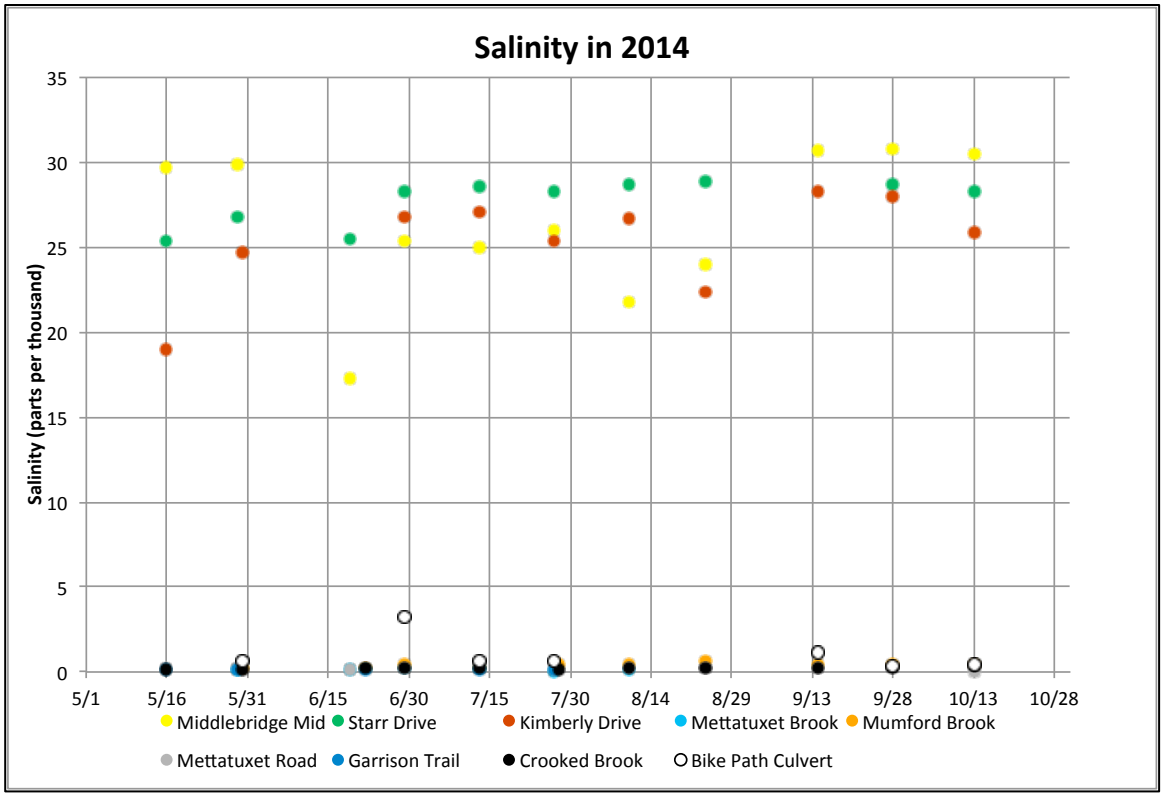


Figure 4b: 2015 Salinity Data

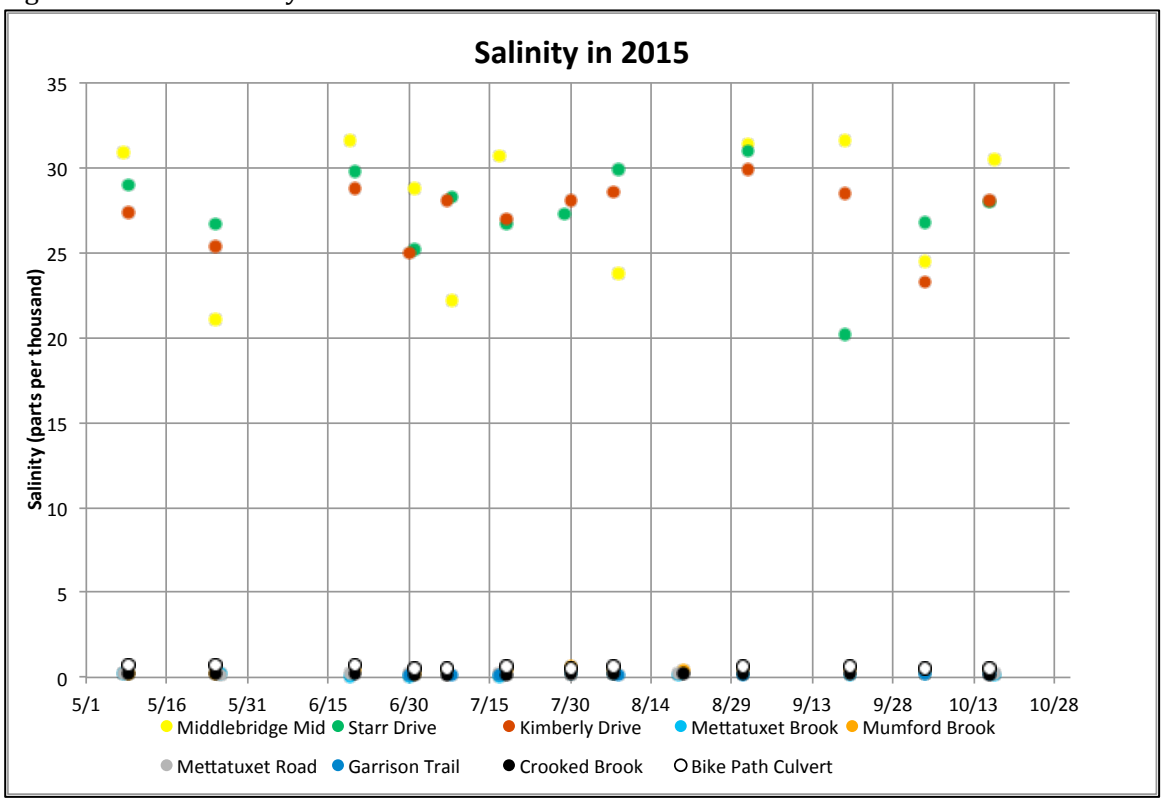


Figure 5a: 2014 Dissolved Oxygen Data

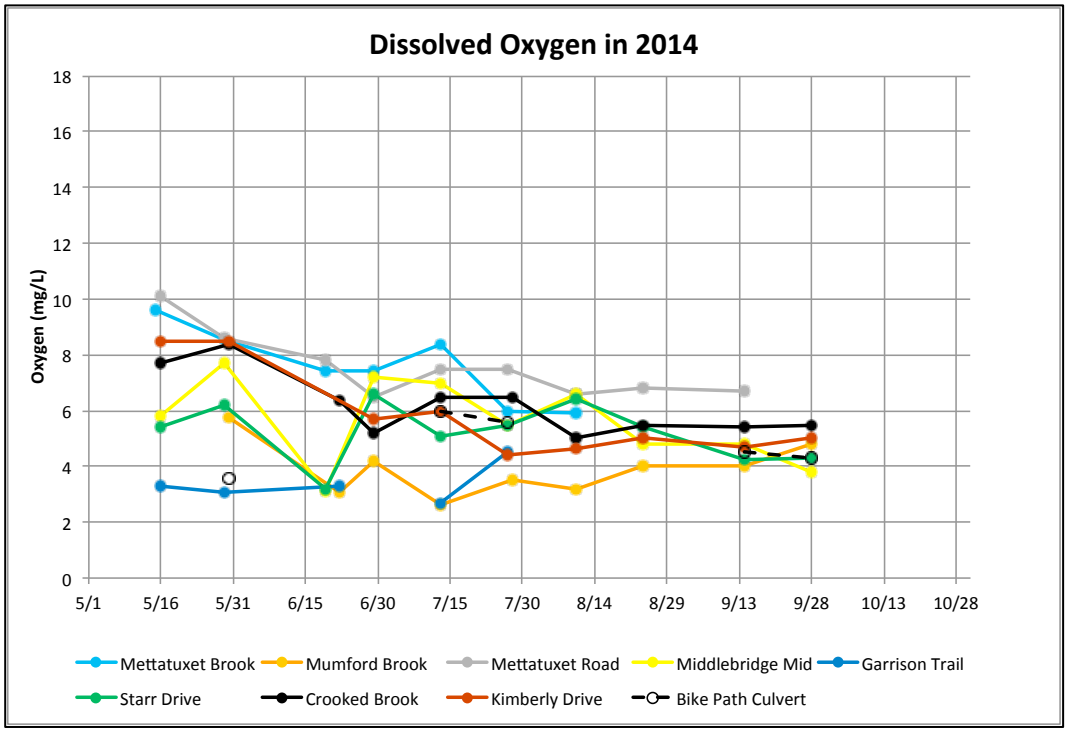
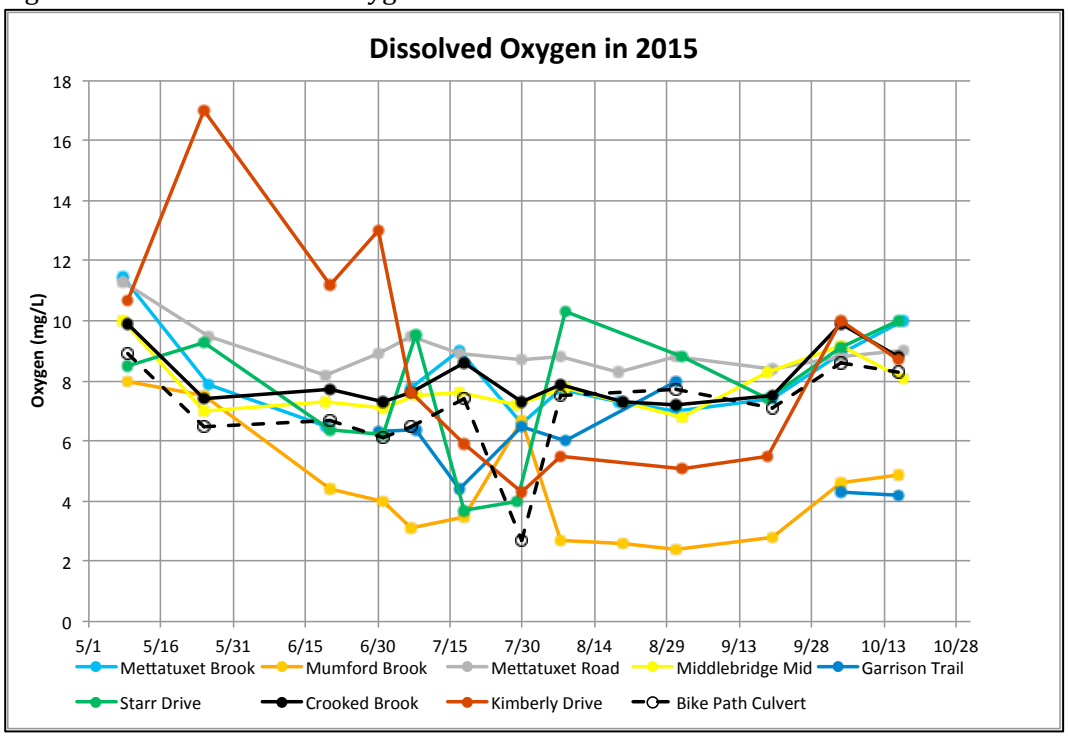
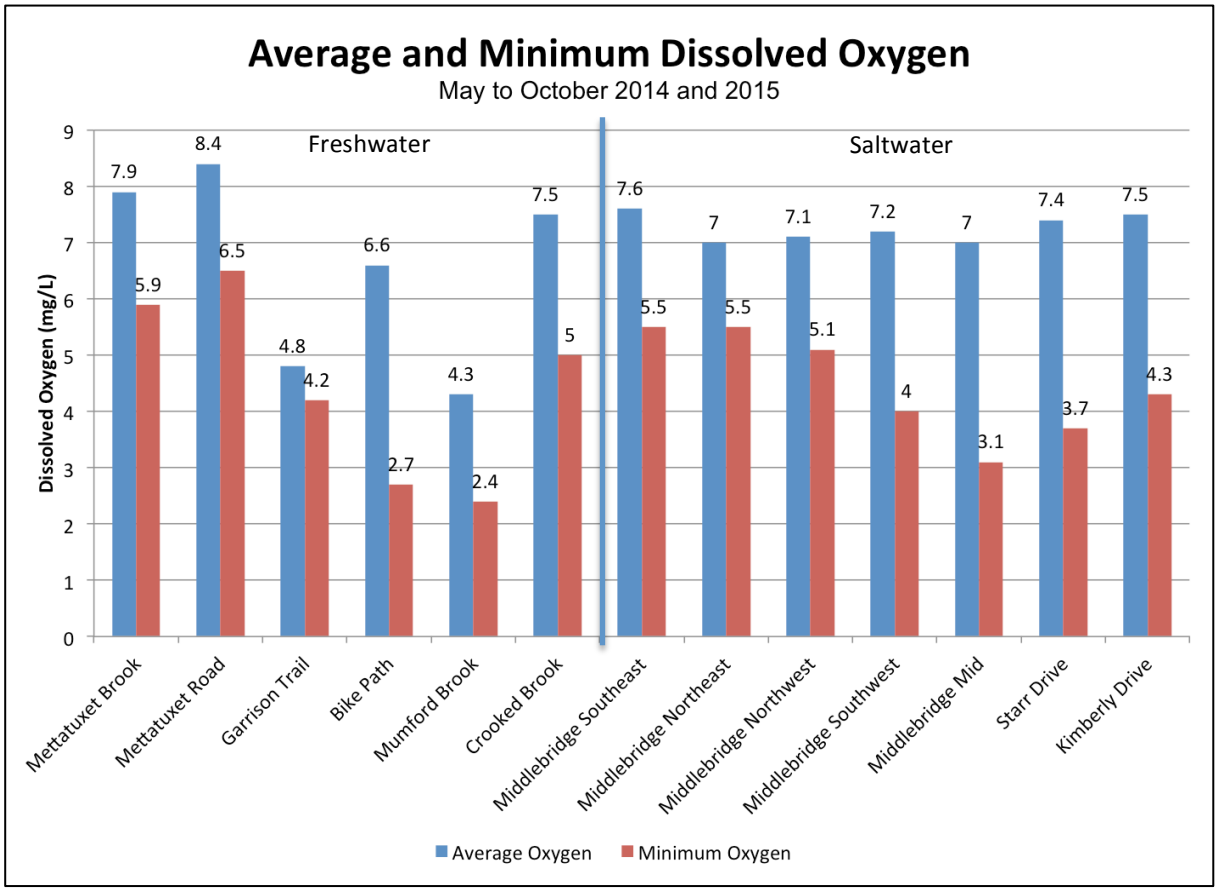


Figure 5b: 2015 Dissolved Oxygen Data



The graph (Figure 6) below shows the average and minimum dissolved oxygen for the different sites. The average oxygen was determined by calculating the average oxygen for each month and calculating the average across all months.

Figure 6: Average and Minimum Dissolved Oxygen Data



Bacteria Data:

Figures 7 and 8 below are plots of the bacteria (fecal coliform and enterococci) data. The marine water (saltwater) sites are plotted on Figure 7 and the fresh water sites are plotted on Figure 8. The red horizontal lines on each of the charts indicate the standards for recreational contact (safe swimming) and for shellfish harvesting.

- Marine water: Standard for shell fishing = <14 FC/mL (red dashed line)
- Fresh and Marine water: RI Standard for recreational contact (swimming) = <60 Enterococci (MPN/dL) for single sample[1]
- Marine water: RI Standard for recreational contact (swimming) = <35 Enterococci (MPN/dL) geometric mean[1]

[1] Bacterial Monitoring, URI Watershed Watch http://cels.uri.edu/docslink/ww/water-quality-factsheets/Bacteria.pdf

Figure 7a: 2014 Fecal Coliform Bacteria at Marine Water Sites

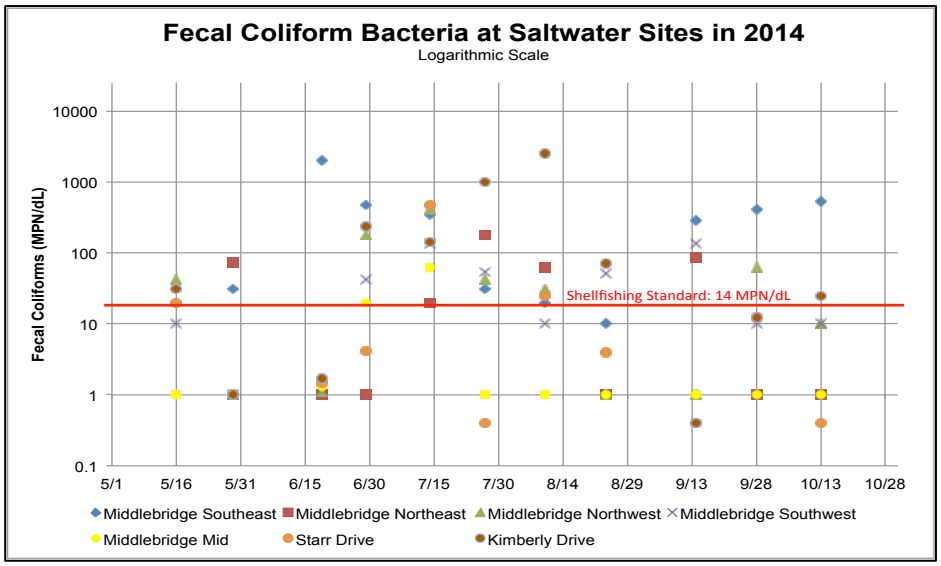


Figure 7b: 2015 Fecal Coliform Bacteria at Marine Water Sites

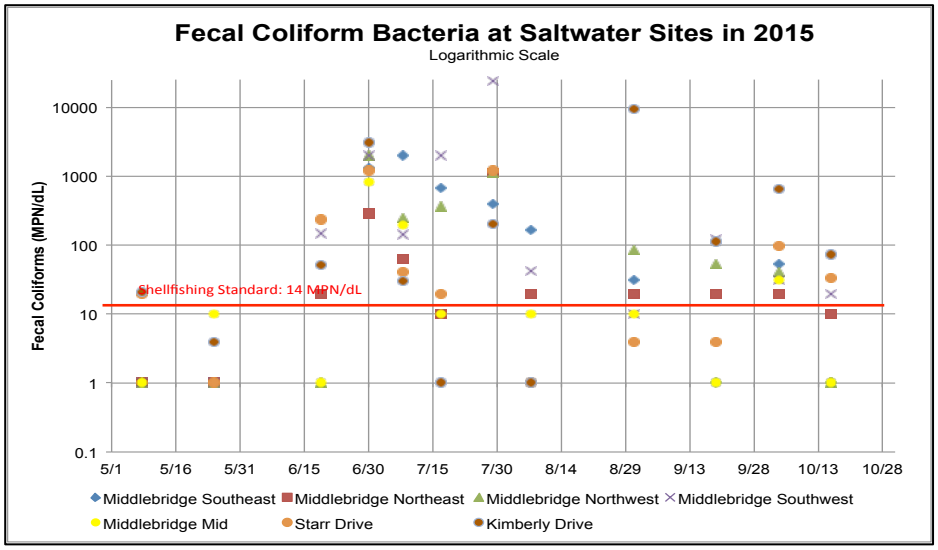


Figure 7c: 2014 Enterococci Bacteria at Marine Water Sites

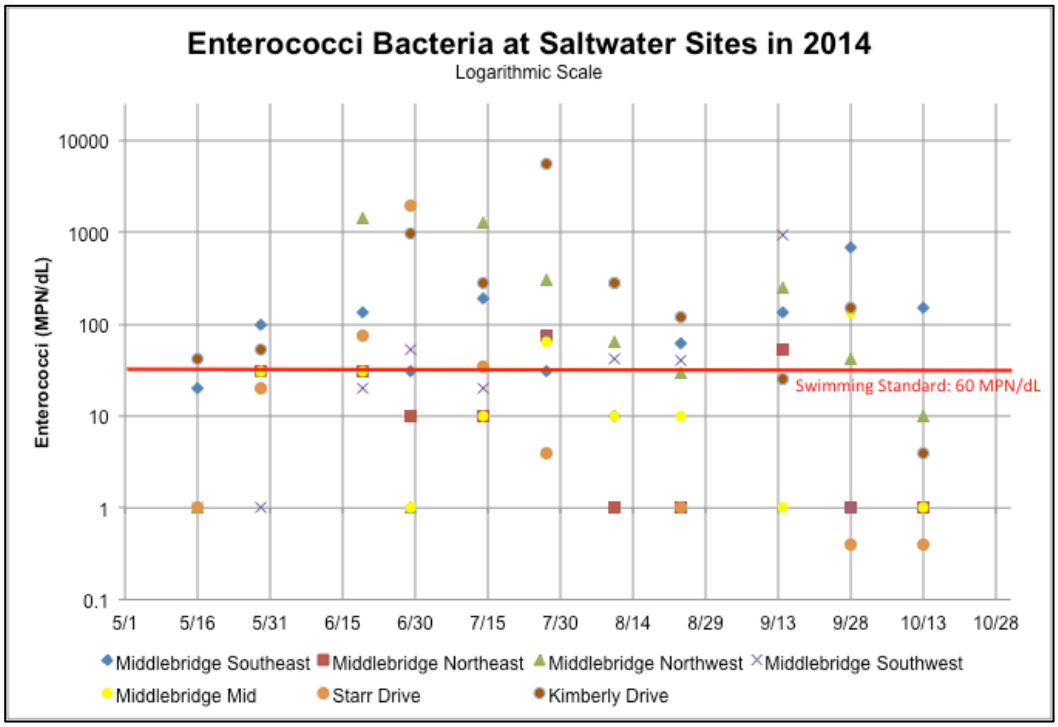


Figure 7d: 2015 Enterococci Bacteria at Marine Water Sites

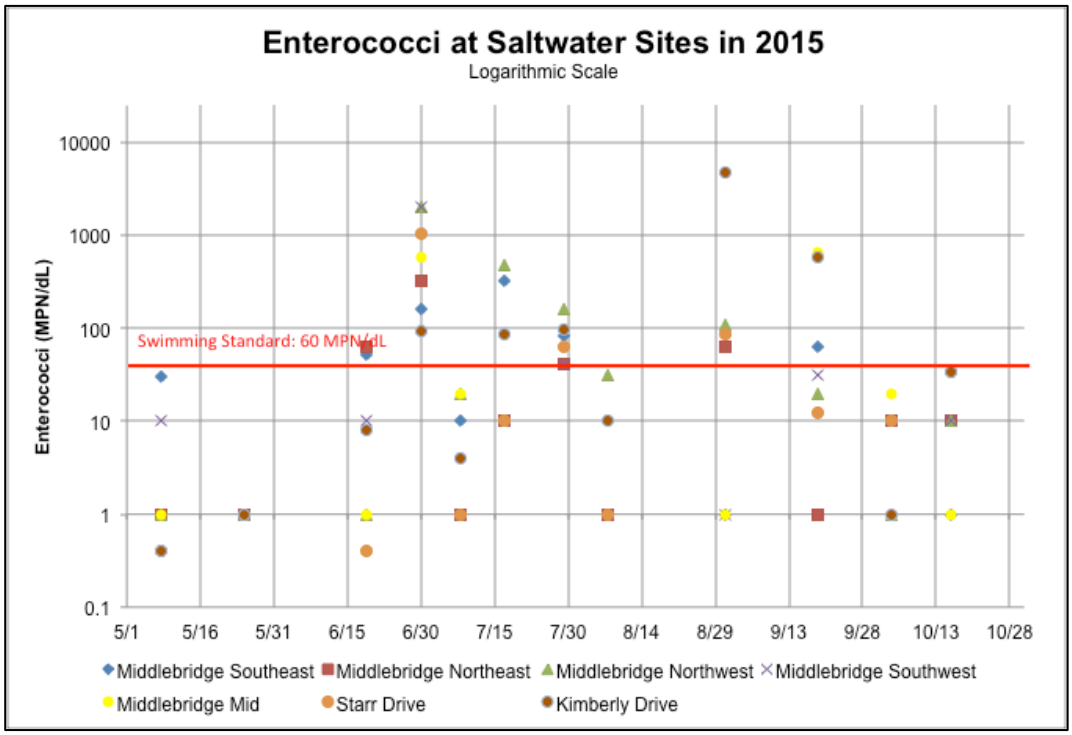


Figure 8a: 2014 Fecal Coliform Bacteria at Fresh Water Sites

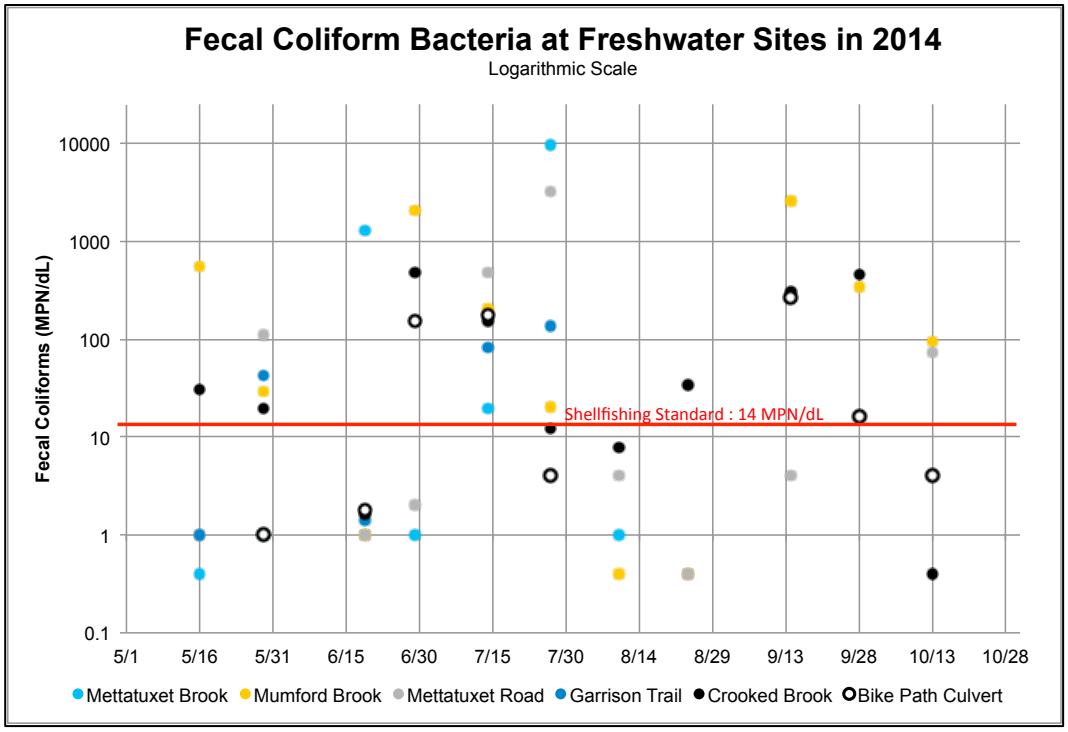
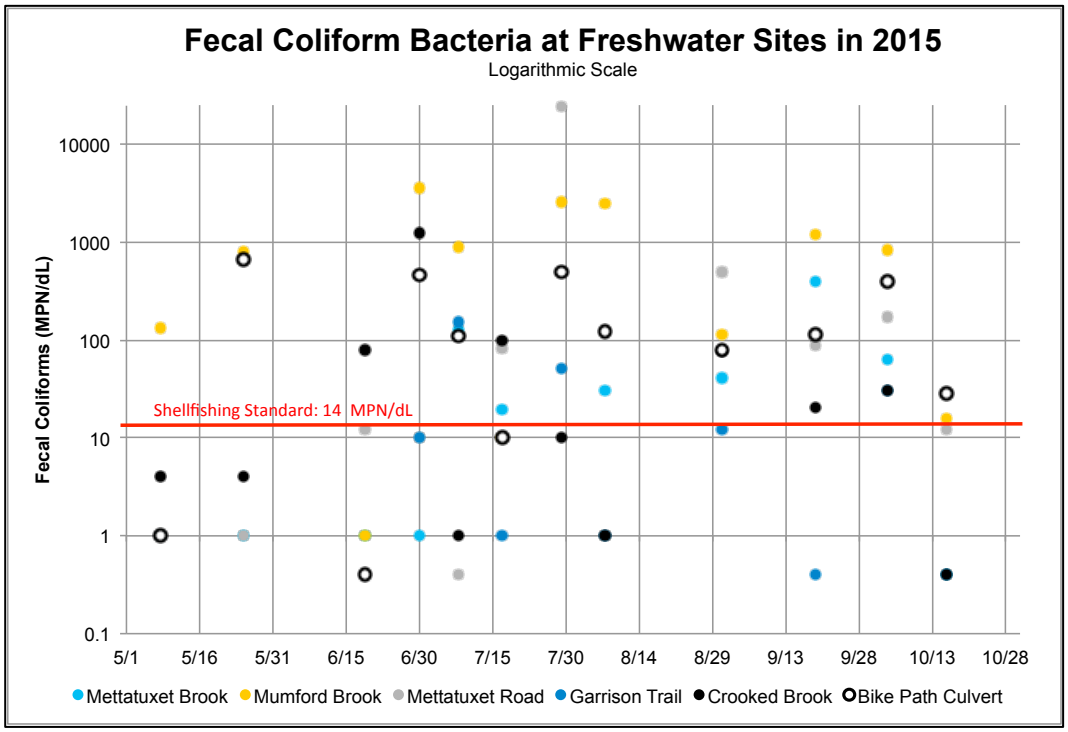


Figure 8b: 2015 Fecal Coliform Bacteria at Fresh Water Sites



Please note: The Shellfishing Standard (red horizontal line) that is illustrated on the plots is for Saltwater. There is no shellfishing standard for freshwater, but since these are tributaries to the Narrow River, we included the red line to provide a perspective on the water quality entering the River.

Figure 8c: 2014 Enterococci Bacteria at Fresh Water Sites

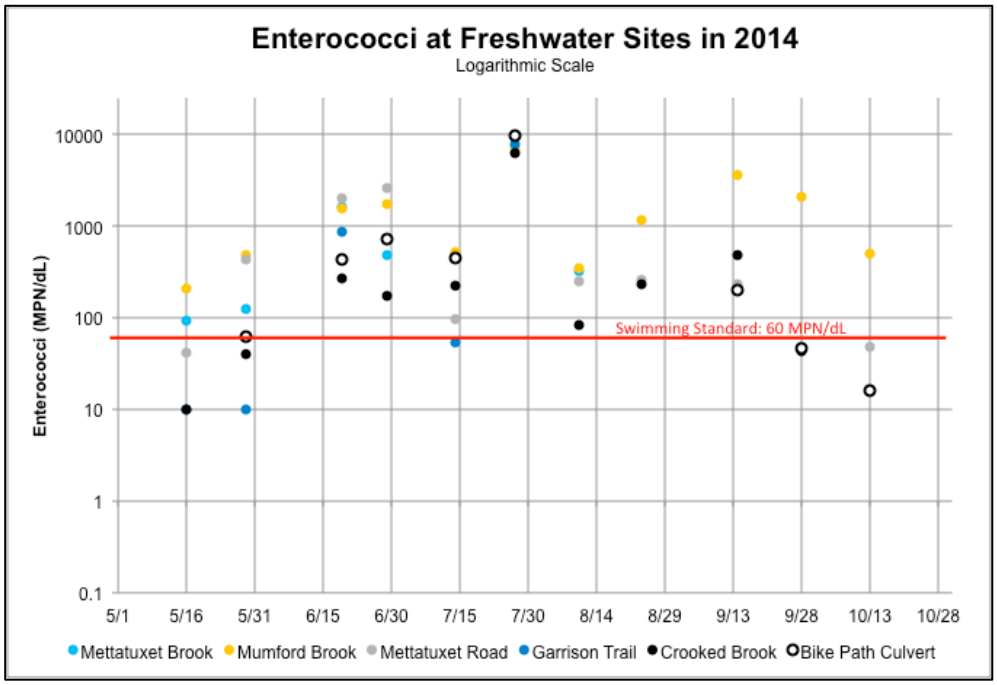


Figure 8d: 2015 Enterococci Bacteria at Fresh Water Sites

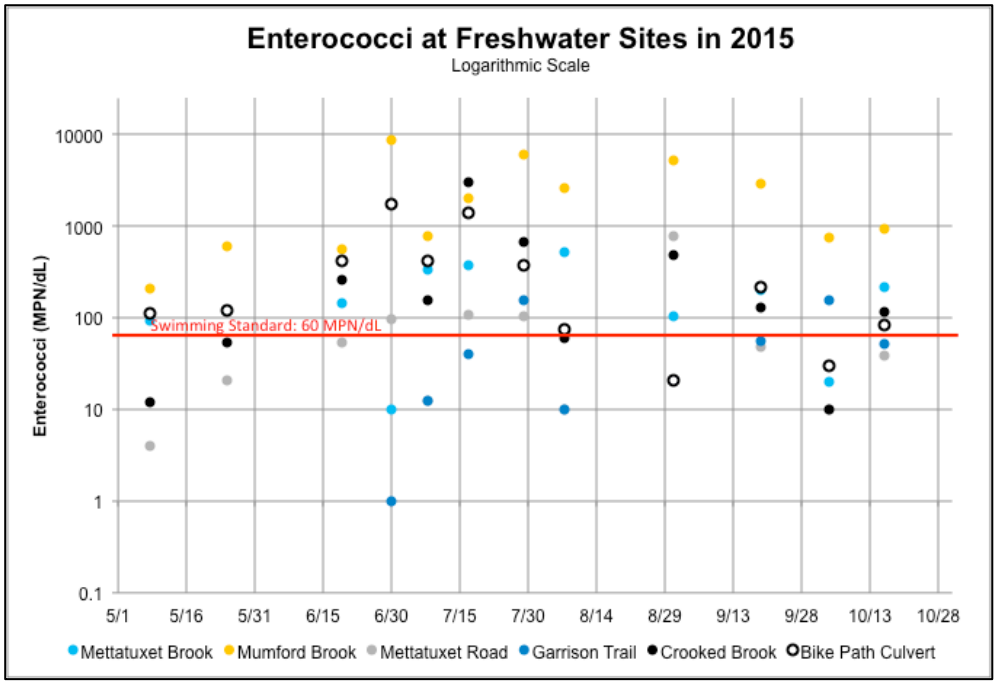


Figure 9: Bacteria Data at Middlebridge Sites

Five sites were sampled at Middlebridge; in each corner and at mid-span. The plots below show the variability in bacteria levels between the various sites.

Figure 9a: 2014 Fecal Coliform Bacteria

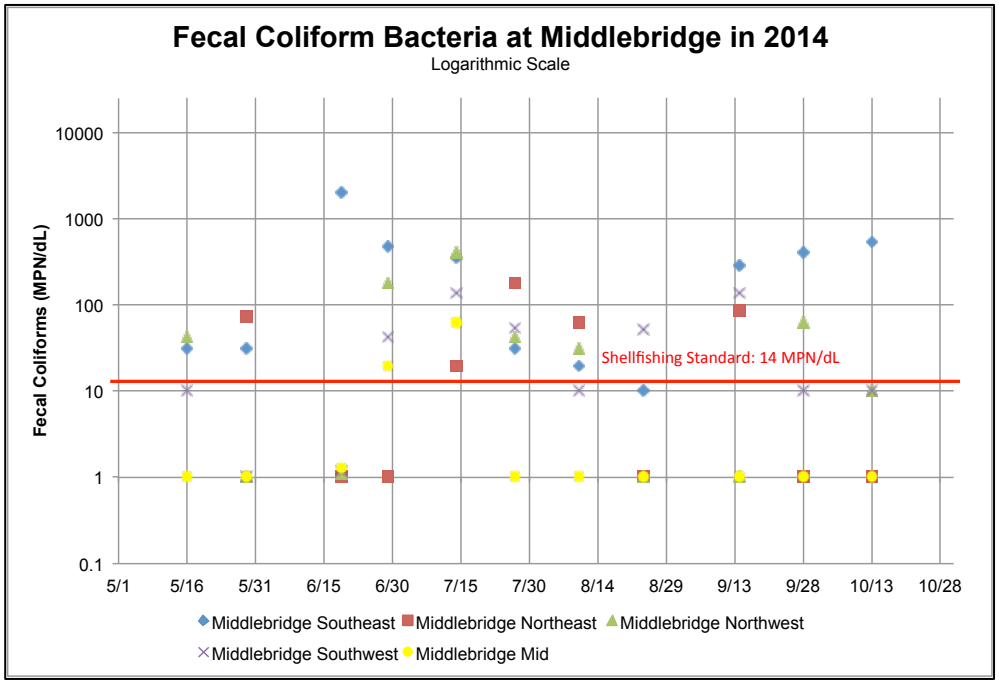


Figure 9b: 2015 Fecal Coliform Bacteria

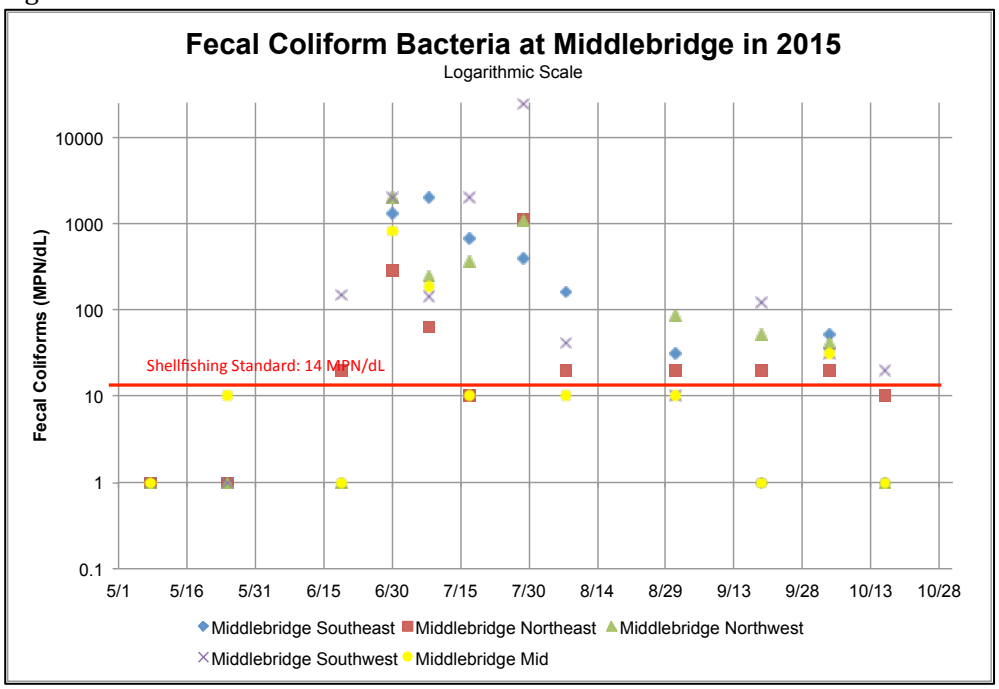


Figure 9c: 2014 Enterococci Bacteria

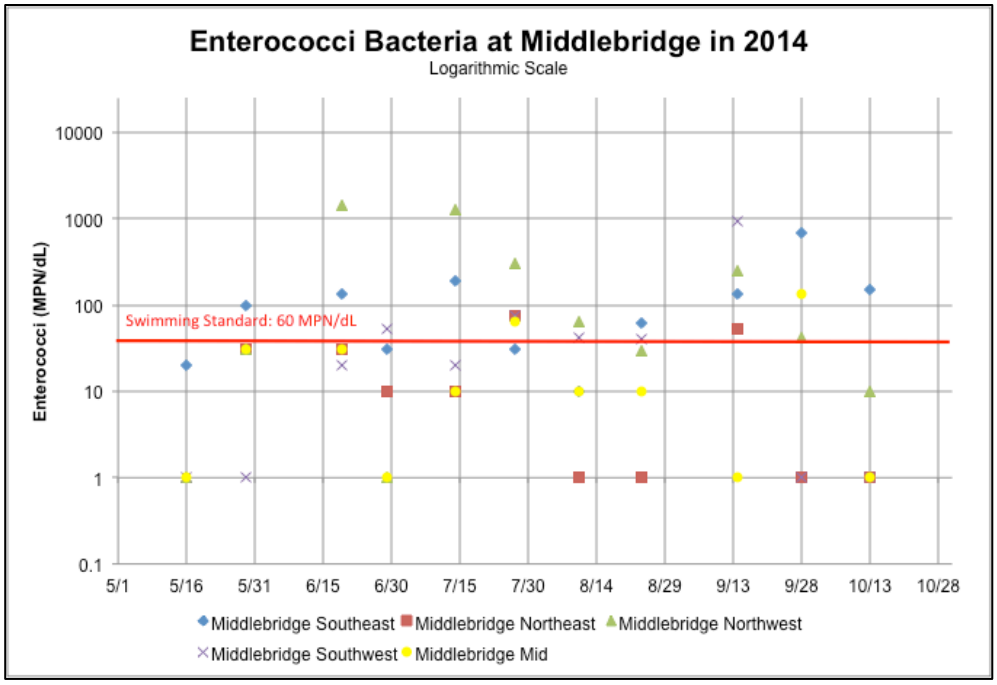


Figure 9d: 2015 Enterococci Bacteria

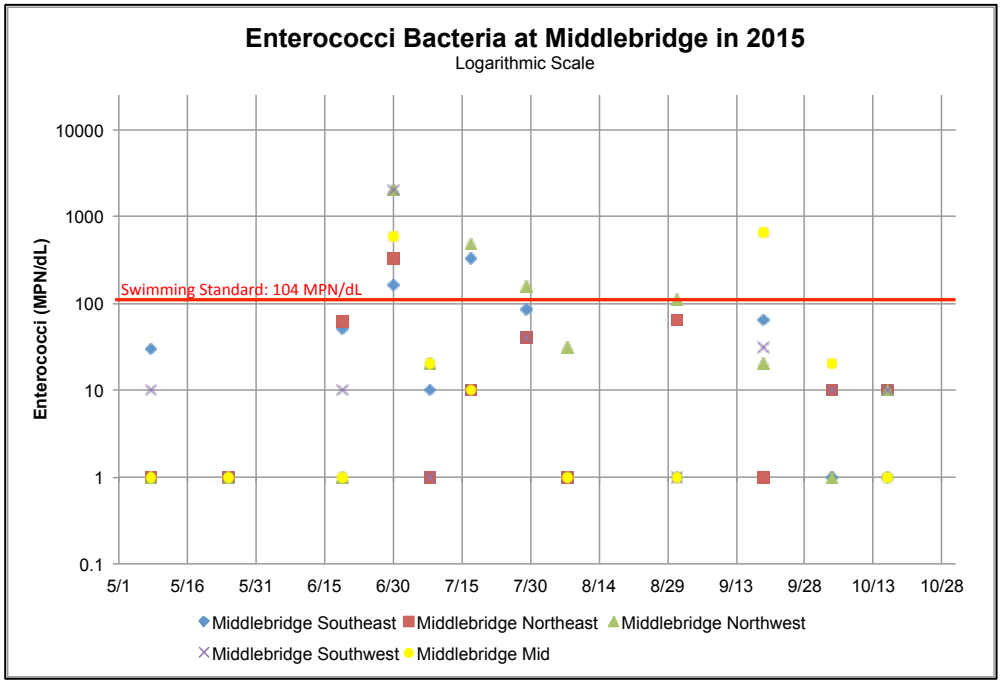
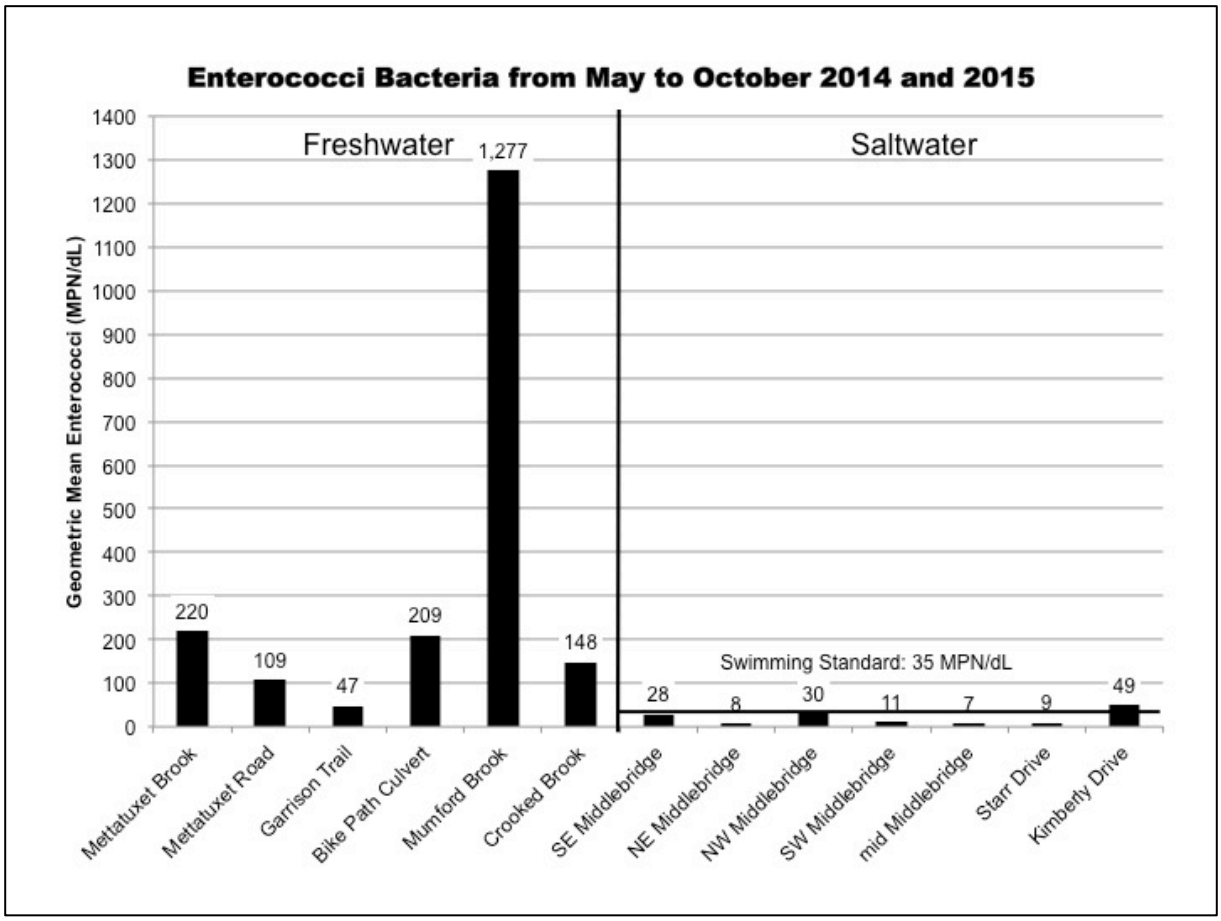


Figure 10: Enterococci Bacteria from May to October 2014 and 2015 (average)
Note that in this graph, the data are separated into freshwater and salt water sites, with sites listed generally in order from north to south.



Nutrient Data:
Note that Figures 11 and 12 have the freshwater sites on the left and the saltwater sites on the right and they are listed generally in order from north to south. For Total Nitrogen, water bodies with levels below 25 umol/L are considered low, between 25 and 54 umol/L are moderate, between 55 and 154 are elevated, and above 154 are hypereutrophic (URI WW 2010). For Total Phosphorus, water bodies with levels at or below 8 umol/L are considered good (RIDEM 2009).

Figure 11: Average Total Nitrogen Data (2014 & 2015)

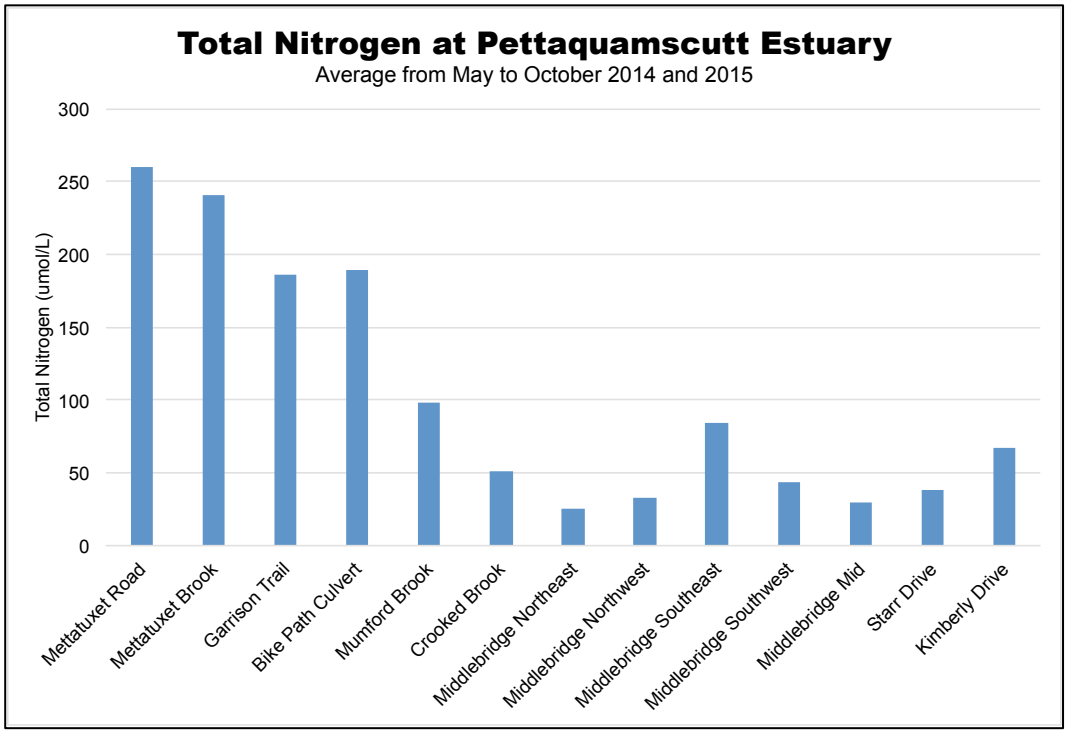


Figure 12: Average Total Phosphorus Data (2014 & 2015)

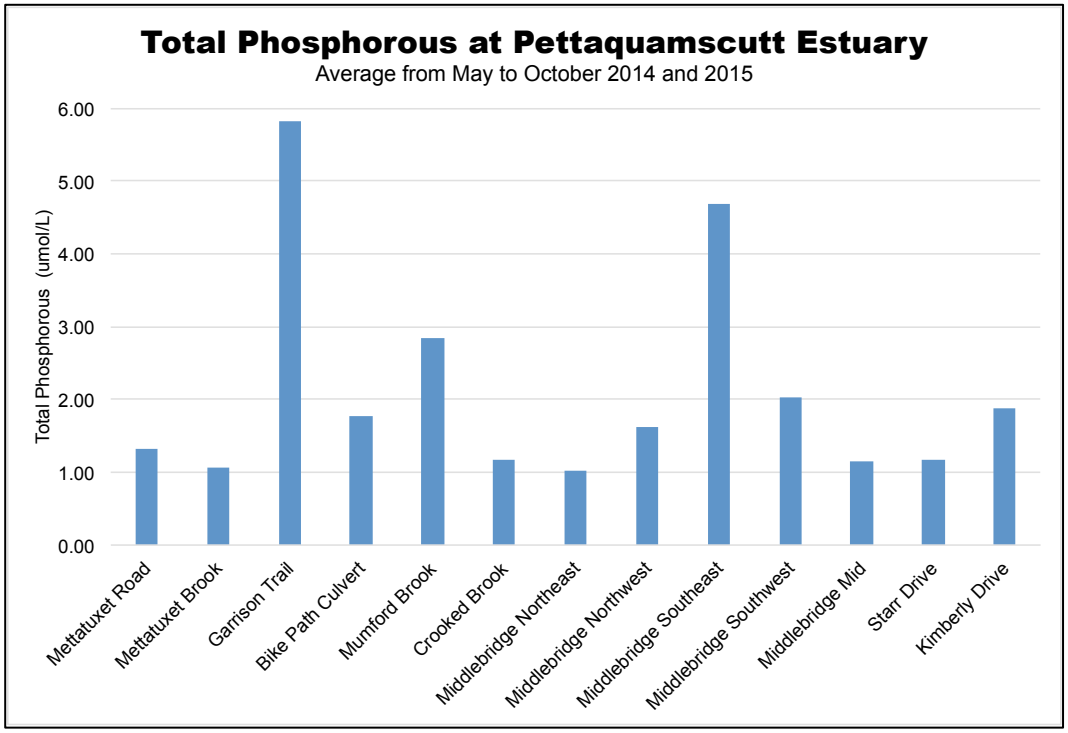


Figure 13a: Total Nitrogen Data (2014)

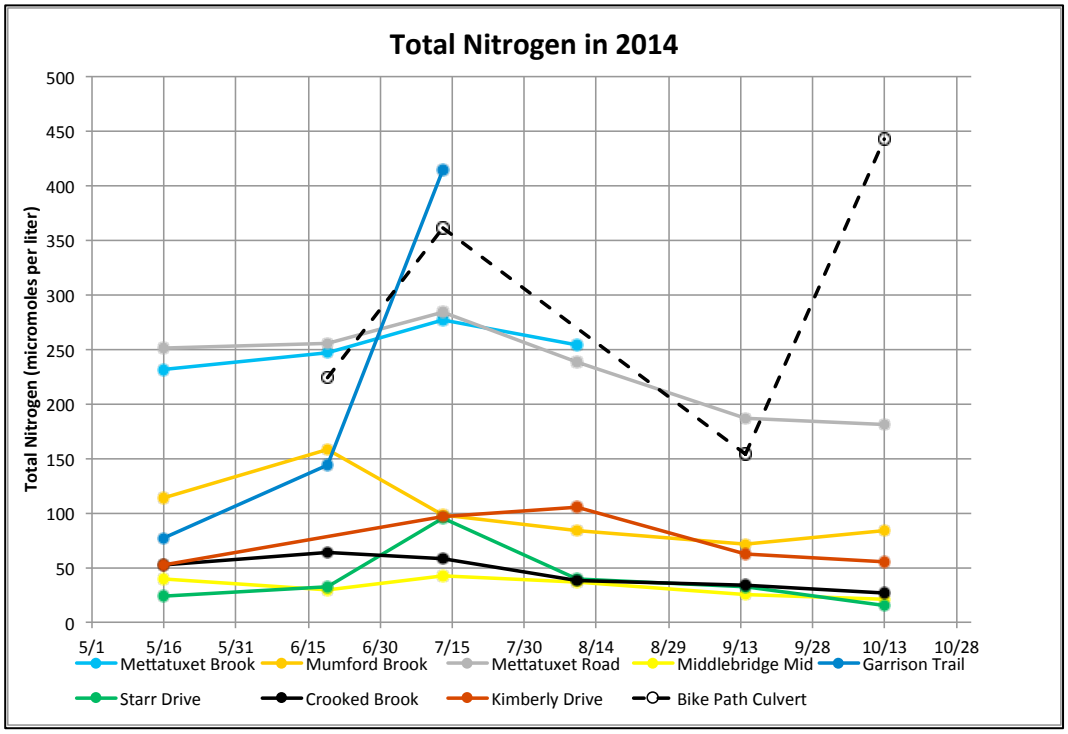


Figure 13b: Total Nitrogen Data (2015)

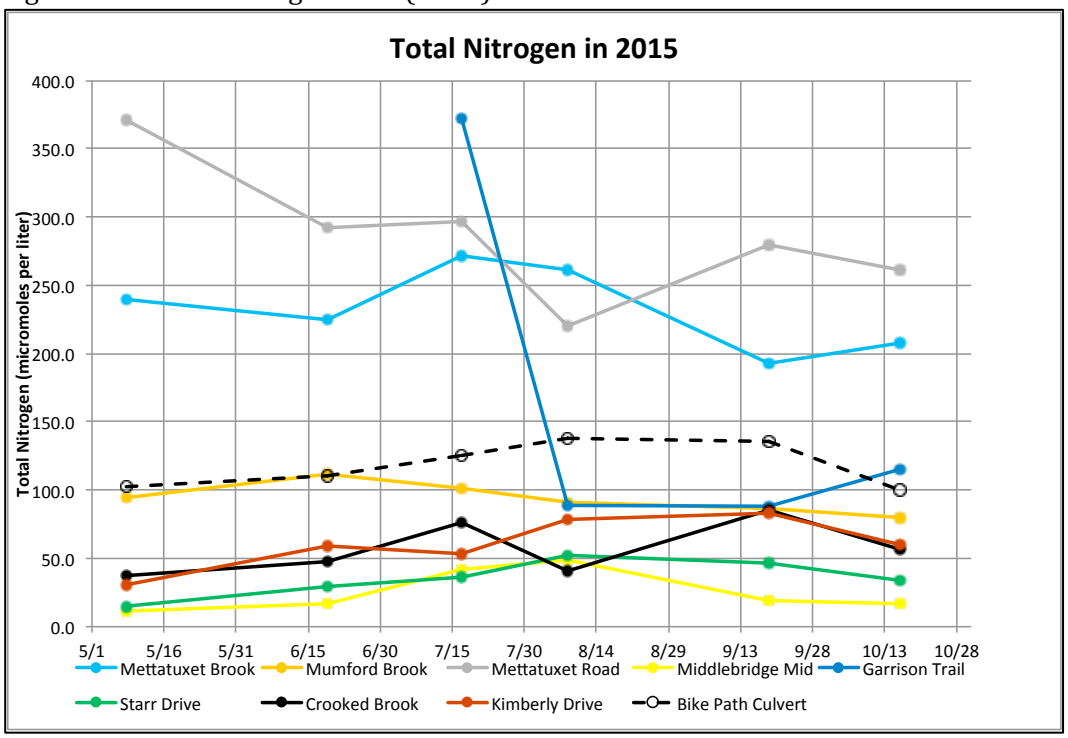


Figure 14a: Total Phosphorus Data (2014)

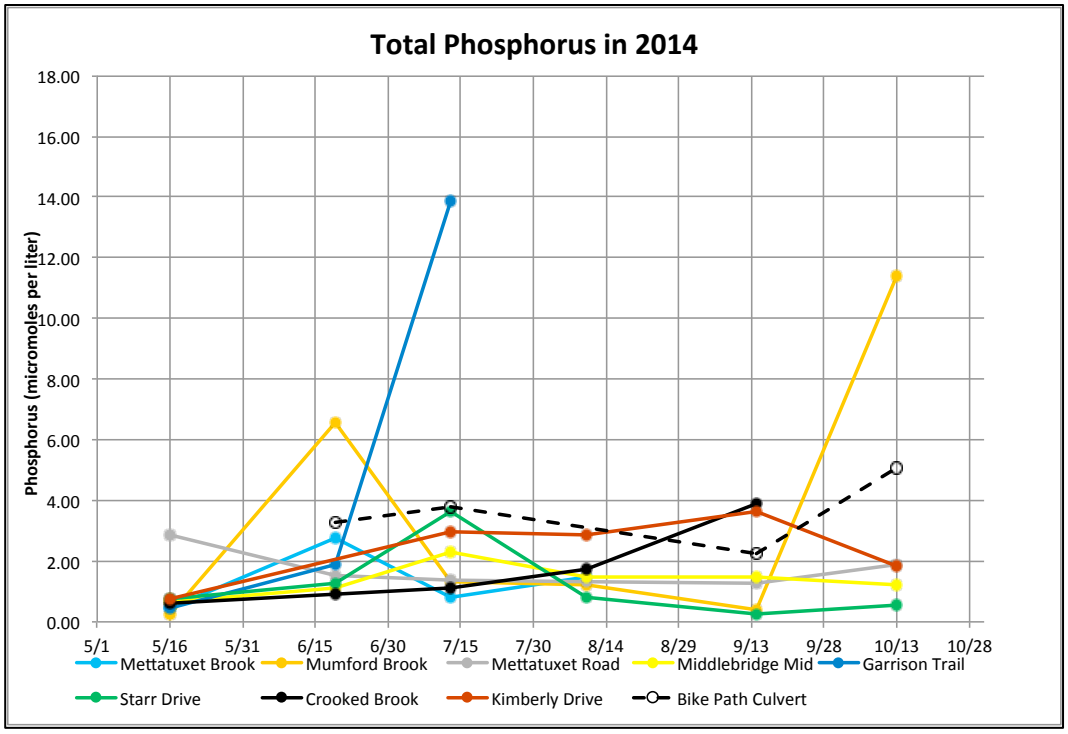
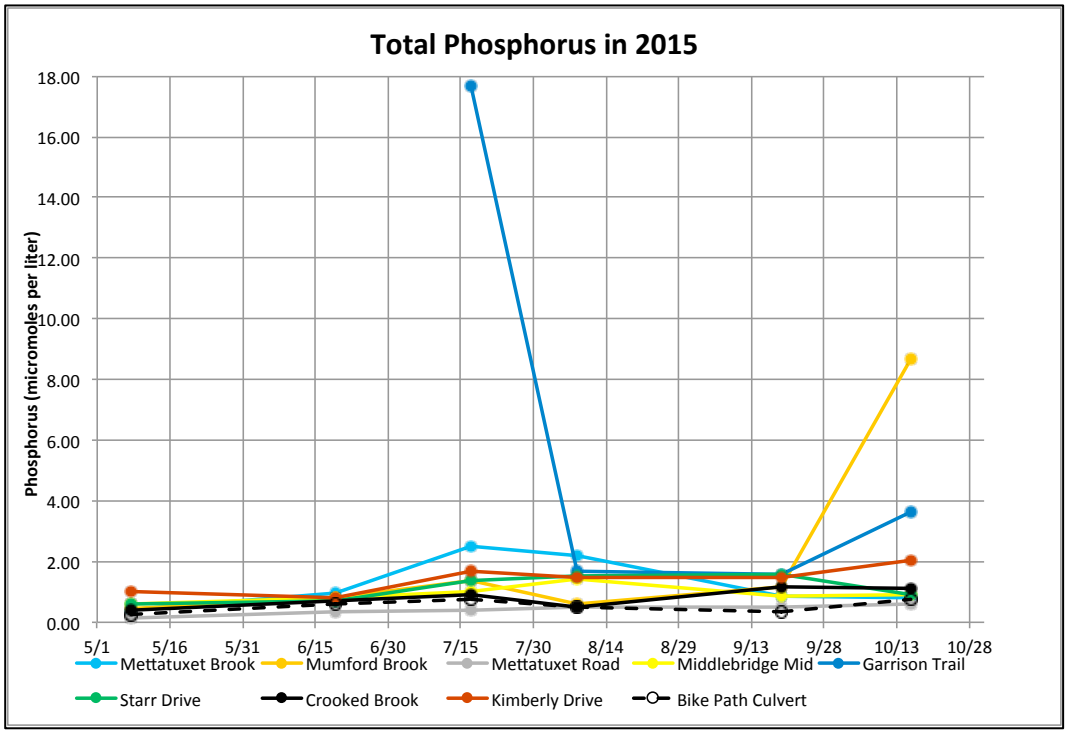


Figure 14b: Total Phosphorus Data (2015)



For Ammonia and Nitrate plus Nitrite, there are only published criteria for these two parameters combined: less than 7 umol/L is considered good, between 7- 35 is considered fair, and over 35 is considered poor (USEPA 2016). Ammonia and Nitrate plus nitrite are graphed separately here to highlight the levels of each parameter.

Figure 15a: Ammonia Nitrogen Data (2014)

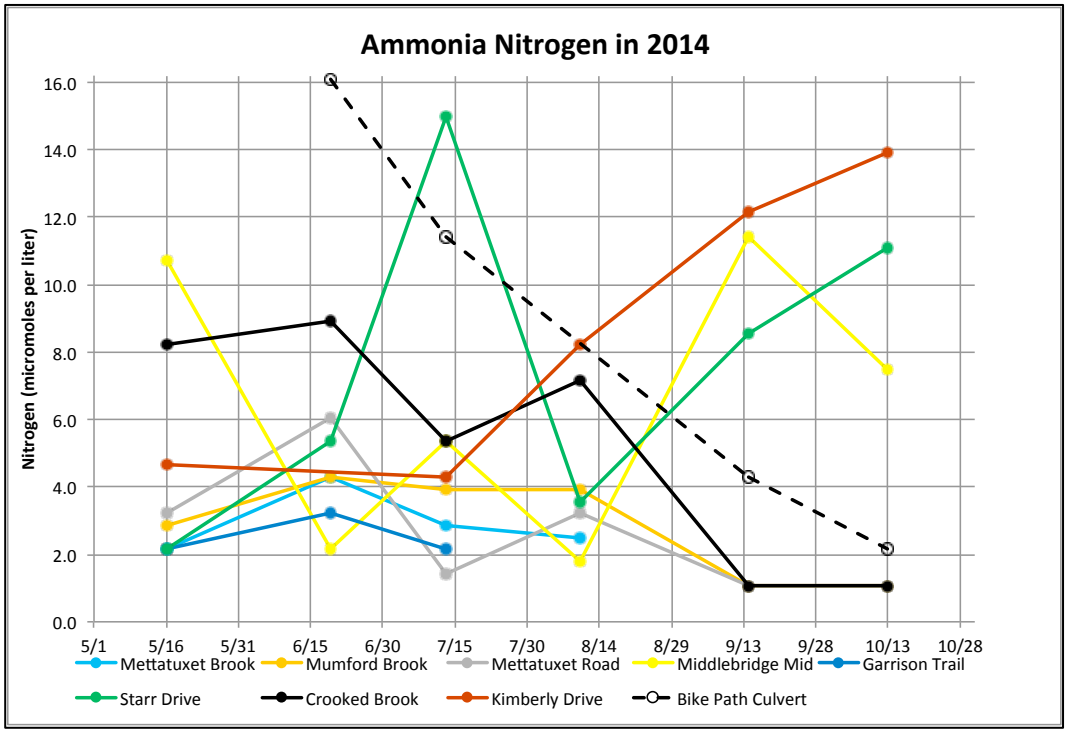


Figure 15b: Total Ammonia Nitrogen Data (2015)

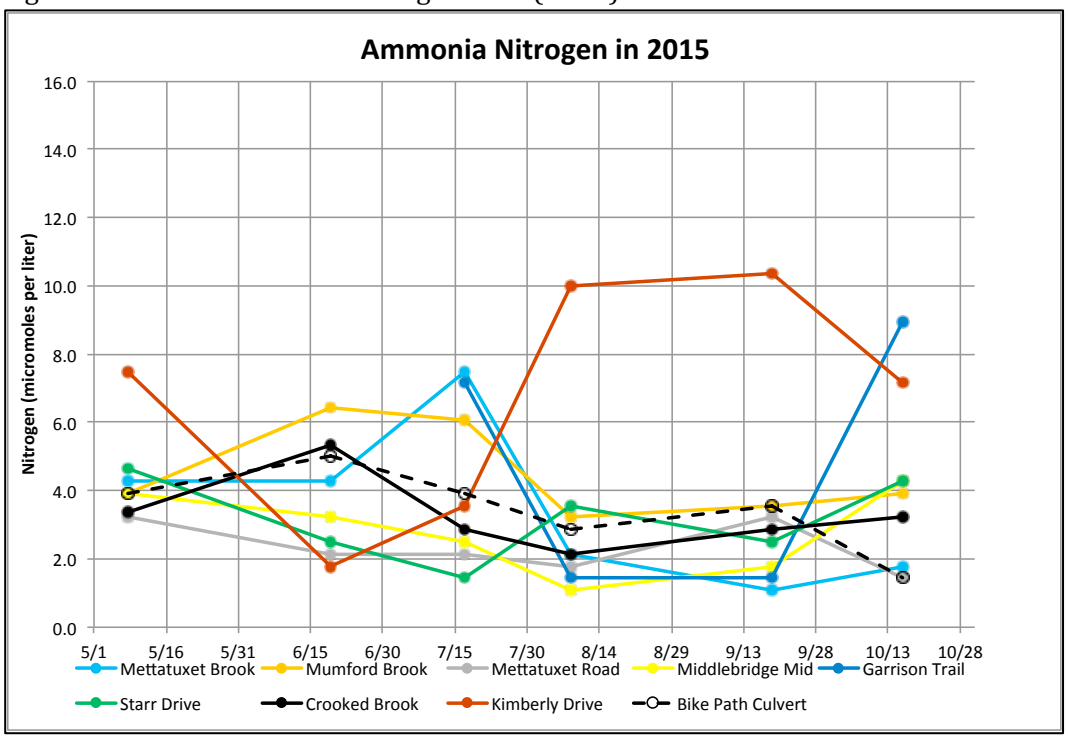


Figure 16a: Total Nitrate+Nitrate Nitrogen Data (2014)

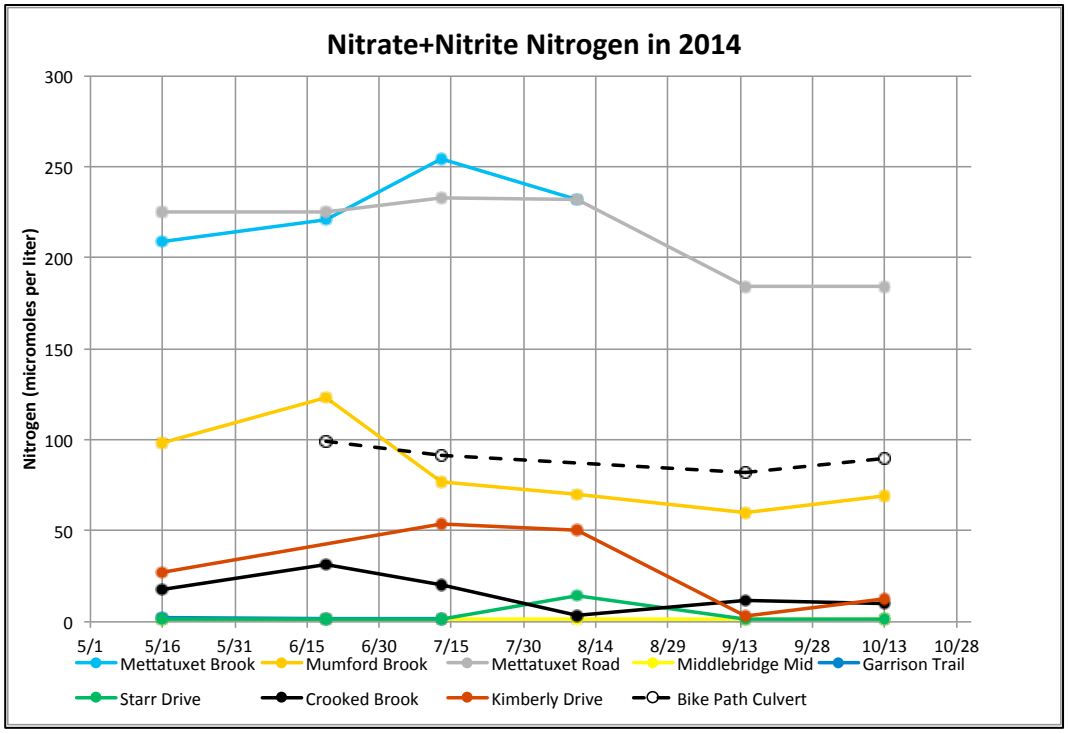
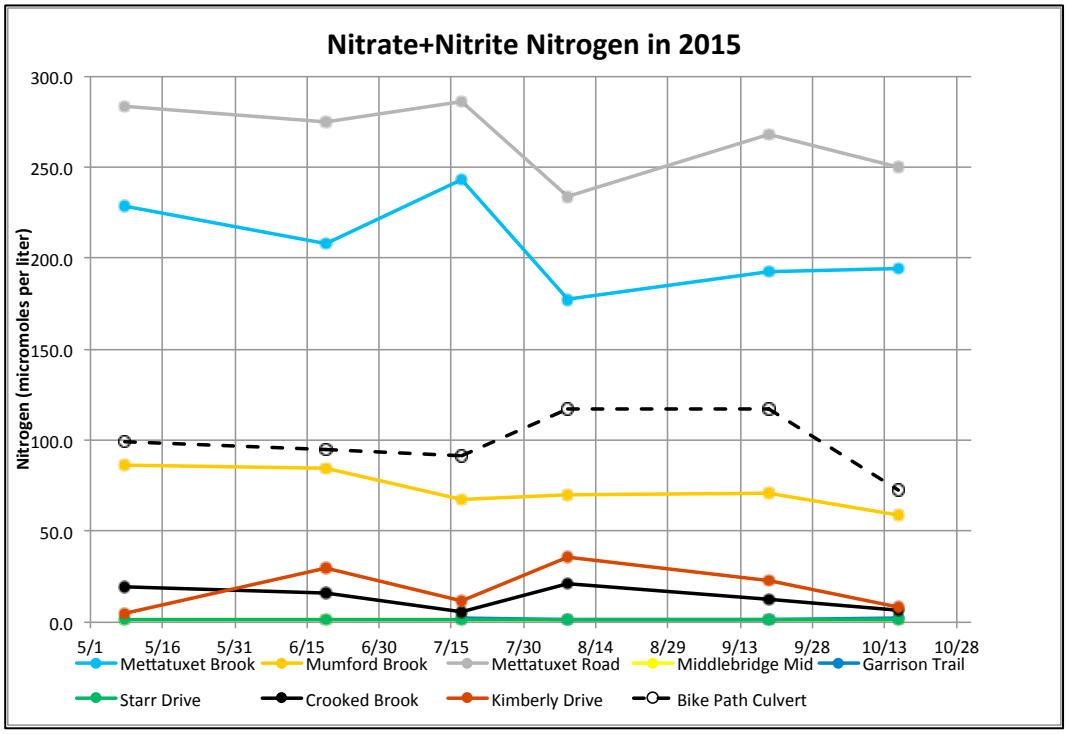


Figure 16b: Total Nitrate+Nitrate Nitrogen Data (2015)



For Dissolved Inorganic Phosphorus, less than 0.3 umol/L is considered good, between 0.3 and 1.6 is fair, and greater than 1.6 is poor (USEPA 2016)

Figure 17a: Dissolved Phosphorus Data (2014)

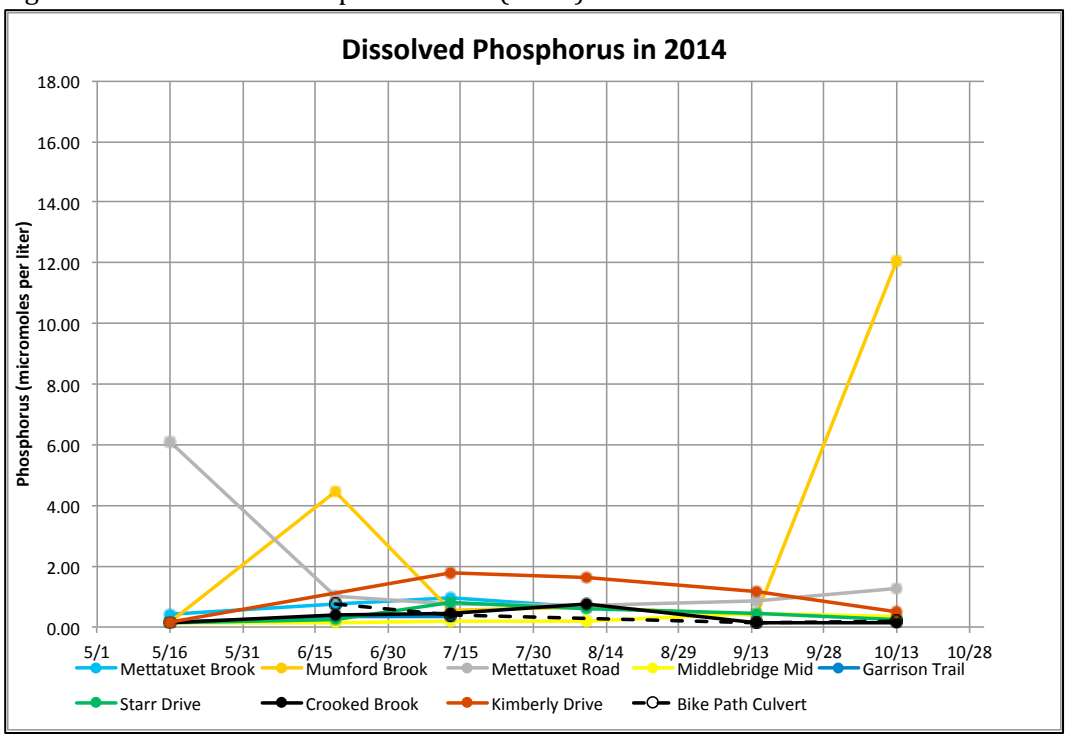
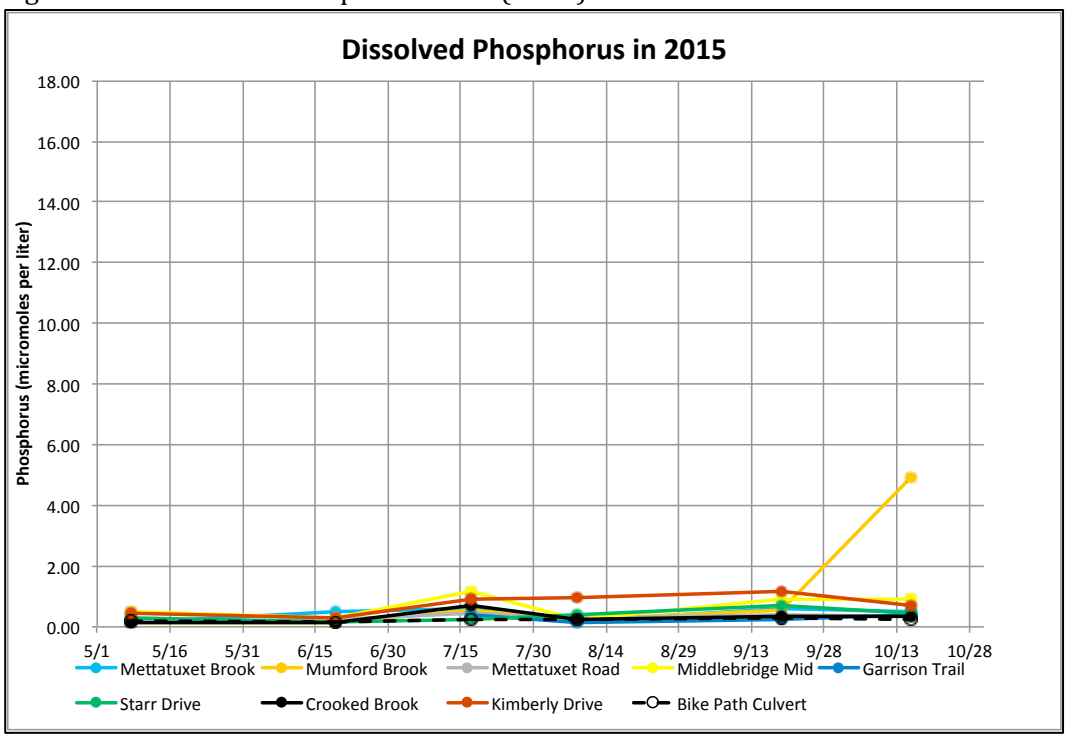


Figure 17b: Dissolved Phosphorus Data (2015)



Findings and Observations:

Below are findings and observations from the 2014 and 2015 data:

- General: A few sites were dry during one or more sampling periods (as evidenced by absence of data) in 2014 but not in 2015.

- Temperature:
  - Temperature data reflects seasonal trends with elevated water temperatures observed at all sites during the summer months.
  - The temperature at all sites during the season fell between a range of 10°C and 30°C.

- Salinity: The stream and brook sites are freshwater because marine waters do not reach there and the salinity levels as expected are at or near zero at these sites.

- Dissolved Oxygen:
  - Oxygen levels varied widely among the sites in the spring and early summer in 2014, but were similar from early August to the end of the sampling.
  - Oxygen levels varied widely among the sites for much of the 2015 season.
  - The average dissolved oxygen for each site over the two years was always at or above the criteria for growth (4.8 mg/L, USEPA 2000) so could support marine life over the sampling season.
  - The minimum measurements were mostly above the criteria for growth but were always above the criteria for adult survival (2.3 mg/L, USEPA 2000) and were never anoxic which would be harmful to aquatic organisms.

- Bacteria:
  - All of the marine water sites had high bacteria levels at least once during the season in excess of the standard for recreational contact.
  - There was considerable variability in bacteria levels at the five different Middlebridge sites on any particular sampling dates.
  - Almost all of the sampled streams had very high bacterial levels on multiple occasions, suggesting that even small streams can contribute bacteria to Pettaquamscutt Estuary.
  - The Mumford Brook site has the most enterococci and fecal coliform bacteria of the sites studied.
  - The data indicates that Mumford Brook releases much more fecal coliform and enterococci bacteria than Crooked Brook or Mettatuxet Brook.
  - Mumford Brook's tributary at the bike path had a lower concentration of bacteria than the main stream. This suggests that there is a larger unknown source of bacteria into Mumford Brook.

- Nutrients:
  - Total Nitrogen:
    - The concentrations of averaged total nitrogen (Fig 11) were very high at most of the freshwater stations and were considered "hypereutrophic" at Mettatuxet Road, Mettatuxet Brook, Garrison Trail, and Bike Path Culvert sites.
    - The freshwater sites Mumford Brook and Crooked Brook were "moderate".
    - All of the seawater sites were "moderate" except for Middlebridge Southeast and Kimberly Drive that were "elevated".

- Looking at the actual data for each year (Fig 13 a,b), it is noticeable that Mettatuxet Road and Mettatuxet Brook are high all season long, while Garrison Trail and Bike Path Culvert have some high spikes.

- Total Phosphorus:
  - Although the freshwater site, Garrison Trail, and the seawater site, Middlebridge Southeast, are much higher in averaged total phosphorus then the other sites, the values at all sites are considered "good" (Fig 12).
  - Looking at the yearly data (Fig 14 a, b), the higher sites, which also includes Mumford Brook, are not high all season long, but have a few high months. The Middlebridge corner sites are not on the yearly graphs because four more lines would be hard to see, but the data shows the southeast site had one high month.
- Ammonia:
  - Most of the ammonia values are considered "good" during both years (Fig 15a,b).
  - The seawater site Kimberly Drive had several high months each year
  - Otherwise the two years were different with 2014 having higher values also at the seawater sites Starr Drive and Middlebridge, and the freshwater site Bike Path Culvert but 2015 having some higher values at the freshwater sites Garrison Trail and Mettatuxet Brook.
- Nitrate plus Nitrite:
  - The two years, 2014 and 2015, were very similar in values and trends for nitrate+nitrite (Fig 16 a, b).
  - Four freshwater sites were very high each year (and in this order): Mettatuxet Road, Mettatuxet Brook, Bike Path Culvert, and Mumford Brook. The next highest (but an order of magnitude lower) was a seawater site, Kimberly Drive, and a freshwater site, Crooked Brook.
  - The remaining freshwater site, Garrison Trail, and seawater sites Middlebridge, and Starr Drive, were very low.
- Dissolved Inorganic Phosphorus:
  - All of the 2014 and 2015 measurement of dissolved phosphorus are in the good to fair range (Fig 17 a, b) except for Mumford Brook in some months.

Conclusion:

For the bacteria data, of all the sites studied, Mumford Brook was the most significant source of bacteria. It had the highest levels of both fecal coliforms and enterococci and the flow measurements demonstrate that is the largest contributor of bacteria to Pettaquamscutt Cove. Where the bacteria are coming from is not clear, since the main tributary was also sampled (Bike Path Culvert) and bacteria values were lower. Recently another small tributary stream has been identified (adjacent to the power line) and this could be an important source.

For the nutrient data, one of the most noteworthy results is the high concentrations of nitrate plus nitrite found at most of the freshwater sites, up to 4.0 mg/L or 286 umol/L. In the review paper by Helsel 1996, he states that 0.7 mg/L or 50 umol/L can be considered a background level for nitrate plus nitrite in streams. Dubrovsky and Hamilton 2010 states that levels above 1 mg/L or 71 umol/L is an indication of human activity. Examples of possible human activity are: failing septic systems, fertilizer runoff, animal waste runoff, and atmospheric deposition resulting from nitrogen oxides in car emissions. Since the Mettatuxet Road site is upstream of the Mettatuxet Brook site, it is not surprising that the values at the 2 sites are similar. And since the Bike Path Culvert site is downstream of the Mumford Brook site, the similar values show that these 2 sites are connected. These two areas should be examined for the indicators of human activity mentioned above. Why the high nitrate plus nitrate numbers may be a cause for concern

is that, if conditions are right, they could be supporting algal blooms in the waters that the streams are flowing into, Pettaquamscutt Cove and off Mettatuxet.

Also it is the nitrate plus nitrite values that are making the total nitrogen numbers so high. Ammonia may be low because it is being oxidized to nitrate plus nitrite. Phosphate does not appear to be a problem in this system.

Concluding Remarks

NRPA appreciates the funding support provided by USFWS and administered by The Nature Conservancy for this program. The data collected continues to provide us with a greater understanding of the water quality of the Narrow River.

References:

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Helsel, D.R. 1997. *Nitrate in the nation's waters: a summary of recent studies.* Nutrient National Synthesis, USGS National Water-Quality Assessment (NAWQA) Program, U.S. Geological Survey. 17pp.

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Appendix
List of Tables and Figures

2015 Bacteria Data - Narrow River Preservation Association Special Project: Fecal coliform and enterococci

In Rhode Island two groups of bacteria are monitored to indicate the presense of human sewage and associated pathogens, or disease causing organisms - fecal coliforms and enterococci. The Rhode Island Department of Health (RIHealth) uses a single-value enterococci standard for licensed swimming beaches. The Rhode Island Department of Environmental Management (RIDEM) uses a geometric mean approach for contact recreation standards on all other waters (fresh and salt). In addition, as required by the National Shellfish Sanitation Program for shellfish waters and their tributaries and as an indicator of overall water quality, RIDEM assesses fecal coliform levels.

While URIWW's analytical laboratories are certified by the State, URIWW data is intended for screening purposes only. Our data are very valuable for targeting areas of concerns and for tracking potential sources of bacterial contamination. Any result above the state standard is considered unsafe, and swimmers should refrain from swimming until results return to acceptable levels, or at least for several days after heavy rain.

RI Department of Environmental Management fecal coliform standards:

Shellfish Waters - Not to exceed 14 fecal coliform per 100 mL (Exceedence indicated by **RED** text).

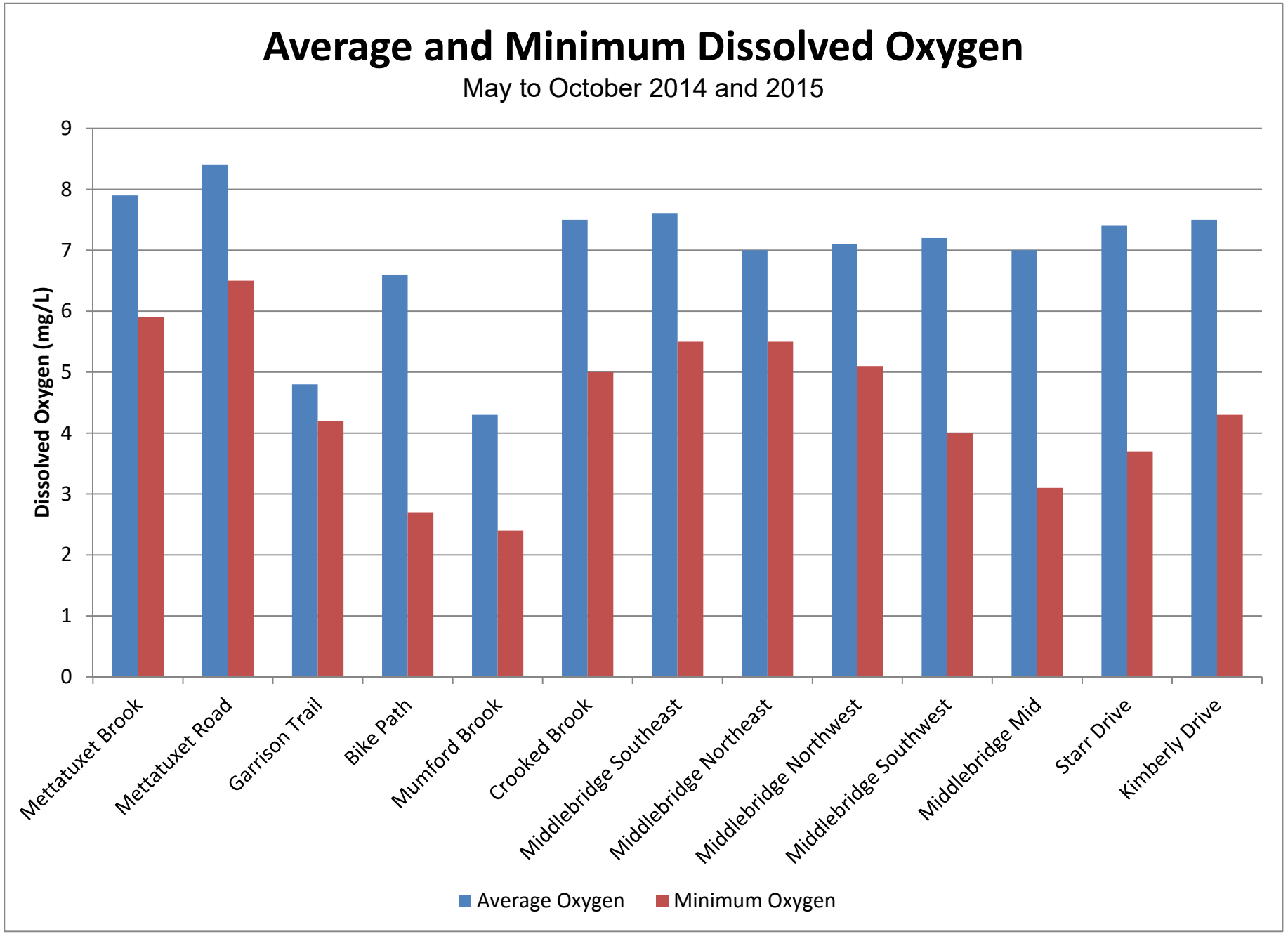
NRPA Project Sites Fecal Coliform Data

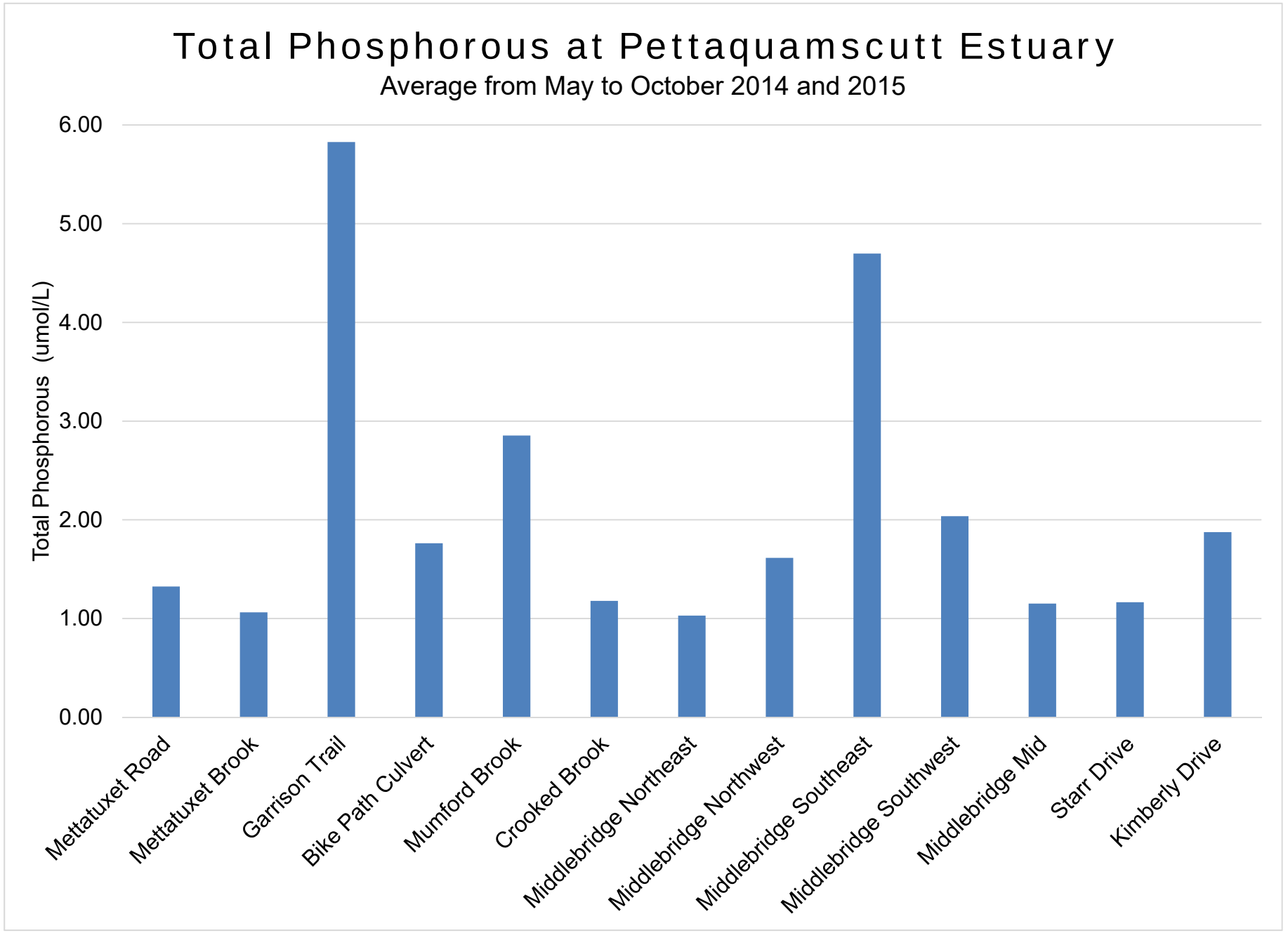
Watershed code	Monitoring Location	May 8/9	May 25/26	June 19/22	June 30 & July 1	July 8 & 9	July 17 & 18	July 29 & 30	Aug 7 & 8	Aug 31 & Sep 1	Sept 19 & 20	4-Oct	Oct 16 & 17	GEOMEAN
		----- Most Probable Number of Fecal coliform per 100 mL -----												
PE	NR 11 - Mettatuxet Brook	<10	<10	<10	<10	127	20	-	31	42	395	63	<4	9
PE	NR 12 - Mumford Brook	132	818	<10	3609	906	10	2613	2489	115	1192	838	16	243
PE	NR 17 - Mettatuxet Road	4	<10	12	10	<4	84	>24196	<10	497	88	173	12	>24
PE	NR 18 - SE Middlebridge	<10	<10	20	1298	2005	691	399	164	31	<10	53	<10	49
PE	NR 19 - NE Middlebridge	<10	<10	20	288	64	10	1112	20	20	20	20	10	21
PE	NR 20 - NW Middlebridge	<10	<10	<10	>2005	246	364	1106	Not run	87	53	41	<10	45
PE	NR 21 - SW Middlebridge	<10	<10	150	>2005	144	>2005	>24196	42	10	124	31	20	>80
PE	NR 22 - mid Middlebridge	<10	10	<10	831	192	10	-	10	10	<10	31	<10	12
PE	NR 23 - Garrison Trail				10	154	<10	52	<10	12	<4	31	<4	6
PE	NR 24 - Starr Drive	20	<10	236	1198	41	20	1211	<10	4	4	96	34	28
PE	NR 25 - Crooked Brook	4	4	80	1234	<10	98	10	<10	76	21	31	<4	18
PE	NR 26 - Kimberly Drive	21	4	53	3076	30	<10	201	<10	9678	115	657	74	64
PE	NR 27 - Bike Path Culvert	<10	661	<4	465	110	10	504	124	79	115	399	29	56

RIDEM Primary Contact Recreationa/Swimming Geometric Mean Density (Geomean):
Not to exceed 35 enterococci per 100 mL.
RIHealth standards at licenced beaches: Not to exceed 60 enterococci per 100 mL

NRPA Project Sites Enterococci Data

Watershed code		May 8/9	May 25/26	June 19/22	June 30 & July 1	July 8 & 9	July 17 & 18	July 29 & 30	Aug 7 & 8	Aug 31 & Sep 1	Sept 19 & 20	4-Oct	Oct 16 & 17	GEOMEAN
		- - - - - Most Probable Number of Enterococci per 100 mL - - - - -												
PE	NR 11 - Mettatuxet Brook	**94**	**122**	**146**	10	**334**	**379**	-	**531**	**104**	**202**	20	**218**	**124**
PE	NR 12 - Mumford Brook	**213**	**612**	**563**	**8664**	**776**	**2014**	**6131**	**2603**	**5199**	**2908**	**758**	**942**	**1535**
PE	NR 17 - Mettatuxet Road	4	21	54	**96**	12	**109**	**104**	10	**796**	48	10	39	**38**
PE	NR 18 - SE Middlebridge	30	<10	52	**164**	10	**323**	**84**	<10	<10	**64**	<10	<10	**11**
PE	NR 19 - NE Middlebridge	<10	<10	**63**	**324**	<10	10	41	<10	**64**	<10	10	10	**<10**
PE	NR 20 - NW Middlebridge	<10	<10	<10	**2005**	20	**478**	**160**	31	**111**	20	<10	10	**19**
PE	NR 21 - SW Middlebridge	10	<10	10	**2005**	<10	10	41	<10	<10	31	10	10	**<10**
PE	NR 22 - mid Middlebridge	<10	<10	<10	**591**	20	10	-	<10	<10	**659**	20	<10	**<10**
PE	NR 23 - Garrison Trail				<10	12	41	**156**	10	21	57	**158**	52	**16**
PE	NR 24 - Starr Drive	<4	<10	<4	**1046**	<10	10	**63**	<10	**87**	12	10	34	**8**
PE	NR 25 - Crooked Brook	12	55	**258**	**1782**	**158**	**3044**	**669**	**61**	**485**	**131**	10	**118**	**166**
PE	NR 26 - Kimberly Drive	<4	<10	8	**95**	4	**86**	**98**	10	**4813**	**578**	<10	34	**22**
PE	NR 27 - Bike Path Culvert	**111**	**122**	**416**	**1780**	**426**	**1391**	**373**	**75**	21	**221**	30	**84**	**188**


Average and Minimum Dissolved Oxygen
May to October 2014 and 2015
Dissolved Oxygen (mg/L)
0
1
2
3
4
5
6
7
8
9
Mettatuxet Brook
Mettatuxet Road
Garrison Trail
Bike Path
Mumford Brook
Crooked Brook
Middlebridge Southeast
Middlebridge Northeast
Middlebridge Northwest
Middlebridge Southwest
Middlebridge Mid
Starr Drive
Kimberly Drive
Average Oxygen
Minimum Oxygen


Total Phosphorous at Pettaquamscutt Estuary
Average from May to October 2014 and 2015
Total Phosphorous (umol/L)
6.00
5.00
4.00
3.00
2.00
1.00
0.00
Mettatuxet Road
Mettatuxet Brook
Garrison Trail
Bike Path Culvert
Mumford Brook
Crooked Brook
Middlebridge Northeast
Middlebridge Northwest
Middlebridge Southeast
Middlebridge Southwest
Middlebridge Mid
Starr Drive
Kimberly Drive