Penobscot River
Phosphorus Waste Load Allocation

Ambient Monitoring Plan Report – 2014

June 2015

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Goals / Methodology

The primary goal of the Penobscot River Ambient Monitoring Plan (PRAMP) is to measure the effectiveness of the Phosphorus-Waste Load Allocation (P-WLA) in eliminating eutrophication driven dissolved oxygen (DO) non-attainment, and to identify potential/particular areas of concern along the river. Eutrophication driven DO non-attainment on the Penobscot primarily occurs in the shallower free flowing reaches of the river where periphyton (bottom attached algae) can flourish. These sections of the river are more prone to large diurnal DO swings than deeper reaches of the river. Diurnal DO swings are produced by algae (and other living plants) that result from net photosynthetic production of oxygen during daylight hours and respirative consumption of oxygen during non-daylight hours. Large diurnal DO swings (> 2 mg/l) are often indicative of nutrient enrichment. Excessive diurnal swings have the tendency to produce early morning DO sags, which are the primary driver of DO non-attainment on the Penobscot River. Longer reaches of free flowing river are considered to be more prone to excessive swings, because the longer travel times equate to longer periphyton contact times.

We can use water quality sondes to measure the relative algae driven DO influence along a particular reach of river by placing them upstream and downstream of the reach being studied. Pairing sondes in this manner allows us to directly assess the relative diurnal DO influence being exerted by the particular reach of river (vs. other non-diurnal influences such as BOD, SOD, and atmospheric re-aeration). This diurnal DO influence is most directly tied to responses associated with nutrient enrichment.

Project Summary for 2014

This Penobscot River Ambient Monitoring Plan (PRAMP) Report has been developed in accordance with the Penobscot River Phosphorus Waste Load Allocation (P-WLA), dated May 2011. The P-WLA was implemented in conjunction with 2011 MEPDES relicensing for wastewater dischargers on the Penobscot River. The purpose of the P-WLA was to eliminate DO non-attainment, which was being caused by excessive phosphorus point source loadings. The basic rationale behind the P-WLA can be summarized as follows:

- The Department has conducted three water quality surveys (1997, 2001, and 2007) on the Penobscot River that demonstrated DO non-attainment and excessive algae growth.

- The water quality surveys also highlighted excessive ambient phosphorus concentrations attributable to point source loadings.
- Early morning DO sags resulting from large diurnal DO swings were the predominant mechanism causing DO non-attainment.
- Reduced phosphorus loadings are expected to alleviate the DO non-attainment by reducing the amount of algae growth and the corresponding magnitude of diurnal DO swings.

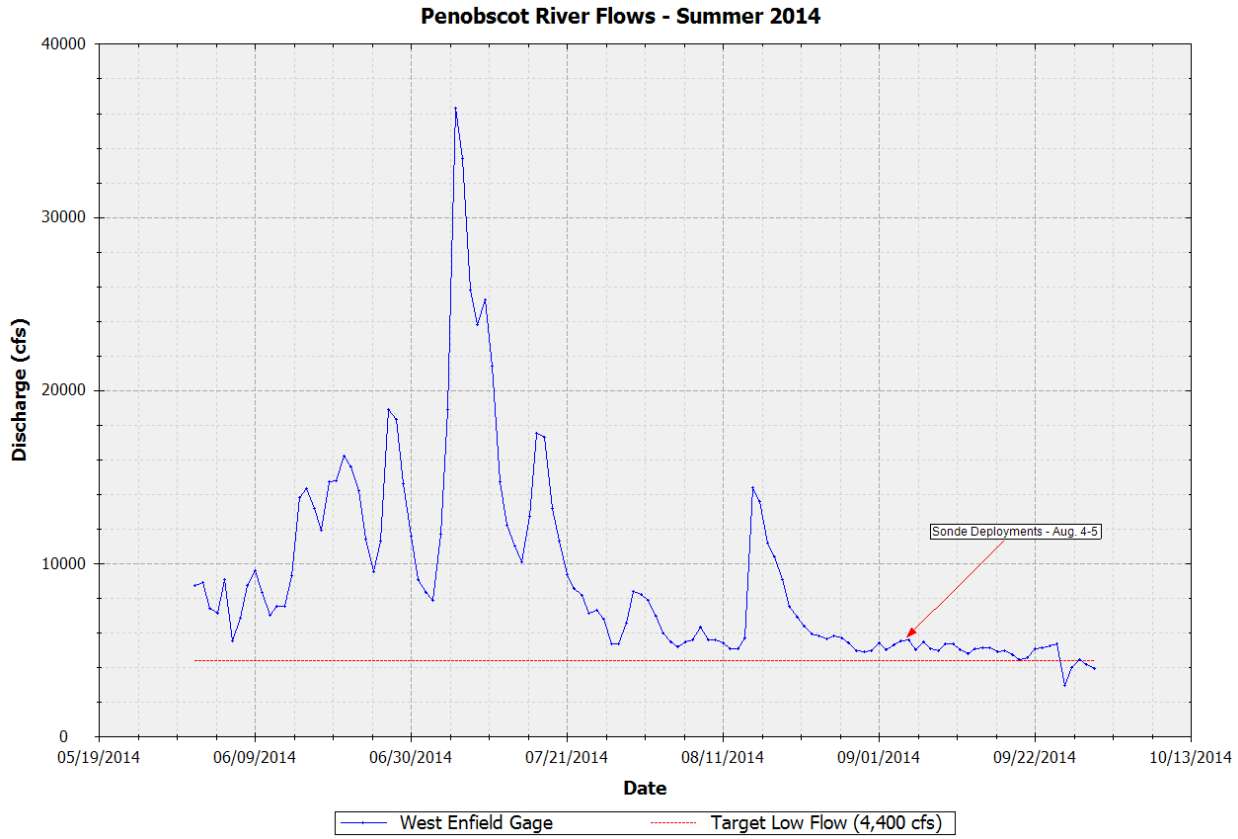
This past summer (2014) was the fourth year of ambient monitoring under the PRAMP, as the majority of MEPDES permit renewals were finalized in May of 2011. The equipment used for this monitoring effort consists of the following;

4 Eureka Environmental – Sub2 Manta2 Multiprobes equipped with the following sensors;

- Optical Dissolved Oxygen– primary parameter of interest with regard to non-attainment.
- Temperature – Temperature data are necessary to calculate DO % saturation. Temperature data also help to decipher potential climatic influences on water quality.
- Conductivity – Conductivity data are helpful in assessing the relative level of impact from pollutant sources (point and non-point).
- pH – pH data are measured to assess compliance with the pH criterion in Maine's Water Quality Standards, often times an indicator of excessive plant growth.
- Depth – Depth information is helpful when collecting profile data, and also helps to assess changes in river flow (stage) for stationary/remote deployments.

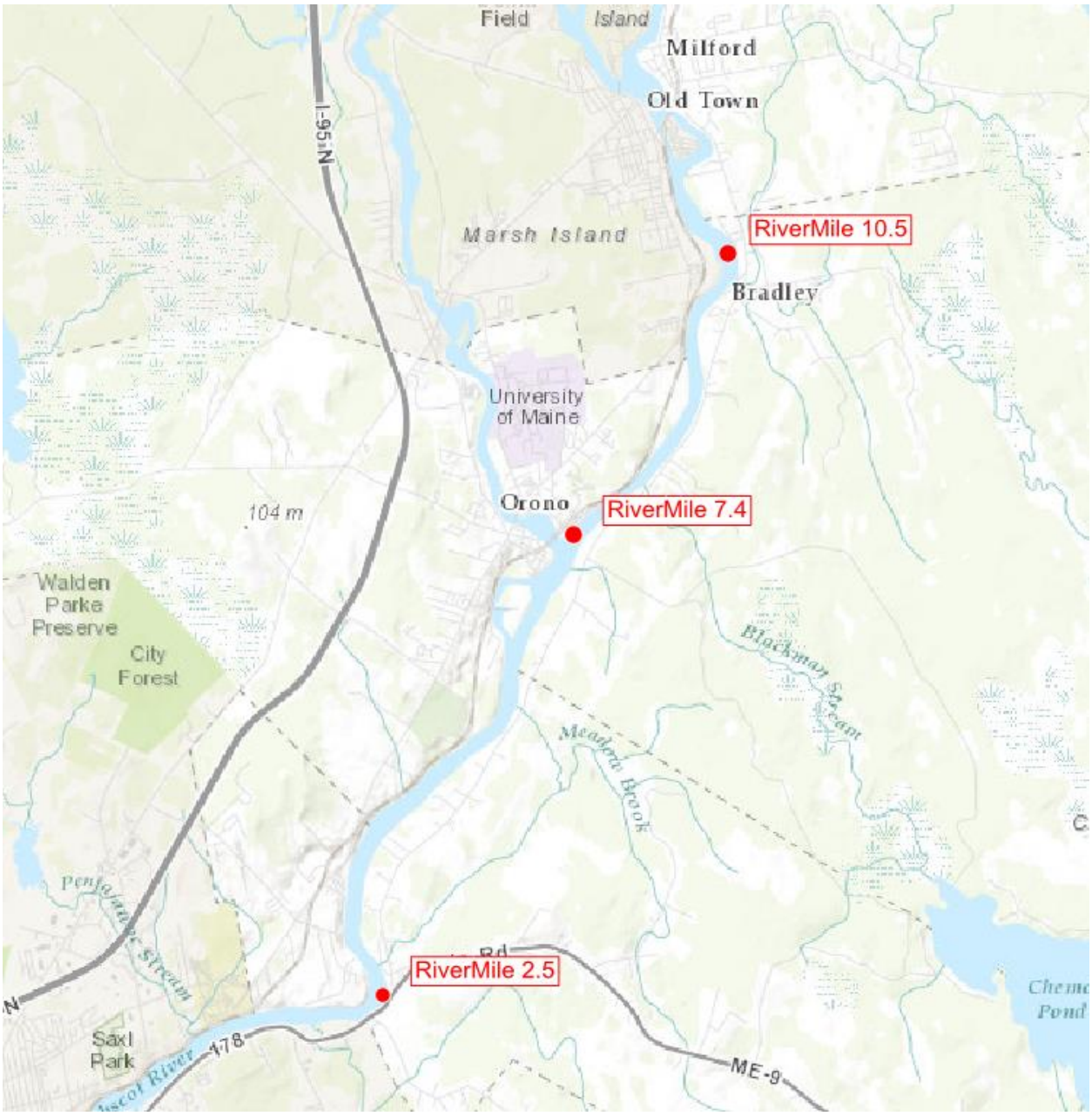
1 Handheld Communication Device to be used to communicate with all 4 multiprobes.

The PRAMP targets periods of low river flow during the warmest summer months (typically mid-June through late August). These periods are considered to be the most critical conditions and represent worst case scenarios with respect to water quality. The Department uses a target flow of 4,400 cfs (as measured at the West Enfield gage) as representative of low flow conditions for the Penobscot River. This target flow represents the 95th percentile of the flow duration curve. The year 2014 was a fairly wet year and the target flow was not reached during the desired summer period. Early September provided a brief window of opportunity with continued warm temperatures and flows somewhat near the target flow. Sondes were deployed on September 4 and subsequently removed on September 5 due to the threat of a thunderstorm. River flows during this brief deployment averaged approximately 5,580 cfs, which is above the target low flow, but as low as it was going to get before temperatures cooled off. It was important to try and capture some limited data to help provide a relative gage of water quality during the year.

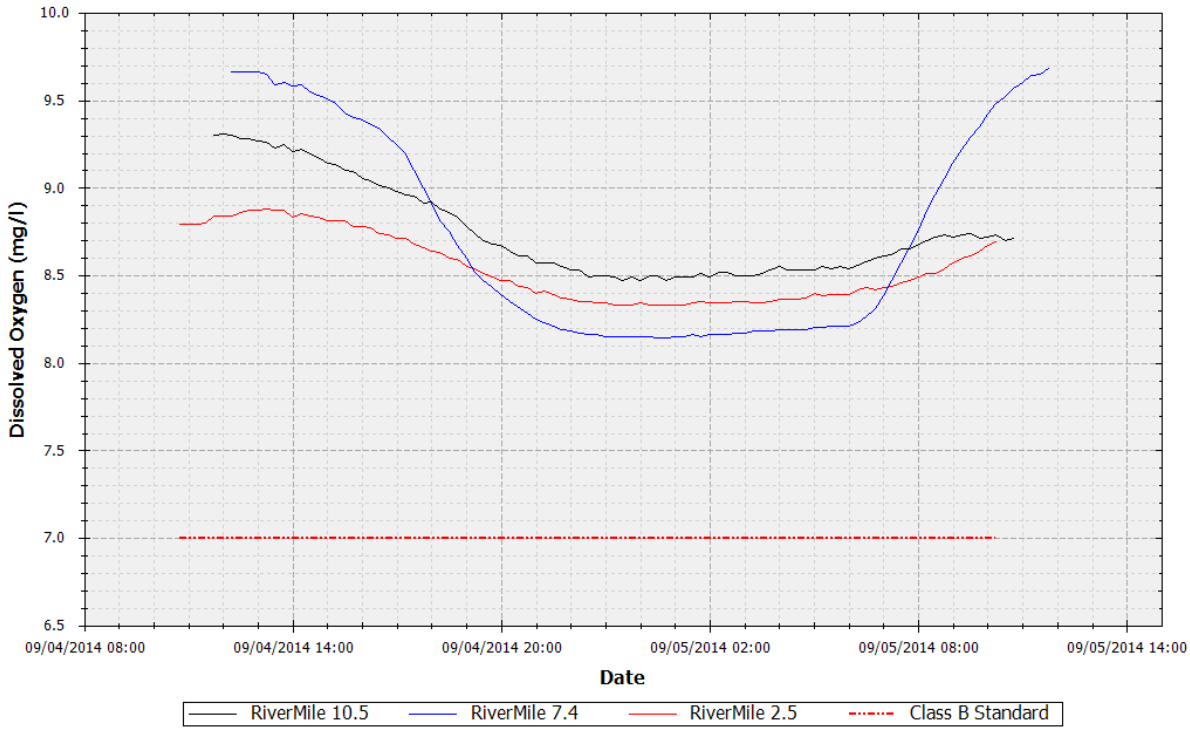


Results

The 2014 monitoring focused on the lower freshwater portion of the river between the former Great Works Dam to the hydraulic head of tide (just below the former Veazie Dam). Based on existing point source loadings, this is the reach of river that we expect to be most significantly influenced by diurnal DO swings. Three sondes were deployed at locations highlighted in the following figure.



This section of river is Class B and has historically exhibited significant diurnal DO swings that have gone below the 7.0 mg/l standard. This stretch has also experienced two dam removals (Great Works Dam and Veazie Dam) as part of the Penobscot River Restoration Project. The 2014 monitoring was quite brief, but did provide a glimpse at a full diurnal cycle during one of the most critical periods of the year. The data is depicted in the following chart:



These data highlight the following;

- The data indicate DO attainment during this critical period of 2014. These data are representative of some of the lowest flows experienced in 2014 and all data are well above associated classification criteria of 7 mg/l.
- Associated diurnal influences corroborate the assumption that the primary driver of diurnal DO swings is attributable to a periphyton response in shallower/free-flowing reaches of the river. The swings are slightly greater at the middle station.
- The maximum diurnal DO swing measured is approximately 1.6 mg/l at the middle station and is less than 1 mg/l at the other two stations. None of these swings are suggestive of significant enrichment.
- Specific conductivity, DO % saturation, pH, temperature and depth data were also collected in conjunction with this DO data. A graphical summary of this supplemental data is provided as an attachment to this report. These data will also be made available electronically upon request.

Phosphorus Point Source Effluent Monitoring

The primary goals of the effluent monitoring program are to demonstrate compliance with P-WLA's and to assess overall phosphorus loadings to the Penobscot River. The 2011 P-WLA includes a provision for routine phosphorus monitoring of the most significant discharges above Bucksport. A summary of these data is provided in the following table. Table allocations and loadings are expressed in pounds per day (PPD). The table includes data from discharges that occur below head of tide, but the primary focus of the P-WLA was discharges to freshwater. The basic rationale for this is that phosphorus is the limiting nutrient in most freshwater systems, whereas nitrogen is the limiting nutrient for most marine/estuarine systems. Documented non-attainment on the Penobscot River is believed to be directly related to eutrophication associated with the freshwater portion of the system.

Penobscot River - Millinocket to Bucksport
Total Phosphorus Loading Summary Table

Discharger Name	Type	Flow (MGD)	River Mile Postion	Permitted Allocation (PPD)	1997 (PPD)	2001 (PPD)	2007 (PPD)	2011 (PPD)	2012 (PPD)	2013 (PPD)	2014 (PPD)
GNP West	Papermill	43	83.3	36	52	287	224	0	0	0	0
Millinocket	POTW	2.33	81.6	-	16	26	12	13	11	14	16
GNP East	Papermill	33	75.7	28	222	292	4	5	10	9	7
Lincoln	POTW	1.07	49.4	-	12	8	7	*9*	*9*	*9*	*9*
Lincoln P&T	Papermill	16.3	49.3	68	78	41	41	42	41	36	3
Howland	POTW	0.03	35.1	-	*3*	2	3	*3*	*3*	*3*	*3*
Old Town	POTW	1.7	11.2	-	31	25	21	23	22	17	18
Red Shield	Papermill	24.4	9.9	102	68	176	205	119	76	90	38
Orono	POTW	1.84	6.9	-	13	15	18	21	17	17	10
Veazie	POTW	0.35	1.6	-	3	2	6	*3*	*3*	*3*	*3*
Sub-Totals Above Head of Tide				**234**	**497**	**875**	**540**	**239**	**191**	**197**	**107**
Bangor	POTW	18	-3	-	140	177	161	104	96	86	72
Brewer	POTW	5.19	-3.3	-	13	6	13	17	34	20	26
Winterport	POTW	11	-15.6	-	4	2	3	*3*	*3*	*3*	*3*
VERSO	Papermill	18	-20.6	-	87	140	155	*127*	*127*	*127*	*127*
Bucksport	POTW	0.46	-22.2	-	6	7	9	*8*	*8*	*8*	*8*
Totals Down to Bucksport					**748**	**1207**	**880**	**497**	**459**	**441**	**342**

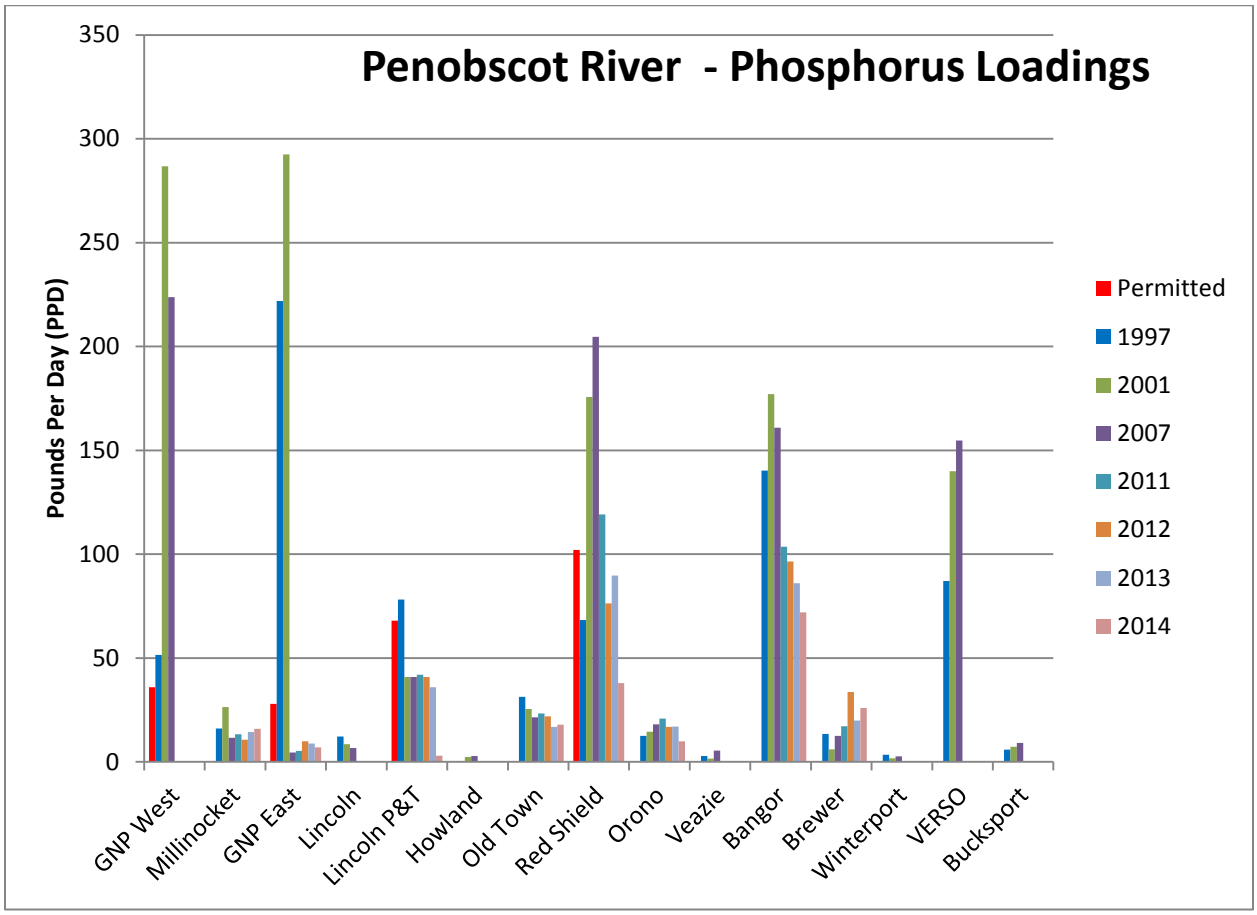
NOTE: Shaded areas are not based on actual data. These data represent facility averages from years when data was collected. It was necessary to fill in these gaps to estimate total loadings to the river.

This table highlights the following:

1. Post P-WLA (2011) loadings to the Penobscot River are substantially less than historic loadings. Freshwater loadings in 2014 are approximately 83% less than historic loadings, and loadings to the entire river are approximately 64% less.

2. The most significant municipal discharges have not fluctuated significantly since the P-WLA was implemented.

These same data are presented in the following chart, which highlights the relative improvement and influence of each discharge from a historical perspective. All of the most significant discharges (historically greater than 50 PPD) have demonstrated significant phosphorus loading reductions since the P-WLA has been implemented.



Conclusions

No DO non-attainment was measured in association with the PRAMP during 2014. All data were well above appropriate classification criteria. There were no measured diurnal DO swings that would suggest excessive nutrient enrichment (i.e., > 2.0 mg/l). The 2014 results provide good reason to be optimistic about continued DO attainment, but continued monitoring is recommended based on the following reasons:

1. The 2014 data were collected during reasonably low flow conditions, but flows were significantly higher than what would be considered a critical 7Q10 condition. The 7Q10 for the Penobscot River is considered to be 3,070 cfs (as measured at the West Enfield Gage), whereas the 2014 water quality data is representative of flows only as low as 5,580 cfs.
2. Nutrient point source loadings were at their lowest levels since the P-WLA was issued primarily since both Millinocket mills were closed and Lincoln Paper and Tissue no longer pulps. Further scrutiny will be warranted should nutrient loadings ramp up.
3. The removal of the Great Works Dam (2012) and the Veazie Dam (2013) in association with the Penobscot River Restoration work has resulted in significant changes to hydraulic conditions in the lower freshwater portion of the river. The changes are expected to result in additional improvements in water quality, but there is no significant data yet that documents the relative impact on water quality.
4. To date, the PRAMP work has not experienced flows at or near 7Q10 conditions. Continued efforts are necessary to better assess lower flow conditions should they occur.

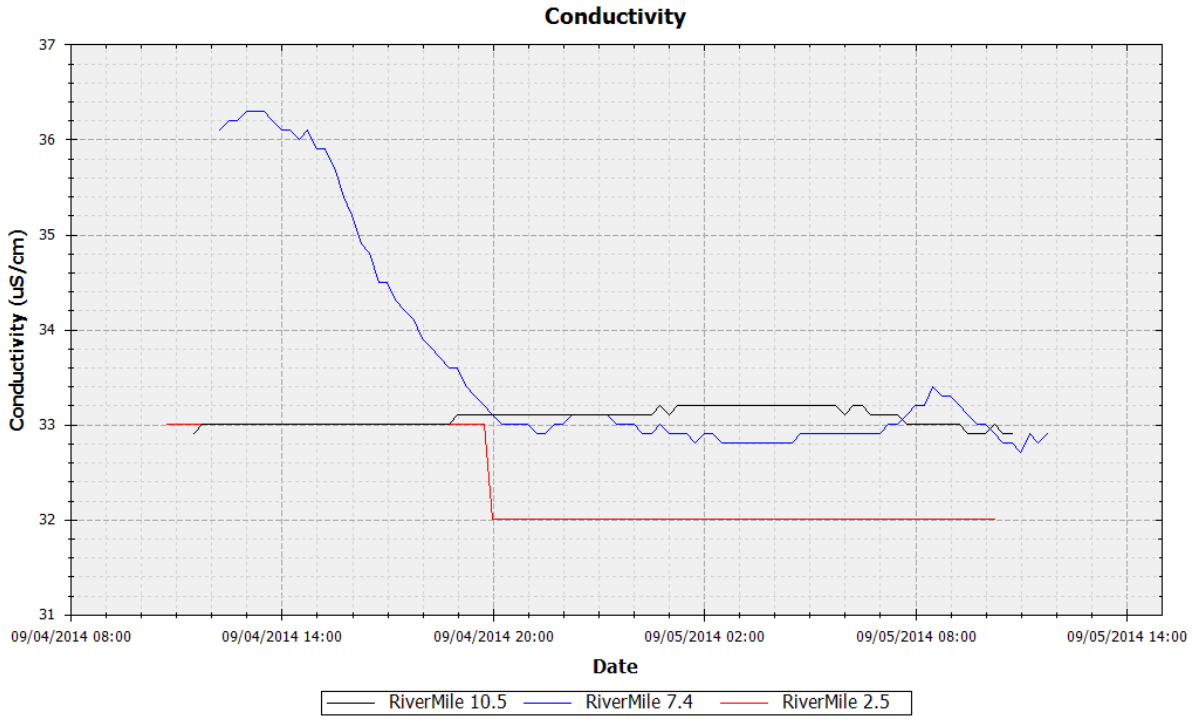
2015 Work Plan

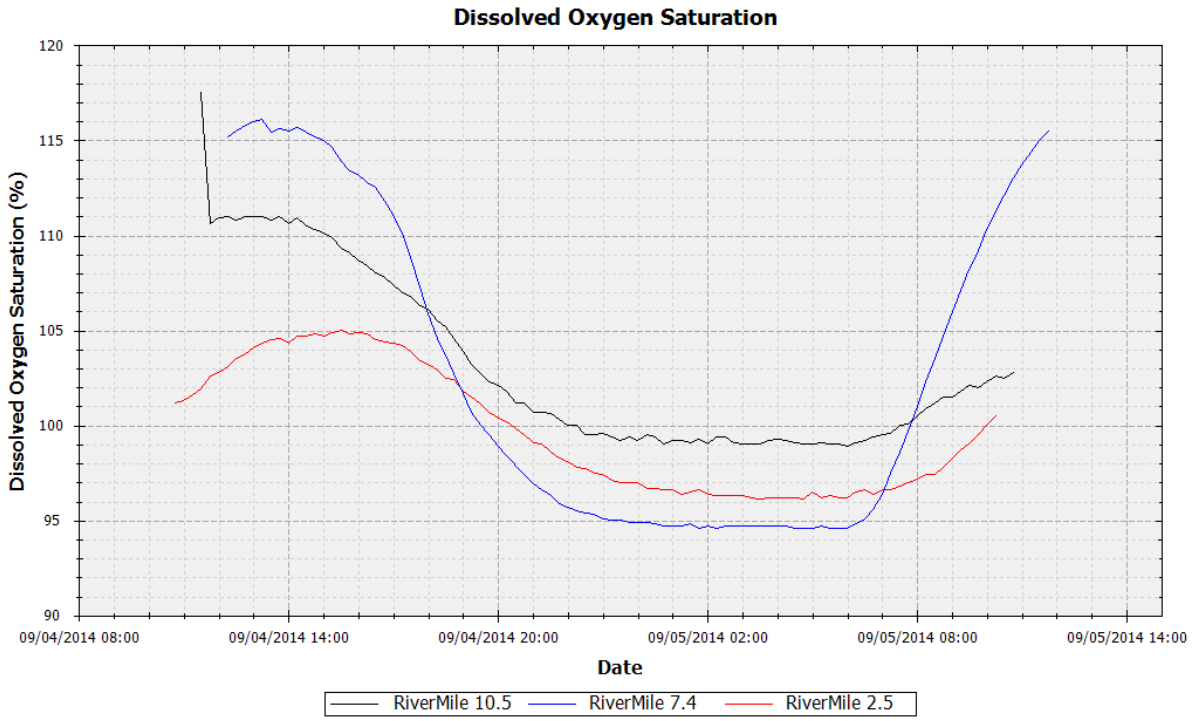
Past PRAMP work provides good insights to prioritize monitoring efforts for the 2015 season. Additionally, the Penobscot River Restoration work provides impetus for future monitoring work. The dam removal efforts are expected to improve downstream water quality, but monitoring is necessary to document the actual influence. The Department will continue with its adaptive management style approach, and intends to move monitoring stations around the river system if unanticipated conditions arise. The anticipated focus for 2015 is detailed as follows;

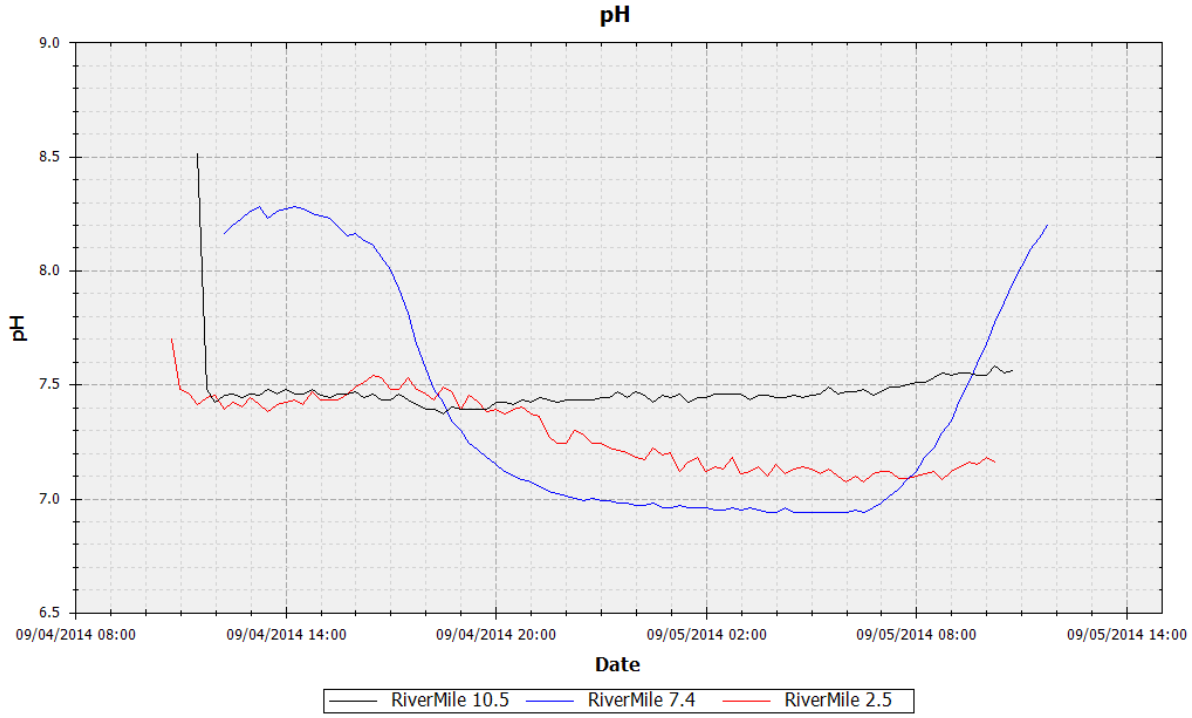
1. The lower freshwater portion of the river is presently experiencing the most significant diurnal DO swings and dam removal efforts are expected to influence this particular dynamic. The Department expects to focus a majority of its efforts on this particular section of river (Old Town to Bangor).
2. The uppermost portion of the river (Millinocket to Old Town) appears to be in pretty good condition, but the Department would like to get at least one more dataset to confirm this. A deployment in Winn (approximate river mile 58) will be planned if river flow conditions are appropriate.
3. The Penobscot Indian Nation (PIN) is still focusing monitoring in Dolby Pond. The Department expects to leverage PIN's monitoring efforts to inform potential future deployments. Future upstream deployments may

consist of only one sonde (i.e., not paired sondes) such that the Departments limited resources can be better utilized in the lower portion of the river.

Supplemental Water Quality Data - (Graphical Representation)



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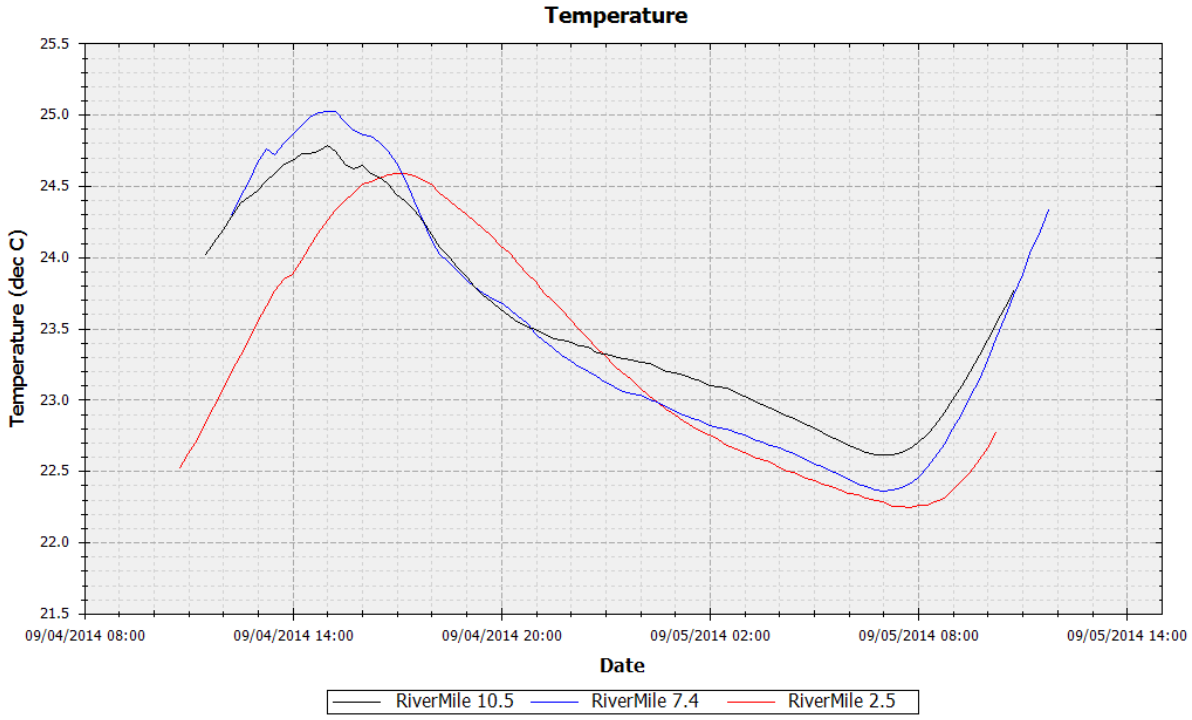
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