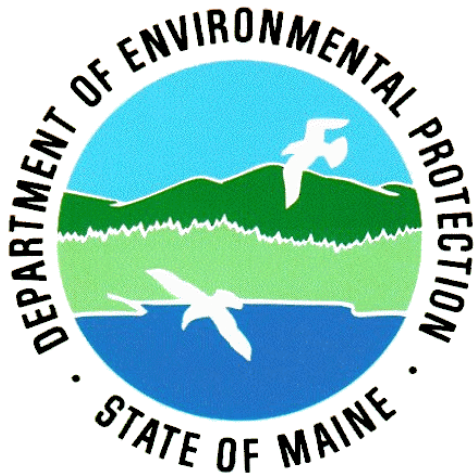


**Penobscot River
Phosphorus Waste Load Allocation
Ambient Monitoring Plan Report - 2011**

May 2012



Prepared by Robert Mohlar, P.E.
Bureau of Land and Water
Division of Environmental Assessment

Goals / Methodology

The primary goal of the PRAMP is to measure the effectiveness of the P-WLA in eliminating eutrophication driven 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 a signal produced by algae (and other living plants) that results 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.

Water quality sondes can be used to measure the relative algae driven influence along a particular reach of river by placing one just above and just below the particular reach of river 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 reaeration). This diurnal influence is most directly tied to nutrient enrichment.

Project Summary for 2011

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 dischargers on the Penobscot River. The purpose of the P-WLA was to eliminate Dissolved Oxygen (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 large diurnal DO swings.

This past summer (2011) was the first year that ambient monitoring was carried out under the PRAMP, as the majority of MEPDES permit renewals were finalized in May of 2011. Once the revised permits were finalized, the Department purchased 4 multi-probe water quality sondes to dedicate to this ambient monitoring effort. The equipment selected for this effort consists of the following;

4 Eureka Environmental – Sub2 Manta2 Multiprobes equipped with;

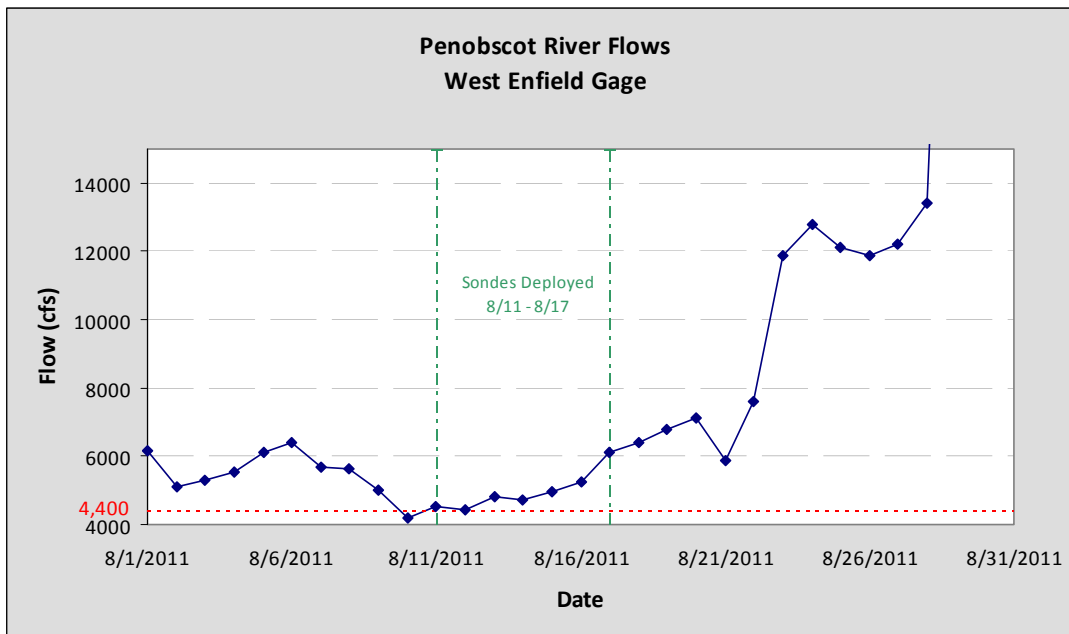
- **Optical Dissolved Oxygen Sensor** – primary parameter of interest with regard to non-attainment.

- **Temperature Sensor** – Temperature data is necessary to calculate DO % saturation. Temperature data also helps to decipher potential climatic influences on water quality.
- **Conductivity Sensor** – Conductivity data is helpful in assessing the relative level of impact from pollutant sources (point and non-point).
- **pH Sensor** – pH data can be useful in discerning relative influences from and changes in water chemistry.
- **Depth Sensor** – Depth information is helpful when collecting profile data, and also helps to assess changes in river flow (stage) for remote deployments.

1 Handheld Communication Device to be used with all 4 multiprobes



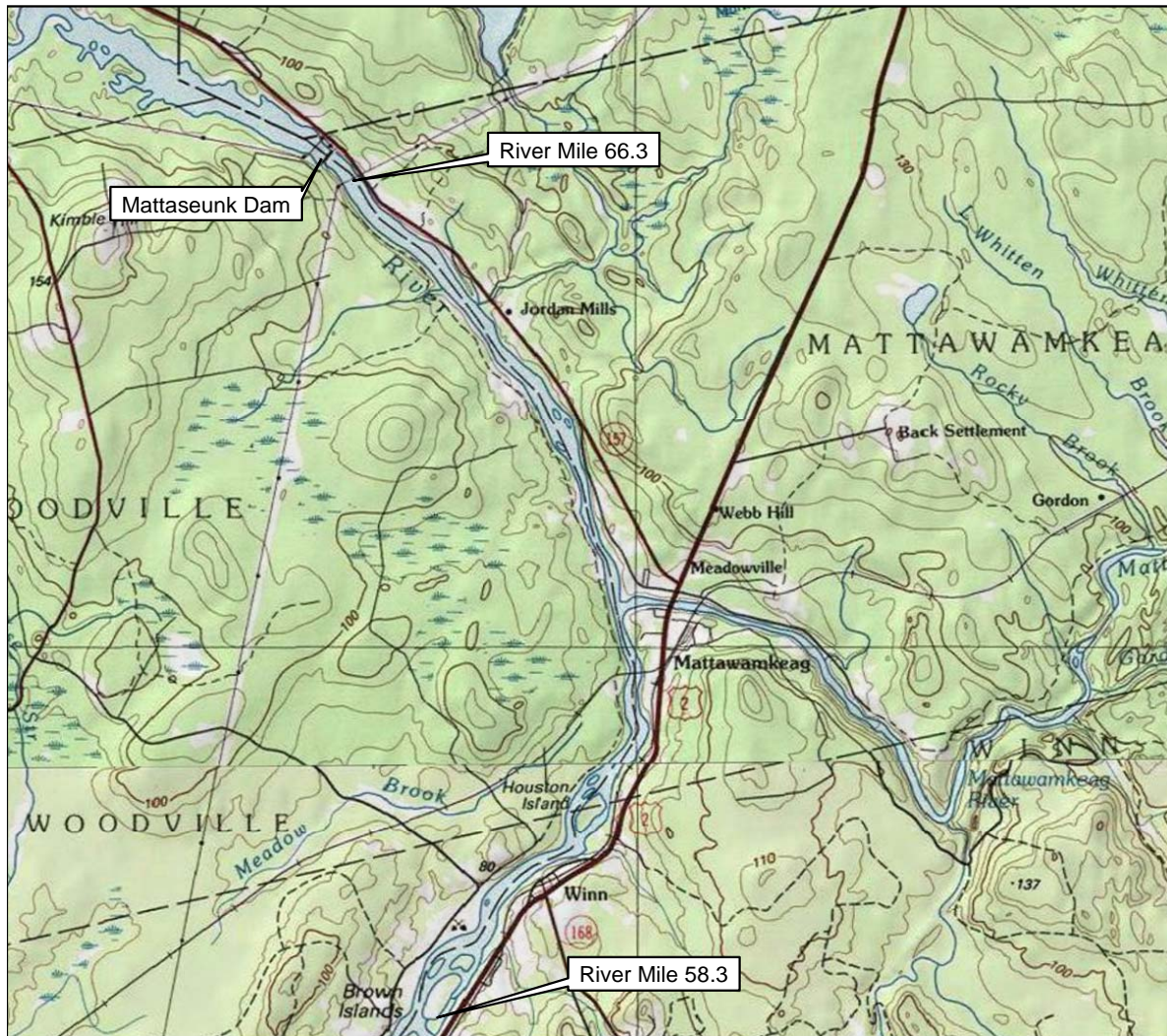
The Department was not able to procure the new monitoring equipment until early August. River flows were reasonably low for a brief period in early August, before wet weather (including Hurricane Irene) arrived in late August. Consequently, there was a relatively small window of time to collect meaningful data during relatively low flow conditions. DEP has generally used a target flow of 4,400 cfs (as measured at the West Enfield gage) as representative of low flow conditions for the Penobscot River. The Department managed to conduct only one such sonde deployment during 2011, as represented on the following chart.



Results

2011 was the first year of a multi-year monitoring effort. The primary goal during this first year of monitoring was to assess the general effectiveness of phosphorus waste load reductions and to identify potential areas of concern with regard to DO non-attainment. Due to the limited sampling window detailed earlier in this report, only two specific reaches of river were monitored during 2011. Each reach addressed priority concerns and provided valuable insights to further prioritize sampling for the 2012 sampling season. Specific details are provided as follows;

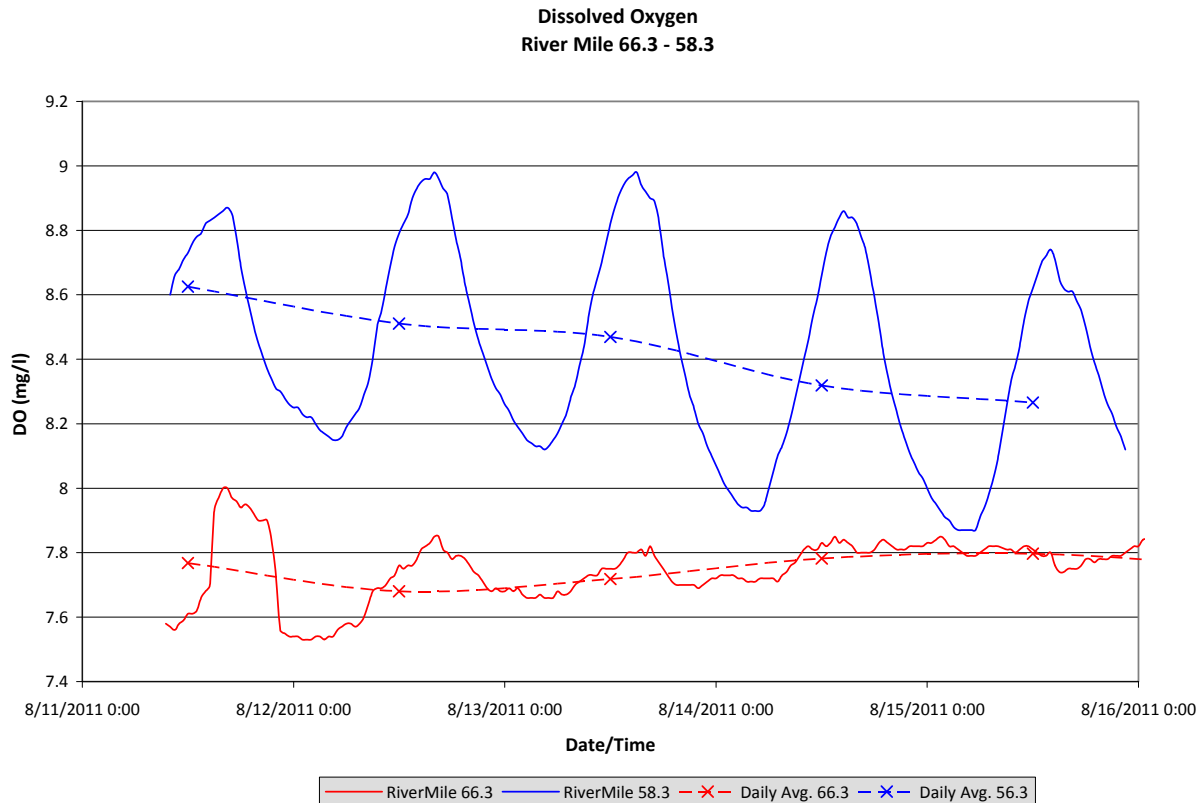
REACH 1 - Below Mattaceunk Dam (River Mile 66.3 to River Mile 58.3)



This eight mile reach of river has historically exhibited some of the largest diurnal DO swings experienced during past surveys of the river. The upper section of this reach is Class C whereas the lower section (below the Mattawamkeag River) is Class B. The 20 mile reach of river immediately upstream of this reach is all Class C and is characterized by two paper mill discharges, two municipal POTW discharge and a series of three dams. Past DO non-attainment in this upper portion of the river has primarily been confined to the Class B portion of this particular reach. The Department suspects that past DO non-attainment has been driven

by excessive phosphorus loadings from the upstream discharges. New phosphorus discharge limits instituted in the spring of 2011 are expected to bring this reach into attainment for DO.

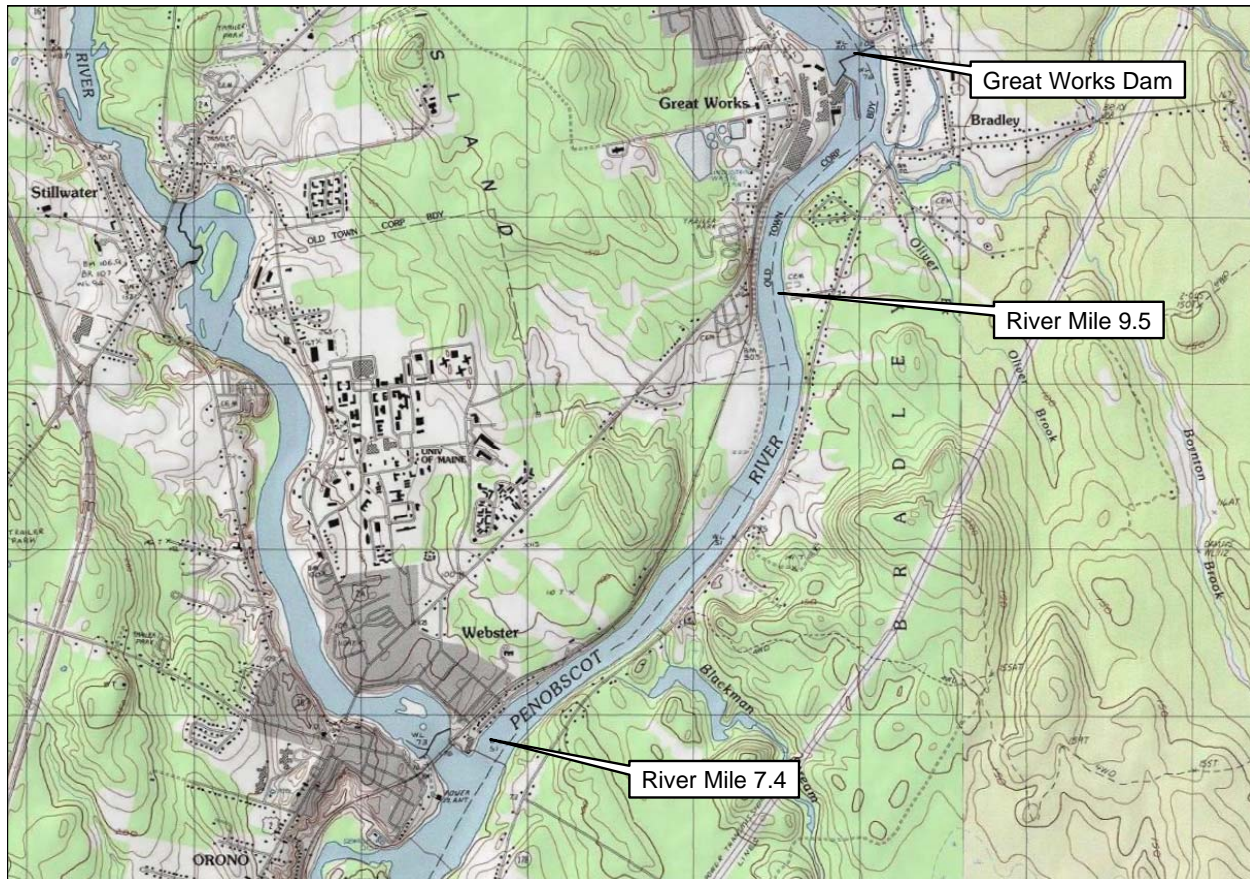
The 2011 DO data for this reach of river are summarized in the following figure.



This data highlights the following;

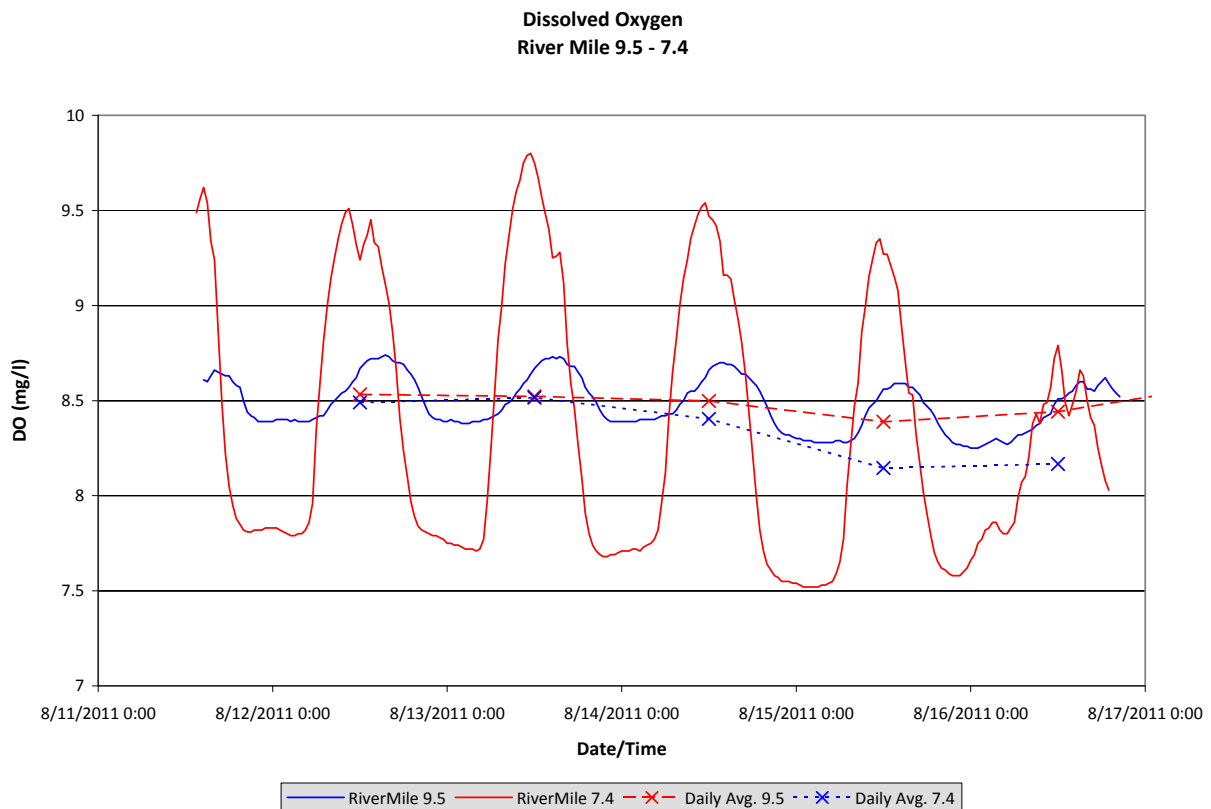
- It appears this reach of river was in attainment for DO during 2011. These data are representative of some of the lowest flows experienced in 2011 and all data are well above associated classification criteria of; 5 mg/l at River Mile 66.3 and 7 mg/l at River Mile 58.3.
- Associated diurnal influences corroborate the assumption that the primary driver of diurnal DO swings is attributable to periphyton. The swings are significantly greater at the downstream location, which is subjected to much longer periphyton contact times.
- The average diurnal DO swing for the downstream location is approximately 0.8 mg/l, which is significantly less than values measured previously in 2001 and 2007 (1.4 mg/l and 2.0 mg/l respectively) at comparably low flows. This suggests that phosphorus loading reductions are effective.
- There is a net increase in DO of approximately 0.5 to 0.8 mg/l from upstream to downstream, which is best demonstrated by comparing the relative daily average values. This is an appreciable recovery for this stretch of river, and is what would be expected for a free flowing reach of this nature as a result of atmospheric reaeration.
- Specific conductivity, pH, temperature and depth data were also collected in conjunction with this DO data. These data will be made available electronically upon request.

REACH 2 - Below Great Works Dam (River Mile 9.5 to River Mile 7.4)



This 3.1 mile stretch of river below Great Works Dam has also historically exhibited some of the largest diurnal DO swings experienced during past surveys of the river. The entire reach is Class B. The 4 mile reach of river immediately upstream of this reach is also Class B and is characterized by one paper mill discharge, one municipal POTW discharge and a series of two dams. Past DO non-attainment in this lower portion of the river has primarily been in this general vicinity. The Department suspects that past DO non-attainment has been driven by excessive nutrient loadings from the upstream discharges. New phosphorus discharge limits instituted in the spring of 2011 are expected to bring this reach into attainment for DO.

The 2011 DO data for this reach of river are summarized in the following figure.



These data highlight the following;

- It appears this reach of river was in attainment for DO during 2011. These data are representative of some of the lowest flows experienced in 2011 and all data are well above the associated classification criteria of 7 mg/l.
- Associated diurnal influences corroborate the assumption that the primary driver of diurnal DO swings is attributable to periphyton. The swings are significantly greater at the downstream location, which is subjected to significantly longer periphyton contact times.
- The average diurnal DO swing for the downstream location ranges between 1.7 and 2.1 mg/l, which is as high as any values measured in prior surveys. This suggests the need for continued monitoring in this particular section of the river. Of note in this regard is that the papermill immediately upstream of this reach has not yet fully implemented final phosphorus loading reductions.
- There is very little net gain or loss of DO occurring in this particular reach of river, which is not too surprising considering that the daily average values are at or near saturation.
- Specific conductivity, pH, temperature and depth data were also collected in conjunction with this DO data. These data will be made available electronically upon request.

Conclusions

No DO non-attainment was measured in association with the PRAMP during 2011. All data were well above appropriate classification criteria. The 2011 results provide good reason to be

optimistic about continued DO attainment, but continued monitoring is recommended based on the following reasons:

1. The 2011 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 2011 water quality data is representative of flows in the 4,400 – 5,200 cfs range. Flows in this range are comparable to flows where past DO non-attainment had been measured.
2. Water quality data from the upper portion of the river look particularly good, but the two Katahdin Mills were discharging at significantly reduced rates. Further scrutiny will be warranted as these mills continue to ramp up operations. The Penobscot Indian Nation (PIN) is continuing regular monitoring of the upstream Dolby Impoundment, which will help the Department to target further monitoring efforts in this reach of river.
3. Water quality data from the lower portion of the river are concerning due to the significant diurnal DO range exhibited at river mile 7.4.

2012 Work Plan

The 2011 provide good insights to prioritize monitoring efforts for the 2012 season. Additionally, the Penobscot River Restoration efforts will result in the removal of Great Works Dam during 2012 and Veazie Dam at a future date. These dam removal efforts are expected to improve downstream water quality, and will be a particular focus of continued PRAMP efforts. The Department will continue with its adaptive management style approach, and intends to move monitoring stations about the river if unanticipated conditions arise. The anticipated focus for 2012 is detailed as follows;

1. The upstream portion of the river appears to be in pretty good condition, but the Department intends to conduct at least at least one sonde deployment to investigate the particular response below the Lincoln Paper & Tissue discharge at river mile 49.3. The 2011 upper river section data were not reflective of influences associated with this particular discharge.
2. The lower portion of the river is still experiencing significant diurnal DO swings and the Department expects to focus a majority of its efforts on this particular section of river (river mile 12 to river mile 0). This particular reach of river will also be the most heavily influenced by dam removal efforts and it will be important to collect data that can help to show the effect that the dam removal has on water quality.