Penobscot River 2007 Data Report
July 2008

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DEPLW-0882

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Introduction

The Penobscot River Basin is the largest river basin lying entirely within the state of Maine. It has a drainage area of 8592 square miles at its mouth. The river segment of interest on the Penobscot River begins in Millinocket below Ferguson Lake as the West Branch, where after 10 miles it joins with the East Branch. It then flows an additional 72 miles before reaching head of tide at the Veazie Dam, 12.5 miles to Reed Brook in Hampden where the classification changes to the marine class SC, and then over 14 additional miles of tidal waters to Bucksport. In this 103 mile segment, there are 15 point source discharges, 12 dams, 11 of which are retrofitted for hydropower, and 9 tributaries that have a drainage area of over 100 square miles.

In the summer of 2007, the DEP and various stakeholders conducted a basin wide sampling effort on the 103 miles of river from Millinocket to Bucksport, which is a follow up to a similar data collection effort in 1997 and 2001. In the spring of 2007, the DEP met with many interested stakeholders in the river basin who participated in both the planning and actual field sampling, similar to 1997 and 2001. Participants in the study included representatives from Maine DEP, Penobscot Nation, USEPA, Kathadin Paper Co, Verso Paper Co, Lincoln Sanitary District, Bangor WWTF, Lincoln Paper & Tissue, Millinocket WWTP and Red Shield of Old Town.

The purpose of the 2007 sampling effort was to collect a third data set, which in conjunction with the 1997 and 2001 data will be used for calibration and verification of a water quality model.

Suitable low river flows (less than 4400 cfs) were present during August of 2007, ideal conditions for the collection of excellent quality data.

Technical Design of Study

The technical design of this study is explained in detail in the Penobscot River Basin Work Plan (Maine DEP, June 2007). Some of the highlights are repeated here for convenience. The sampling that was undertaken involved one three-day intensive survey. The sampling was tentatively targeted for three weeks of the summer of 2007 (July 31, August 1, and 2; August 7, 8, and 9; or August 21, 22, and 23) and was dependant upon achievement of a satisfactory low flow condition. The sampling occurred from July 31 and August 1st to 2nd, when low flow was less than 4400 cfs.

Dissolved Oxygen (DO) and temperature (all locations), and salinity (tidal locations only) were sampled twice daily at thirty main stem locations (Table 1), and eleven tributary locations (Table 2). In addition, samples were collected for nutrient analysis (NH3-N, TKN, NO2+NO3-N, TP, and PO4-P); chlorophyll a, and ultimate BOD (all) and Secchi disk transparency (where possible) at eighteen main stem locations (Table 1) and eleven tributary locations (Table 2). Composite samples were collected for fifteen point sources inputs (Table 3) for nutrient, ultimate BOD, and BOD5 analysis.

The data collection effort also resulted in the placement of continuous recording equipment for DO and temperature by the Environmental Protection Agency (EPA) and the Penobscot Nation. In addition, core samples were collected for sediment oxygen demand analysis at twelve locations by the EPA later in the summer, separate from the three day event.

Table 1 **Penobscot River Sampling Locations**	**Table 2** **Tributary Sampling Locations**

Station Code	Station Location	Chemical Parameters
West Branch Penobscot		
WBP1	Ferguson Lake Outlet	All
WBP2	Dolby Pond Inlet	All
WBP3	Above Dolby Dam	All
WBP4	Above Mill Dam 2	DO / Temp
WBP5	Above Rockabema Dam	All
Main Stem Penobscot		
Pn1	Above Weldon Dam	All
Pn2	Winn	DO / Temp
Pn3	North Lincoln	All
Pn4	South Lincoln	All
Pn5	Above West Enfield Dam	All
Pn6	Passadumkeag	DO / Temp
Pn7	Greenbush	DO / Temp
Pn8	Costigan	DO / Temp
Pn9	Milford Dam	All
Pn10	Great Works Dam	DO / Temp
Pn11	Orono near Water Co.	DO / Temp
Pn12	Above Veazie Dam	All
Pn13	Above Bangor Dam	All
DupR	River Duplicate	All
Tidal		
PnE1	Bangor Rte 9 / 1a Bridge	DO/Temp/Sal
PnE2	South Brewer	All
PnE3	North Orrington (ledges)	DO/Temp/Sal
PnE4	Orrington (near PERC)	DO/Temp/Sal
PnE5	Orrington Center	All
PnE6	Bald Hill Cove	DO/Temp/Sal
PnE7	South Orrington	All
PnE8	North Bucksport	DO/Temp/Sal
PnE9	Winterport	All
PnE10	Confluence Marsh Stream	DO/Temp/Sal
PnE11	Harriman Cove	DO/Temp/Sal
PnE12	Fort Knox	All
DupE	Estuary Duplicate	All

Station Code	Station Location	Chemical Parameters
MiS	Millinocket Stream	All
EBPn	East Branch Penobscot	All
MaR	Matawamkeag River	All
PiR	Piscataquis River	All
StR	Stillwater River	All
DupT	Tributary Duplicate	All
PaR	Passadumkeag River	All param. day 2, only
PuS	Pushaw Stream	
KeS	Kenduskeag Stream	DO / Temp all 3 days
SoS	Soudabascook Stream	
MaS	Marsh Stream	

Table 3
Effluent Sampling Locations

Station Code	Station Location	No. Days Sampled
KATW	Kathadin Paper West	3
Mill	Millinocket	3
KATE	Kathadin Paper West	3
Lpp	Lincoln Paper & Tissue	3
Linc	Lincoln S.D.	1
Howl	Howland	1
OldT	Old Town	3
REDS	Red Shield	3
Orono	Orono	3
Veaz	Veazie	1
Bang	Bangor	3
Brew	Brewer	3
Wint	Winterport	1
Buck	Bucksport	1
VER	Verso Bucksport	3

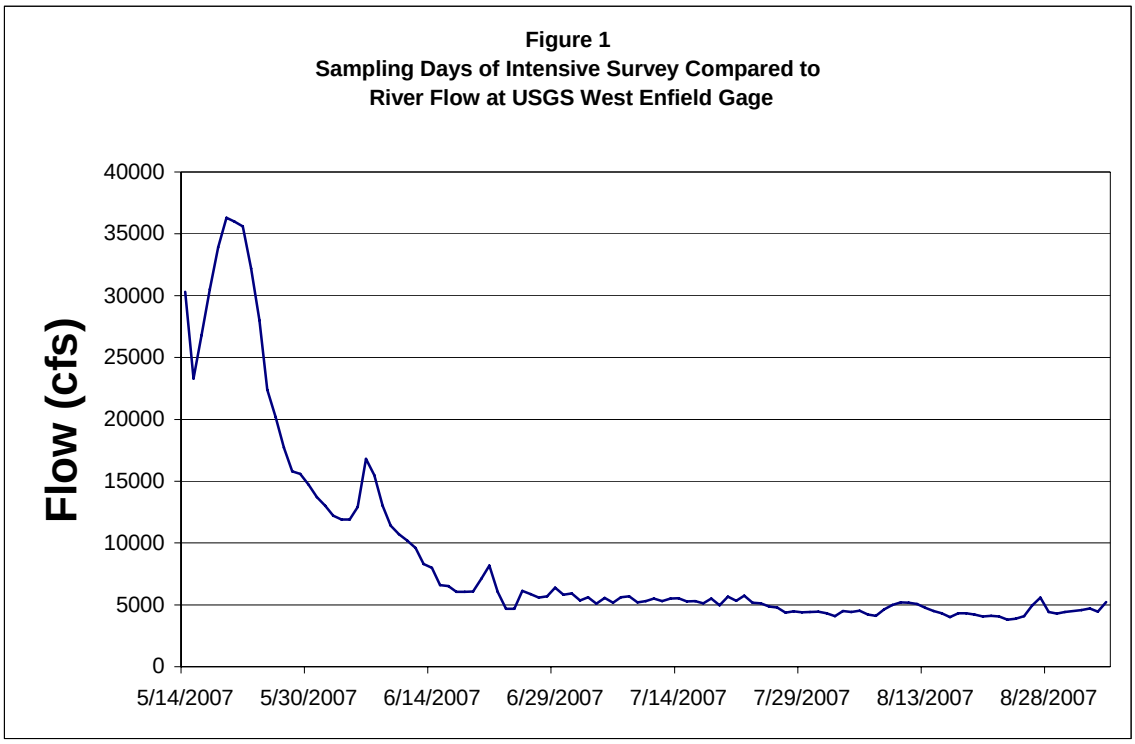
Note: Effluents were collected as composite samples and analyzed for BOD5, ultimate BOD, TP, PO4-P, TKN, NH3-N, and NO2+ NO3-N.

Hydrologic Data

River flow data are available at a number of locations on the Penobscot River and some limited tributaries. There is a USGS gage at West Enfield. Flow estimates are available from Katahdin Paper Co. on the West Branch at Dolby dam, the East Branch of the Penobscot, and Weldon dam; and flow estimates from Bangor Hydro Co. at Milford and the Stillwater Branch. There are also tributary gaging data from USGS on the Piscataquis River at Dover Foxcroft and Medford and the Mattawamkeag River at Mattawamkeag.

Trigger flows were established utilizing the USGS gage in West Enfield to determine whether or not flow was sufficiently low enough to make the sampling effort worthwhile. For the three-day survey 90% flow duration (4400 cfs) was set as the upper trigger flow. The three day average flow of 4290 at West Enfield when sampling was undertaken is lower than the upper target flow (Figure 1) indicating acceptable low flow conditions occurred.

Figure 1
Sampling Days of Intensive Survey Compared to
River Flow at USGS West Enfield Gage



Ambient Chemical Data

The chemical data collected for the three day intensive survey were DO (DO), temperature, salinity in tidal waters, total phosphorus (TP), orthophosphorus (PO4-P), total kjeldhal nitrogen (TKN), ammonia nitrogen (NH3-N), nitrite plus nitrate nitrogen (NO2+NO3-N), chlorophyll a (chl a), and ultimate BOD (TBODu). All of these parameters were measured in the early morning before 10:00 am and, in addition, mid afternoon readings of DO, temperature, and salinity were made to capture diurnal effects. Secchi disk transparency measurements were made on one day of the three day surveys.

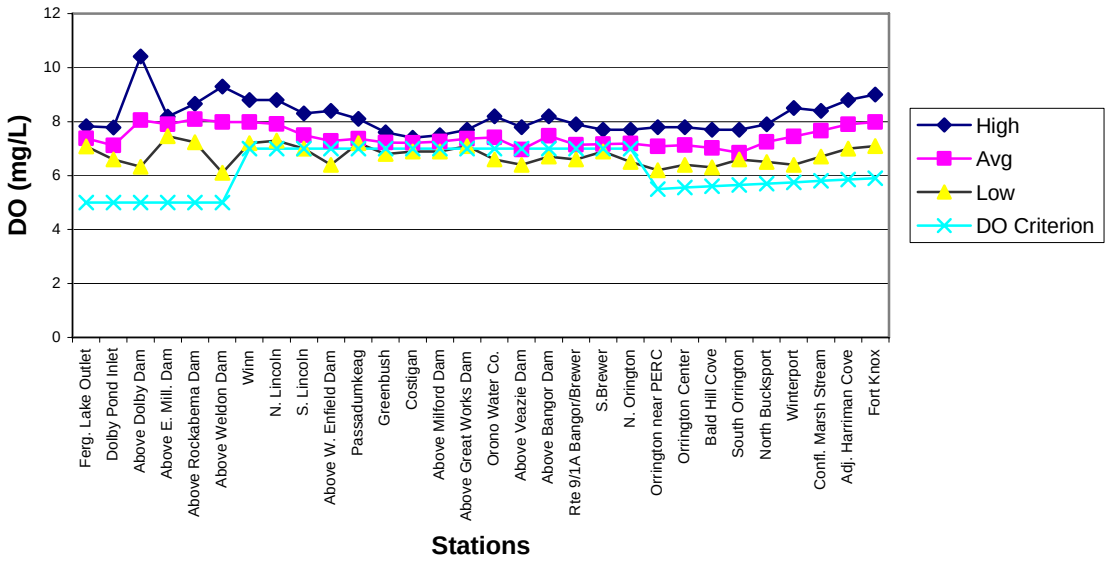
To improve the accuracy of the Water Quality Model it is desirable to sample the river under steady state conditions of flow and water chemistry. Not only is it easier to interpret the data under steady conditions, but is also essential for application of the water quality model, which assumes steady state. The flow, water chemistry and effluent data were very constant from day to day and the quality is therefore considered good for application with the model.

DO, Temperature, and Salinity

DO and temperature were measured with YSI portable meters. The meters were calibrated in the early morning and checked frequently during sampling. In addition, the meters were cross checked with other meters from adjacent sampling teams both prior to and after sampling.

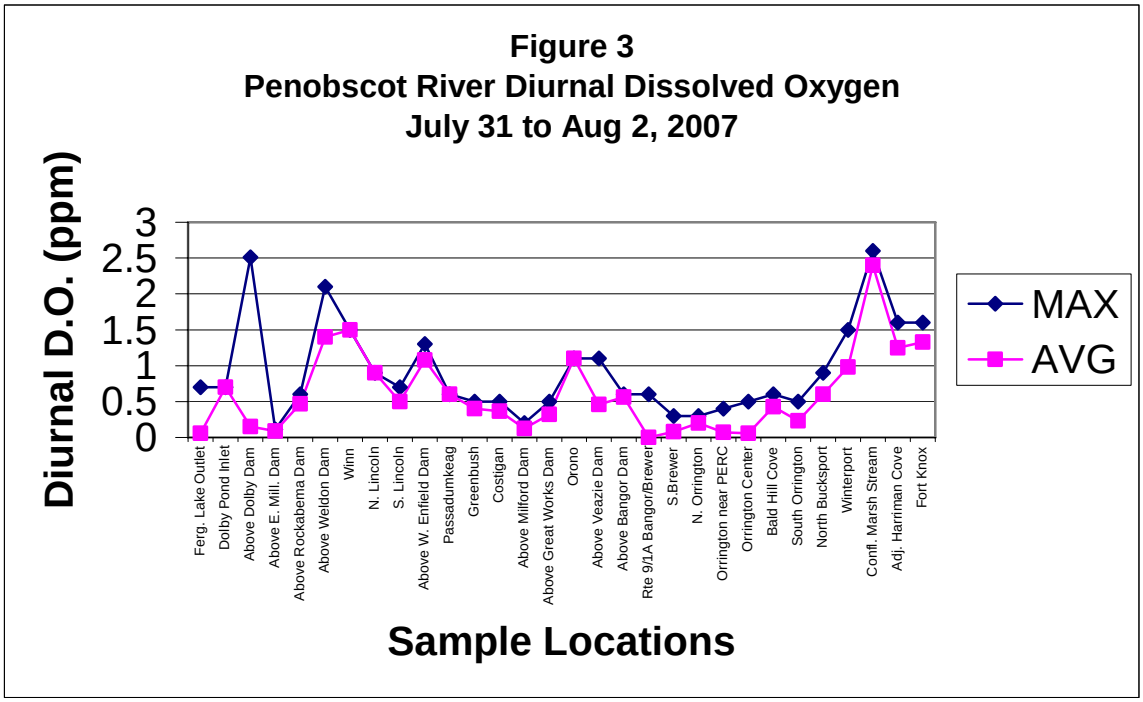
The DO readings on the Penobscot River from July 31st to August 2nd did not meet DO criteria at a number of locations (Figure 2). Class C minimum DO criteria of 5 ppm and 60% of saturation were met at all 6 sampling locations that are classified C (five locations on West Branch, and one above Weldon impoundment). However on class B segments, where there are fifteen sampling locations, only five locations (Winn, N. Lincoln, S. Lincoln, Passadumkeag and above Great Works dam) met minimum class B criteria of 7 ppm and 75% of saturation. DO readings of sampling locations which didn't meet class B minimum criteria, ranged from 6.4 to 6.9 ppm. In the estuary, a minimum class SC D O criterion of 75% of saturation was met at all nine sampling locations.

Figure 2
Dissolved Oxygen Data Compared to Minimum Criteria
July 31 to August 2, 2007



Diurnal DO is the range of DO measured at a specific sampling location over a given day. Large diurnal DO fluctuations indicate the presence of algal activity and a productive system. One disadvantage of a productive system is low early morning DO, which typically occurs after an extended period of nighttime plant respiration. The daily minimum DO usually occurs in the

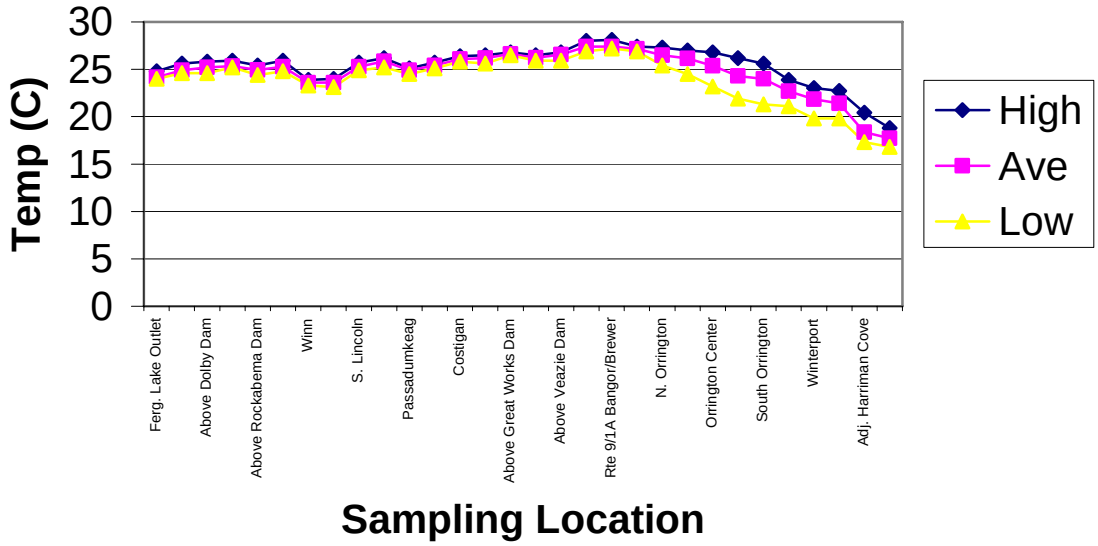
early morning before sunrise and daily maximum DO occurs in mid to late afternoon. The differences between early morning and mid afternoon DO readings in any given day are used to estimate the diurnal DO range at various sampling locations (Figure 3).



The average diurnal DO fluctuation between early morning and midday is 2 ppm at some sampling locations (above Dolby dam, above Weldon dam and the confluence of Marsh Stream) and 0.5 ppm at other locations.

Water temperatures on the Penobscot in 2007 during the sampling period were high compared to most summers. The data were collected during an extended heat wave in which air temperatures typically exceeded 32^{o}C during the afternoon sampling run. Penobscot River temperature generally was lowest at the upstream boundary or most inland station (Ferguson Lake outlet) and increased in the downstream direction reaching the maximum temperature in the Bangor area. The three-day average temperature for all riverine sampling locations varied from a low of 24^{o}C at Ferguson Lake outlet to a high of 27.4^{o}C at Bangor (Figure 4).

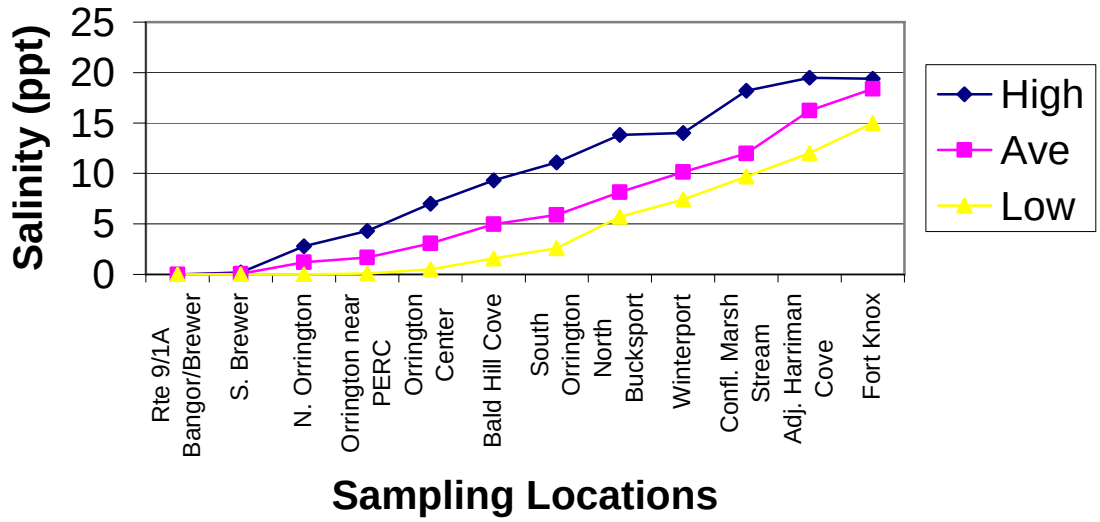
Figure 4
Penobscot River Temperature
July 31 to Aug 2, 2007



In the estuary, temperatures were highest at the most landward stations in the Bangor area and decreased in the seaward direction reaching the minimum at the downstream boundary station at Fort Knox. Temperatures were also lower at high tide conditions when compared to low tide conditions. Both of these effects are due to the influence of the cooler ocean water. The three-day average temperature for all estuarine sampling locations varied from a high of 26.9 ^{o}C in Bangor to a low of 17.7 ^{o}C at Fort Knox.

There is usually negligible salinity from Bangor to South Brewer. The first measurable salinity is observed at the North Orrington site. The average salinity observed were 1.69 parts per thousand at the Orrington site near PERC, 4.98 ppt at Bald Hill Cove, 10.14 ppt at Winterport, and 18.39 ppt at Fort Knox (Figure 5).

Figure 5
Penobscot Estuary Salinity
July 31 to Aug 2, 2007



Ultimate BOD

The ultimate biochemical oxygen demand (BODu) procedure follows the overall BOD5 test of standard methods with some modifications. The tests are run for at least 60 days until there is no more significant depletion of DO. Ambient samples are run without reagents. When samples readings for DO approach 2 ppm, the samples are reaerated. A minimum of 10 to 12 readings of DO was taken over the duration of the tests.

The final result estimates the ultimate or final BOD (BODu) as well as a partitioning of carbonaceous and nitrogenous portions. The BODu is estimated from a plot of BOD (DO consumed) vs. time and is typically determined at the “leveling off" of the curve or where no additional oxygen is consumed over time. This value is not necessarily the last BOD reading of the test and is typically estimated with a model. A two stage model accounting for both the carbonaceous and nitrogenous fractions was employed to estimate CBODu.

If the final nitrate reading (taken after commencement of test) is larger than the initial nitrate reading, it can be deduced that ammonia nitrogen has oxidized to nitrate nitrogen, consuming oxygen in the process as nitrogenous BOD (NBOD). An estimation of NBODu is made by the difference of initial and final nitrate readings times 4.33, the stoichiometric coefficient of nitrogen, i.e. amount of oxygen consumed per unit nitrogen converted.

A plot of the BODu vs river mile (Figure 6 a,b,c) reveals that more than 80% the BODu is carbonaceous. Average NBODu levels were always less than 1.2 ppm and CBODu levels ranged from 3 to 6 ppm. The observed BODu of the Penobscot River are typical values seen on rivers with low levels of pollution.

Figure 6a
Penobscot River Ultimate BOD
July 31, 2007

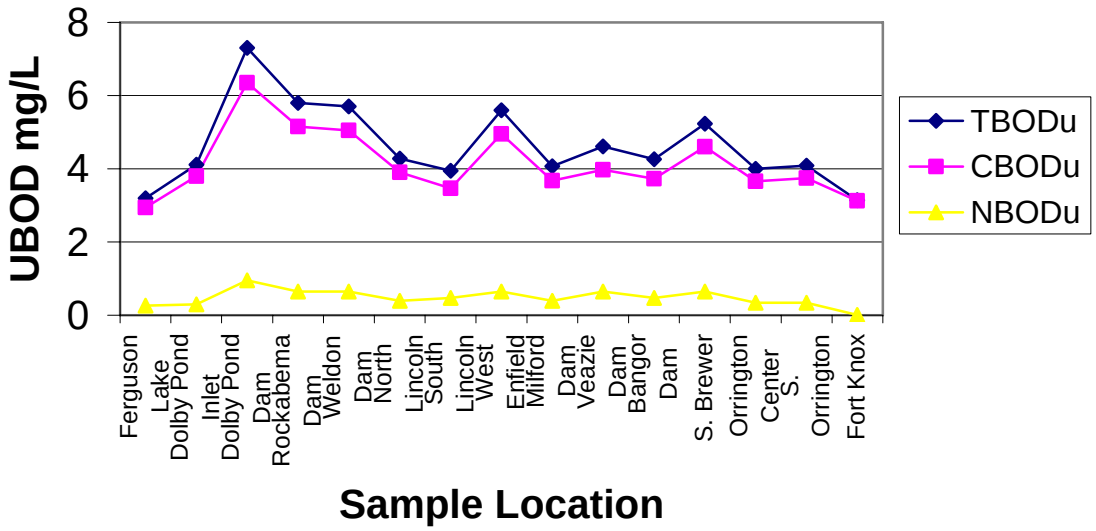


Figure 6b
Penobscot River Ultimate BOD
Auguust 1, 2007

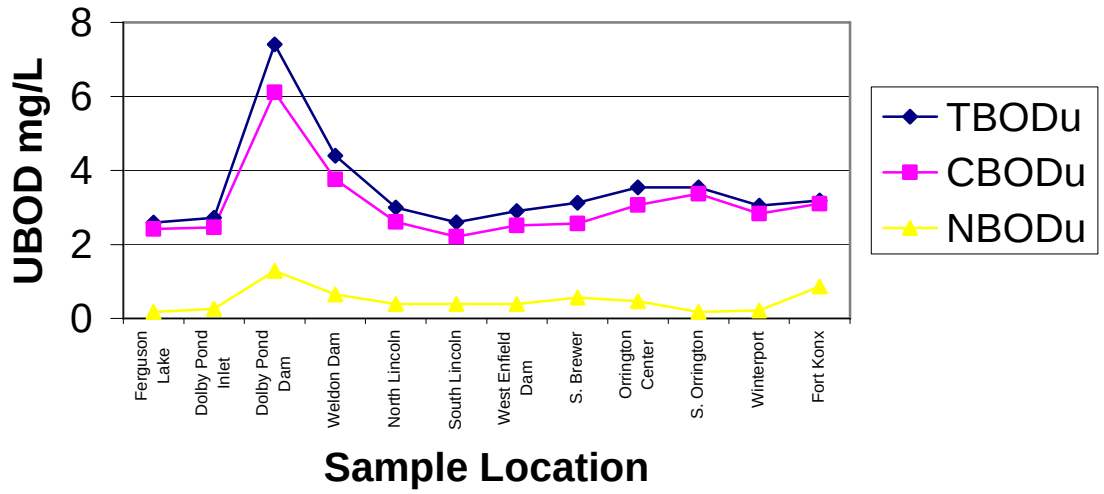
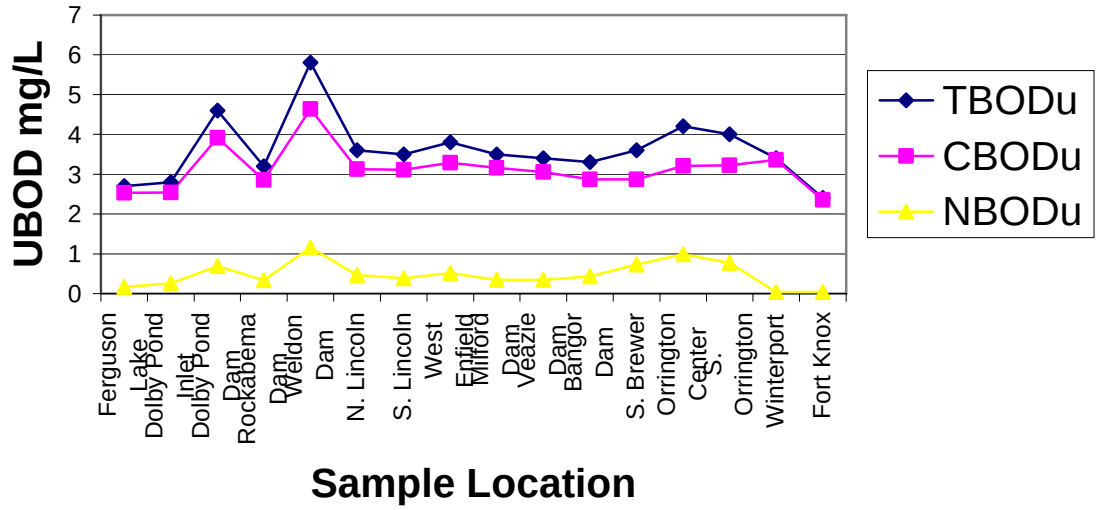


Figure 6c
Penobscot River Ultimate BOD
August 2, 2007



Phosphorus Series

Average total phosphorus observed below point source discharges was usually in between 20 and 30 ppb on the riverine sample stations with the exception of the sampling locations South Orrington and Fort Knox (Figure 7a,b,c). TP ranges of 20 to 30 ppb are indicative of nutrient enrichment, and 70 ppb a high level of nutrient enrichment. Orthophosphorus (OPO4-P) was usually less than 10 ppb at riverine locations.

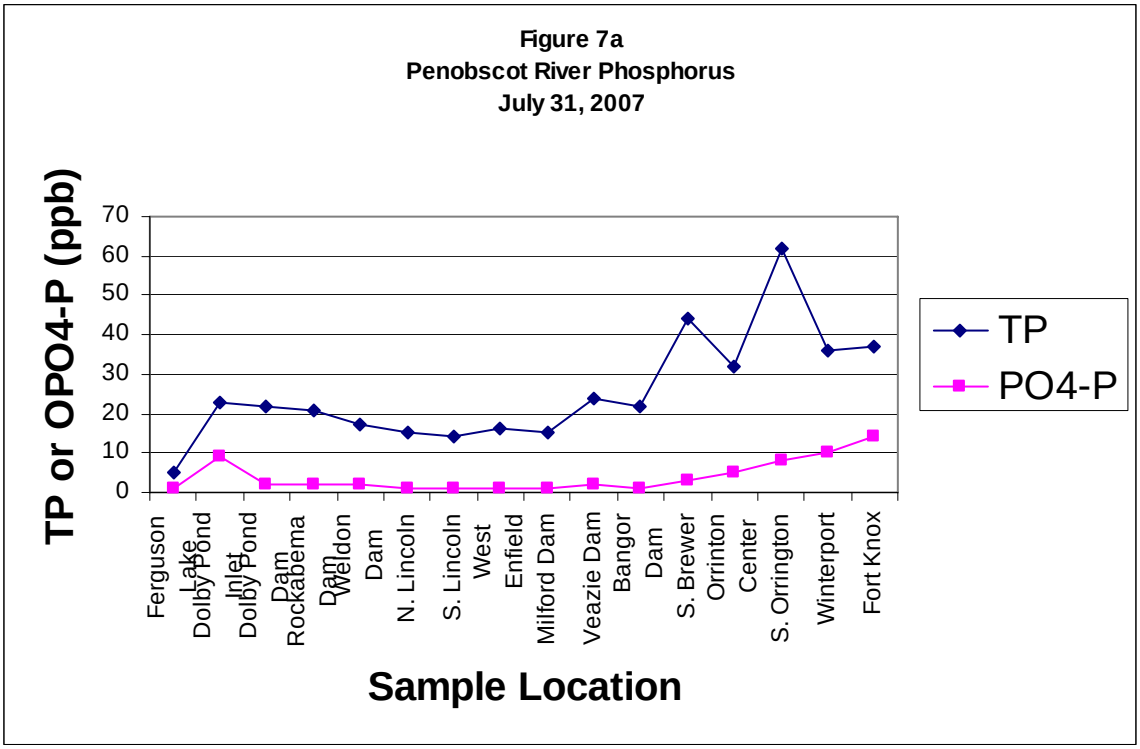
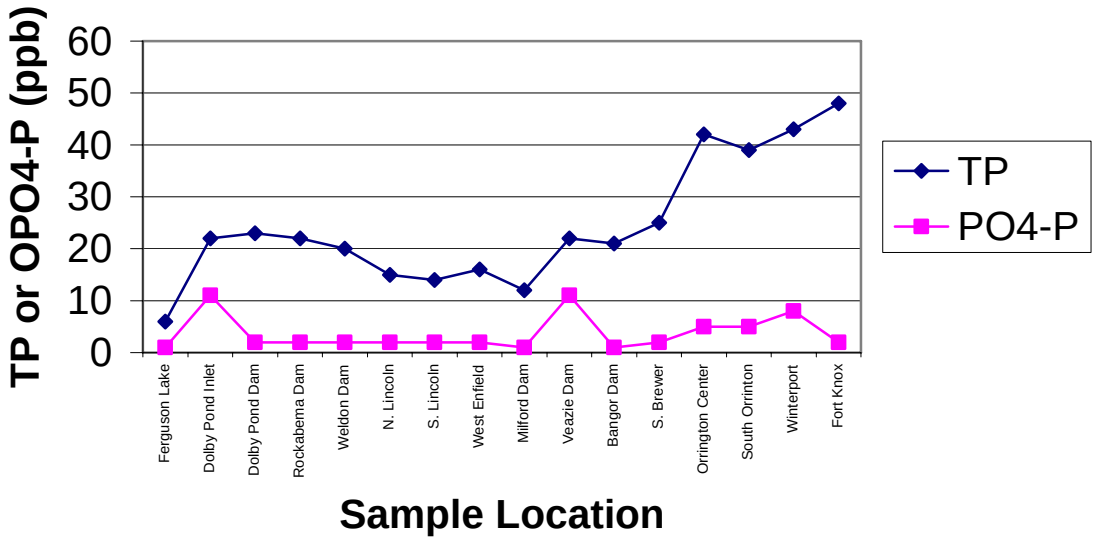
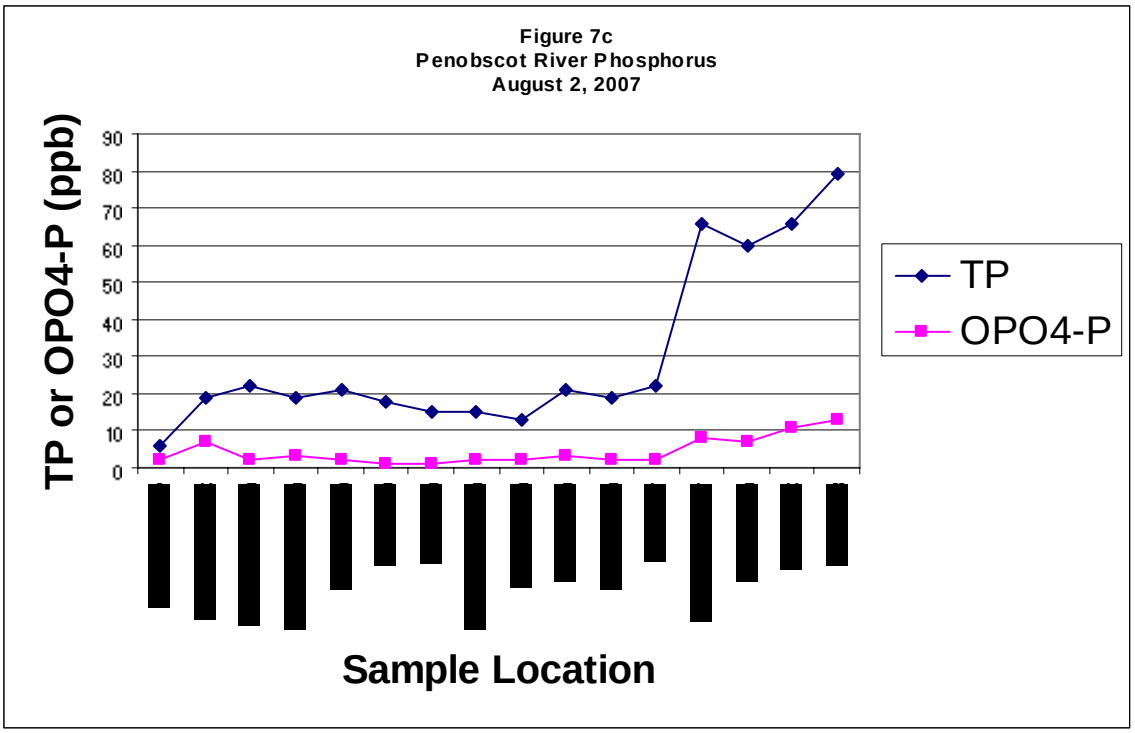


Figure 7b
Penobscot River Phosphorus
August 1, 2007





Nitrogen Series

Average TKN for all riverine and estuarine locations ranged from 0.2 to 0.5 ppm (Figure 8). Average ammonia nitrogen was less than 0.01 ppm at all locations. Average nitrite plus nitrate nitrogen for all riverine and estuarine stations was less than 0.01 ppm at all locations. These values represent relatively low levels of nitrogen and are consistent with the reported low NBODu levels. Tributary stations had similar low nitrogen levels, except TKN levels on two occasions were 0.5 ppm.

Figure 8a
Penobscot River Nitrogen
July 31, 2007

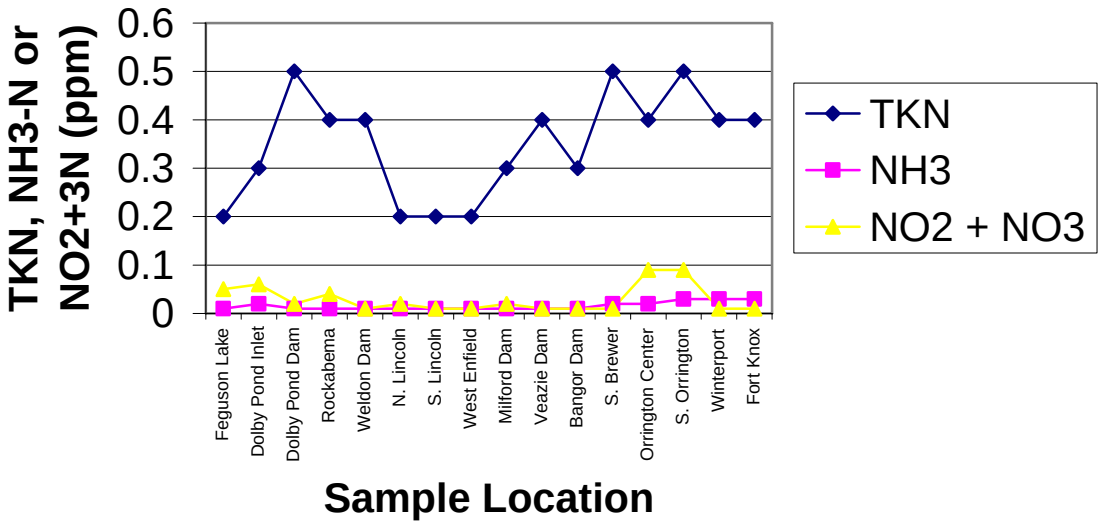
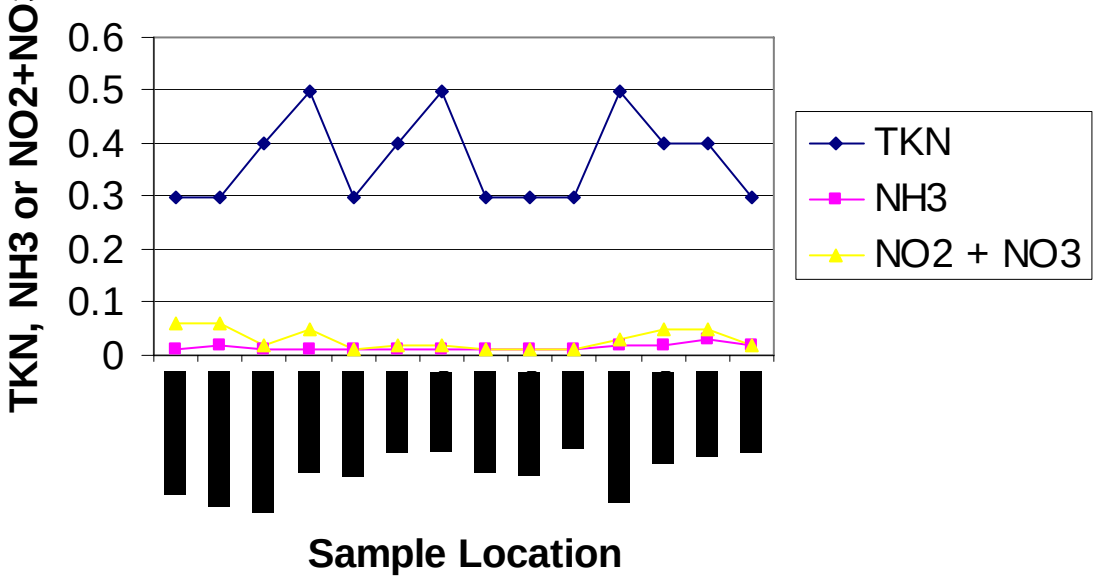
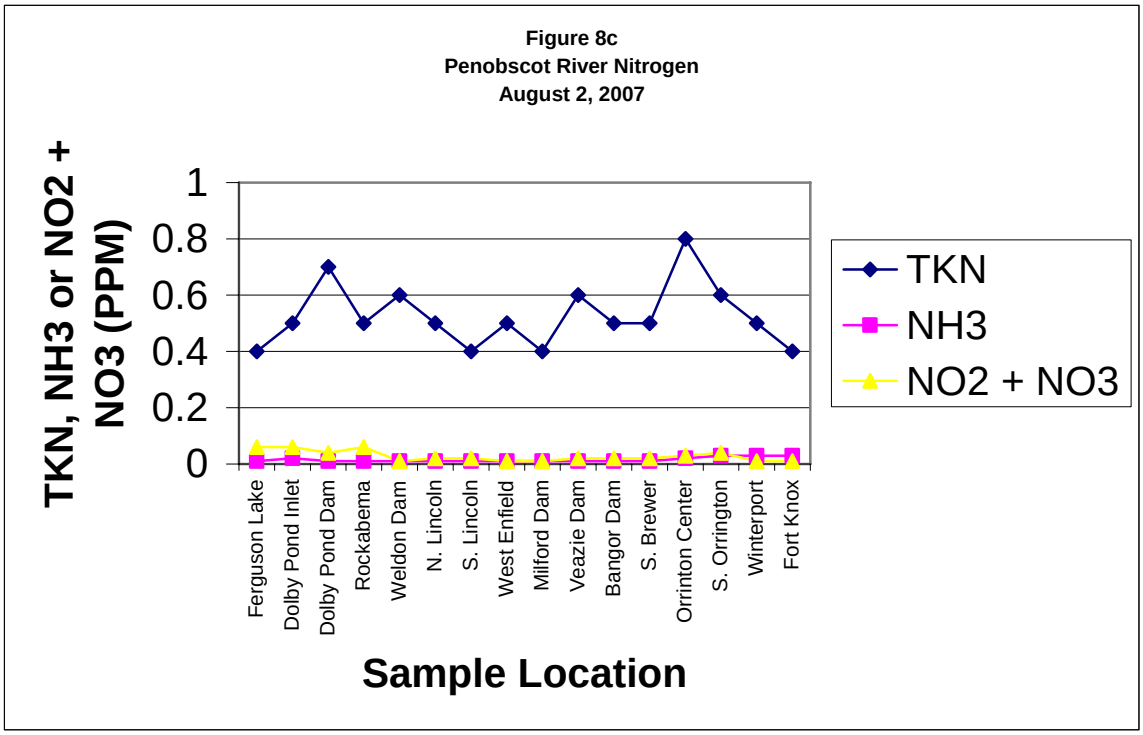


Figure 8b
Penobscot River Nitrogen
August 1, 2007





Chlorophyll a

Chlorophyll a is used as an indicator of the amount of algal biomass in a water body. Higher values are generally undesirable and can result in DO depletion and a poor aesthetic quality from green tainted waters. The algae produce oxygen during daylight hours which often results in supersaturated DO in the afternoon and consume oxygen during night time hours resulting in minimum DO readings at dawn. Low DO can persist all day in deeper stratified waters as well.

Chlorophyll a levels at seven of the ten stations on the Penobscot ranged from 2 to 3 ppb indicating low levels of algae (Figure 9 a, b, c). Chlorophyll a was similarly low on all of the tributary stations. At Dolby Pond, and Weldon dams chlorophyll a values ranged from 20 to 30 ppb and represent conditions of a bloom. Chlorophyll a in the tidal portion gradually increased in the seaward direction reaching levels indicative of mild bloom conditions at Orrington Center location. It can be concluded that cultural eutrophication on the Penobscot is at levels of concern.

Figure 9a
Penobscot River Chlorophyll-a
July 31, 2007

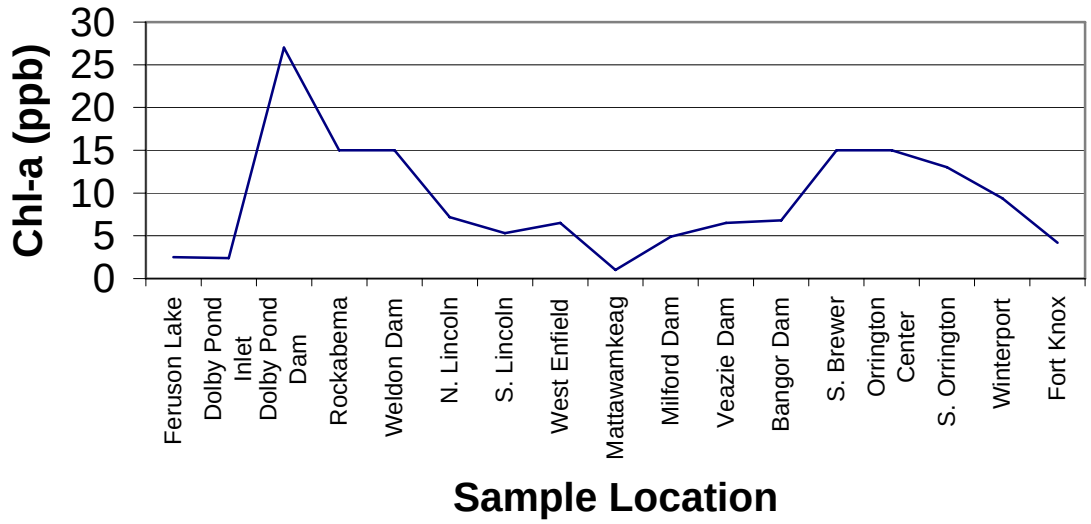
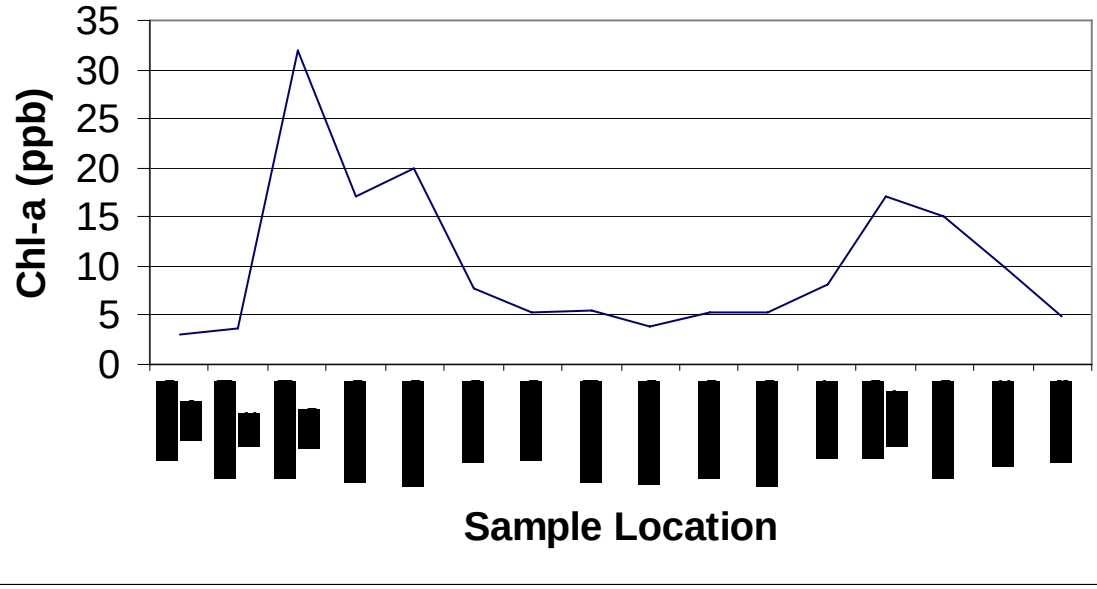
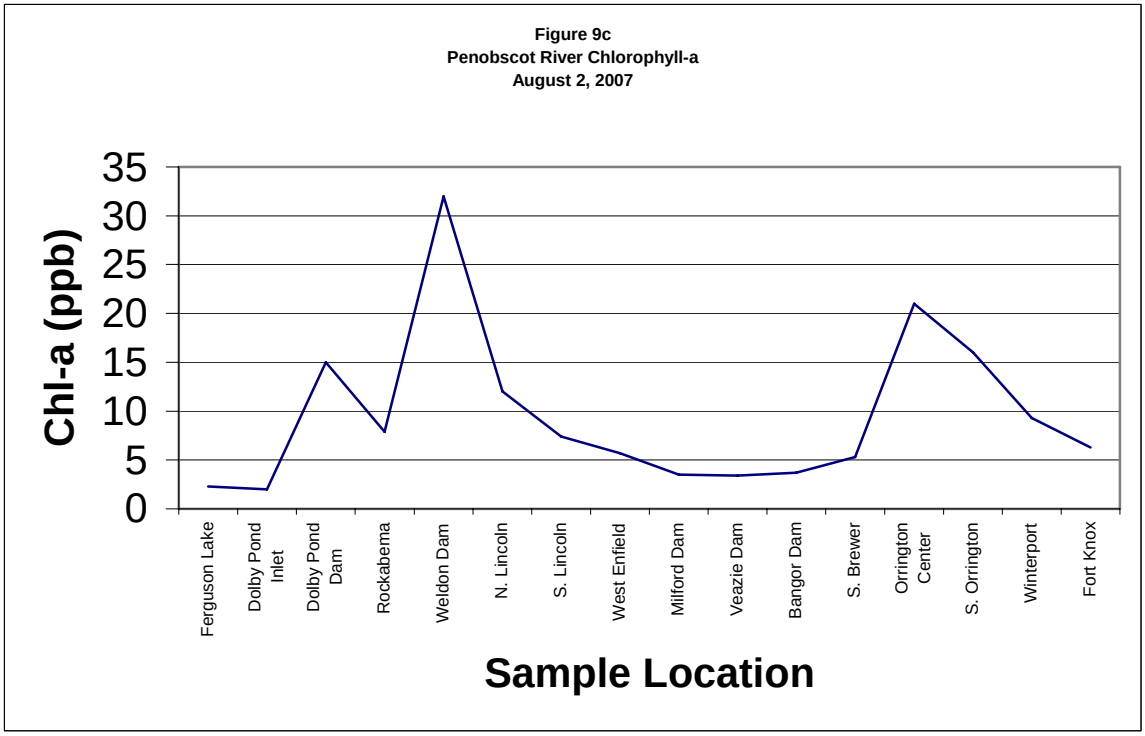


Figure 9b
Penobscot River Chlorophyll-a
August 1, 2007

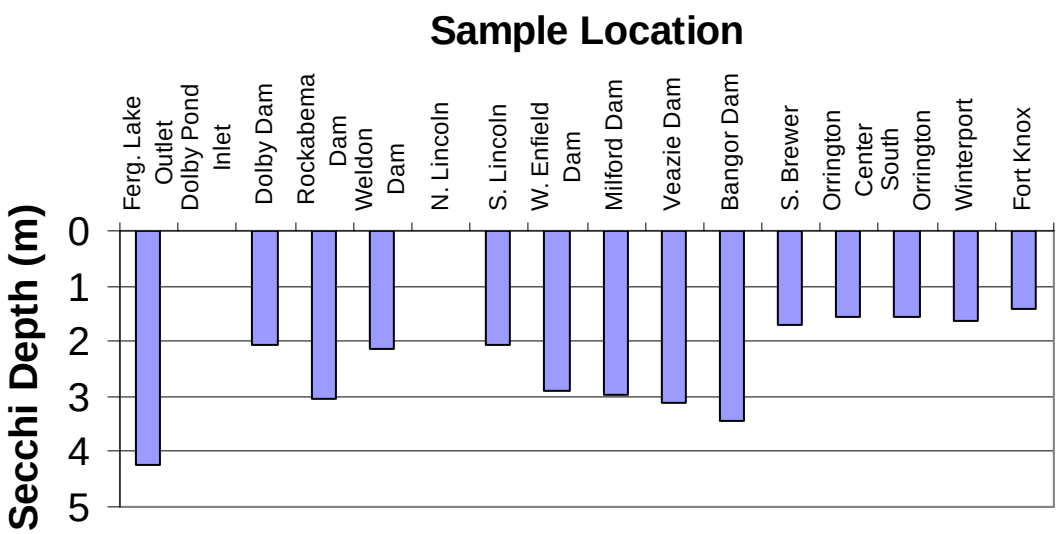




Secchi Disk Transparency

Secchi Disk transparency is a measure of water transparency or clarity that is accomplished by lowering a black and white disk on a chain into the water column by an observer in a boat. Secchi disk transparency was measured on a minimum of one day at all locations with sufficient depth. All values ranged from 1.4 to 4.2 meters (Figure 10). The lowest readings occurred at Weldon dam, which also had high chlorophyll-a levels. All of the estuary sites had low transparency readings. Transparency readings on the low end of this range would be considered poor readings for lakes, but are not necessarily an indication of algae or a cause for concern in rivers. Besides being more turbid than lakes, rivers often have high color that influences transparency. Secchi disk transparency measurements in waters with color exceeding 30 platinum cobalt units are not used as primary indicators of algal blooms. Data taken by the DEP in the late 1980's indicated that the Penobscot River and its tributaries have a moderately elevated color of natural origin that is further elevated by both paper mill and non point source discharges.

Figure 10
Penobscot Secchi Disk Transparency
7/31/07



Effluent Chemical Data

Effluent chemical data collected included composite samples of BOD5, BODu, total phosphorus, orthophosphorus, total kjeldhal nitrogen, ammonia nitrogen, and nitrite plus nitrate nitrogen. In addition, BOD5 data and treatment plant flow information were available as discharge monitoring data from the point source discharges on the Penobscot. Effluent total ultimate BOD results are summarized in plots of loads experienced during the three-day intensive survey (Figure 11a to 11c). The loads are more indicative of potential impact to the river and concentrations more indicative of the waste strength. The lower concentrations represent better treated waste.

Figure 11a
Effluent Total Ultimate BOD Discharged
July 31, 2007

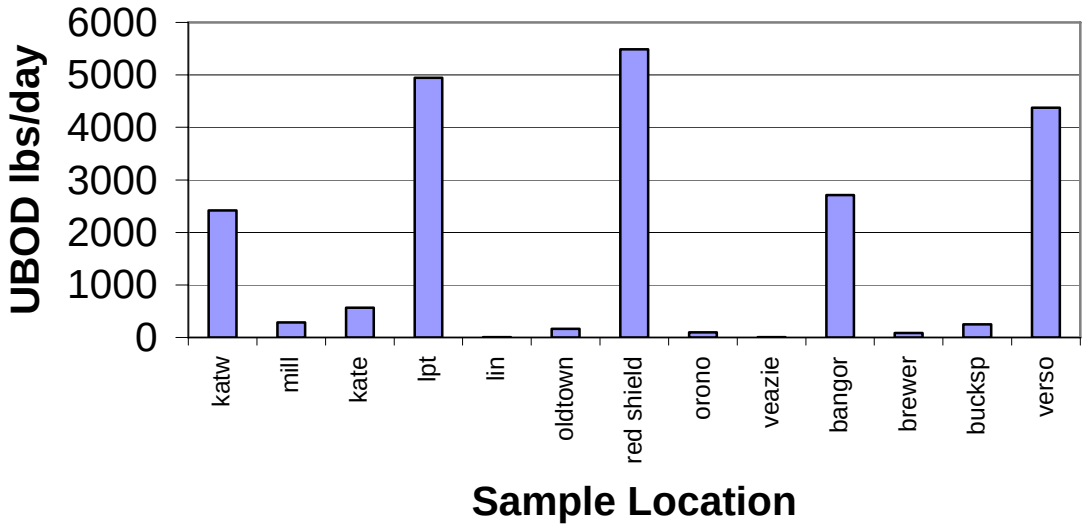


Figure 11b
Effluent Total Ultimate BOD Discharged
August 1, 2007

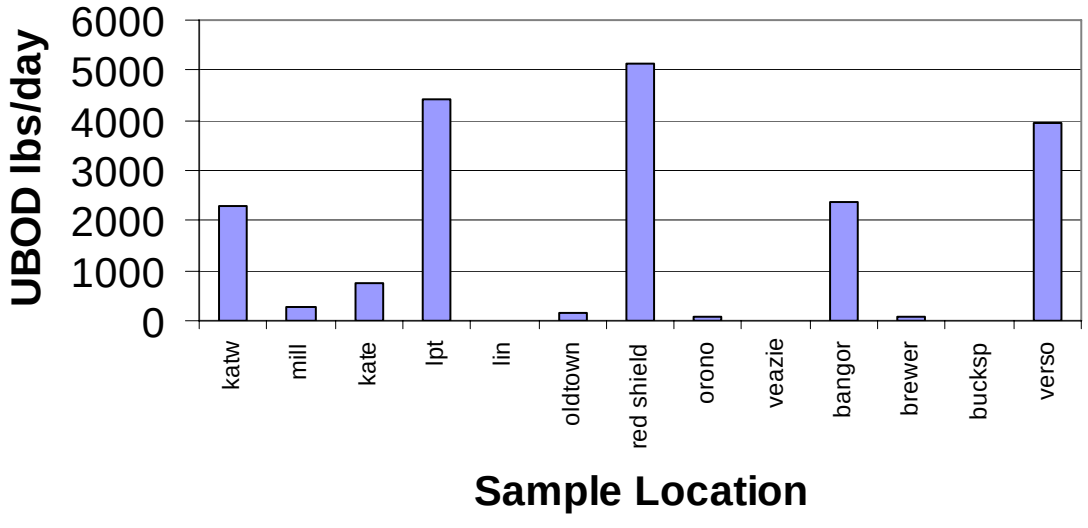
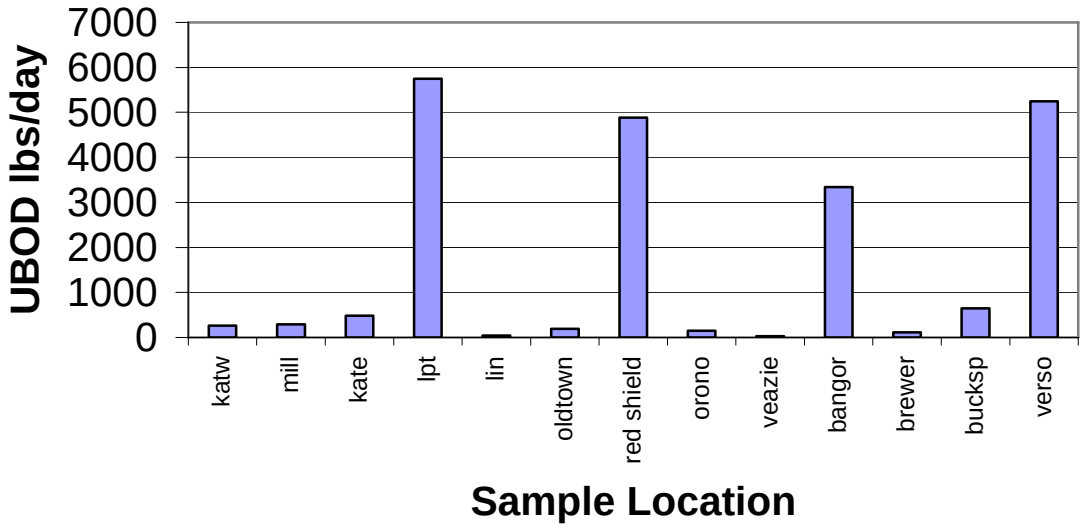


Figure 11c
Effluent Total Ultimate BOD Discharged
August 2, 2007



It can be seen that, although Bucksport has a much higher waste strength when compared to other discharges, its low flow volume results in a small pollutant load. The higher waste strength is expected since this town has primary treatment compared to secondary treatment of the other discharges. Many of the discharges sampled during the survey had very low concentrations of BOD, indicating good treatment.

Point source discharges are licensed as BOD5 concentration (mg/L) and/or mass (lbs/day). Actual loads discharged are plotted comparatively as a percent of the allowable licensed mass loads (Figure 12 a,b,c). This is for a worse case scenario in which it is assumed point sources are discharged at their allowable licensed load. This indicates that on the average, point sources collectively were only at about 5% of their permitted allowable daily maximum load. As to be expected, the paper mill discharges have the highest mass loading of BOD5 due to their large volume of flow.

Figure 12a
% of License BOD5
July 31, 2007

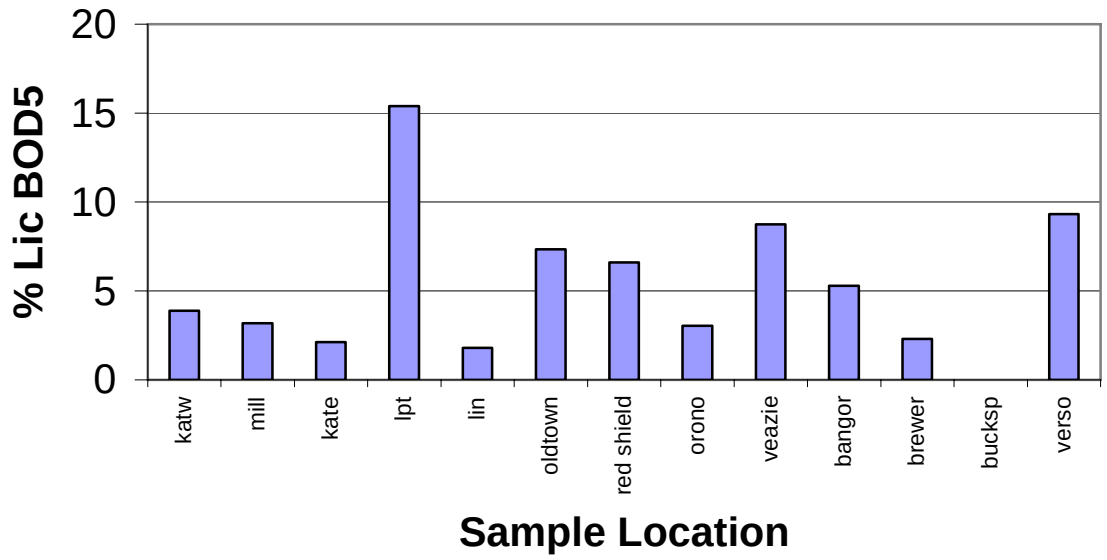
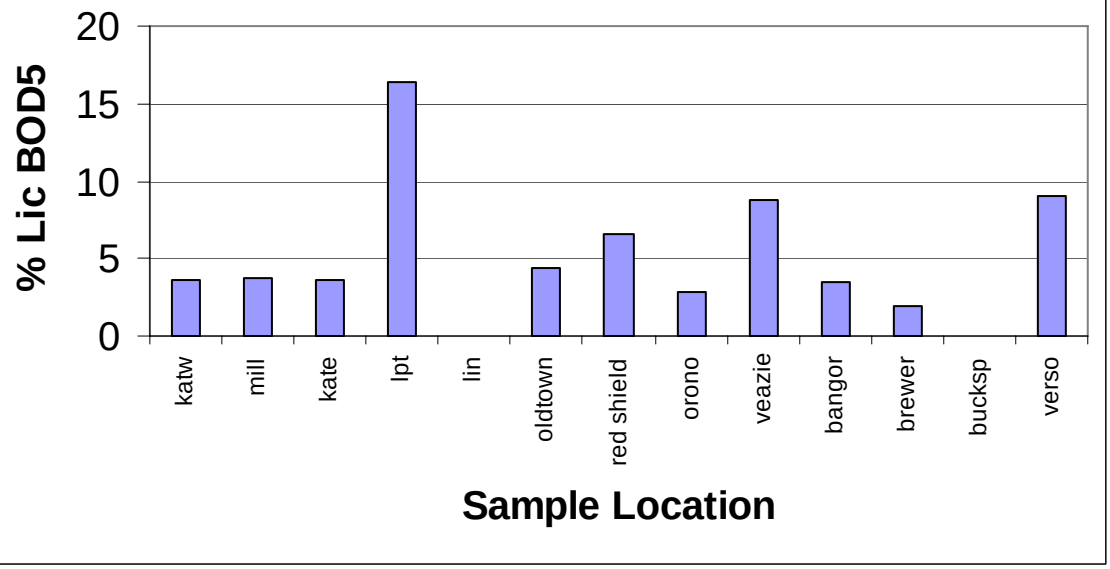
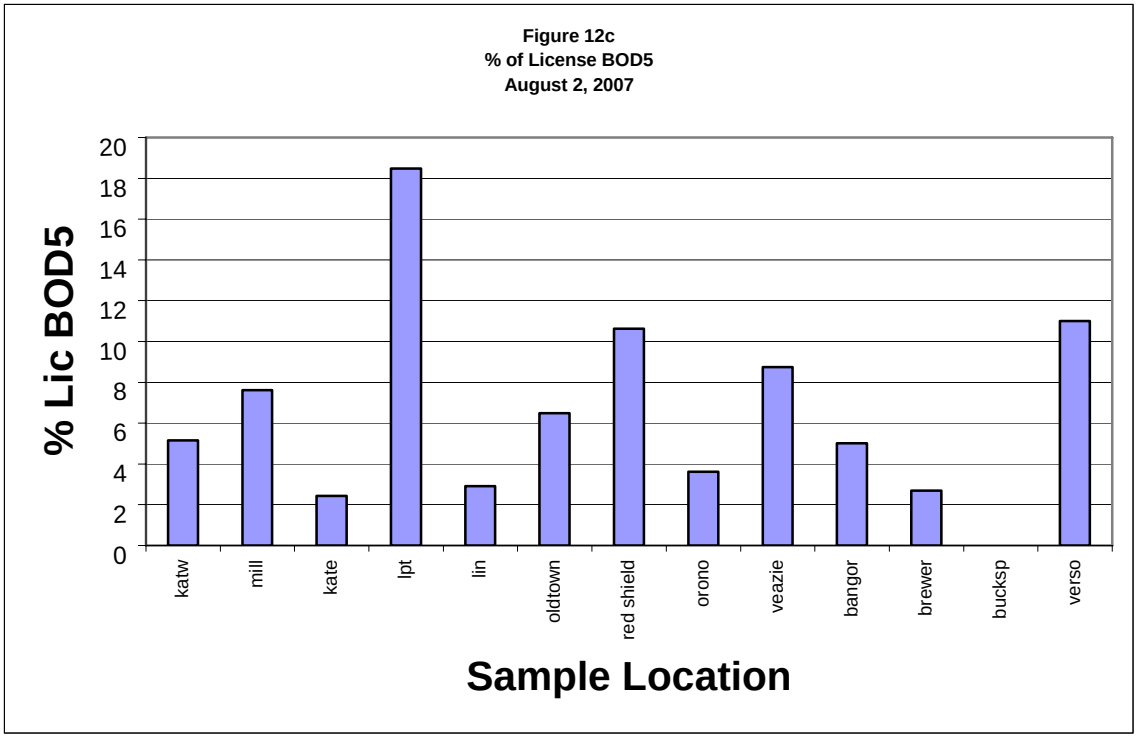


Figure 12b
% of License BOD5
August 1, 2007





Total phosphorus and total nitrogen (TKN + NO2+NO3-N) are also plotted and compared (Figures 13a,b,c, and,14a,b,c). Some facilities were sampled only one out of the four days. When considering nutrient sources for eutrophication, phosphorus is generally the limiting nutrient in fresh water systems, and conversely nitrogen is limiting in estuarine systems. Kathadin West, Red Shield, Verso and Bangor had the highest TP effluent discharge. Kathadin West, Red Shield, Verso, Lincoln Paper and Tissue, and Bangor had the highest nitrogen discharged.

Figure 13a
Effluent Total Phosphorus Discharged
July 31, 2007

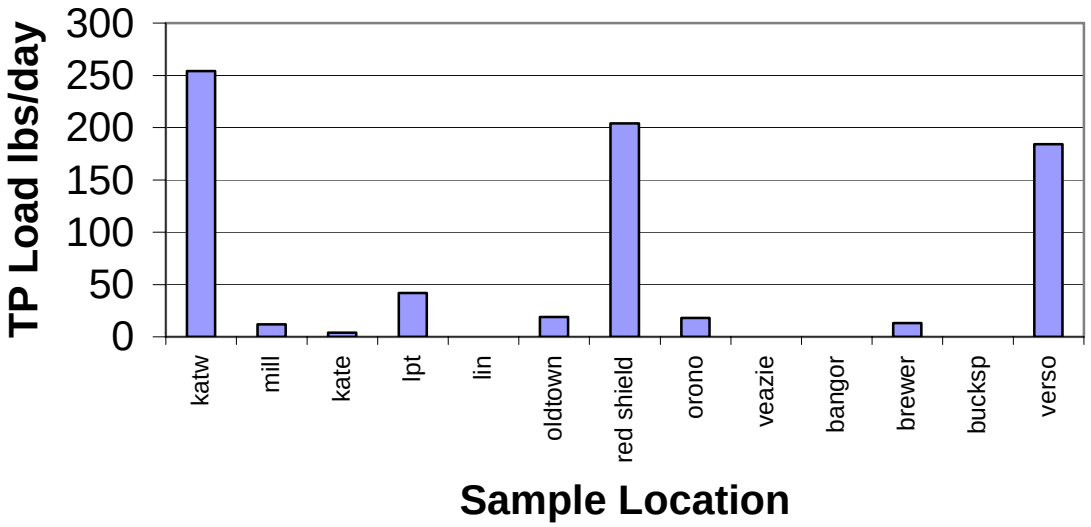


Figure 13b
Effluent Total Phosphorus Discharged
August 1, 2007

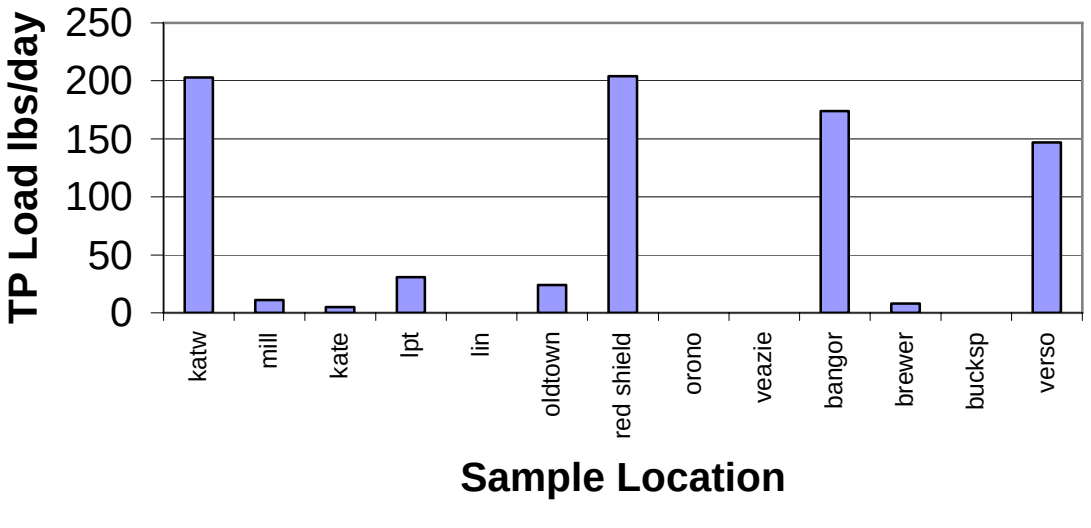


Figure 13c
Effluent Total Phosphorus Discharged
August 2 2007

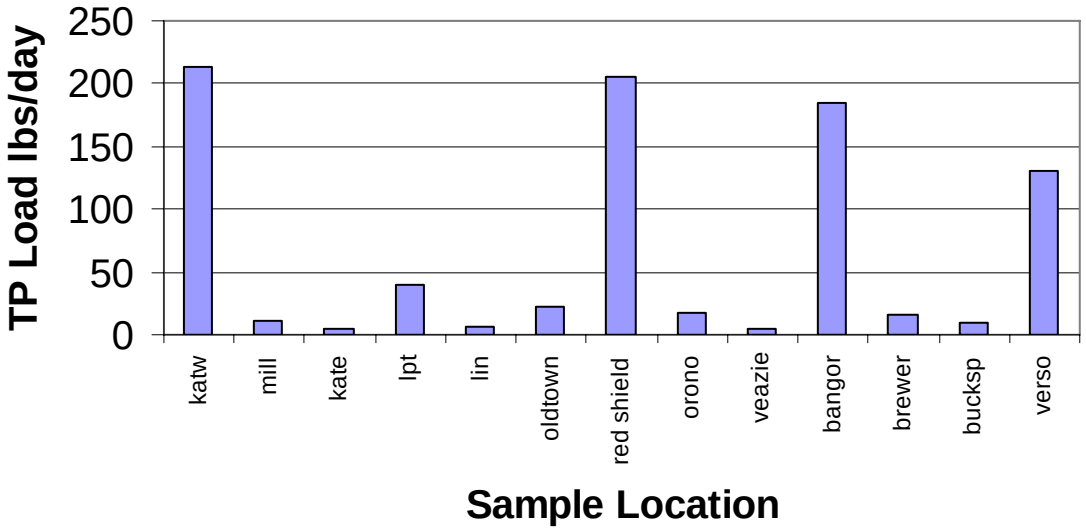


Figure 14a
Effluent TKN Discharged
July 31, 2007

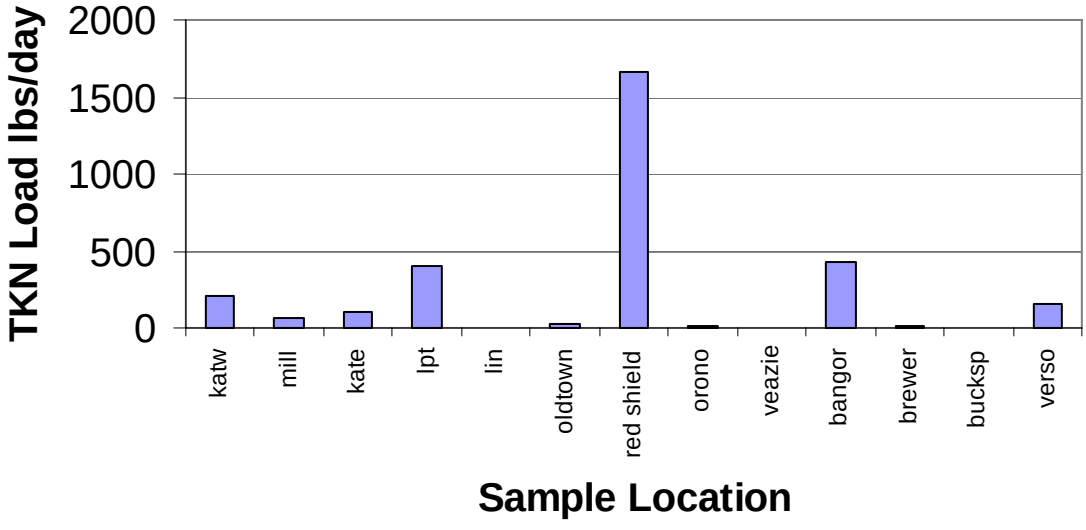


Figure 14b
Effluent TKN Discharged
August 1, 2007

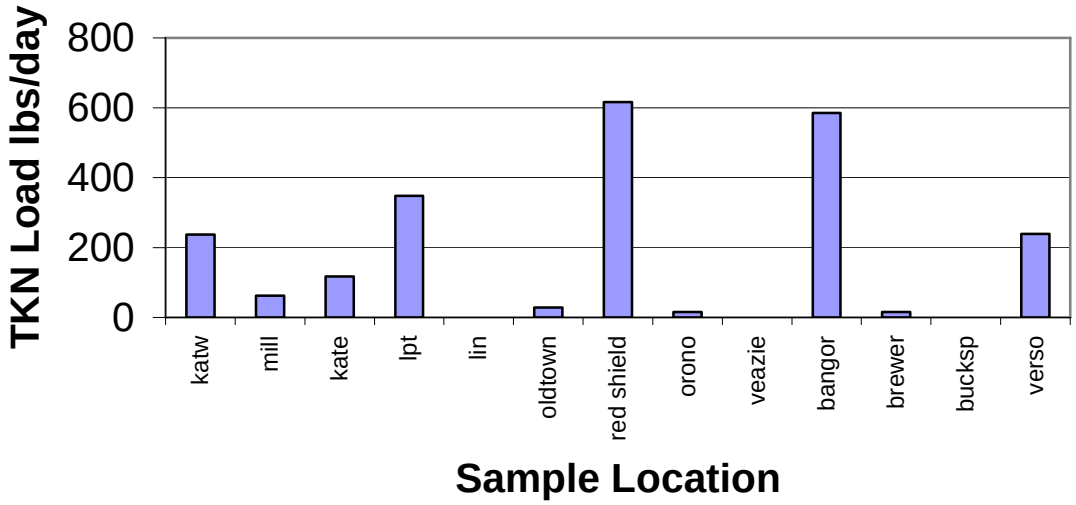
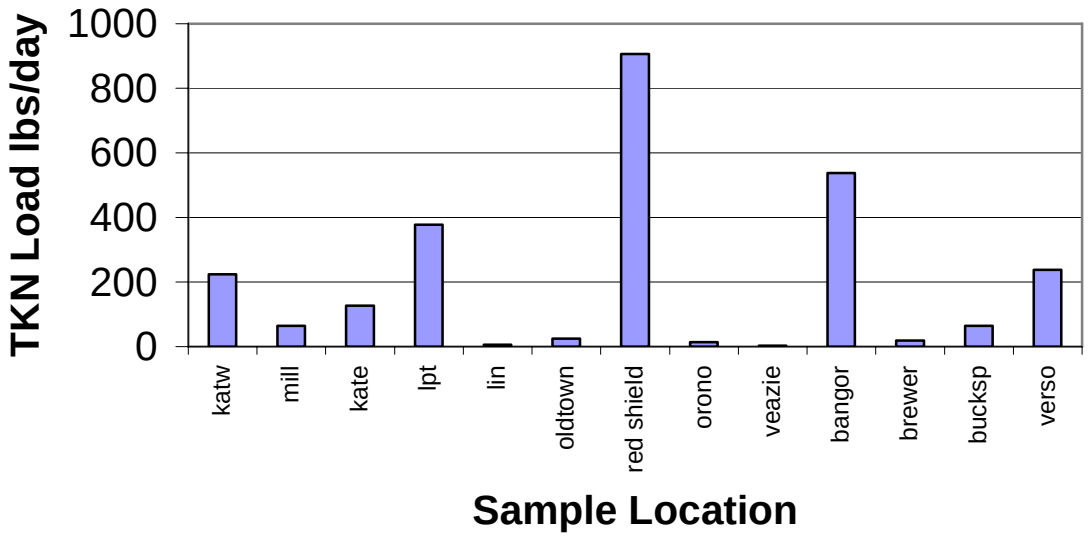


Figure 14c
Effluent TKN Discharged
August 2, 2007



Penobscot River Sediment Analysis

The ten sampling locations selected were based on the presence of fine sediment and proximity to stations used in the MDEP Water Quality Surveys. A fifth sample location at the mouth between High Head and Oak Point was attempted, but the seas were too rough during the survey to sample.

	MEDEP WQ	SOD	SOD
	Station ID	g/m2day	Std dev
Dolby Pond	WBP3	1.03	0.33
Rockabema	WBP5	1.56	0.68
Mattaseunk	PN1	0.69	0.69
West Enfield	PN5	0.42	0.42
Milford	PN9	1.03	1.03
Veazie	PN12	0.61	0.49
South Brewer	PNE2	0.96	0.67
Orrington Center	PNE5	0.77	0.21
South Orrington	PNE7	1.28	0-.21
Winterport	PNE9	1.27	1.01

Plant Growth

Observations were made to describe the relative growth of rooted and attached growth within two weeks of the intensive survey. These observations were made by transecting the river at the sample locations from one bank to another. An acquascope (same as used for Secchi Disk reading) was tried without success. We were note able to view the bottom as all times with the acquascope. An aqua vue (an underwater camera with light) was used with some success; however, power failure limited its use.

Station	Location	Observation
WBP2	Dolby Pond Dam (inlet)	Very little attached growth
WBP3	Dolby Pond Dam (above)	Some rooted growth on shoreline
WBP4	Rockabema Dam (below)	Some rooted growth on shoreline
Pn1	Weldon Dam (above)	Very little attached growth/silty bottom
Pn1	Weldon Dam (below)	Some attached algae
Pn2	Winn	Very little rooted/Rocks have very little attached
Pn3	North Lincoln	Very little attached growth
EBPu	East Branch Penobscot	Very little attached growth

ENP4	E. Millinocket Dam (above)	Very little rooted growth or attached algae
WBP5	Rockabema Dam	Limited growth on shoreline
WBP4	E. Millinocket Dam (below)	Limited growth on shoreline
MiS	Millinocket Stream	Some rooted growth
KeS	Kennduskeag Str.	Some attached and some filamentous
Pn5	West Enfield (above)	Clean
PiS	Piscataquis R.	Clean
SoS	Soudabascook Str.	Little rooted and some filamentous
Pn6	Passadumkeag	Some rooted and attached growth
Pn7	Greenbush	Some rooted near shore
Pn8	Costigan	Some rooted near shore
Pn9	Milford dam (below)	Clean
Pn10	Great Works Dam (above)	Clean
Pn10	Great Works Dam (below)	Very little attached
PuS	Pushaw Stream	Some attached growth
Pn11	Orono nr. Water Co.	Clean
Pn12	Veazie Dam	Some attached growth
Pn13	Bangor Dam	Clean

Tributaries

In appendix B, the field monitoring data show that 5 out of the 8 tributaries had DO levels below 7.0 mg/L on July 31, 2007. On August 1 and 2, 2007 the monitoring data shows that 3 out of the 8 tributaries had DO levels below 7.0 mg/L. Afternoon DO levels were always above 7.0 mg/L.

Quality Control

Proper quality control is essential for any sampling effort to assure data collected are of acceptable quality. Quality control procedures were practiced in both field sampling and the laboratory analysis of various parameters. DO meters were calibrated prior to and as needed during sampling. In addition, meters were cross checked amongst adjacent sampling teams to assure consistency and accuracy of results. The DO meters were cross checked after initial morning calibration and again after commencement of sampling. This procedure was repeated for the afternoon sampling run. If meters did not agree favorably after commencement of sampling, meters were re-calibrated and rechecked.

The work plan specified that DO readings amongst sampling teams should be within 0.3 ppm and temperature within 2 ^{O}C when cross checking readings. A column plot of crosscheck for the DO meters indicates that this criterion was met (Figures 15-17).

Figure 15
DO Meter Cross Check 7/31/2007

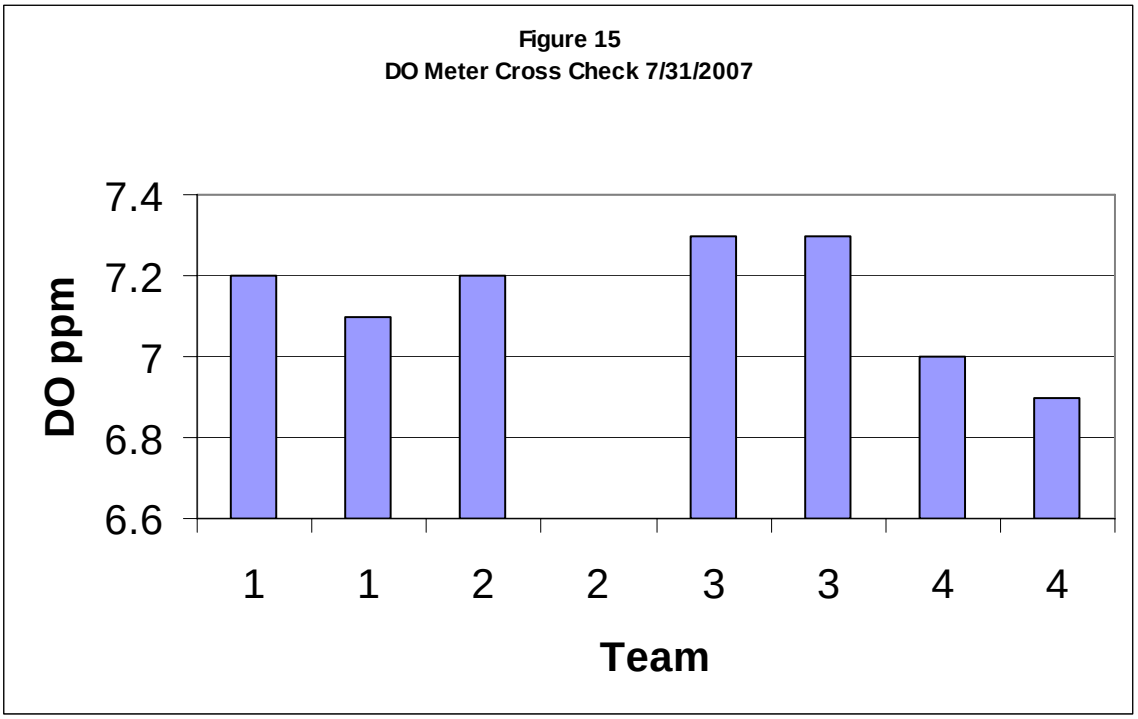


Figure 16
DO Meter Cross Check 8/1/2007

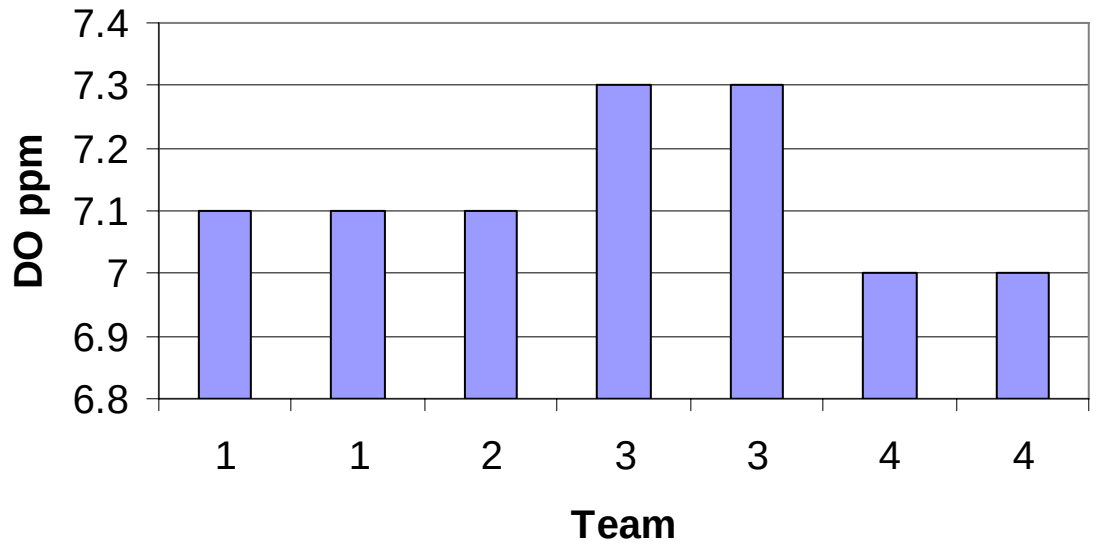
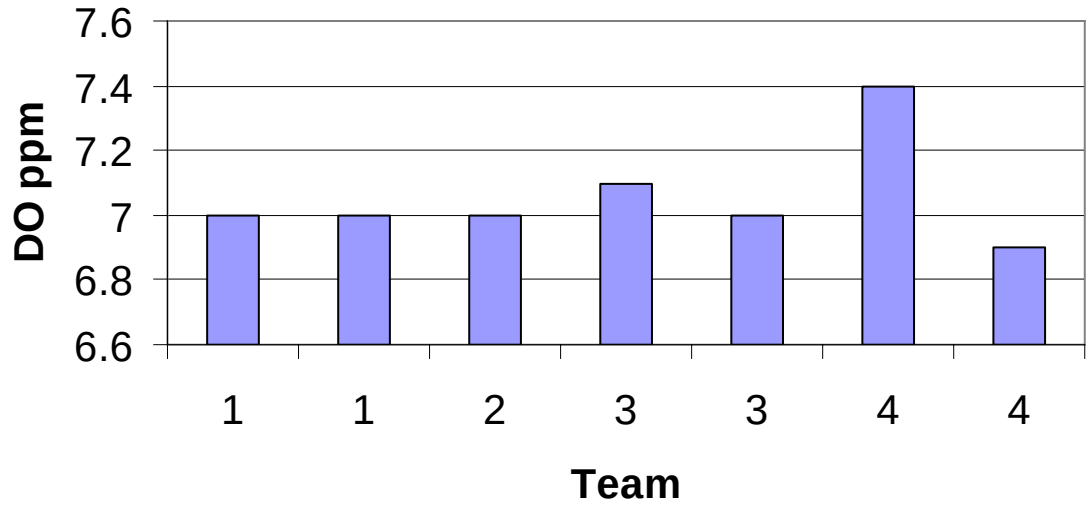


Figure 17
DO Meter Cross Check 8/2/2007



Field duplicate samples were collected for all parameters at a river, estuary, tributary, and effluent station each day during the intensive survey. When the results for some of various parameters are compared graphically for ambient (Figures 18-28) and effluent (Figure 29-30) samples, good agreement occurs for most of the samples. An examination of the deviation of the duplicate from the actual sample indicates the following:

It can be concluded from Table 5 that the average deviation of 64 duplicate samples is 4.6%. Also 98% of all duplicates were within a 10% deviation and 100% were within a 20% deviation. Chlorophyll a and TKN were the most accurate reading with an average deviation of 0%. Temperature was also very accurate with deviations of 0.32%. Nitrite and nitrate were the least accurate with an average deviation of 14.2%. The favorable quality control results and consistency of the data results in a conclusion that the data are good quality and adequate for re-calibration of the water quality model.

Table 5 Duplicate Sample Deviation

Parameter	Number	Ave Deviation	% with Deviation < 10%	% with Deviation < 20%
DO	40	0.95 %	100%	100%
Temperature	19	0.32%	100%	100%
Total Phosphorus	1	8.1%	100%	100%
Ultimate BOD	1	8.7%	100%	100%
Chlorophyll a	1	0%	100%	100%
Total Kjeldhal Nitrogen	1	0%	100%	100%
Nitrite + Nitrate Nitrogen	1	14.2%	0%	100%
Totals	64	4.6%	98%	100%

Figure 18a Dolby Pond Inlet
DO Duplicate Sampling

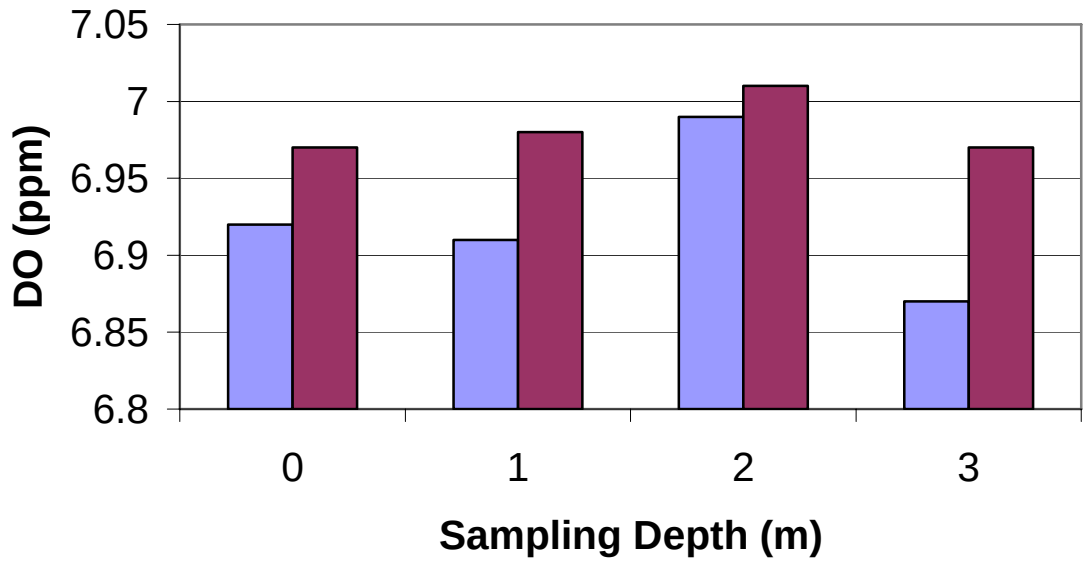


Figure 18b Dolby Pond Inlet
Temperature Duplicate Sampling

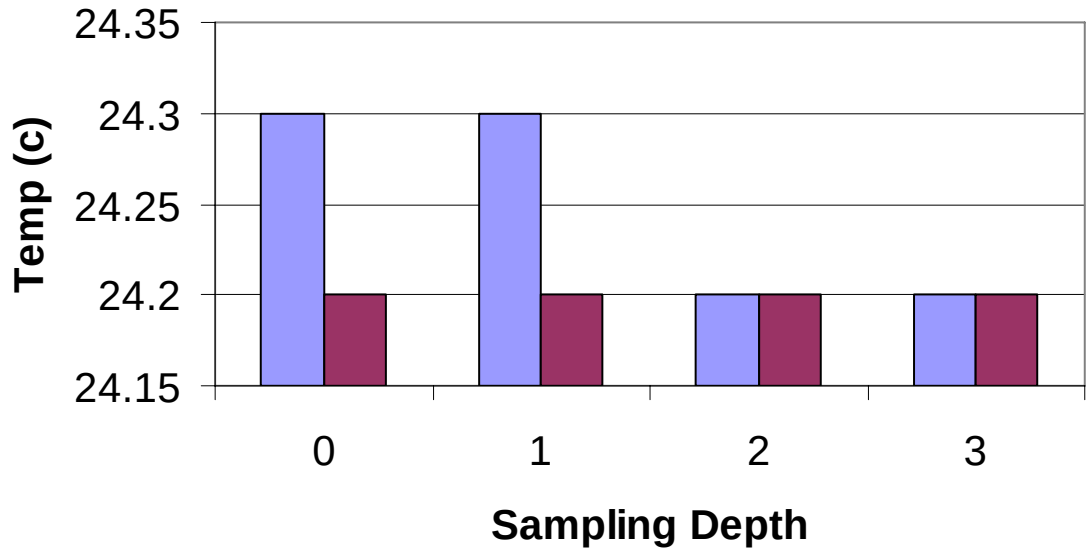


Figure 19a Weldon Dam
DO Duplicate Sampling

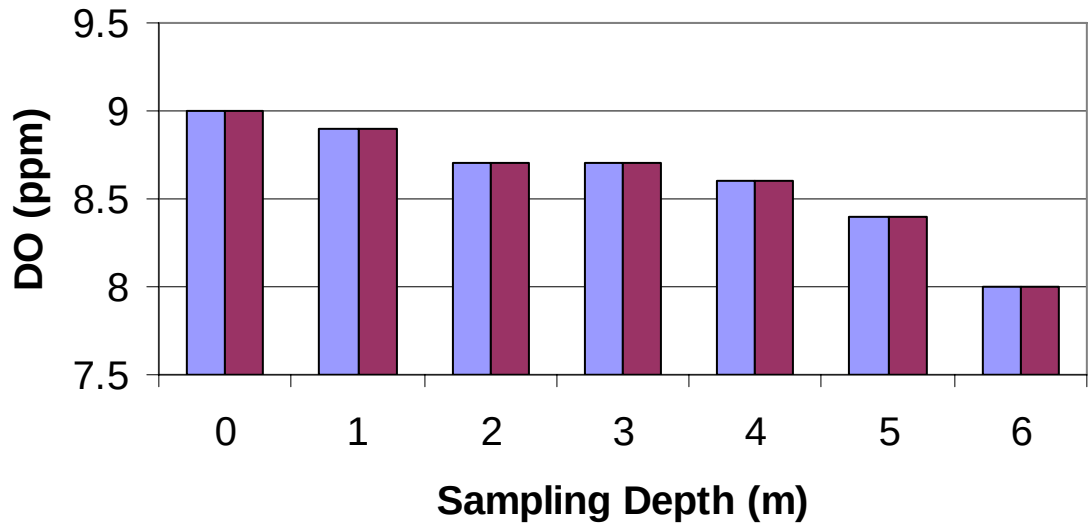


Figure 19b Weldon Dam
Temperature Duplicate Sampling

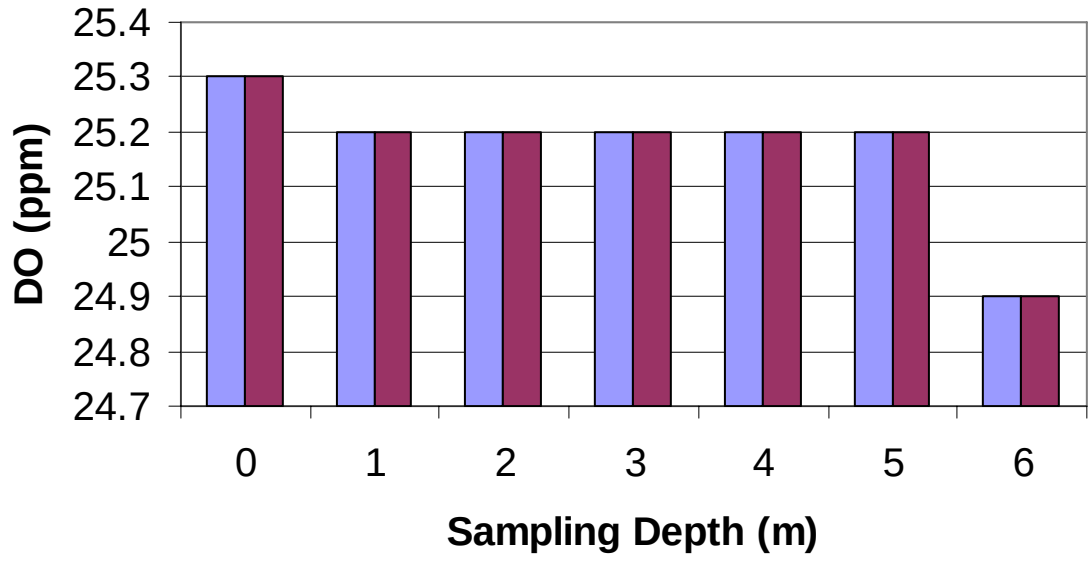


Figure 20a Stillwater R.
DO Duplicate Sampling

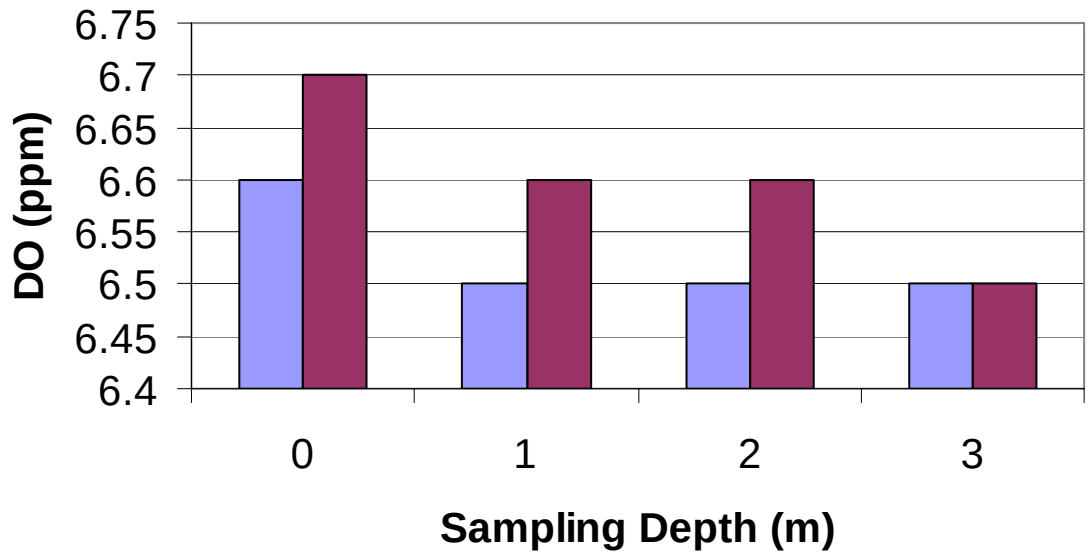


Figure 20b Stillwater R.
Temperature Duplicate Sampling

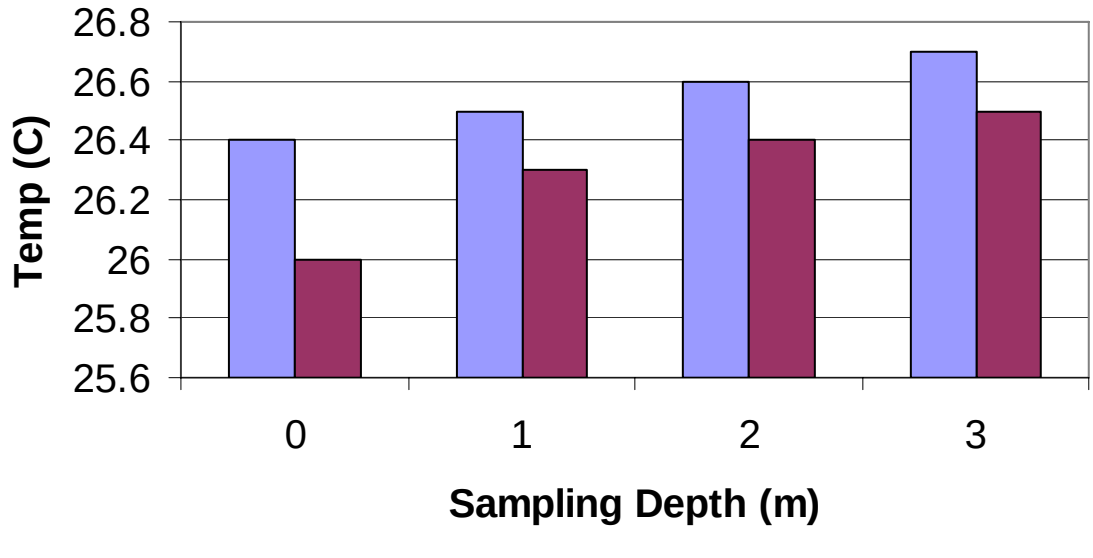


Figure 21a Winterport
DO Duplicate Sampling

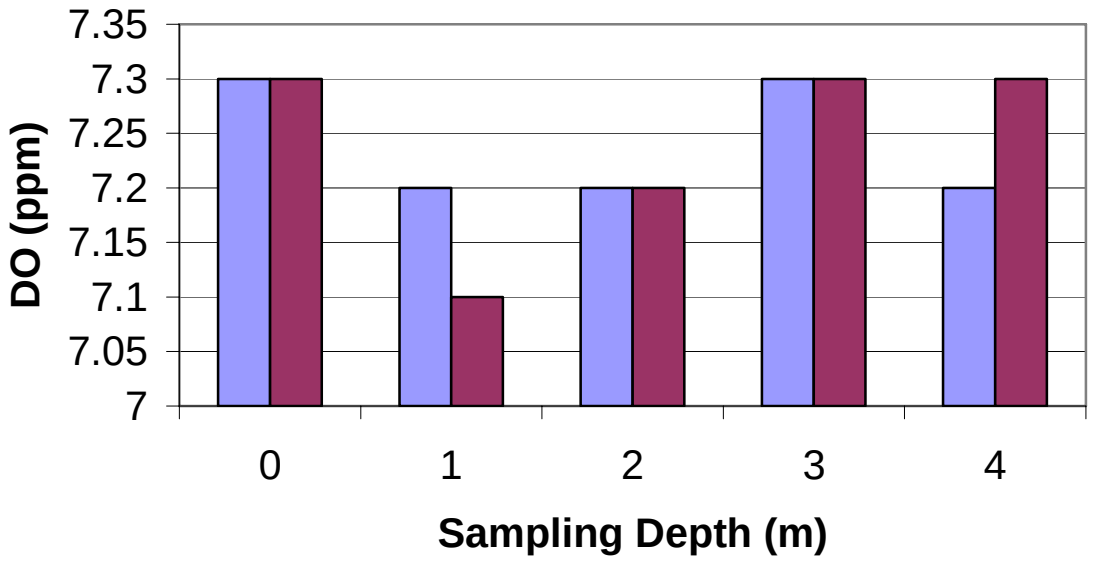
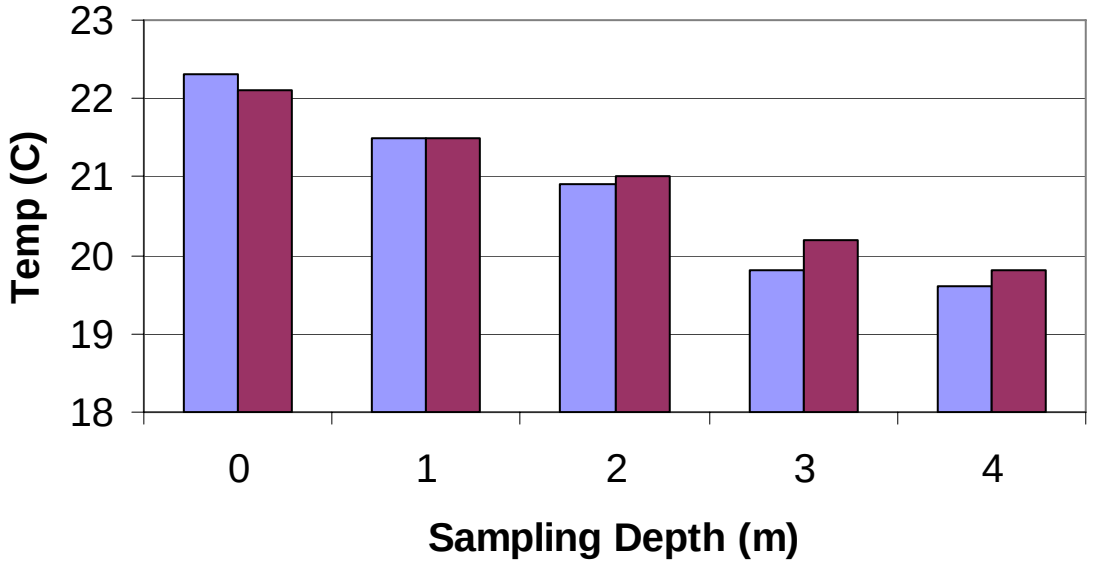
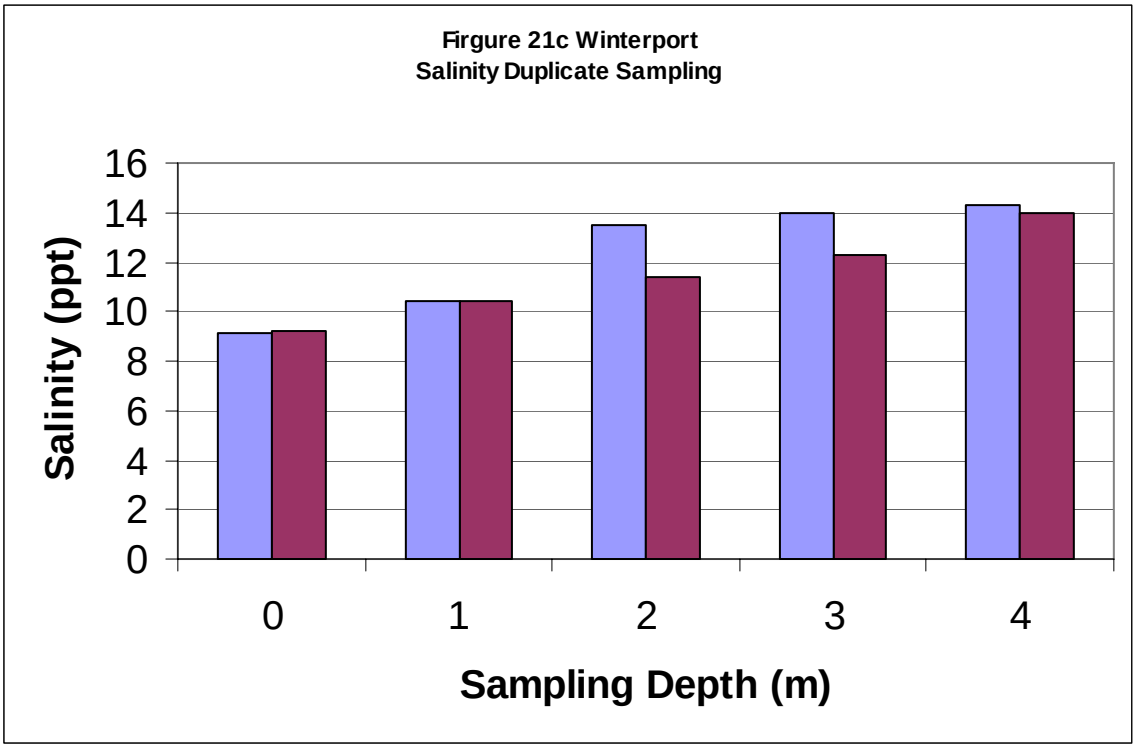


Figure 21b Winterport
Temperature Duplicate Sampling




Firgure 21c Winterport
Salinity Duplicate Sampling
Salinity (ppt)
16
14
12
10
8
6
4
2
0
0
1
2
3
4
Sampling Depth (m)

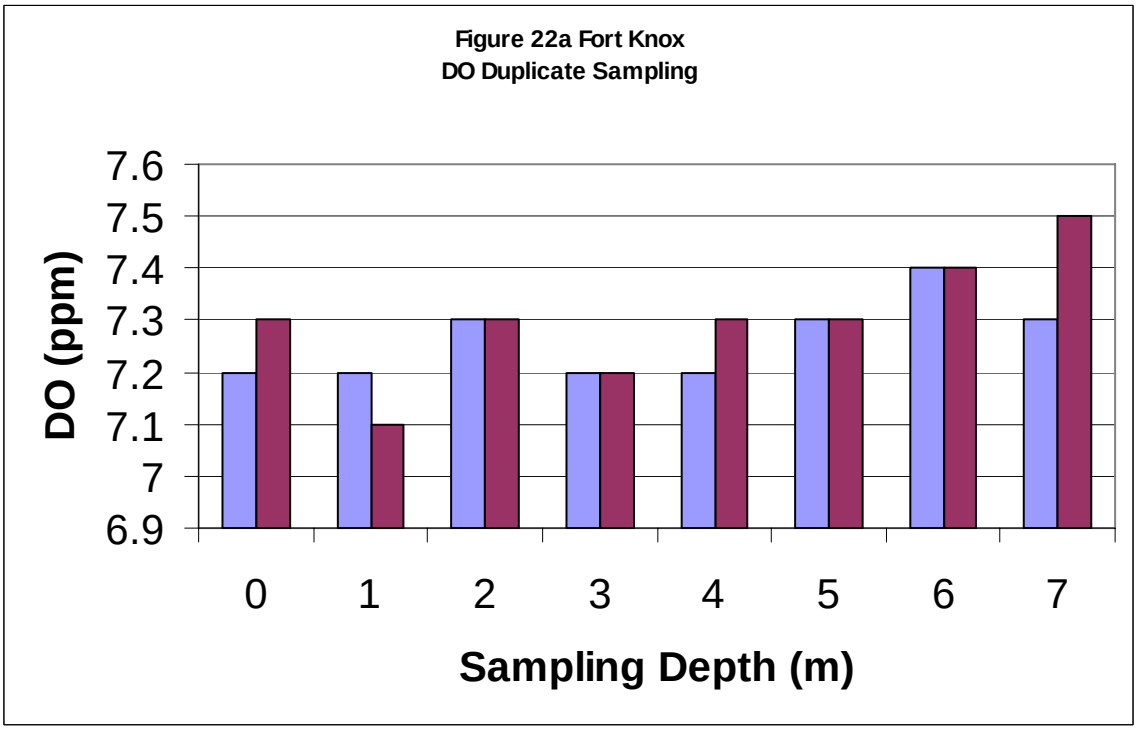


Figure 22a Fort Knox
DO Duplicate Sampling
DO (ppm)
7.6
7.5
7.4
7.3
7.2
7.1
7
6.9
0
1
2
3
4
5
6
7
Sampling Depth (m)

Figure 23a South Orington
DO Duplicate Sampling

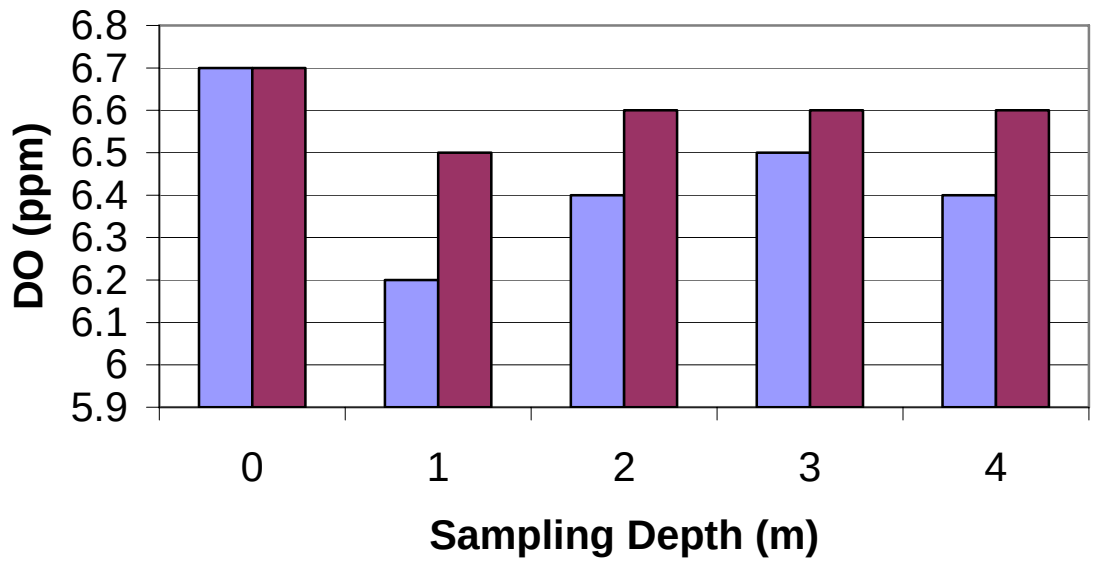


Figure 23b South Orington
Temperature Duplicate Sampling

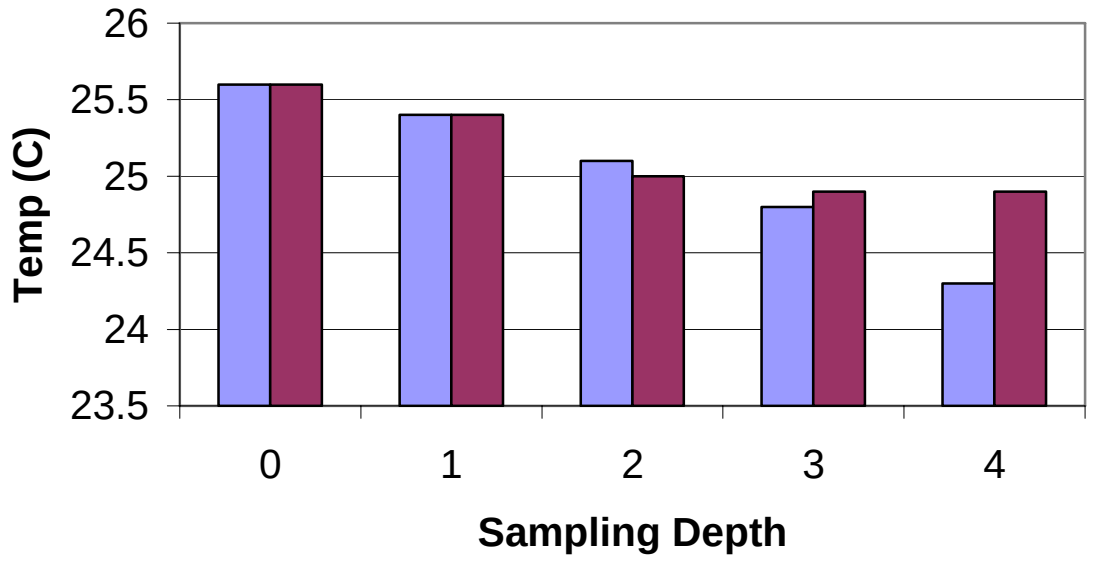


Figure 23c South Orington
Salinity Duplicate Sampling

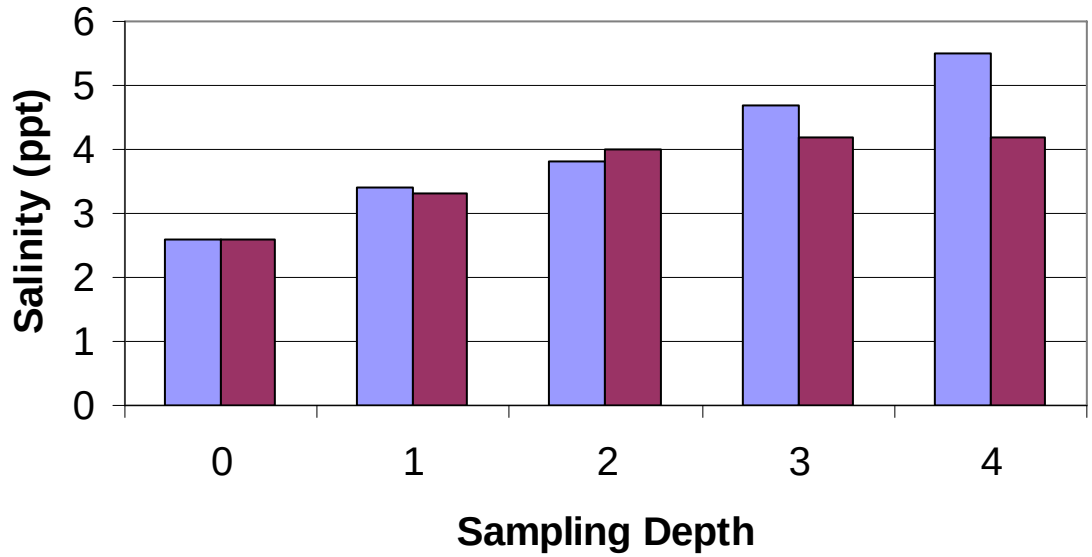


Figure 24
Ambient Total Ultimate BOD Sample vs. Duplicate

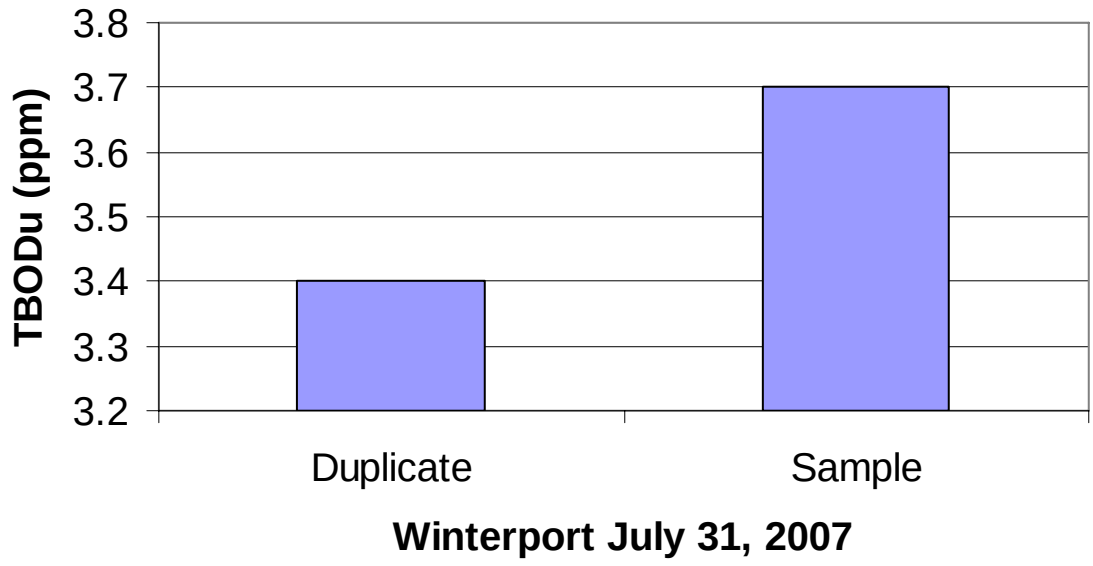


Figure 25
Ambient Total Phophours Sample vs. Duplicate

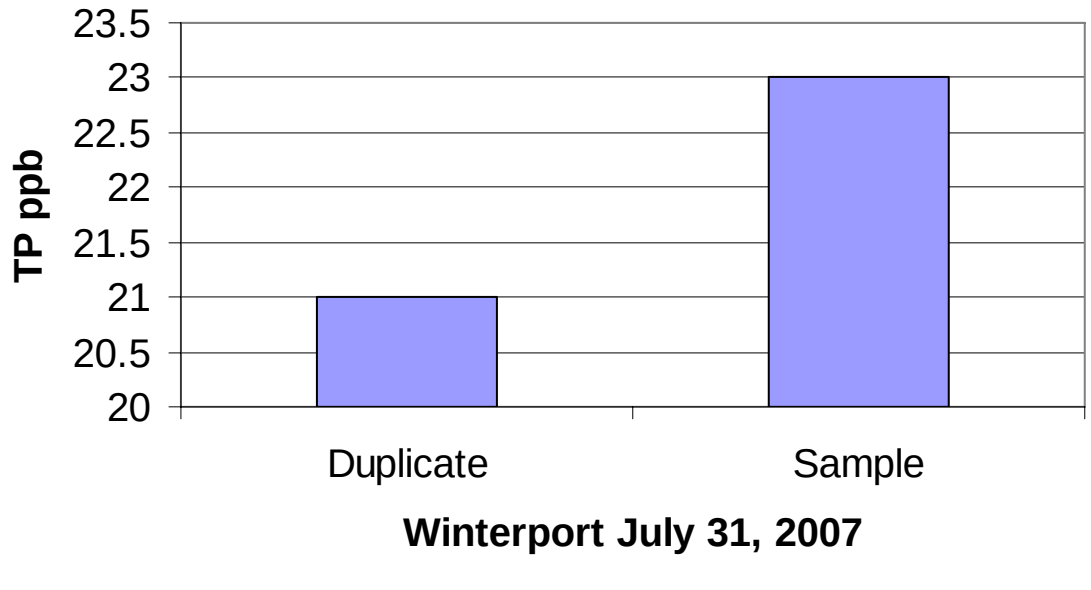


Figure 26
Ambient chl-a Sample vs. Duplicate

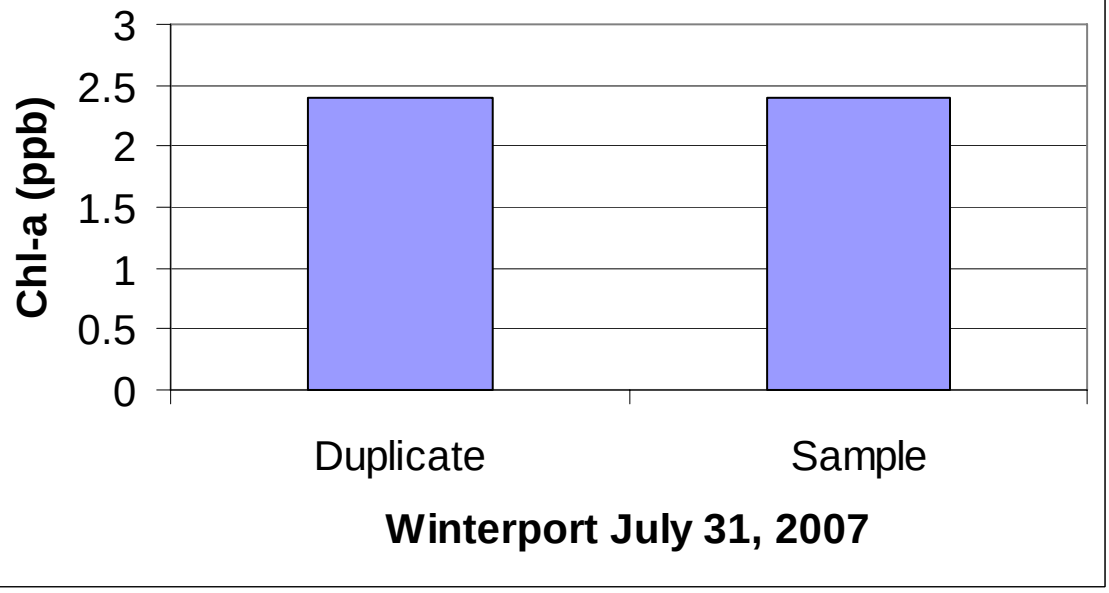


Figure 27
Ambient TKN Sample vs. Duplicate

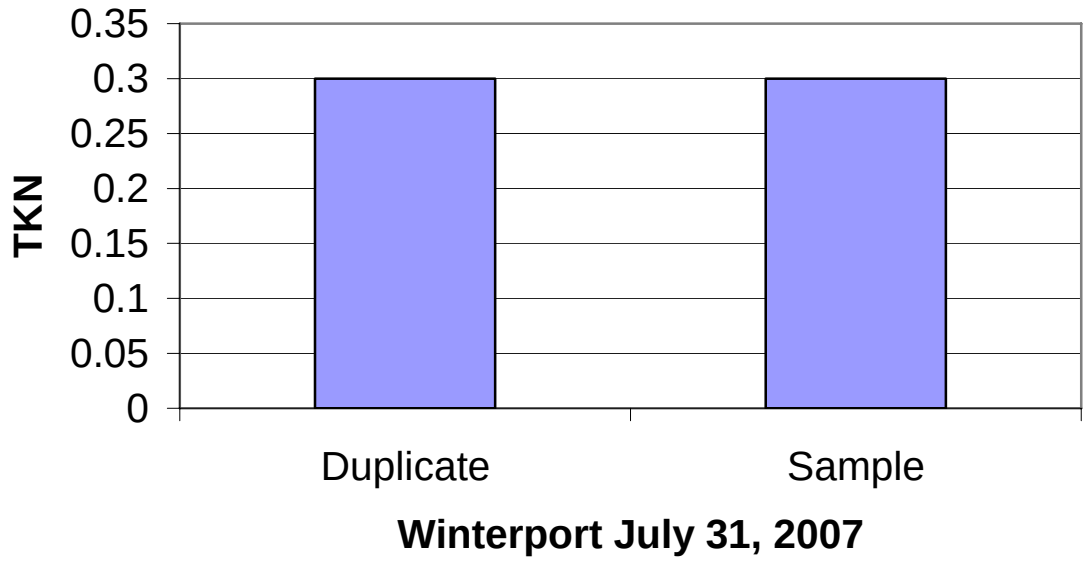


Figure 28
Ambient NO2 + NO3 Sample vs. Duplicate

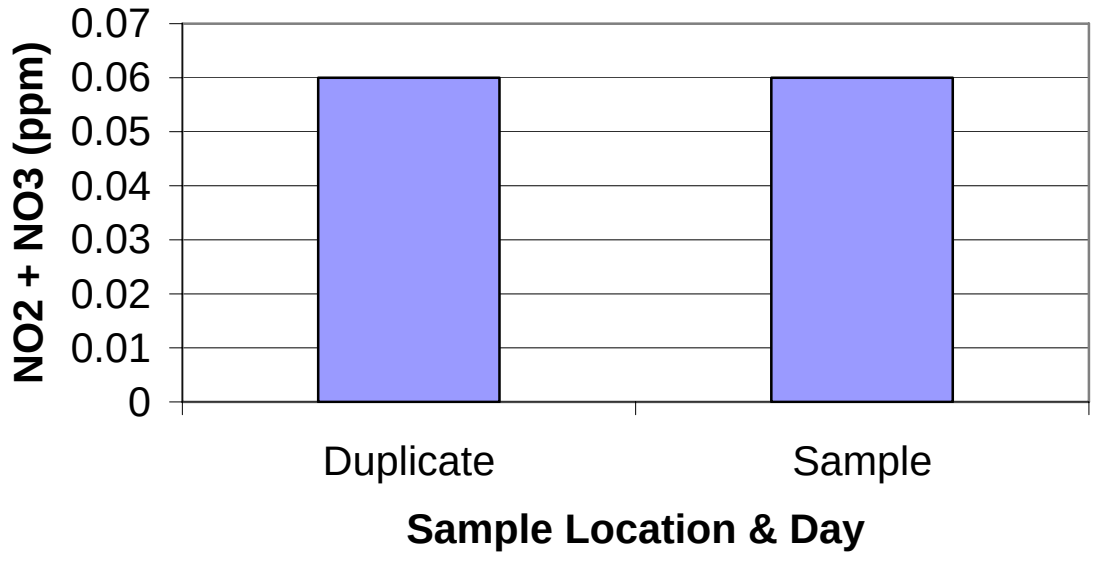


Figure 29
Effluent Samples vs. Duplicate

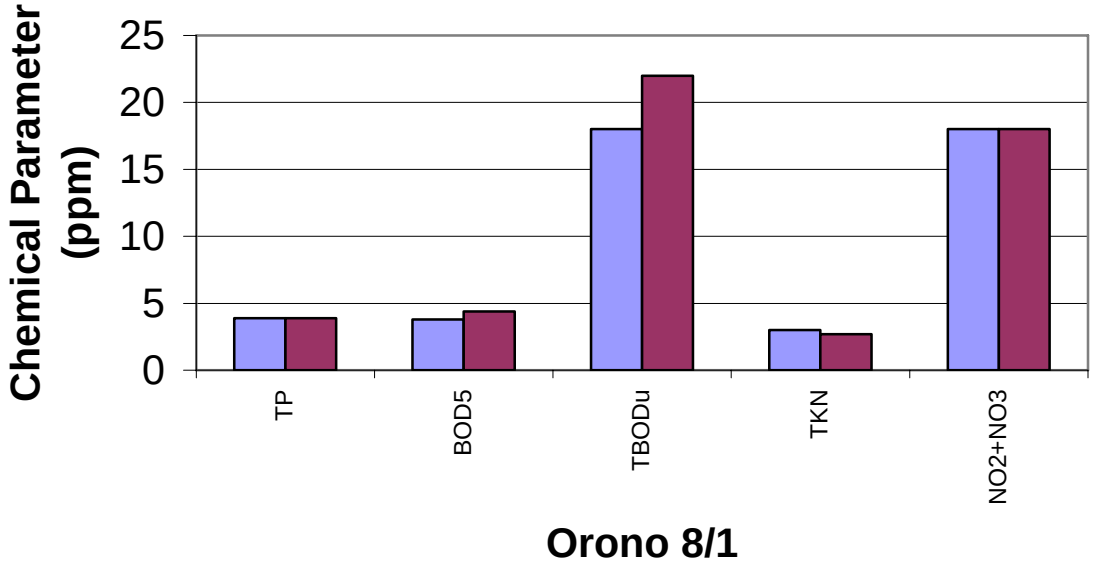
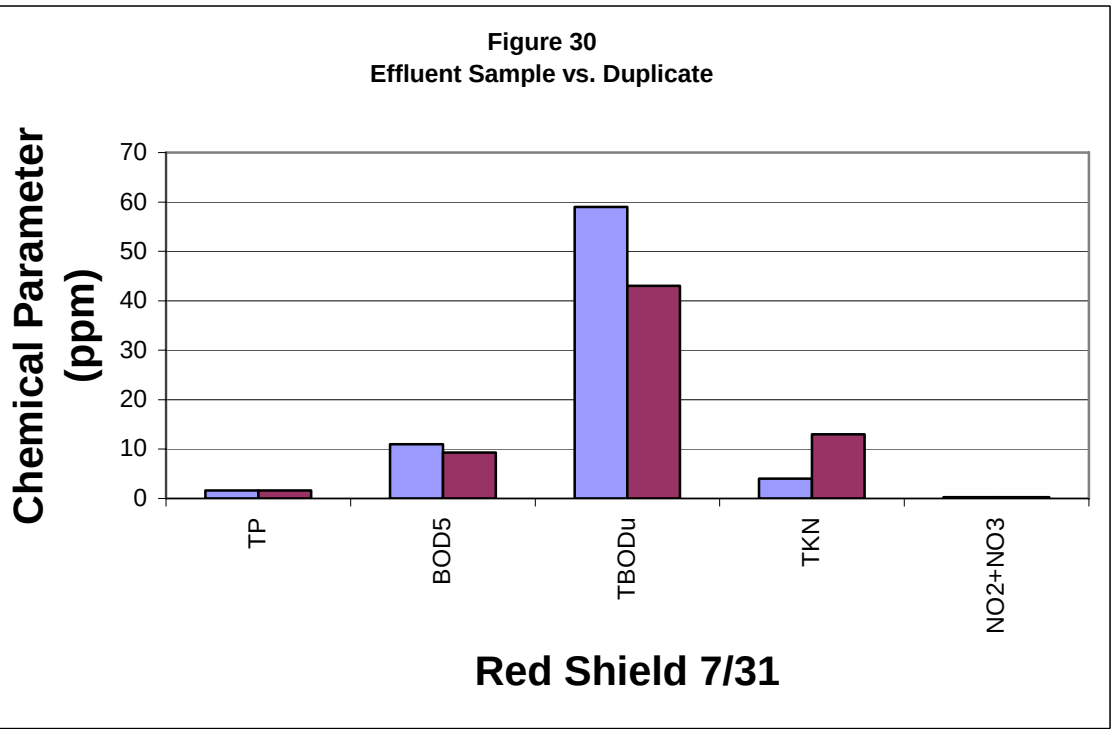


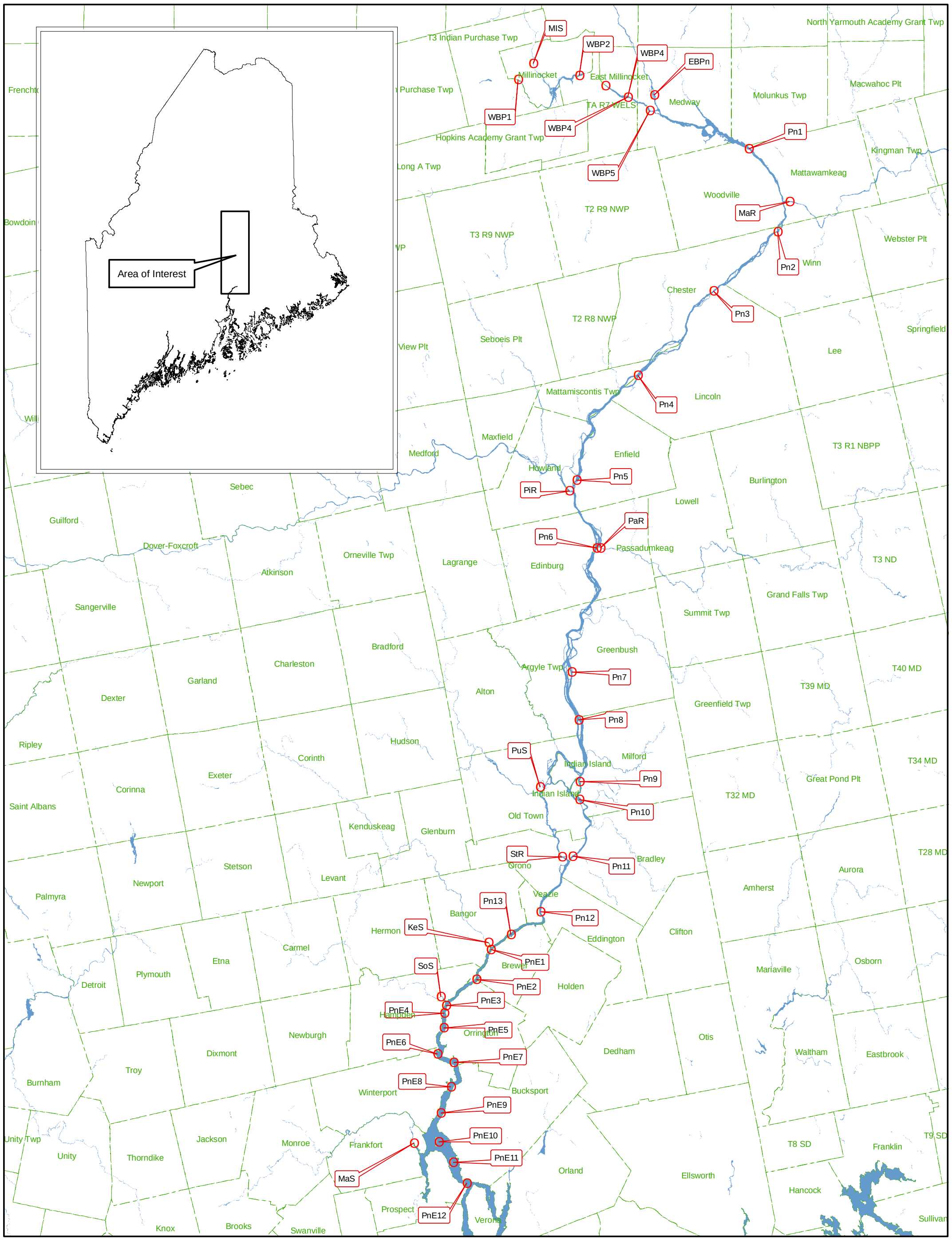
Figure 30
Effluent Sample vs. Duplicate



Sondes Data

The sondes data show that the DO criteria were met almost all of the time. The only DO violations occurred at the Rockabema Dam site on August 2, 2007.

Appendix A
LOCATION MAP


Area of Interest
MIS
WBP2
WBP4
EBPn
WBP1
WBP4
WBP5
Pn1
MaR
Pn2
Pn3
Pn4
Pn5
PIR
PaR
Pn6
Pn7
Pn8
PuS
Pn9
Pn10
StR
Pn11
Pn12
Pn13
KeS
PnE1
SoS
PnE2
PnE3
PnE4
PnE5
PnE6
PnE7
PnE8
PnE9
PnE10
PnE11
MaS
PnE12
T3 Indian Purchase Twp
North Yarmouth Academy Grant Twp
Millinocket
East Millinocket
Medway
TA R7 WELS
Molunkus Twp
Macwahoc Plt
Purchase Twp
Hopkins Academy Grant Twp
Long A Twp
Kingman Twp
Mattawamkeag
Woodville
T2 R9 NWP
T3 R9 NWP
Webster Plt
Winn
Chester
T2 R8 NWP
Seboeis Plt
View Plt
Springfield
Lee
Mattamiscontis Twp
Lincoln
Maxfield
Medford
Enfield
Howland
T3 R1 NBPP
Burlington
Lowell
Sebec
Guilford
Dover-Foxcroft
Orneville Twp
Lagrange
Edinburg
Passadumkeag
T3 ND
Atkinson
Sangerville
Grand Falls Twp
Summit Twp
Greenbush
Bradford
Charleston
Argyle Twp
Garland
Dexter
Alton
T40 MD
T39 MD
Greenfield Twp
Ripley
Hudson
Corinth
Exeter
Corinna
Indian Island
Milford
T34 MD
Great Pond Plt
T32 MD
Saint Albans
Old Town
Kenduskeag
Glenburn
Stetson
Levant
Orono
Bradley
T28 MD
Newport
Palmyra
Veazie
Aurora
Amherst
Bangor
Hermon
Eddington
Clifton
Carmel
Etna
Plymouth
Detroit
Brewer
Holden
Mariaville
Osborn
Hampden
Orrington
Newburgh
Dixmont
Troy
Otis
Dedham
Waltham
Eastbrook
Burnham
Winterport
Bucksport
Unity Twp
Unity
Thorndike
Jackson
Monroe
Frankfort
T8 SD
Franklin
T9 SD
Orland
Ellsworth
Hancock
Prospect
Verona
Sullivan
Knox
Brooks
Swanville

Appendix B

PENOBSCOT RIVER INTENSIVE SURVEY FIELD DATA

(see station numbers in Penobscot River 2007 data file)

Appendix C
PENOBSCOT RIVER AMBIENT WATER QUALITY
SAMPLES DATA
(see Penobscot River 2007 data file)

APPENDIX D
EFFLUENT SAMPLES DATA
(see Penobscot River 2007 data file)

APPENDIX E
FIELD FILTERED VERSUS LAB FILTERED

Comparison Of for ortho- Phosphorus

samples
filtered in the field vs. filtered in the lab.

HETL

	FILT IN	FILT IN	
	FIELD	LAB	
folder #			sample date
C035062			7/31/2007
	o phos	o phos	
	(ppb)	(ppb)	report date
wbp1 d01	1	1	12/4/2007
wpb2 d01	9	8	
mis d01	2	2	
wbp3 d01	2	1	
wbp5 d01	2	2	
pn1 d01	2	1	
pn3 d01	1	1	
pn4 d01	1	1	
pn5 d01	1	1	
mar d01	1	1	
pis d01	2	1	
ebpn d01	1	1	
katw d01		1700	
kate		8	
orono d01	3400	3400	
REDS	1200	1200	
REDS DUP	1300	NO SAM	
OLD TN	3000	3100	
LPT	240	220	
MIL		2200	
STR	<1	1	
PN9 D01	1	1	
PN 12D01	2	1	
PN13D01	1	1	
PNE12 D01	14	14	
PNE 9 D01	10	9	
PNE 7 D01	8	8	
PNE 5 D01	5	3	
PNE 2 D01	3	1	
PAR D01	2	NO SAM	
PUS	2	1	
MAS	1	1	
VER	1100	1200	
BREW	1300	1300	
BANG	2500	2500	
TRIB DUP	<1	<1	
rivdup1 d01	9	9	
ESTU DUP	9	8	

Ultimate versus BOD5 Ratio

		2007	2001	1997
KATW				
	TBODu	20.3	84.3	72.7
	BOD5	7.1	21.5	15
	BODu/BOD5	2.86	3.92	4.85
MILL				
	TBODu	62.3	109	73.4
	BOD5	9.5	15	10
	BODu/BOD5	6.36	7.26	6.67
KATE				
	TBODu	4.5	9.5	14.7
	BOD5	1.86	1.96	6.33
	BODu/BOD5	2.42	4.85	2.32
LPT				
	TBODu	52.3		51.7
	BOD5	16		27.6
	BODu/BOD5	3.27		1.87
LINC				
	TBODu	18	29	45.8
	BOD5	5.1	11.36	17
	BODu/BOD5	3.53	2.55	2.69
HOWL				
	TBODu	45	36	
	BOD5	8.8	12	
	BODu/BOD5	5.11	3	
OLDT				
	TBODu	30.3	117.3	103.3
	BOD5	7.7	39	35.3
	BODu/BOD5	3.93	3	2.9
REDS				
	TBODu	40.3	44	30.7
	BOD5	11.16	9.3	4.86
	BODu/BOD5	3.61	4.73	6.3
ORONO				
	TBODu	23	19	18.6
	BOD5	4.6	6.33	9.66
	BODu/BOD5	5	3	1.93
VEAZ				
	TBODu	28	43	55.6
	BOD5	6.5	9	12
	BODu/BOD5	4.3	4.77	4.63
BANG				
	TBODu	66.6	46	28.3
	BOD5	7.36	5.66	8.33
	BODu/BOD5	9	8.13	3.94
BREW				
	TBODu	10.3	9.2	91
	BOD5	3.06	3.33	2.96
	BODu/BOD5	3.36	2.79	3.07
WINT				
	TBODu	500	321	244
	BOD5	210	200	153

	BODu/BOD5	2.38	1.6	1.59
BUCK				
	TBODu	380	403	262
	BOD5	140	120	105
	BODu/BOD5	2.7	3.35	2.49
VER				
	TBODu	38.3	32.3	28.3
	BOD5	8.46	9.0	8.16
	BODu/BOD5	4.53	3.58	3.47