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2007 Gulf Island Pond Monitoring Program Report

Maine Department of Environmental Protection

August 2008

EXECUTIVE SUMMARY

This report is prepared in accordance with the requirements of Public Law 2005, chapter 409, An Act to Amend Water Quality Standards. Section 7 or that law requires that by February 1 annually from 2006 to 2011, the Maine Department of Environmental Protection (DEP) shall submit a report on the status of activities undertaken pursuant to this Act to the Joint Standing Committee on Natural Resources. In this regard, DEP's activities for 2007 focused on monitoring of the water quality of Gulf Island Pond in the Androscoggin River to assess attainment of Maine's Water Quality Standards, specifically dissolved oxygen criteria necessary to provide 'habitiat for fish and aquatic life', and 'support of indigenous species of fish', as well as provide for 'recreation in and on the water' (swimming, i.e. presence of algae blooms).

Aerial flights and water quality monitoring of Gulf Island Pond (GIP) on Maine's Androscoggin River was undertaken by DEP in the summer of 2007. The primary goal of this activity was to continue monitoring initiated in prior years to determine compliance with dissolved oxygen criteria and the presence/absence of algal blooms. No algal blooms were observed in 2007. Secchi disk transparency (SD) readings were also taken, and in 2007 the mean was similar to those for all prior years when measured, 2004-2006, and was above the 2 m threshold for blooms in lakes for all but one sampling event. A minimum Secchi Disk Transparency of 1.1 meter on July 17 was due to sediment from an intense storm event on July 11 above Bethel which resulted in a flash flood and extensive erosion, eventually travelling downriver to Lisbon as documented by DEP (Appendix 1). The mean total phosphorus concentration was lowest of all recent years with a maximum concentration occurring during the erosion event. The mean chlorophyll-a concentration was similar to those of 2005-2006. The maximum chlorophyll-a concentration occurred on June 19 and was slightly above the threshold established for lakes (8 micrograms per liter) but below the interim threshold for GIP (10 micrograms per liter). Chlorophyll-a concentrations did not increase with the peak total phosphorus during the erosion event.

Within Gulf Island Pond, minimum and monthly average dissolved oxygen criteria were met for all sampling dates only immediately below the point of oxygen injection into the river at Upper Narrows; One or both of the criteria were not met up to 50% of the time for other stations at various depths. These results emphasize the need for improved and increased oxygenation in Gulf Island Pond as required in the permits that are currently issued. With the current monitoring strategy, it is difficult to fully assess and describe the extent of non-attainment of the criteria. The weekly sampling was not continuous, and the continuous monitoring was not at the needed location and depths and did not provide necessary depth profile data. Beginning in 2008, the monitoring strategy was changed to collect necessary profile data, measuring temperature and dissolved oxygen at one meter increments from top to bottom at the "deep hole" in Gulf Island Pond every two hours during the summer. Further refinements to dissolved oxygen monitoring will likely be needed in 2009 in order to accurately assessment attainment at the point of thermal stratification.

GULF ISLAND POND WATER QUALITY MONITORING REPORT, 2007

Introduction

Water quality monitoring of Gulf Island Pond (GIP) on Maine's Androscoggin River was undertaken by the Maine Department of Environmental Protection (DEP) in the summer of 2007. The primary goal of this activity was to continue monitoring initiated in 2004 and earlier to determine the attainment of Maine's water quality standards (WQS), specifically dissolved oxygen criteria necessary to provide 'habitiat for fish and aquatic life', and 'support of indigenous species of fish', as well as provide for 'recreation in and on the water' (swimming, i.e. presence of algae blooms). A second goal was to gather more data to help determine total phosphorus (TP) and chlorophyll-a (CHLa) thresholds for algal blooms in GIP. And a third goal was to determine the effect of recent reductions in point source discharges on increased attainment of WQS.

An algae bloom in Maine lakes is currently defined as a planktonic growth of algae which causes Secchi disk (SD) transparency to be less than 2 meters (DEP Regulation Chapter 581). However, in waters where color exceeds 30 platinum cobalt units (PCU), SD may be significantly influenced by color as well as algae. Therefore, for colored waters, such as GIP, CHLa is a better measure of blooms. In lakes, blooms have been associated with CHLa concentrations greater than 8 micrograms per liter (ug/l) . Given their higher current velocities, rivers may have higher thresholds of CHLa for blooms. Also, observations of a bloom by the general public include an aspect of visibility, which is affected by light, sky cover, and turbulence (velocity, wind and wave action) on the surface of the water. Although GIP is legally classified as a river, it sometimes acts like a lake or a hybrid of the two where the algae are not uniformly distributed as would be expected in a lake. Therefore, the CHLa threshold for a bloom in GIP, then, may be different, possibly in the range of 8-12 ug/l. The total maximum daily load (TMDL) calculated for GIP, (approved by the federal Environmental Protection Agency -EPA) on July 18, 2005, sets a pond average value of 10 ug/l CHLa as the interim threshold. For calculation of the pond average, CHLa will be included only at those stations where a bloom has been observed. The TMDL also specifies that annual monitoring should continue in order to further refine the CHLa threshold for blooms.

Given the uncertainty in knowing the threshold for an algae bloom in GIP, water quality data specific to GIP were collected and correlated to observations of bloom conditions in 2004, 2005, 2006 and 2007. Aerial observations of bloom and scum layers were documented visually in conjunction with ambient monitoring of CHLa.

There were four parts to the 2007 monitoring program;

1) Aerial flight observations of the presence/absence of wide spread algal blooms,
2) Water quality sampling at the Lower Narrows station during the aerial flights by DEP,
3) Water quality sampling at several stations by the Gulf Island Pond Oxygenation Project (GIPOP) partnership, and
4) Continuous monitoring of temperature and dissolved oxygen at theTurner (Center) Bridge, the deep hole station, and dam station (Figure 1) also by the GIPOP partnership.

Each of these parts is discussed below.

1). Aerial Flight Observations

During the summer of 2007, the Maine Department of Environmental Protection (DEP) conducted weekly aerial monitoring of Gulf Island Pond (GIP) and the Androscoggin River to determine the extent and conditions for algae blooms. The aerial monitoring was conducted by DEP staff from a commercial seaplane base on the Androscoggin River in Turner. A four-person, high wing single engine seaplane (SES) was utilized and afforded the opportunity to land on the river to collect water chemistry data at the Lower Narrows (LN) monitoring station and to also collect water column samples at other locations if bloom conditions occurred. Observations were conducted weekly from May 29 through September 18, 2007, with additional flights on July 13 and 16 to track an unusually high runoff and erosion event that started in the Bethel area. The seaplane had a scheduled departure from Turner at 10 am and typically flew from Turner to Rumford prior to landing at the Lower Narrows (LN) monitoring station in order to collect water chemistry data. All data were recorded on a standard log sheet.

There were ten locations that were part of the aerial monitoring program (Figure 1). . Moving from GIP dam upriver they are denoted as:

(1) Deep Hole-DH
(2) Gulf Island Pond #4-GIP4;
(3) Lower Narrows-LN;
(4) Upper Narrows-UN;
(5) Turner Center Bridge-TCB;
(6) Twin Bridges-TWB;
(7) Androscoggin Lake-AL, and
(8) Dead River Dam-DRD.
(9) Verso Paper discharge –VP
(10) Rumford Paper discharge- RPC

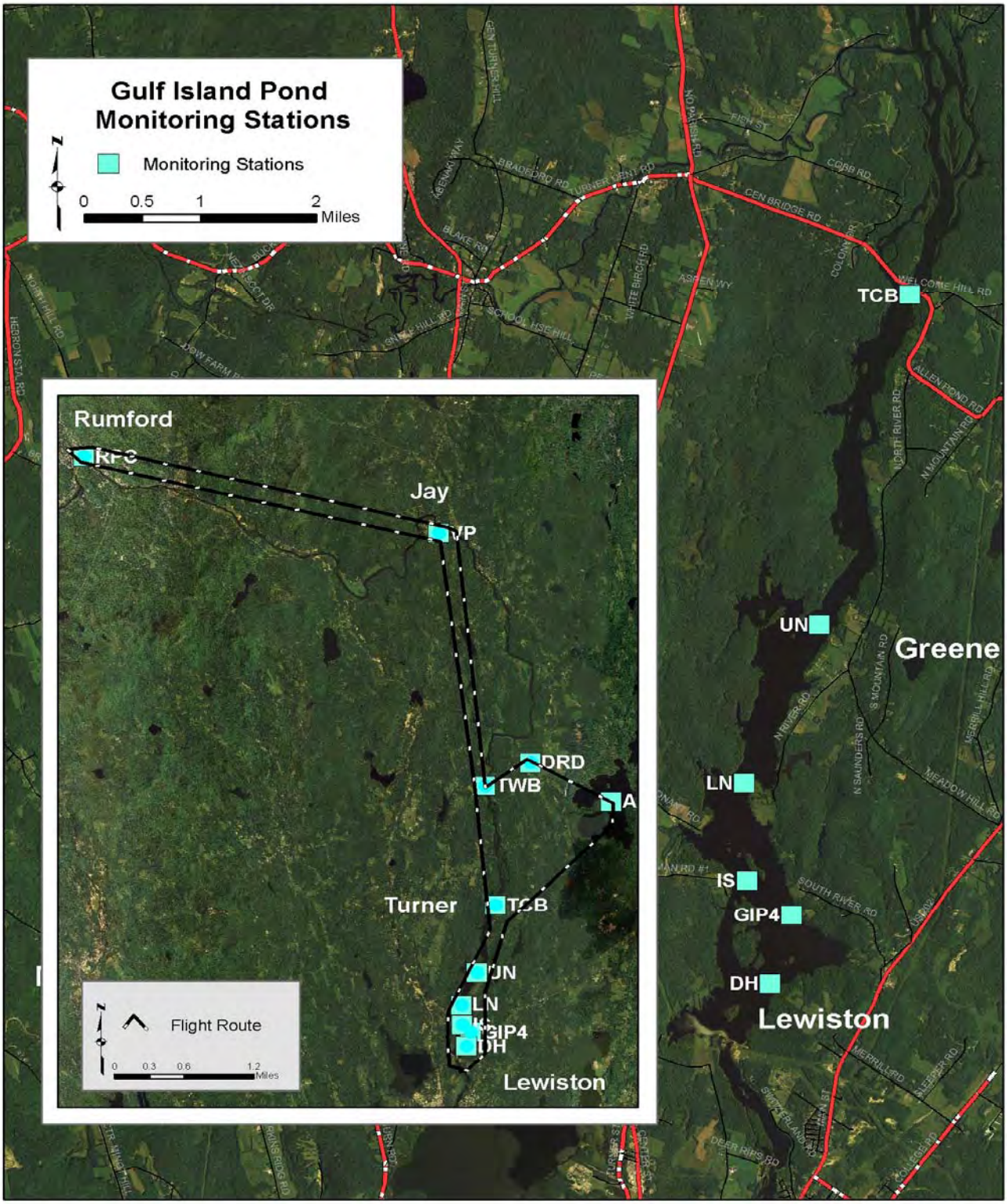
In addition, the monitoring effort included certain locations upriver from Gulf Island Pond in order to determine potential sources of nutrient loading to the watershed. The aerial survey route was northerly to the Upper Narrows monitoring station and northerly along the river to Center Bridge, Androscoggin Lake, Twin Bridges, and then to the paper mills in Jay and Rumford. A southerly route was then taken to the most southerly monitoring stations (Gulf Island Pond monitoring station #4 and to the Deep Hole). At these locations photographs were collected with various aspects in order to collect representative images of the monitoring locations and to collect additional water samples if needed and/or possible based on observations. Digital photographs of the mill discharge outfalls were also taken and compared with reported discharge levels (see the Department's website at http://www.maine.gov/dep/blwq/topic/gip/index.htm). These photos have documented the presence of visible plumes from dischargers on the Androscoggin River. These plumes could possibly represent non-attainment of the recreational designated uses in Maine's Water Quality Standards, which prohibits the *"Discharge of pollutants to waters of the State that imparts color, taste, turbidity, toxicity, radioactivity or other properties that cause those waters to be unsuitable for the designated uses and characteristics ascribed to their class;"* (Title 38 Ch. 3 §464.4).

During 2008 DEP will be conducting public meetings followed by a public hearing by the Board of Environmental Protection, as part of a statutory triennial review of water quality classifications and

standards. At that time the issue will be brought before the public to solicit input about the level of public concern with the potential impact on recreational uses, and the possible need for revisions of water quality standards to address that concern.

On July 11, 2007 there was a 6 to 8 inch rainfall event in the Bethel area which resulted in a flash flood in Chapman Brook, a tributary of the Androscoggin River, which resulted in severe soil erosion and discharge of sediments to the main stem of the river for several days, impacting the river all the way downstream to Lisbon (Appendix 1). The flow rate of the Androscoggin River at Rumford increased from 2,420 cubic feet per second (cfs) to 13,200 cfs within 24 hours (July 11-12, 2007). Aerial observations conducted by fixed wing aircraft on July 13, 2007 revealed a sediment plume extending approximately 63 river miles from Chapman Brook to just north of Center Bridge in Turner Aerial monitoring conducted on July 16, 2007 revealed the sediment plume extended approximately 18 river miles from just north of Center Bridge in Turner to Lewiston near the Lewiston-Auburn Water Pollution Control Authority. Aerial monitoring conducted on July 17, 2007 revealed that the sediment plume extended from Upper Narrows in Greene (near the GIPOP system) to the dam at Lisbon Falls (approximately 24 river miles). Low clouds, rain and obscured conditions prevented additional aerial monitoring of this event beyond July 17, 2007. DEP has prepared a separate report, including photographs, of the event (Appendix 1).

Figure 1. Androscoggin River Aerial Monitoring Stations and Gulf Island Pond monitoring stations



River Flow

Despite the high flow event in mid-July, mean monthly flows for 2007 from the U.S. Geological Survey (USGS) gage at Auburn were among the lowest of the last four years (Figure 2). Mean flow for the three month summer period of 2007 was lower than those of 2005 and 2006, but higher (3913 cfs) than that of 2004 (2928 cfs). In 2007 the mean daily flow (discharge) fluctuated with the high flow event and weekly regulation for hydropower generation, but was generally below the long term median for the period of record (Figure 3).

Figure 2. Mean monthly flow (Qr) in the Androscoggin River at Auburn, Maine, 2004-2007

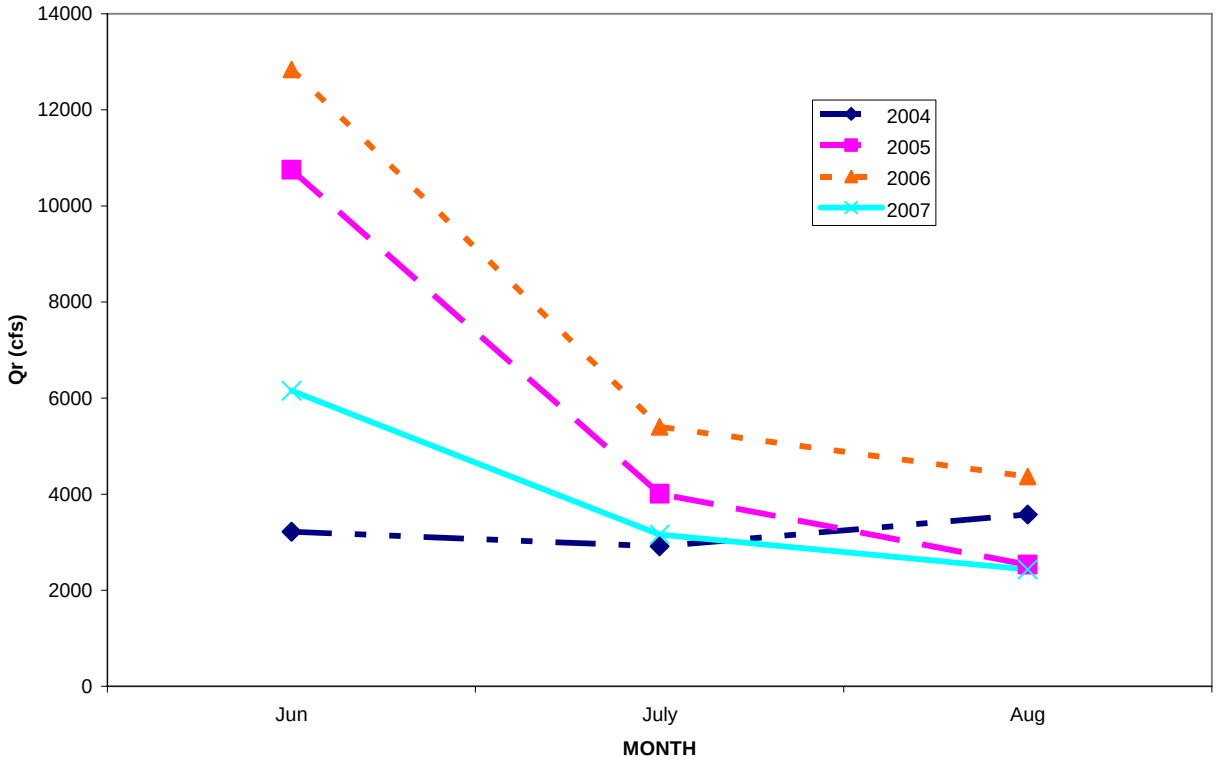
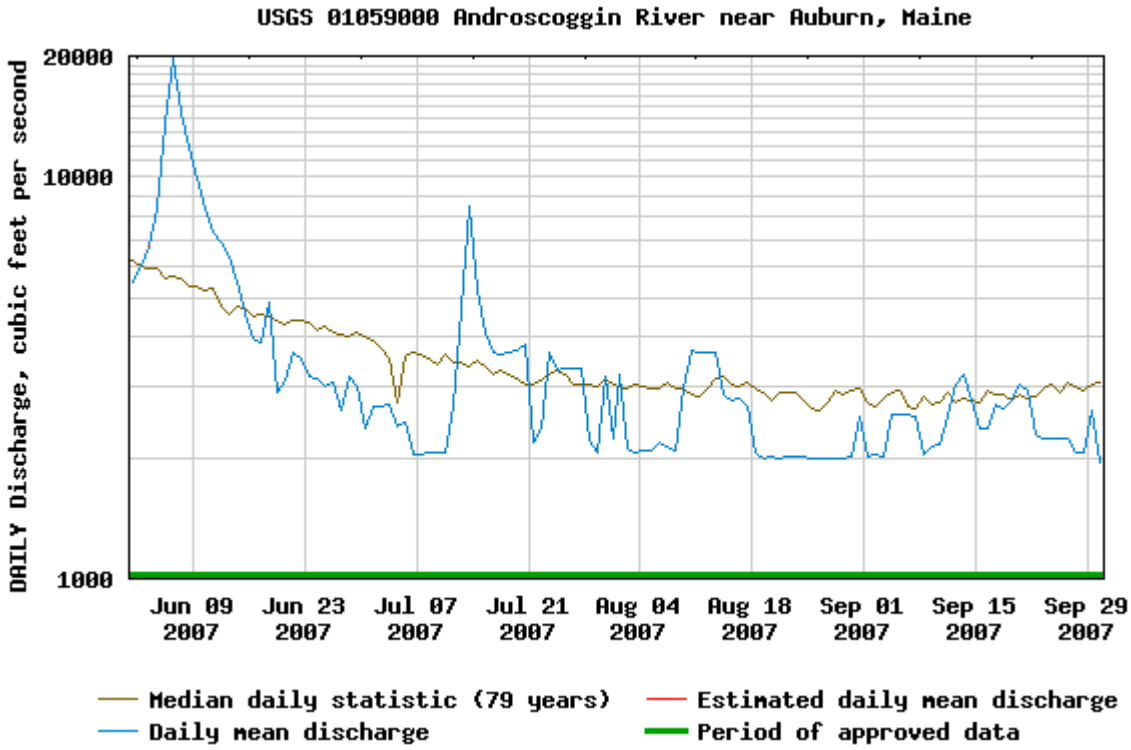


Figure 3. Mean daily discharge

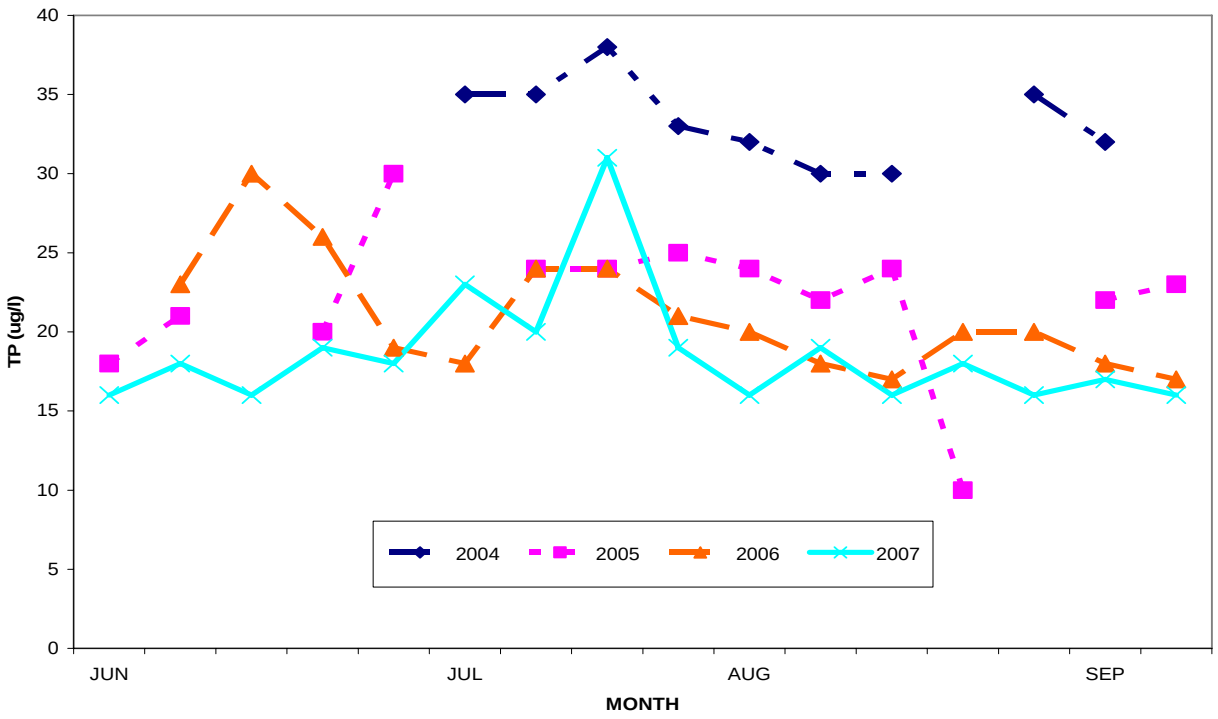


2. Water Quality Sampling at Lower Narrows by DEP, and
3. Water Quality Sampling at 6 GIP stations by Acheron on behalf of the GIPOP partnership

TOTAL PHOSPHORUS

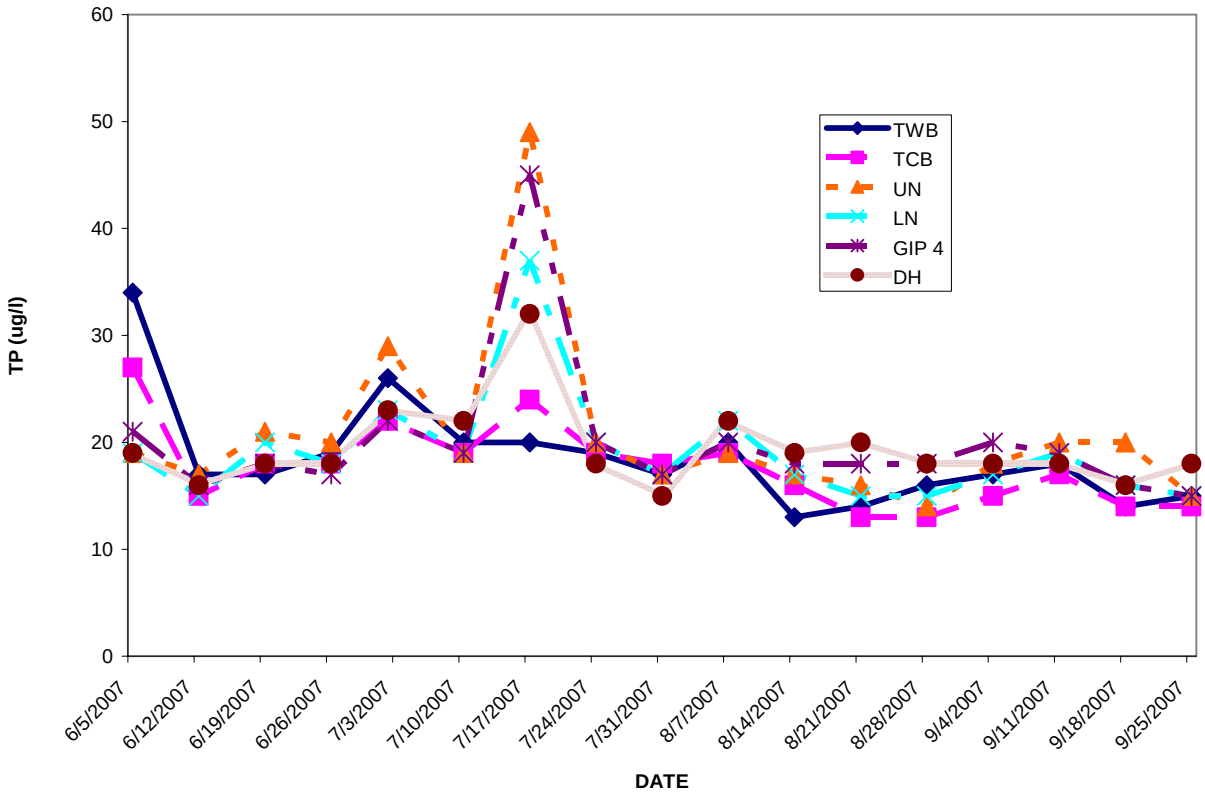
Samples for total phosphorus (TP) were collected by DEP weekly at Lower Narrows (LN) during the aerial flights. Additional samples were to be collected at any other locations where a bloom was observed, but no blooms were observed in 2007. The highest TP concentration (31 ug/l) occurred on July 17 and was well above the threshold (15 ug/l) normally associated with blooms in lakes with low color. (Figure 4). In colored lakes (>30 PCU), higher TP concentrations are usually required to cause a bloom due to chelation of TP by tannins and lignins responsible for the high color and also due to the limited depth of sunlight penetration to depth. Given that GIP usually has color >30 PCU at summer flows due to the mill discharges, the TP threshold for blooms is likely higher than in waters with low color. The peak TP in 2007 was due to the high runoff event in Chapman Brook above Bethel on July 11 which resulted in a flash flood event and massive soil erosion into tributaries and the river (Appendix 1). River flow at Rumford increased from 2,420 cubic feet per second (cfs) to 13,200 cfs in 24 hours (July 11-12, 2007). The plume from the sediment load was tracked by DEP aerial flights all the way downstream to Lisbon by July 17. Mean TP for 2007 (19 ug/l) was slightly but significantly lower than those of 2004 (33 ug/l), 2005 (22 ug/l), and 2006 (21 ug/l) likely due to improvements in effluent quality from the mills. This decrease in TP was not due to increased river flows since in 2007 mean summer river flow (3913 cfs) was actually lower than those from 2005 and 2006 (Figure 2), although higher than that of 2004 (2928 cfs).

Figure 4. Total phosphorus (TP) at Lower Narrows (LN) in GIP, 2004-2007



Weekly samples for Ortho-Phosphorus (OP), TP and chlorophyll a were taken and analyzed by Acheron at the first 6 locations in DEP's aerial monitoring program. TP concentrations in the upper (euphotic) zone were quite constant over the summer with few exceptions (Figure 5). The TP peak on June 5 occurred on the rising slope of the hydrograph from a storm on June 4 (Figure 3) when there was more than 2 inches of rain (as recorded in Portland). The peak TP on July 17 is consistent with the arrival of the sediment load from the erosion event above Bethel on July 11. The small TP peak on July 2 was not correlated with high river flow, however. There was good correspondence for mean summer TP at LN from the Maine Health and Environmental Testing Lab (HETL) (18.6 ug/l) and Acheron (19.1 ug/l) and, for most days, differences were less than 1 ug/l with the maximum difference of 6 ug/l on July 17.

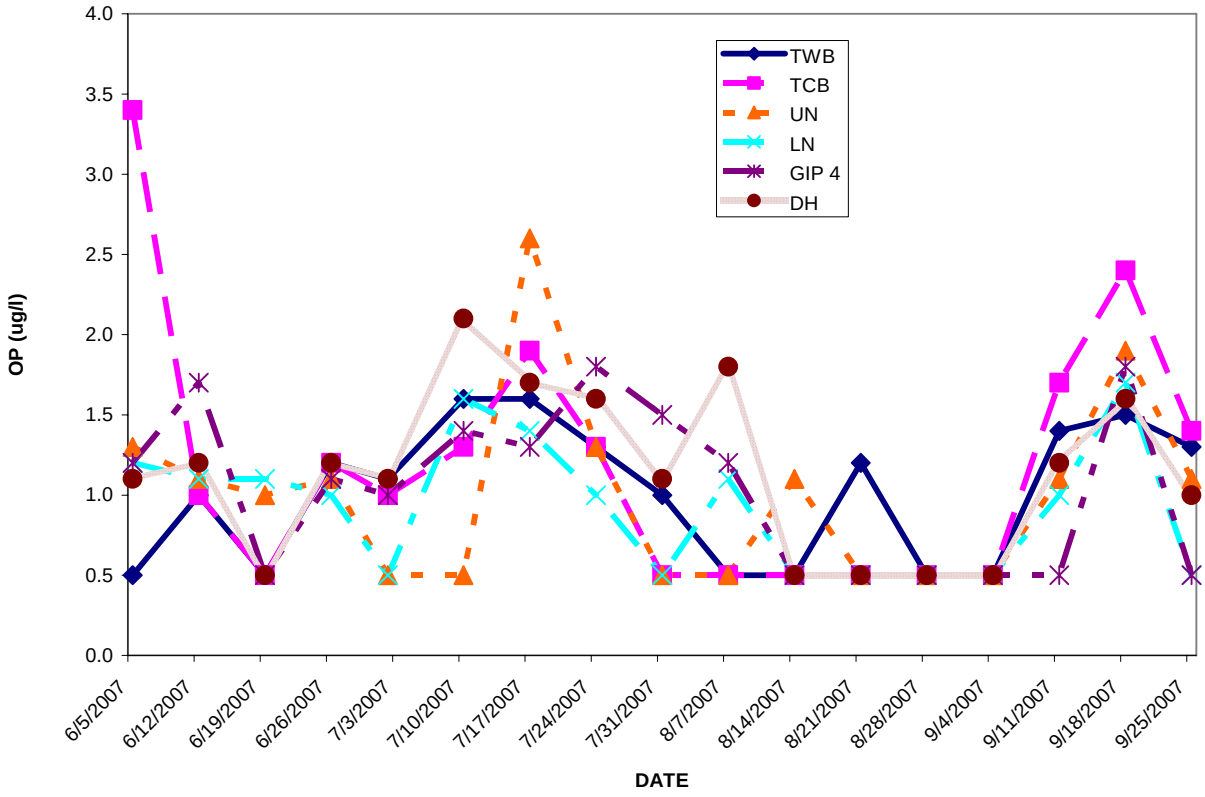
Figure 5. Total phosphorus (TP) at 6 stations in GIP, 2007



ORTHO-PHOSPHORUS (OP)

Dissolved ortho-phosphorus (OP) values were quite low and generally followed the same pattern as TP, but with more variability (Figure 6, non-detects calculated at one half the detection limit at 0.5 mg/l). The peaks in early June and July 17 occurred at the same time as those for TP. The peak OP in September was not seen with TP. But the range for OP at that time is small and may represent reduced uptake with cooling temperatures near the end of the season that may not be significant.

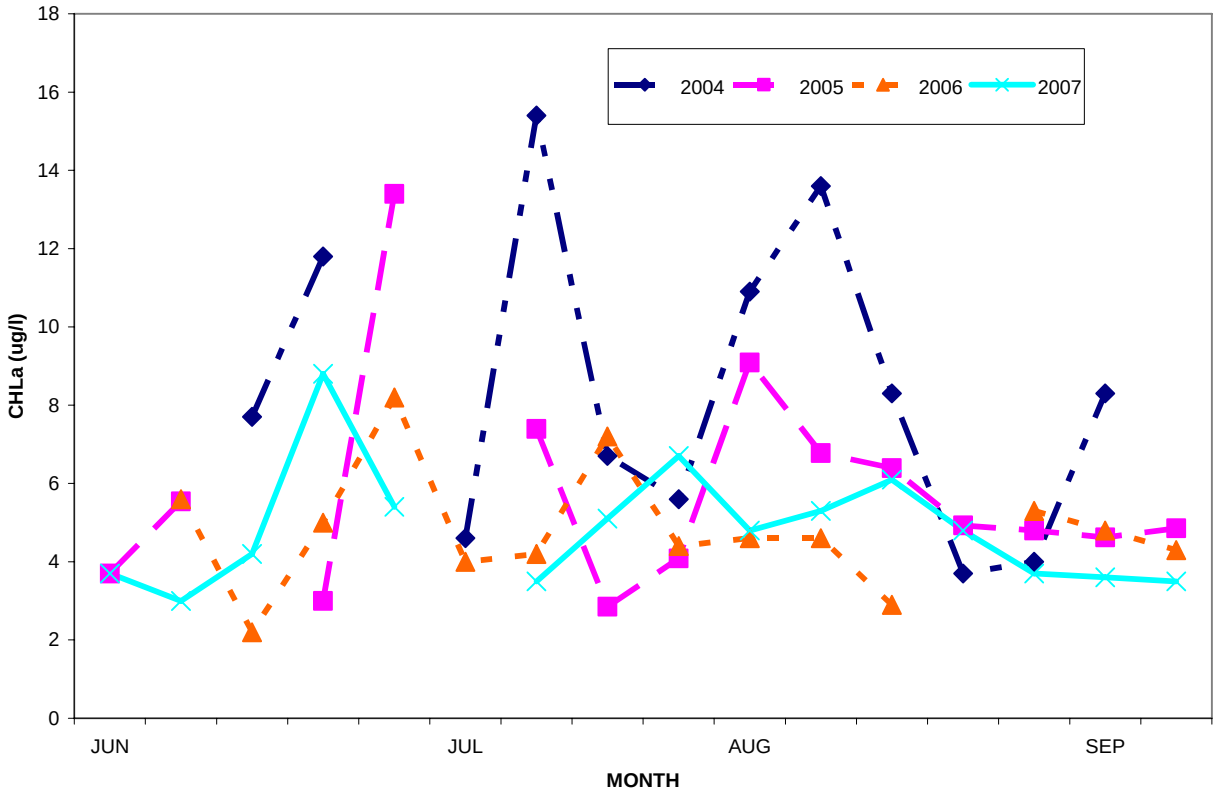
Figure 6. Dissolved ortho-phosphorus (OP) at 6 stations in GIP 2007



CHLOROPHYLL –A (CHLa)

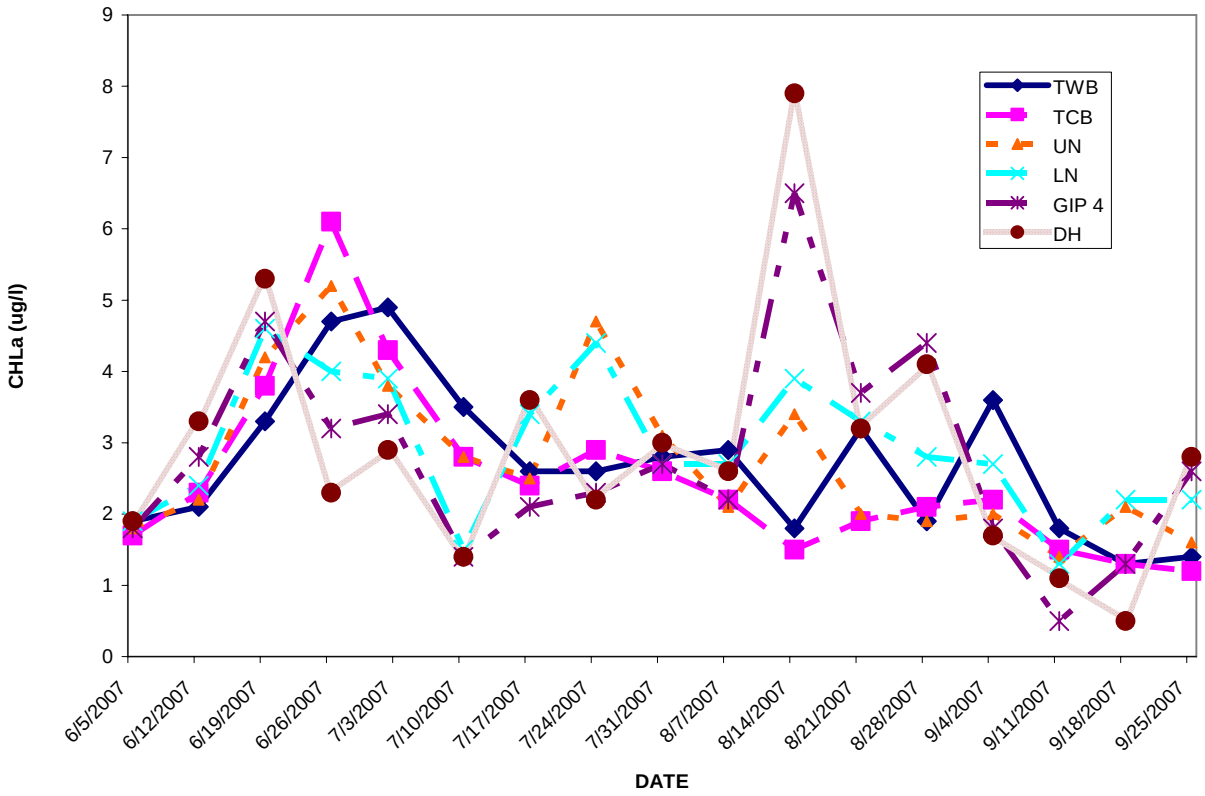
In 2007 DEP sampling at LN found that the mean CHLa concentration of 4.8 ug/l for the summer was significantly lower than that of 2004 (8.4 ug/l) but not those of 2005 (5.9 ug/l) and 2006 (4.8 ug/l) which were also significantly lower than those of 2004. Sampling on June 19, 2007 documented CHLa just above the threshold used for lakes (8 ug/l) for defining a phytoplanktonic algae bloom but below the interim threshold (10 ug/l) proposed for GIP (Figure 4). There was no observation of a bloom from the aerial flights on this or any other sampling date. CHLa on July 17, the date of the highest TP concentration, was not particularly high (5.1 ug/l) and not correlated with TP.

Figure 7. Chlorophyll-a (CHLa) at Lower Narrows (LN) in GIP, 2004-2007



Weekly sampling at 6 stations by Acheron for the GIPOP partnership showed only one event with CHLa approaching the 8 ug/l bloom threshold for lakes (Figure 8) This event was on August 14 at the DH station and the value (7.9 ug/l) represents the mean of two quite disparate duplicates (9.6 ug/l and 6.2 ug/l). On this date at LN, CHLa = 6.1 ug/l from HETL while CHLa = 3.9 ug/l from Acheron. In fact there was a significant discrepancy between the two labs for the mean summer CHLa (HETL CHLa = 4.8 ug/l vs Acheron CHLa = 2.9 ug/l). The date with the highest CHLa values for both labs was the same, June 19, although the values were significantly different (DEP/HETL CHLa = 8.8 ug/g vs Acheron CHLa = 4.6 ug/l). Three weekly samples from all stations collected by Acheron and split to be analyzed at each lab showed values from Acheron ranging from 0.9-1.7 ug/l lower than those from HETL. In 2008 three weekly samples will be split between Acheron, HETL, and the University of Maine Sawyer Environmental Chemistry Research Lab (SECRL). Previous split sample results between HETL and SECRL have shown good correspondence. Regardless of the discrepancy in CHLa values between the two labs, CHLa did not exceed the interim threshold for algal blooms in GIP (10 ug/l).

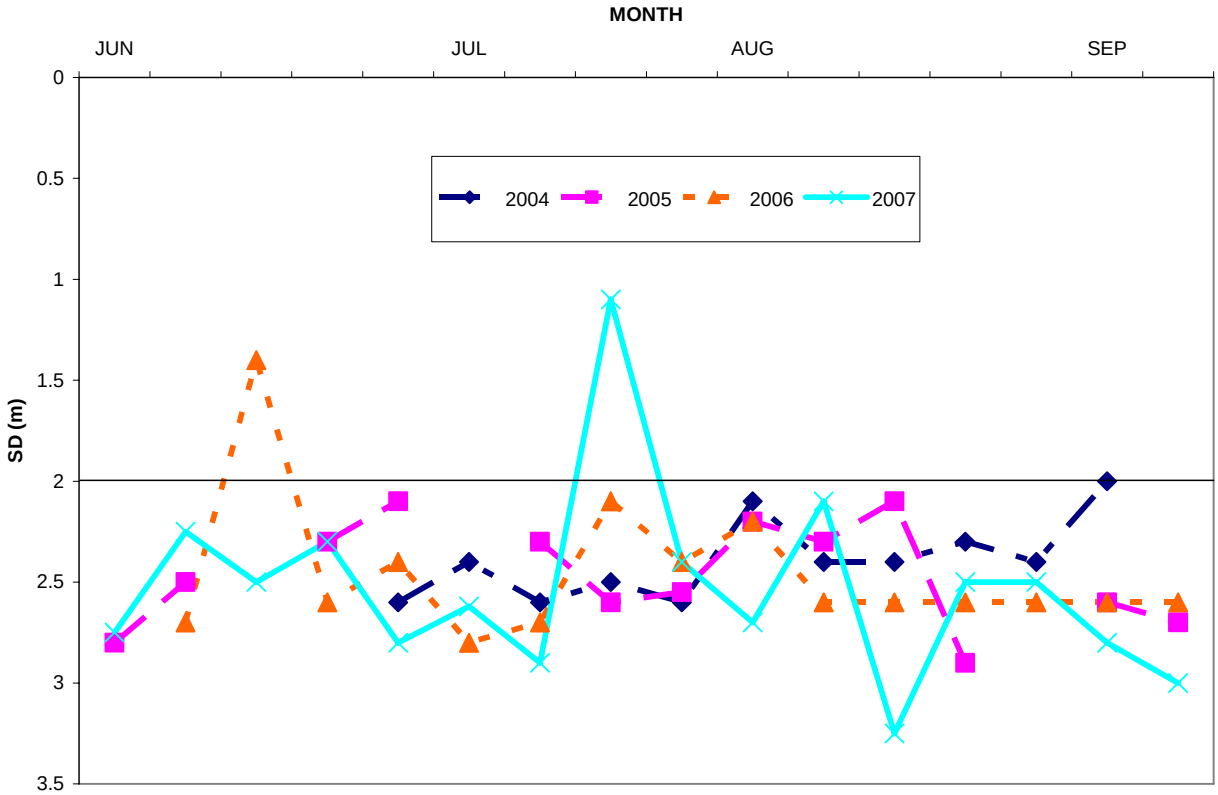
Figure 8. Chlorophyll-a (CHLa) at 6 stations in GIP, 2007



SECCHI DISK TRANSPARENCY (SD)

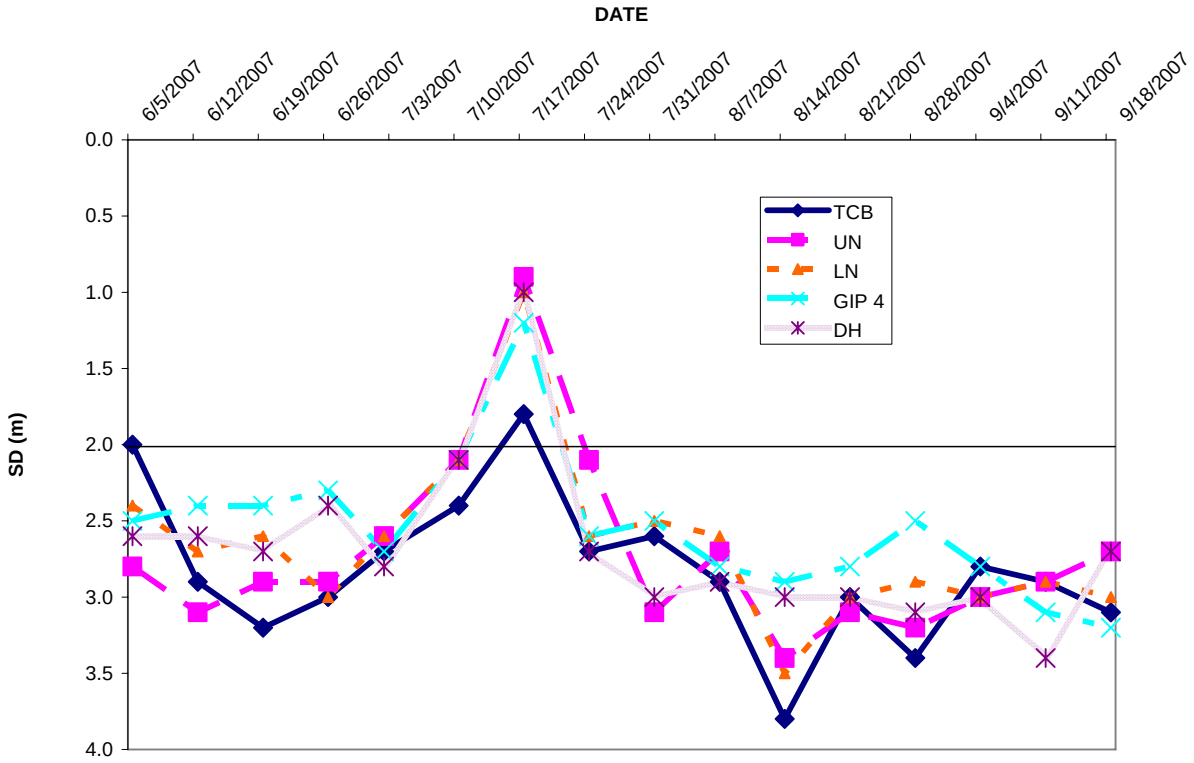
DEP sampling in 2007 at LN documented a SD less than 2 m (meters), the definition of a bloom in uncolored lakes, only on July 17 (Figure 5). This was caused by sediment from the upriver erosion event and the algal density as measured by CHLa was not unusually high on this date. Mean summer SD was no different than it has been since the present monitoring strategy began in 2004. SD is not the most sensitive measure of algal biomass in GIP due to elevated color which affects the SD as does algal density.

Figure 9. Mean Secchi Disk (SD) transparency at Lower Narrows, GIP, 2004-2007



Sampling by Acheron documented SD>2 m except for July 17 at all stations (Figure 10). Transparency was best at TCB and lower downriver as the suspended solids plume passed downstream. There was not a lot of difference between stations, although SD at TCB was more often greater than at GIP 4 or DH stations. This is not unexpected as the TCB station is upstream and more riverine than the other two stations, which would allow algae less ability and time to maintain position in the water column to develop than at the two lower stations.

FIGURE 10. SECCHI DISK (SD) TRANSPARENCY AT 6 STATIONS IN GULF ISLAND POND, 2007



TEMPERATURE AND DISSOLVED OXYGEN

In order to meet Maine's Water Quality Standards, particularly the narrative criteria which requires that Maine waters'provide habitat for fish and aquatic life… and … support indigenous species of fish' with respect to measurement of dissolved oxygen in riverine impoundments, Maine statute at 38 M.R.S.A. §464.13, specifies the following:

Measurement of dissolved oxygen in riverine impoundments. Compliance with dissolved oxygen criteria in existing riverine impoundments must be measured as follows.

A. Compliance with dissolved oxygen criteria may not be measured within 0.5 meters of the bottom of existing riverine impoundments.
B. Where mixing is inhibited due to thermal stratification in an existing riverine impoundment, compliance with numeric dissolved oxygen criteria may not be measured below the higher of:

(1) The point of thermal stratification when such stratification occurs; or

(2) The point proposed by the Department as an alternative depth for a specific riverine impoundment based on all factors included in section 466, subsection 11-A and for which a use attainability analysis is conducted if required by the United States Environmental Protection Agency.

For purposes of this paragraph, "thermal stratification" means a change of temperature of at least one degree Celsius per meter of depth, causing water below this point in an impoundment to become isolated and not mix with water above this point in the impoundment.

C. Where mixing is inhibited due to natural topographical features in an existing riverine impoundment, compliance with numeric dissolved oxygen criteria may not be measured within that portion of the impoundment that is topographically isolated. Such natural topographic features may include, but not be limited to, natural deep holes or river bottom sills.

Notwithstanding the provisions of this subsection, dissolved oxygen concentrations in existing riverine impoundments must be sufficient to support existing and designated uses of these waters. For purposes of this subsection, "existing riverine impoundments" means all impoundments of rivers and streams in existence as of January 1, 2001 and not otherwise classified as GPA. (emphasis added).

Thermal stratification typically results in three vertical zones or layers;

1) the epilimnion (top layer which is relatively homothermous,),
2) the metalimnion or thermocline (middle layer of thermal transition) and
3) the hypolimnion (bottom layer which is relatively homothemous).

The thermocline is defined as the zone where the temperature decreases at least one degree Celsius per meter of depth. Typically this zone is several meters thick, and therefore, to determine compliance with the statute in thermally stratified riverine impoundments, it is necessary to choose one depth within this zone as the 'point' of compliance. As defined in statute and in consideration of the last paragraph as the overall controlling section, DO levels must be sufficient to support designated and existing uses of the waterbody, which requires the protection of a cold water zone providing habitat for indigenous species of

fish, i.e. some amount of water cold enough with enough oxygen to support cold water fish. After consultation with the Department of Inland Fisheries and Wildlife, the Commissioner of DEP stated in a letter of January 23, 2007 to the Gulf Island Pond Partnership (GIPOP), that for thermally stratified impoundments, "the Department will consider the point of thermal stratification to be the bottom of the first meter segment in the thermal profiling data where the temperature gradient is one degree Celsius or greater per meter". The intention of this clarification is to ensure that there is at least one meter of cold water within the thermocline with enough oxygen so that the narrative water quality criteria are met.

DEP Sampling at Lower Narrows

In 2007, DEP measured temperature and dissolved oxygen (DO) at Lower Narrows (LN) weekly in vertical profiles at 1 meter (m) increments. Maximum depth at LN is approximately 15 m, and varies weekly by 1-2 m due to drawdown for hydropower generation at the Gulf Island Dam. Although not the deepest part of GIP, LN exhibited thermal stratification on 5 of the 16 sampling days, including an extended period from June 19 to July 2 (possibly extending from as much as June 15 to July 6) and single weeks around May 31 and August 7 (Appendix 2). There were excursions below the minimum DO criterion of 5 mg/l during both stratified and non-stratified sampling events. DO levels were below 5 mg/l at or above the point of thermal stratification (POTS), which is indicated on the charts below and is measured at a depth of 1 meter below the first indication of thermal stratification, for 5 of 16 sampling dates (June 19, 26, July 2, 31, August 7) (Figures 11-15). Given that these dates were single sampling events, assumed to be representative of all the days between the dates, and assuming a linear transition in DO levels between adjacent weekly sampling dates, then there is about 31% of the summer sampling period when DO is below 5 mg/l.

Figure 11. Temperature (T) and dissolved oxygen (DO) at LN June 19, 2007

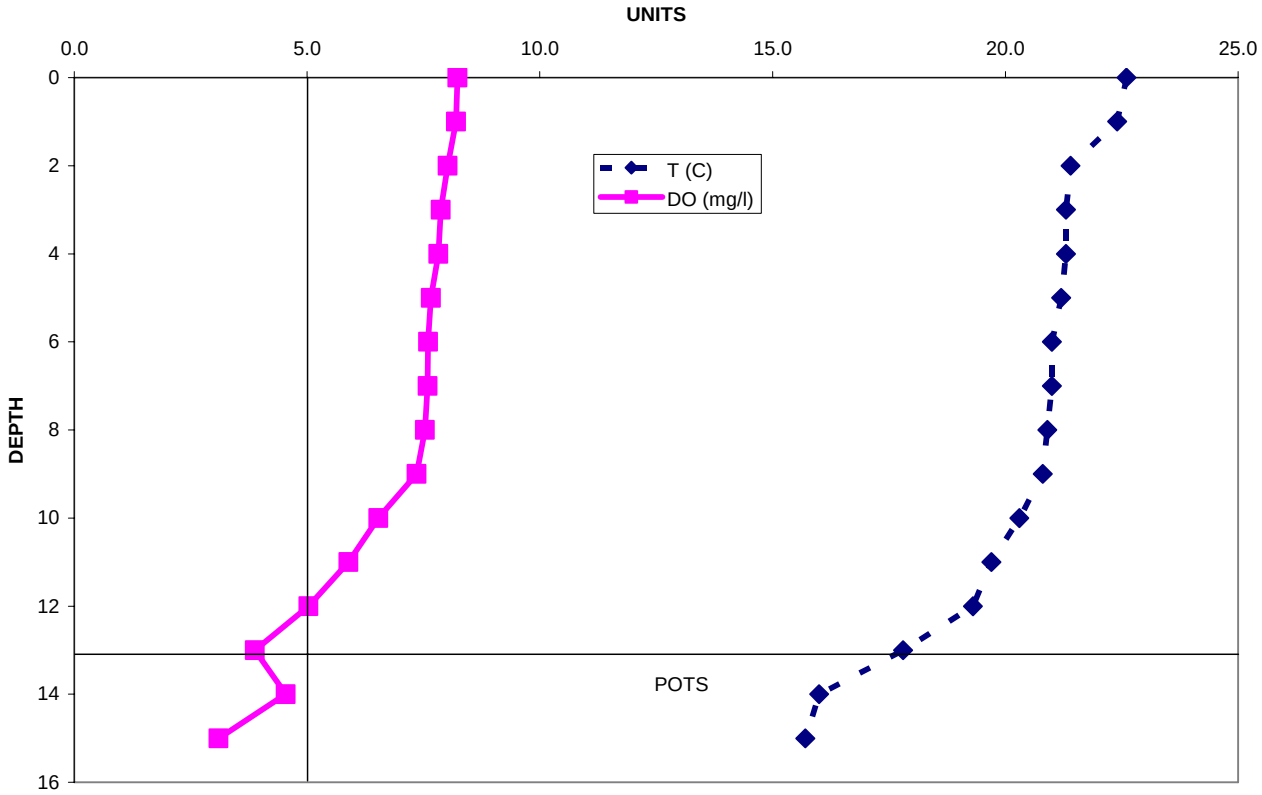


Figure 12. Temperature (T) and dissolved oxygen (DO) at LN June 26,2007

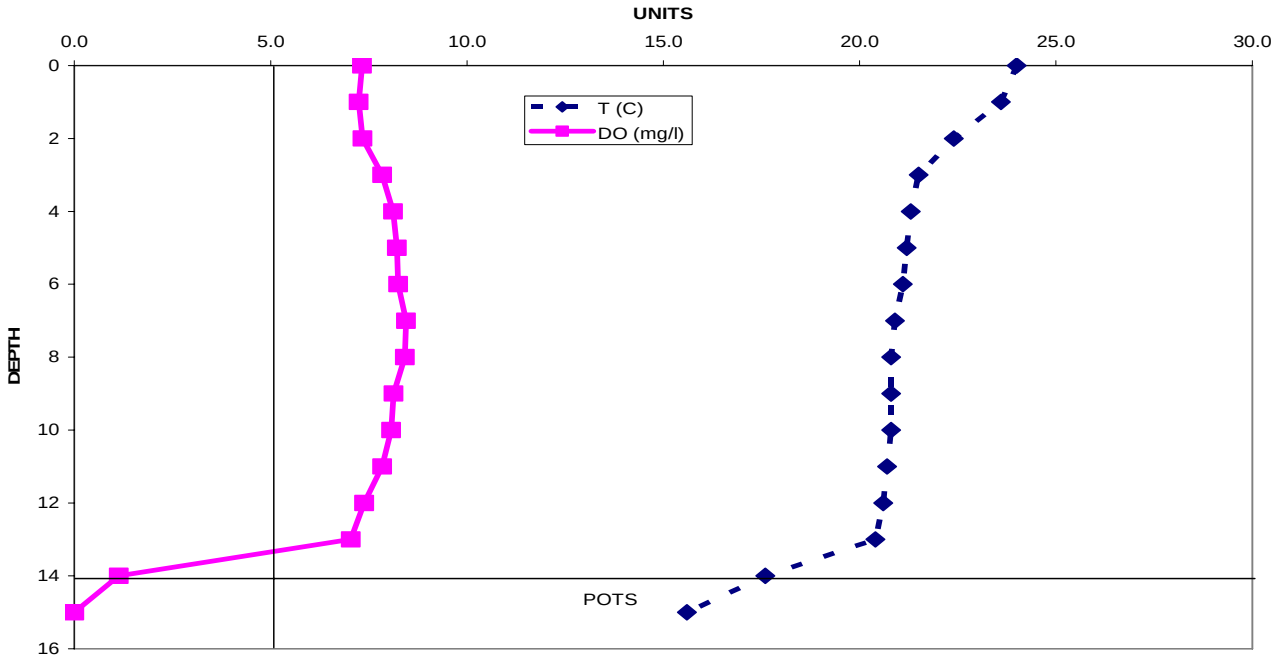


Figure 13. Temperature (T) and dissolved oxygen (DO) at LN July 2, 2007

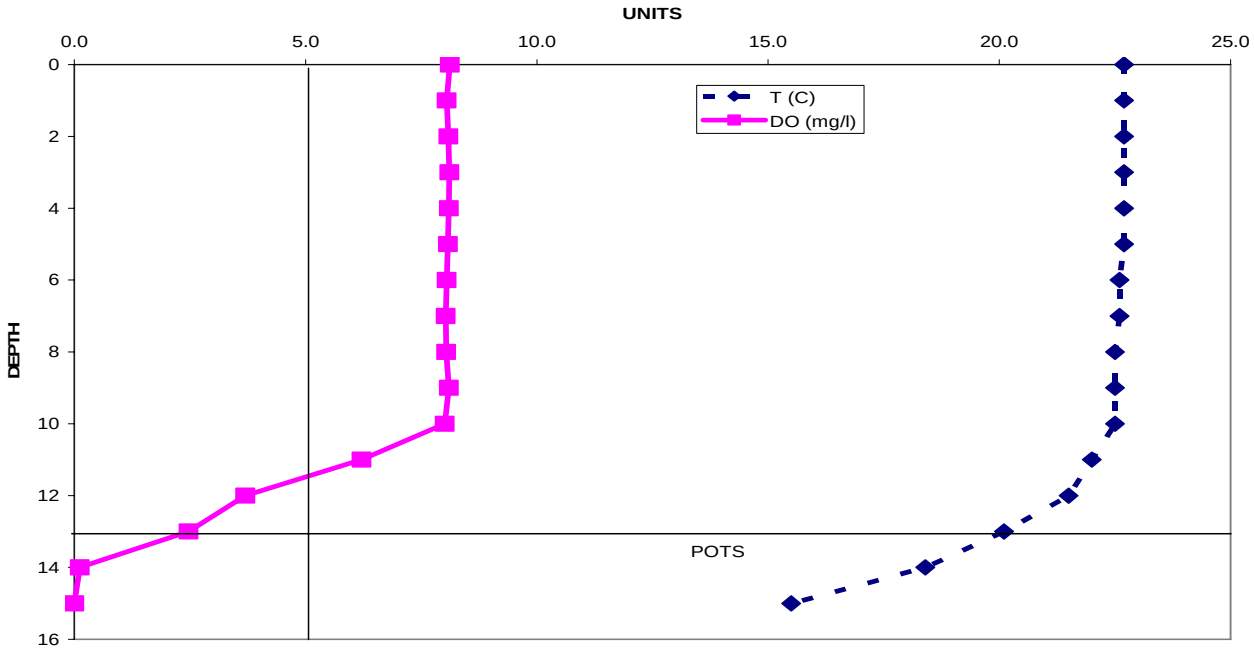


Figure 14. Temperature (T) and dissolved oxygen (DO) at LN July 31, 2007

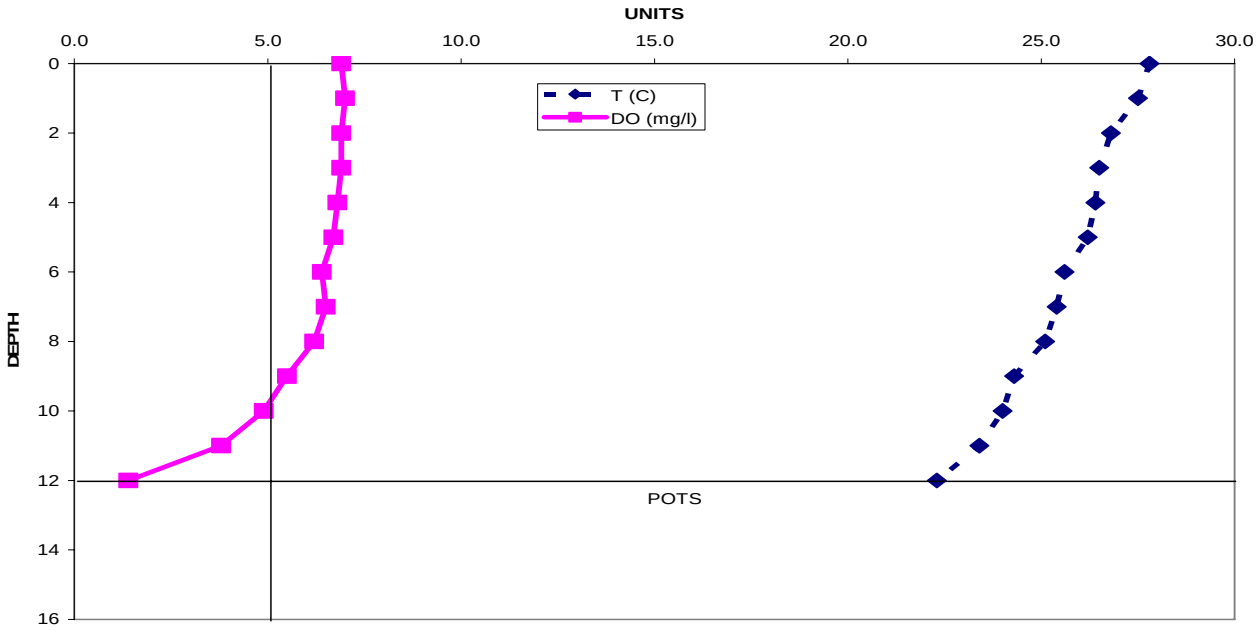
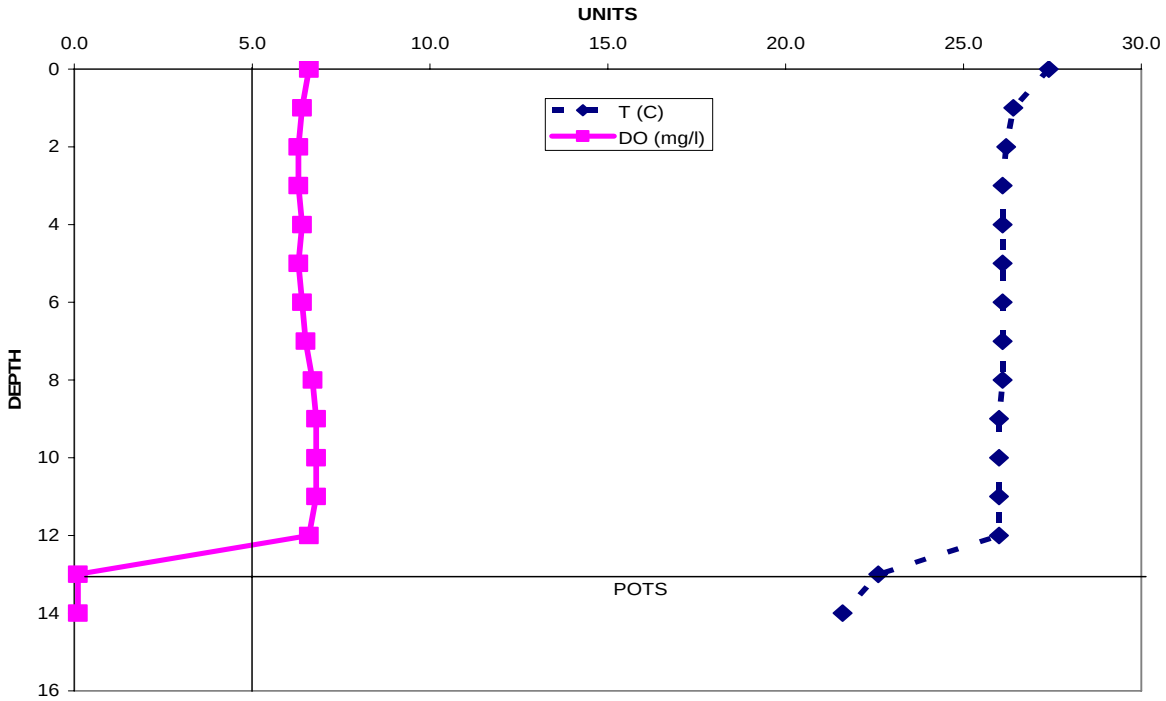
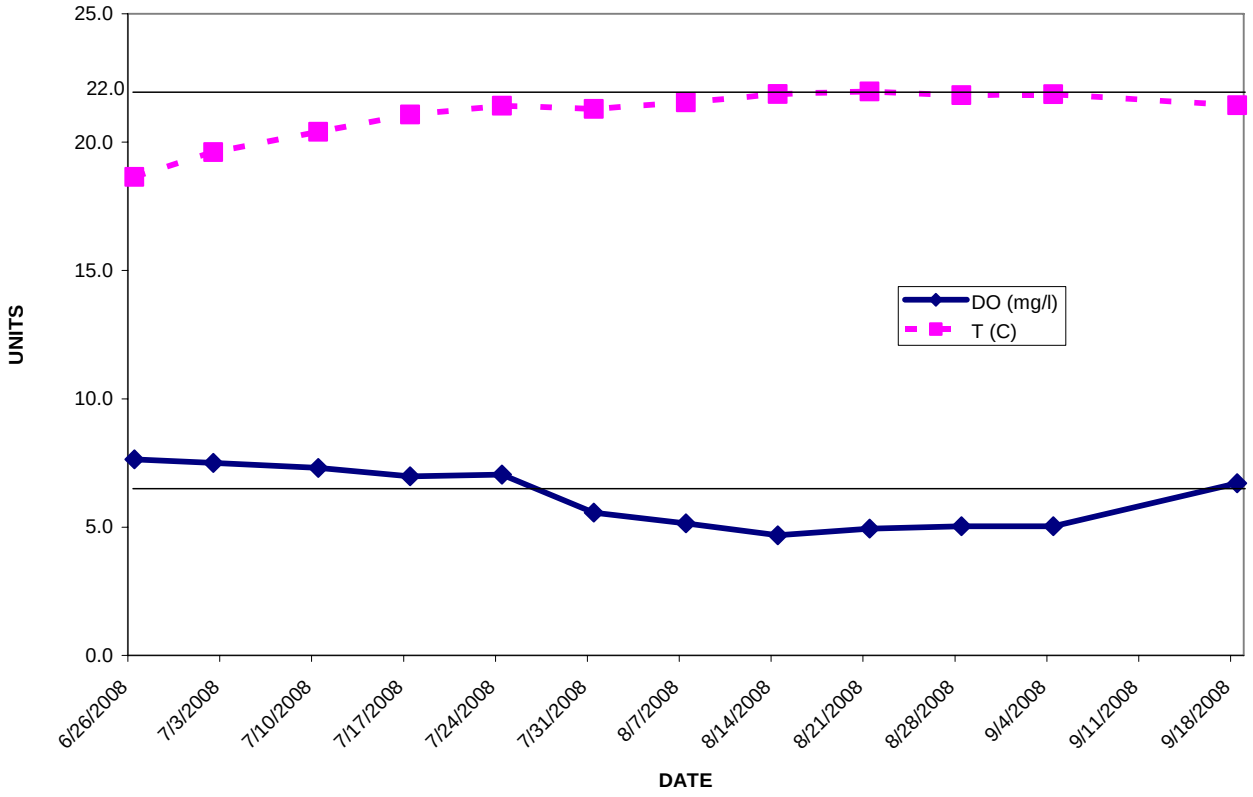


Figure 15. Temperature (T) and dissolved oxygen (DO) at LN August 7, 2007



The rolling monthly average DO criterion of 6.5 mg/l applies when temperature is 22°C or below (38 MRSA § 465 (4)(B)). In 2007 at Lower Narrows there was non-attainment of the 6.5 mg/l monthly average criterion from about July 27 through September 16, about 44% of the summer sampling period, assuming a linear transition of DO and interpolating between sampling dates (Figure 16). The rolling monthly average (RMA) DO was calculated for each sample date as the depth integrated mean for all data in the previous four weeks where the mean temperature was less than or equal to 22°C at the point of thermal stratification.

Figure 16. Rolling monthly average temperature (T) and dissolved oxygen (DO) at LN 2007



Sampling by GIPOP

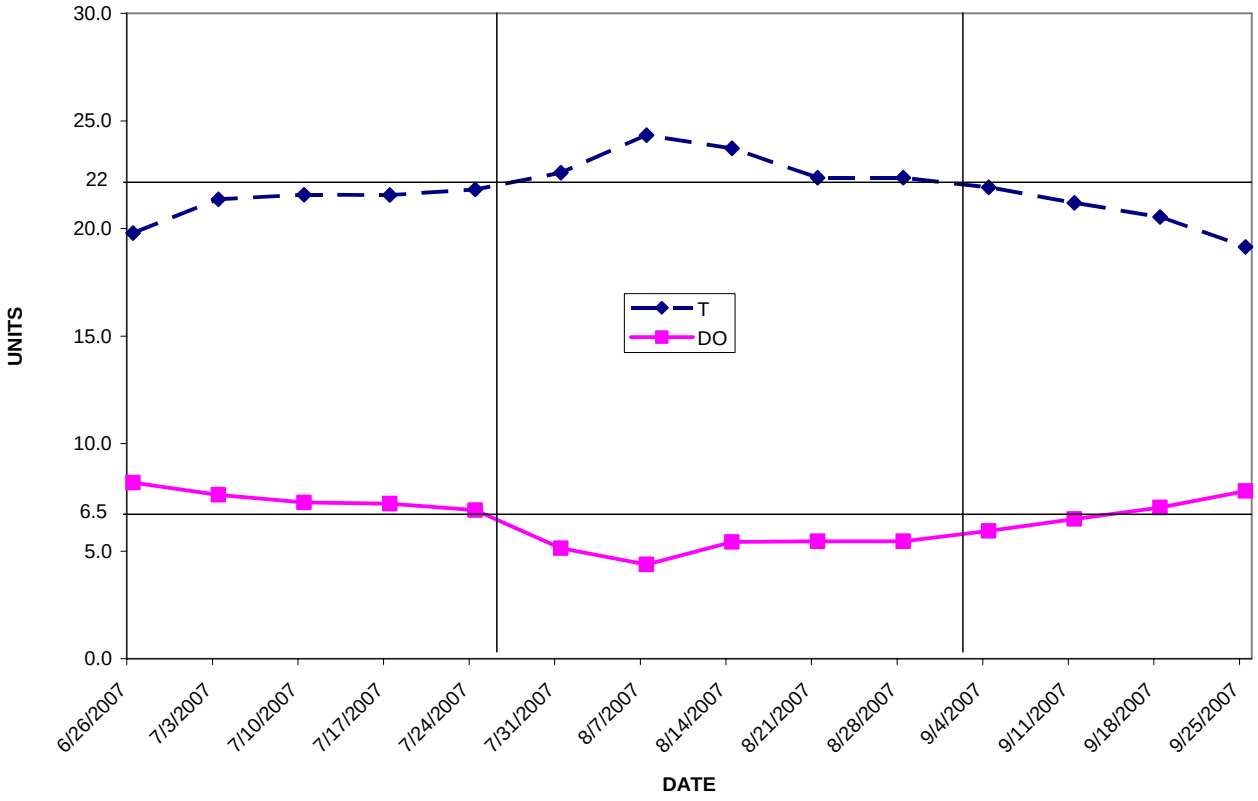
Detailed results of weekly temperature and DO profile measurement made at 5 GIP stations by Acheron are available for viewing in paper copy or on CD at DEP or on the web at http://www.maine.gov/dep/blwq/topic/gip/ . This report states that there were 67 points above the thermocline where DO was less than 5 mg/l. Since this included all depth readings on a given day where DO was less than 5 mg/l, the report overstates the non-compliance. However, it does not include portions of the thermocline above the point of compliance, and therefore is not a complete analysis. There were measurements taken in both the morning and afternoon on 17 weeks. Examination of the data reveals the

findings that follow, by stations. The bottom most reading is not counted as it is difficult to determine if the probe is in the sediments and the reading may reflect sediment DO more than the water DO.

TCB Station

At TCB there were 5 of 17 sampling dates (July 24, 31, August 7, 14, 28), representing 29% of the summer, when DO was in non-attainment of the minimum DO criterion of 5 mg/l during morning, afternoon, or both. The rolling monthly average (RMA) DO was below the 6.5 mg/l monthly average criterion from about July 25 to September 14 (Figure 17). However, water temperature was greater than 22°C, when the monthly average criterion does not apply (between the 2 vertical lines), for all but a few days before and after this period, leaving about 14% of the summer sampling period for which the RMA was calculated when the monthly average criterion was not attained.

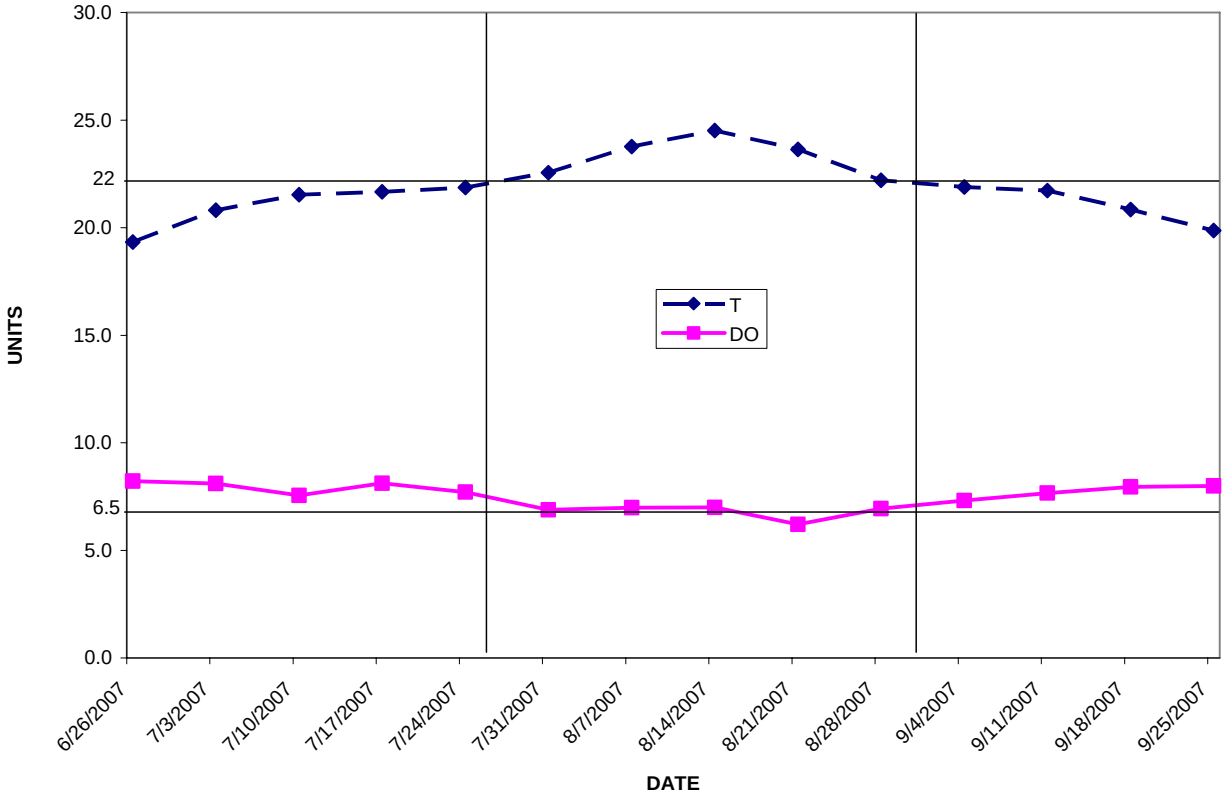
Figure 17. Rolling monthly average temperature (T °C) and dissolved oxygen (DO, mg/l) at TCB, 2007



UN Station

At UN there were 0 of 17 sampling dates, when DO was in non-attainment of the minimum DO criterion of 5 mg/l, which would be expected since it is immediately below the point of oxygen injection into the river. There was only one of the fourteen calculated RMAs that was below the 6.5 mg/l criterion (Figure 18). On 8/21 the RMA was 6.2 mg/l but this was during the period when the temperature was greater than 22°C (between the two vertical lines) and therefore the monthly average DO criterion does not apply.

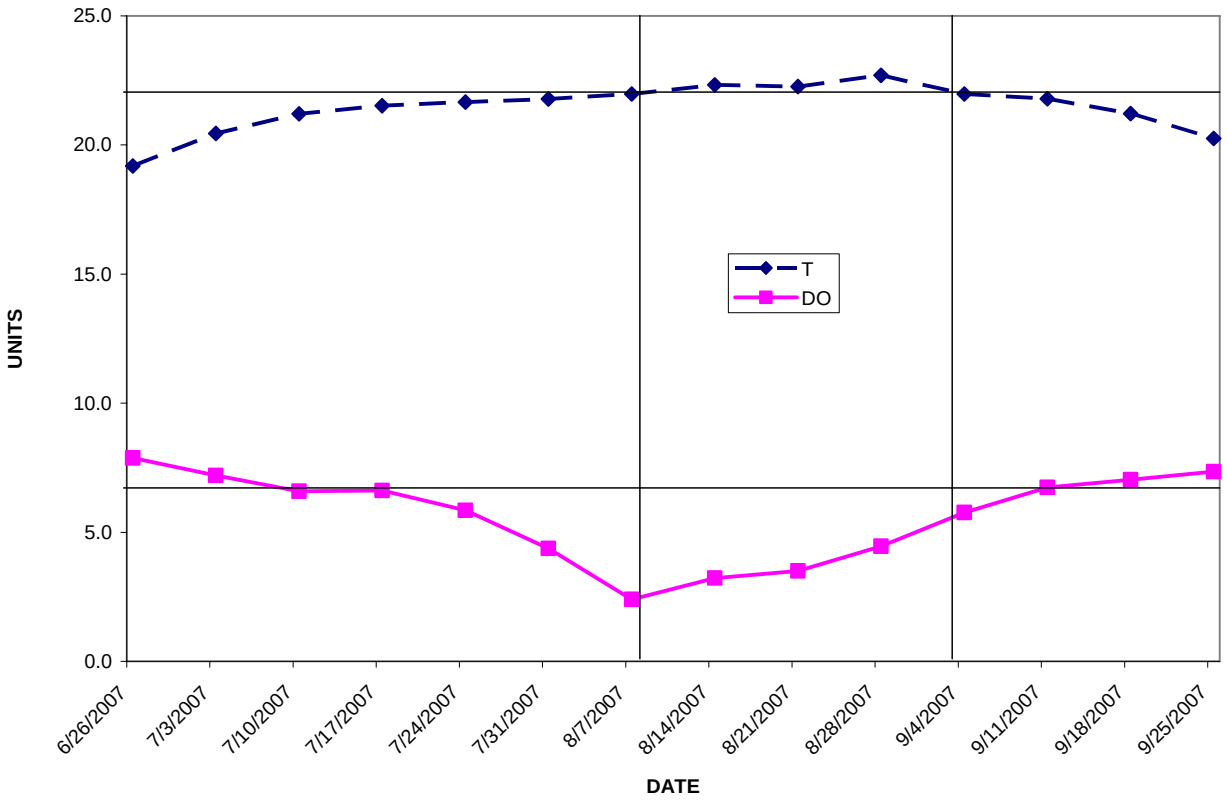
Figure 18. Rolling monthly average temperature (T °C) and dissolved oxygen (DO, mg/l) at UN, 2007



LN Station

At LN there were 5 of 17 sampling dates (June 19, July 3, 31, Aug 7, 14), representing 29% of the summer, when DO was in non-attainment of the minimum DO criterion of 5 mg/l during morning, afternoon, or both. The RMA DO was below the monthly average 6.5 mg/l criterion from about July 18 to September 9, or about 57% of the summer sampling period for which the RMA was calculated (Figure 19). However, the temperature was greater than 22°C, when the monthly average criterion does not apply, from about August 9 to September 3 (between the two vertical lines), leaving about 30% of the period when the monthly average criterion was not attained. The reason that this plot and % non-attainment is different from DEP data from the same location is due to several factors. The Acheron data were collected in the early morning and afternoon whereas DEP data were collected around mid-day, which can make a difference in both the temperature and DO. Acheron collects data from an anchored boat whereas DEP collects data from a float plane where it is more difficult to stay at the exact same point. The DEP data (Figure 16) showed no period where the temperature was greater than 22°C and therefore there was no period where the monthly average DO criterion did not apply. The Acheron data showed temperatures just a little higher during mid August, but enough that the temperature was greater than 22°C and that the monthly average DO criterion did not apply as noted above.

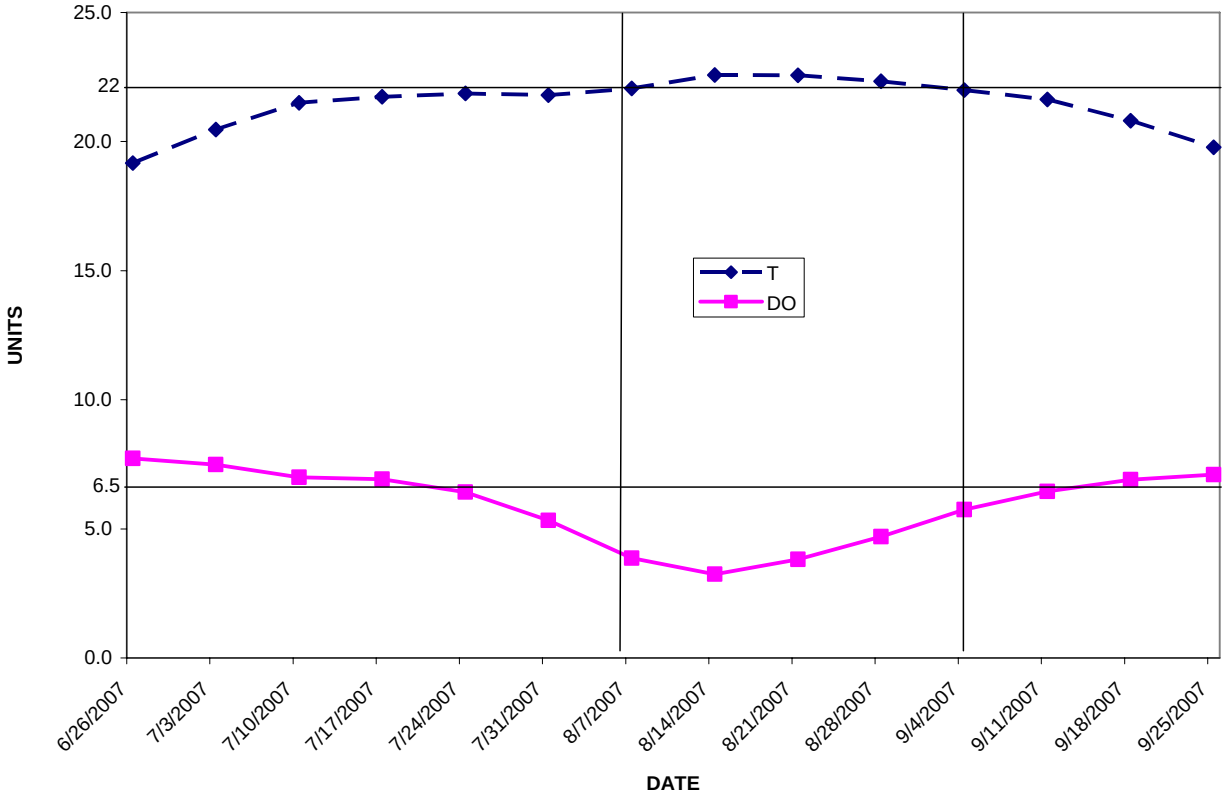
Figure 19. Rolling monthly average temperature (T °C) and dissolved oxygen (DO, mg/l) at LN, 2007



GIP 4 Station

At GIP 4 there were 6 of 17 sampling dates (June 19, July 3, 24, 31, August 7, 14), or about 35% of the summer, when DO was in non-attainment of the minimum DO criterion of 5 mg/l during morning, afternoon, or both. The RMA DO was below the monthly average 6.5 mg/l criterion from about July 23 to September 11, or about 51% of the summer sampling period for which the RMA was calculated (Figure 20). But the temperature was greater than 22°C, when the monthly average criterion does not apply (between the two vertical lines) from about August 6 to September 2, leaving about 21% of the period when the monthly average criterion was not attained.

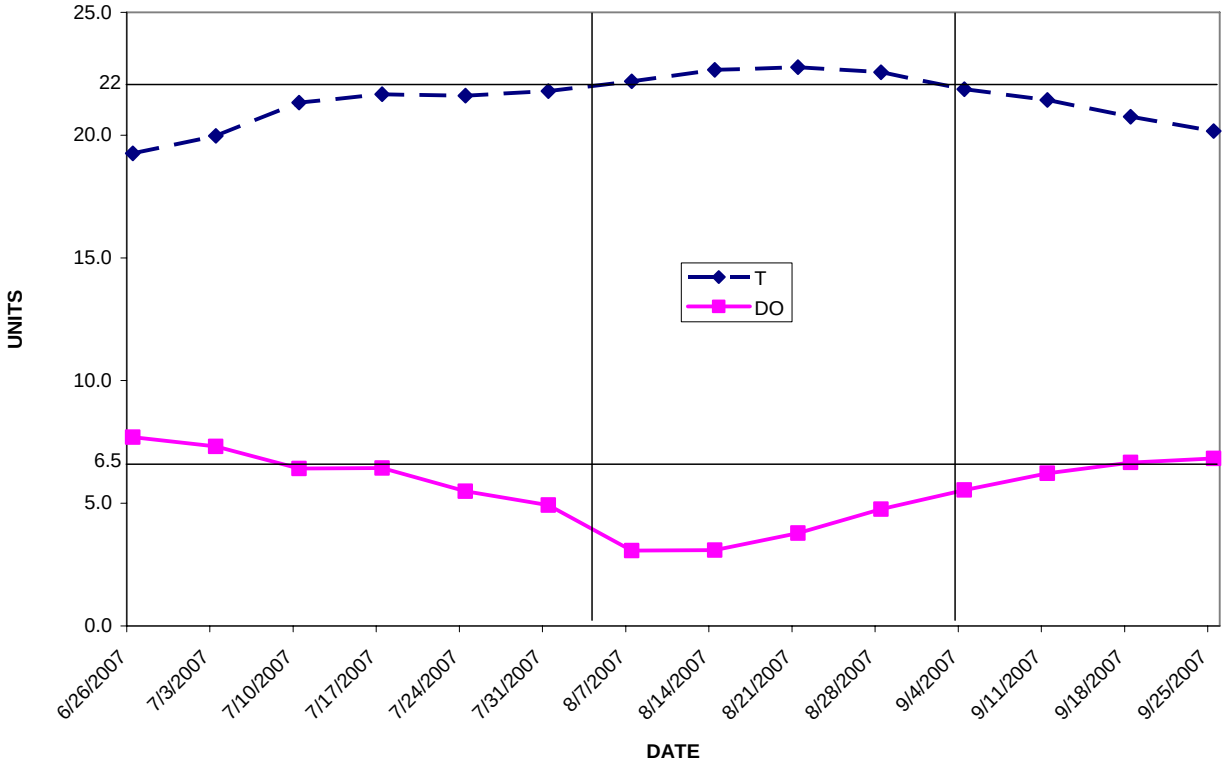
Figure 20. Rolling monthly average temperature (T °C) and dissolved oxygen (DO, mg/l) at GIP4, 2007



DH Station

At the DH there were at least 8 of 17 sampling dates (June 19, 26, July 3, 10, 24, 31, August 7, September 4), representing about 47% of the summer, where DO was in non-attainment of the minimum DO criterion of 5 mg/l during morning, afternoon, or both. The rolling monthly average DO was below the monthly average 6.5 mg/l criterion from about July 5 to September 15, representing about 71% of the summer sampling period for which the RMA was calculated (Figure 21). However, the temperature was greater than 22°C, when the monthly average criterion does not apply (between the two vertical lines), from about August 2 to September 2, leaving 39% of the summer where the monthly average DO criterion was not attained.

Figure 21. Rolling monthly average temperature (T °C) and dissolved oxygen (DO, mg/l) at DH, 2007

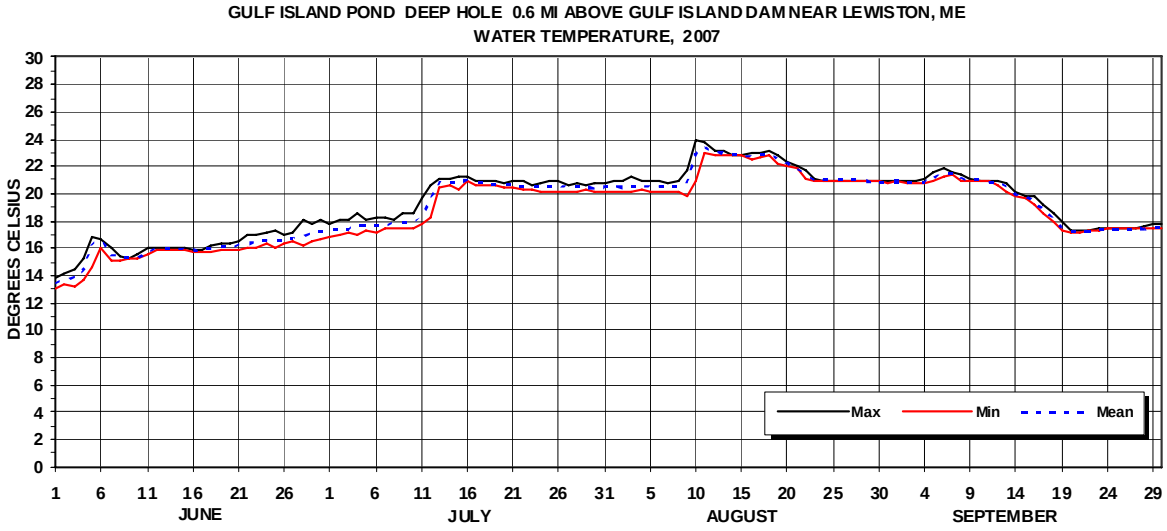


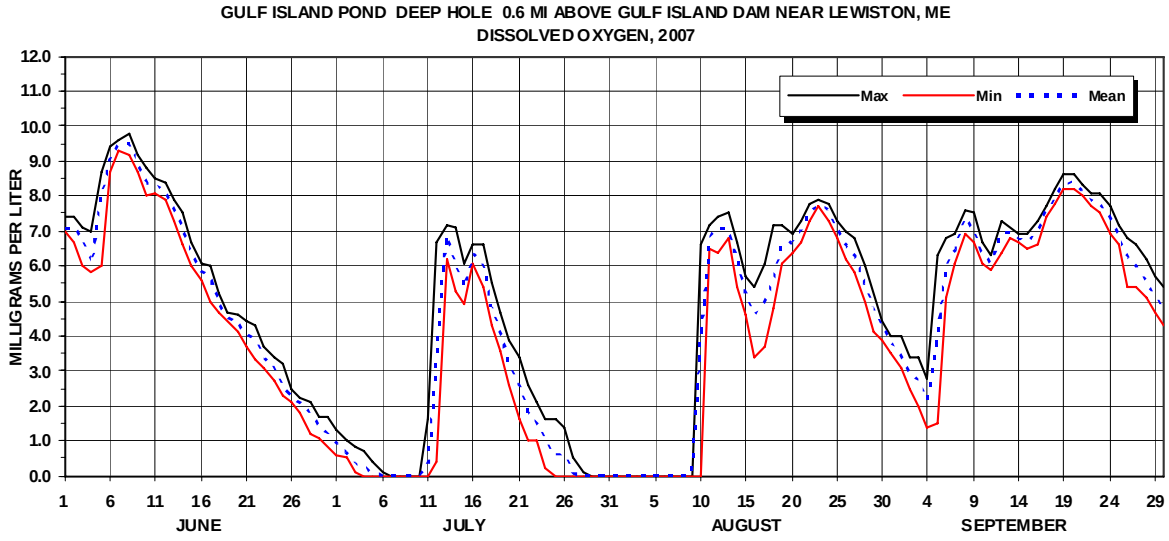
4. CONTINUOUS TEMPERATURE AND DISSOLVED OXYGEN DATA

The current temperature (T) and dissolved oxygen (DO) continuous monitoring plan was approved as an attachment to the consent agreements with Boise Cascade and International Paper in 1990 in order to verify the water quality model for GIP. Continuous monitoring was required at the bottom of the river at TCB upstream of the diffuser and at the 5, 20, 35, and 50 foot depths 0.2 miles upstream of the dam. Later at the DEP's request, continuous monitoring at DH was initiated 0.6 miles upstream of the dam, but only at a single depth somewhere near the bottom. This monitoring strategy never was sufficient to determine compliance with Maine's water quality criteria for dissolved oxygen. Consequently, DEP conducted its own monitoring after the diffuser began operation in 1992, measuring DO profiles from the surface to the bottom at the deep hole and other stations. With the enactment of 38 MRSA 464 (13) the continuous monitoring at the 5, 20, 35, and 50 foot depths is even less useful for monitoring compliance with the water quality criteria as it is insufficient to determine the location of the point of stratification and thermocline.

Nevertheless, the continuous monitoring data from 2007, gathered and reported by Water Monitoring Services, Inc. on behalf of the GIPOP, can provide some information about compliance. Data from the 50 foot depth at the dam station show that the minimum DO<5.0 ppm for about 11% of the summer sampling period. The mean monthly DO for July was 6.4, just under the monthly average criterion of 6.5 mg/l. The DH data also can be used. Data from Water Monitoring Services show T and DO recorded at a depth of 20-25 feet from the bottom during 2007 (Figure 22). The data show that when is less than or equal to 22 C, DO is less than 5 mg/l about 29% of the summer sampling period. If 1 meter profiles had been measured to provide better data, actual amount of time of non-compliance would likely have been more. Raw data are available for viewing in paper copy at DEP or on the web at http://www.maine.gov/dep/blwq/topic/gip/ .

Figure 22. CONTINUOUS MEASUREMENT OF the temperature AND DO AT DH AT ~18 M, 2007 (data from Water Monitoring Services on behalf of GIPOP)





POINT OF THERMAL STRATIFICATION (POTS)

As stated in Commissioner Littel's January 23, 2007 letter, "the Department will consider the point of thermal stratification to be the bottom of the first meter segment in the thermal profiling data where the temperature gradient is one degree Celsius or greater per meter" and " this approach is designed to ensure the existence of an oxygen enriched area where cold water species of fish can retreat to during warm

weather that will provide the statutory dissolved oxygen level for cold water fish for at least one meter of depth, and is consistent with both the statute's clear language and pupose".

While a literal view might be that the POTS in a thermally stratified body of water is the shallowest depth where temperature is one degree Celsius cooler than the temperature one meter above in the water column, DEP's extensive experience with lakes reveals that this depth may not always guarantee at least one meter of cold well-oxygenated water. In strongly stratified waters, temperature can change by more than one degree within a depth increment as little as ~0.2 m (< 1 foot) as shown below for some data from Webber Pond based on measured values at 1 m increments (Figure 23). An expanded view of the segment between 4 and 5 m (labeled here as between 1 and 2 m due to limitations of Excel) overstates the suitable habitat (~1.2-2 = 0.8 m) (e.g. temperature less than 23°C) when measurements are made at only 1 m increments with a straight line interpolation (Figure 24). Actual suitable habitat is much less (~1.8-2 = 0.2 m) if more frequent measurements were made as shown by a synthesized example of typical observations at more frequent increments (0.2 m here) between 1 and 2 meters.

Figure 23. Temperature profile Webber Pond 8/16/01

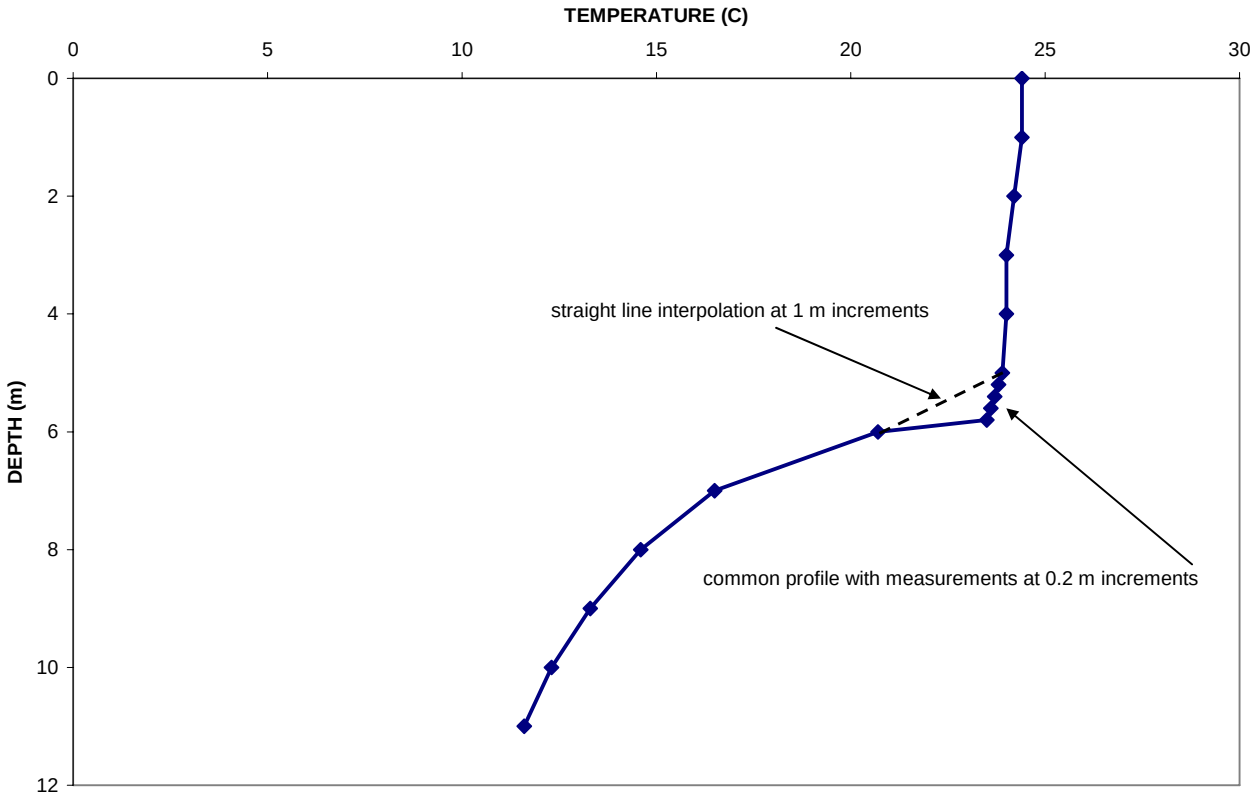
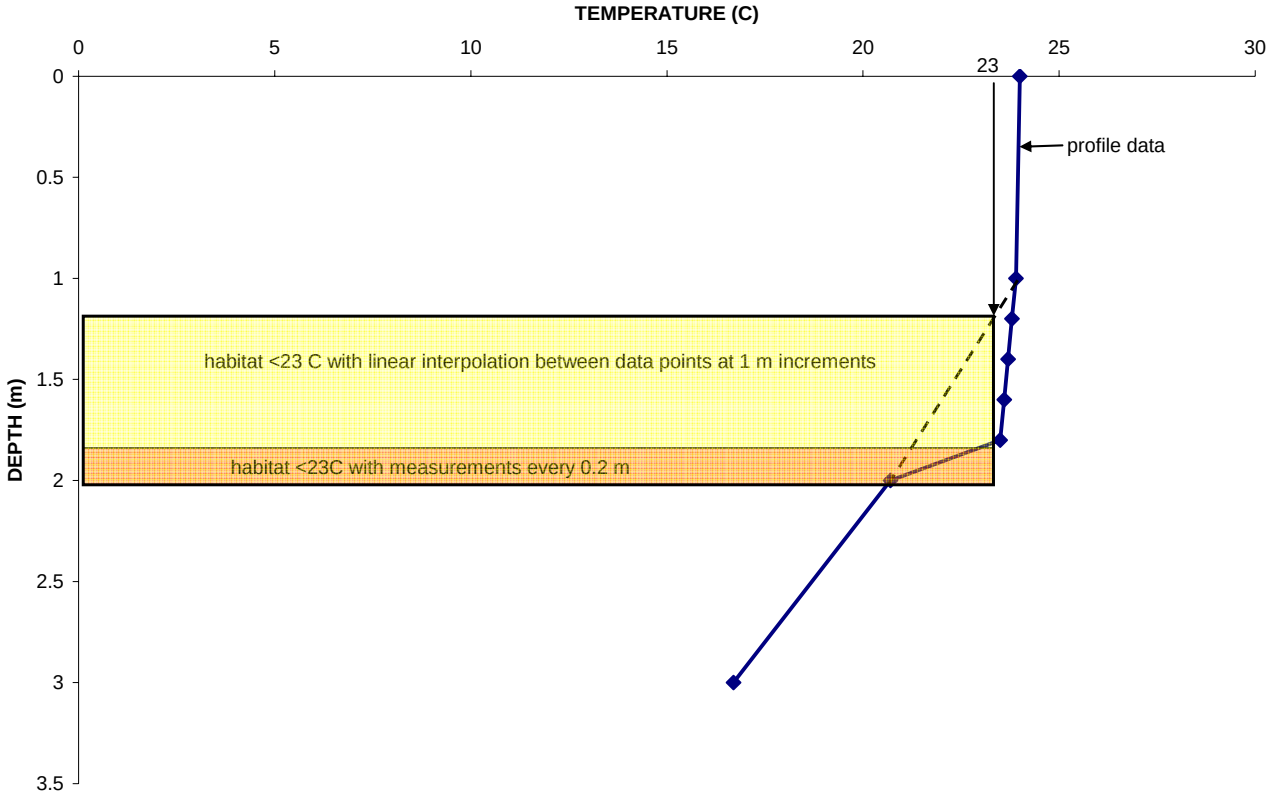


Figure 24. Webber Pond Temperature 4-7 m



As a consequence, there may be only a fraction of a meter of suitable habitat for cold water fish, which is not enough to support the population as required by statute. In these cases, it would be necessary to meet the DO requirements to a greater depth. The continuous monitor data collected by the GIPOP partnership to date has been at 5 foot increments, insufficient to determine the POTS. The weekly monitoring by Acheron at 1 m depth increments is better but still not necessarily sufficient to determine whether the minimum habitat within the thermocline has been provided. In 2008, refinements of DO monitoring will be necessary in order to determine a more accurate determination of the POTS.

GIPOP

The Gulf Island Pond Oxygenation Project (GIPOP) system is just upstream of the Upper Narrows sample location. The system's operating parameters are outlined in Rumford Paper Co. and Verso's (formerly International Paper Co.) discharge permit as follows:

Begin GIPOP at Upper Narrows operation when the 3-day average temperature(1) at the Turner Bridge is greater than 18°C in June.

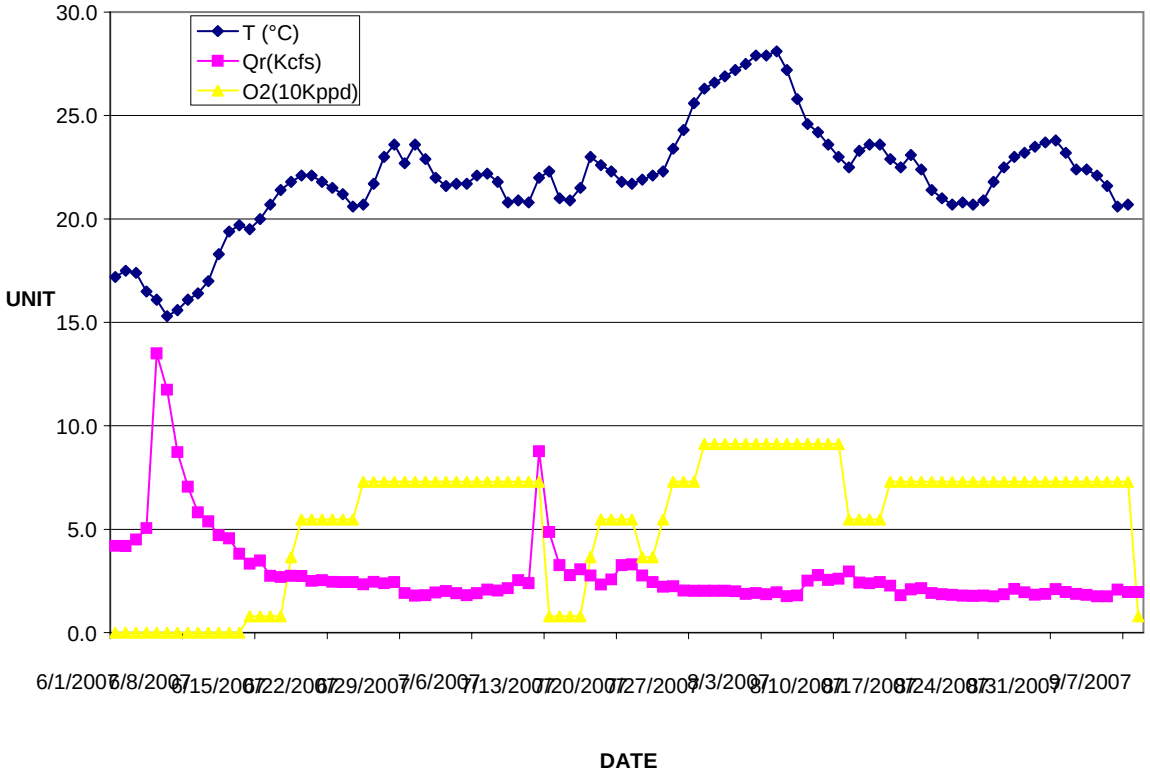
Oxygen Injection Thresholds	% Normal Capacity	Oxygen Injection* (lb/day)
Q(2) > 3500 cfs	Idle	8,000
T<24°C & 3,000 < Q ≤ 3,500	50%	36,500
T<24°C & 2,500 < Q ≤ 3,000	75%	54,750
T<24°C & Q < 2,500	100%	73,000
T≥24°C & Q ≤ 3,500	125%	91,000

(1)All temperature (T°C) measurements shall be obtained from the continuous temperature monitor at Turner Bridge and shall be expressed as a 3-day rolling average. Because the monitor records maximum and minimum temperatures for a given day, the daily average temperature will be defined as the arithmetic mean of the maximum and minimum temperatures for any given day. The 3-day rolling average is defined as the arithmetic mean of three daily average temperature values.

(2)All flow measurements (Qr, Kcfs=thousand cubic feet per second) shall be obtained from the USGS gage at Rumford and shall be expressed as a 3-day rolling average. The flow gage does record average daily flows; thus the 3-day rolling average is defined as the arithmetic mean of the three daily average flow values.

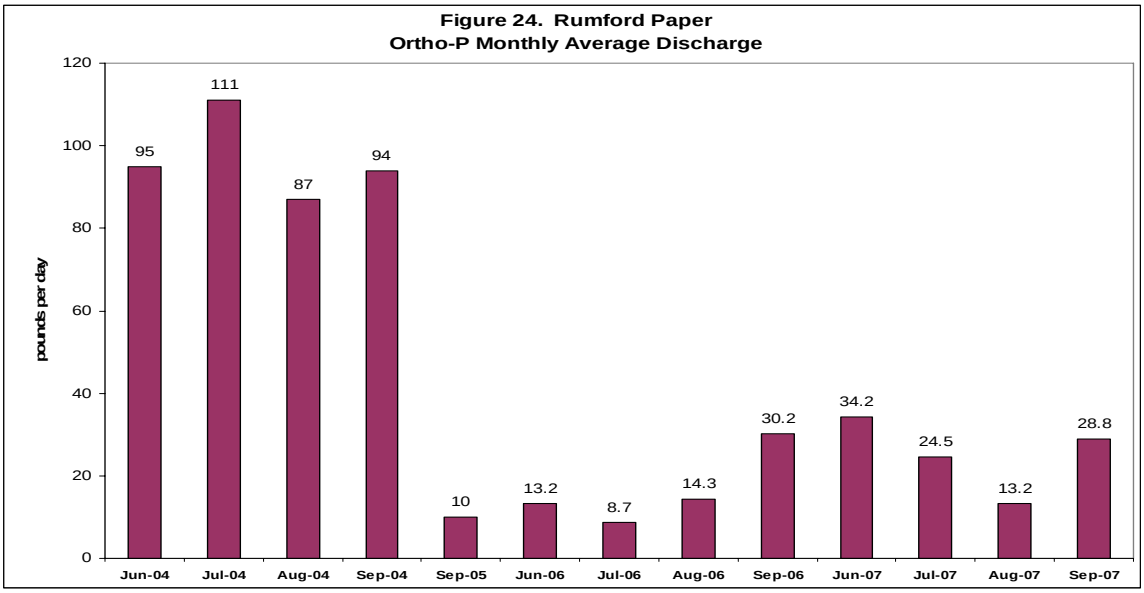
Actual river temperatures and flows and oxygen injection rates (O2, Kppd=thousand pounds per day) are show below (Figure 23).

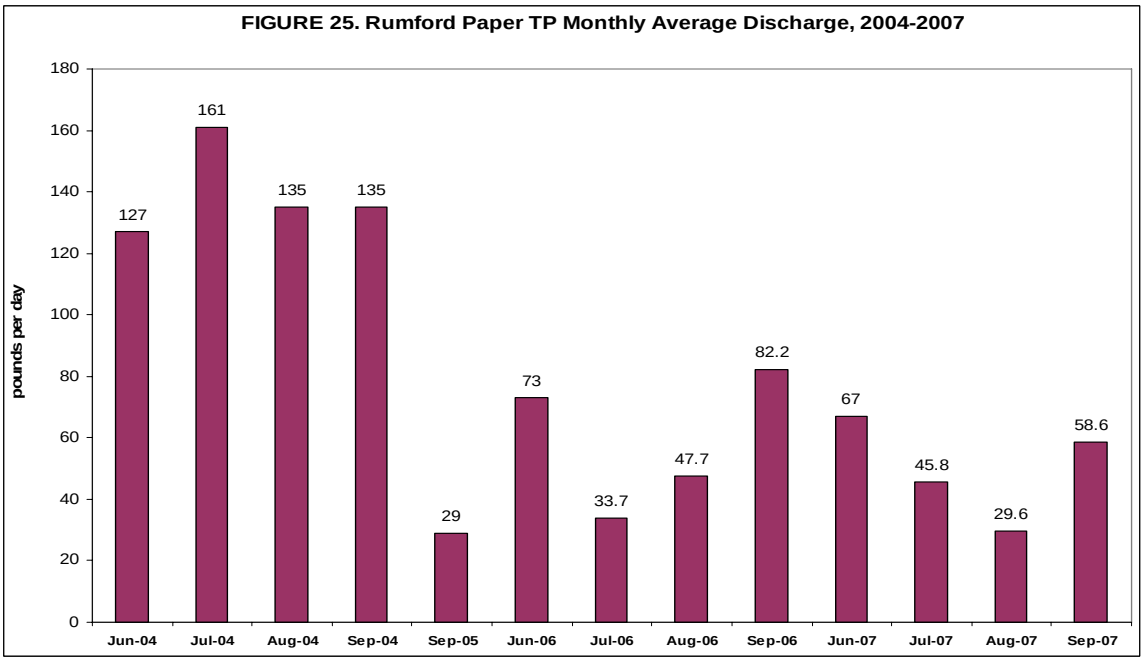
FIGURE 23. RIVER TEMPERATURE, FLOW, AND OXYGEN INJECTION RATE FOR GIP AT UN, 2007



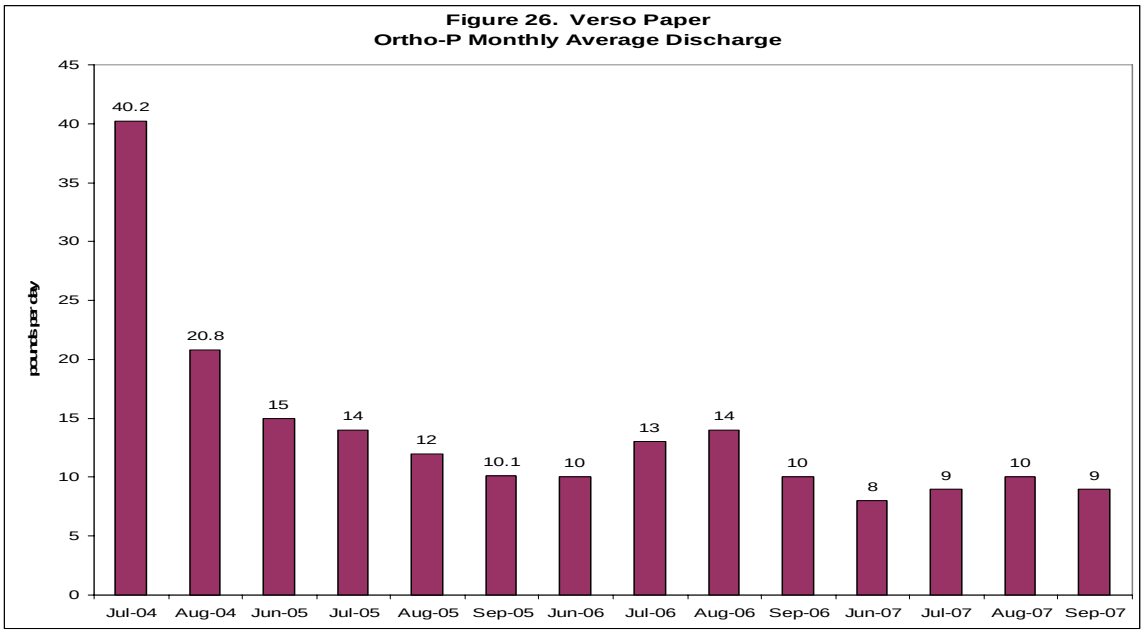
MILL EFFLUENT ORTHO-PHOSPHORUS (OP) and TOTAL PHOSPHORUS (TP)

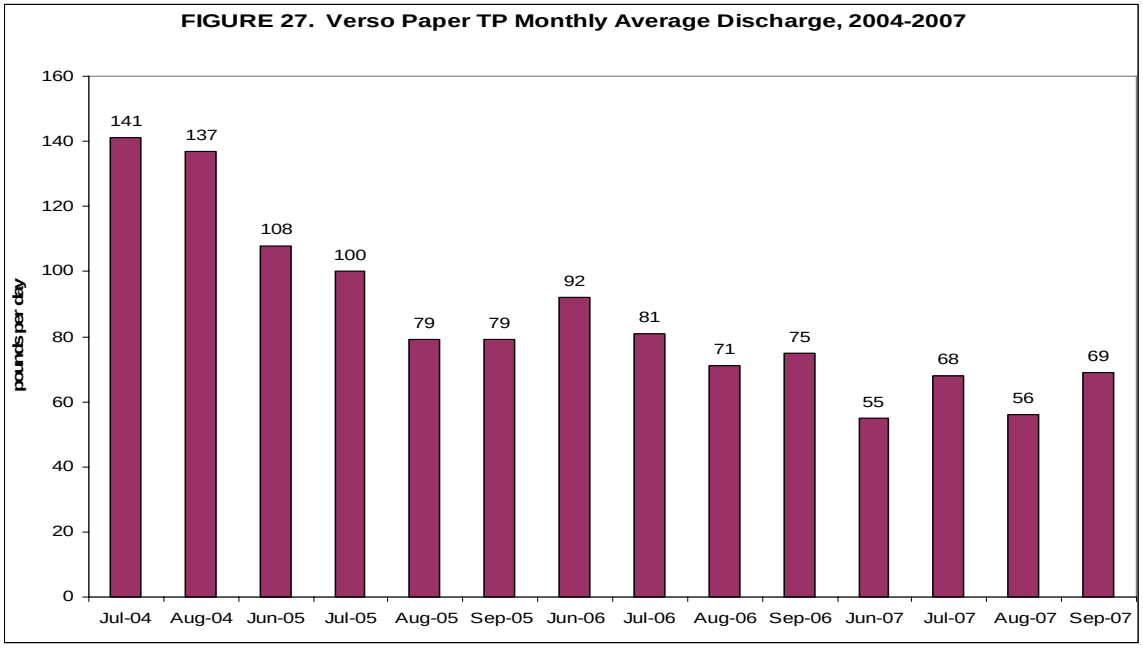
The Maine Pollutant Discharge Elimination System (MPDES) permit for the Rumford Paper Co. in August 2006 requires that the discharge of OP and TP not exceed 107 and 160 pounds per day (ppd) respectively upon issuance in 2006 and 97 and 152 ppd of OP and TP respectively by 2008. The Rumford Paper Co. has reduced its discharge of OP and TP by more than 50% since 2004 and is well within its permit limits (Figures 24 and 25).





The MPDES permit issued in September 2005 and new Board of Environmental Protection order issued February 2008 for Verso Paper Co. requires that the summertime discharge of OP and TP not exceed 33 and 150 ppd respectively by June 1, 2008 and 22 and 130 ppd respectively by June 1, 2010. The discharge of OP and TP from Verso has been reduced by approximately 50% since 2004 and has met the 2008 and 2010 limits since (Figures 26 and 27).





CONCLUSIONS

Aerial observations did not detect an algal bloom at Gulf Island Pond in 2007. Total phosphorus was significantly lower in 2007 than in all previous years since the present monitoring strategy began in 2004. This reflects decreased discharges at the Rumford Paper Co. and Verso Paper Co. mills in Rumford and Jay respectively and to a lesser extent perhaps the closure of the Fraser Pulp mill in Gorham, New Hampshire. Consequently, chlorophyll-a concentrations slightly exceeded the threshold for blooms in lakes (8 ug/l) but not the interim threshold for Gulf Island Pond (10 ug/l) and was similar to concentrations of 2005 and 2006, all of which were significantly lower than that of 2004. There was a flash flood in the upper watershed above Bethel which resulted in a large erosion event with much sediment discharged into the river which was tracked by DEP aerial surveillance downstream to Lisbon. This sediment resulted in peak concentrations of total phosphorus and minimum Secchi disk transparency, both unrelated to algal density as measured by chlorophyll-a.

Dissolved oxygen concentrations were below both the minimum criterion of 5 mg/l and monthly average criterion of 6.5 mg/l (at a temperature of 22°C or less) for up to 47% of the summer in the deeper portions of several stations in Gulf Island Pond. Although the mills met their phosphorus discharge limits, these data validate the need for additional remediation, such as reduced discharge limits and increased oxygen injection in Gulf Island Pond, as required in the current permits for Rumford Paper Co, Verso Paper, and Florida Power and Light .

References

Acheron , 2007. Androscoggin River and Gulf Island pond Water Quality Monitoring Report, 2007. Submitted to the Maine Department of Environmental Protection, Augusta, Maine, November 30, 2007.

Water Monitoring Services, 2008. Final Report of Water-Quality Monitoring Data, June-September 2007. Submitted to the Maine Department of Environmental Protection, Augusta, Maine, November 9, 2007.