Maine Salmon Rivers Water Quality Monitoring
Progress Report for 2002 Field Season

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I. Introduction:

A. River Baseflow Conditions:

In 1999, the Maine Department of Environmental Protection and volunteers from the Salmon Rivers Watershed Councils began a water quality monitoring program in the official salmon rivers. The 1999 and 2000 programs concentrated on river baseflow water chemistry. The river "baseflows" are those conditions when river flows are dominated by groundwater. For our program, baseflow sampling takes place in summer and samples are taken when there were no significant rainfall events (equaling 1.0 inch or more) within the last 7 days. In 2001, Cove Brook was added to the list of official salmon rivers and additional baseflow samples were taken from all the rivers.

Field measurements included pH, dissolved oxygen (DO), and water temperature. In most cases, water samples were collected for lab analysis at the U of Maine George Mitchell Center. Lab analysis consisted of pH, ANC, specific conductance, major cations (Ca, Na, K, and Mg), major anions (SO_4, Cl, NO_3), total P, total and dissolved Al, and dissolved organic matter (DOC). For samples with pH < 6.0, aluminum was speciated into organic and exchangeable fractions.

The baseflow monitoring program found that the summer water quality of the salmon rivers is generally very good, although some non-point source pollution (NPS) problems were identified in all the rivers. The pH and alkalinity (or Acid Neutralizing Capacity, ANC) were moderate (pH range 5.72-8.23, ANC range 25-2,350 ueq/L) and within ranges that are known to be healthy for Atlantic salmon and other aquatic life. There was no evidence of chronic acidification or extreme nutrient or organic loading. The Sheepscot River was identified as the river most affected by land-based human activities. The downeast rivers were identified as the most sensitive to acidic episodes during high flow events.

B. Stormwater Conditions:

Beginning in the 2001 field season, the rivers were systematically sampled during high flow events (after major rainfall events of 1.0 inch of rain or more, or during significant melt events that affect flood stage). Some summer baseflow samples were also taken from a reduced number of sites. For high flow events with obvious water cloudiness, lab analysis was expanded to include turbidity and total suspended solids (TSS). The results from last year's work show that pH and ANC remained moderate at most samples sites even during high flow periods. The exceptions were Rocky Brook, a tributary of the East Machias (pH = 5.72, exchangeable Al = 96 ug/L, for a baseflow sample taken on July 17) and Venture Brook, a tributary to the Dennys River (pH ranged 5.76-5.96 and exchangeable Al ranged 61-107 ug/L for six sites sampled on November 8 during high flows). However, the 2001 field season was not representative of normal stormwater or spring melt conditions. Meteorological data from 2001 show that it was the driest year on record (Bangor Daily News, 200]).

II. 2002 Sample Plan:

For the 2002 field season, water quality monitoring concentrated on better characterizations of stormwater and snow melt events. Particular attention was given to looking for acid ram events in the downeast river mainstems (the Narraguagus R, Pleasant R, Machias R, East Machias R, and Dennys R) or turbidity and other NPS pollution issues in the central Maine rivers (Sheepscot R, Ducktrap R, and Cove Brook).

Since the water quality of rivers is the sum of the contributions of its tributary watersheds, individual tributaries can be thought of as having a "role." For instance, some tributaries may be sources of cold water in the summer time, some may be acidic, while others may be significant sources of ANC. A second goal of the 2002 field season was to profile the water quality of some tributaries. We planned to investigate a few tributaries each year until all the important tributaries had high flow and baseflow profiles. Since river access is difficult during wet and icy conditions the number of tributaries that were sampled were determined by our financial and personnel resources. The tributaries that were sampled in 2002 are:

Baker Brook (in the Cove Brook drainage),

Palermo Brook, Hewett Brook, Griffin Brook, Dearborn Brook, Choat Brook, Meadow Brook, Wingood Brook, and Branch Brook (Sheepscot R),

East Little River and Western Little River (Pleasant R),

Baker Brook, Sinclair Brook, Bobcat Brook, Humpback Brook, Gould Brook, Barrel Brook, and West Branch of the mainstem (Narraguagus R),

Pork Brook (W Branch of the Narraguagus R),

Bear Brook, Joe Hill Brook, Sam Hill Brook, Honeymoon Brook, Dead Stream - Boles Lake, and Dead Stream - First Lake (Old Stream in the Machias R drainage),

Holmes Brook, Big Springy Brook, New Stream, Joe Meadow Brook, Pembroke Stream, and Lanpher Brook (Machias R),

Rocky Brook and Beaverdam Brook (E Machias R),

and Venture Brook (Dennys R).

Most of these streams are small first- or second-order streams- Headwater streams are thought to be the most sensitive to acid rain events and to NPS pollution inputs. Often problems are first identified in smaller streams.

In Maine, the highest flood stages typically occur in February and March, and may continue into April and sometimes into May. Lower rainfall and vastly increased evapotransporation makes summer a low flow period (except for thunderstorms and hurricanes). Another high flow period takes place in the fall. Except for fall hurricanes, the fall storm events typically have lower flows than in the spring. Spring runoff events are typically greatest during rain-on-melting-snow events. Several of these occurred in the spring of 2002. In spite of the continuing drought, spring and fall river stages were normal for most of Maine (Figure 1).

Access in the springtime was especially difficult in the downeast area where year-around roads are few and widely spaced. River mainstems were sampled from major road crossings (especially from the US Route 1 and Route 1A, and from Route 9 on the downeast nvers). In order to conserve financial resources, field measurements of pH were taken on the downeast rivers in the spring in order to screen them for additional analysis. Often if field measurements on river mainstems were above pH 6.0 or "close to pH 6.0" (i.e. pH 5.8 or greater) no samples were taken for lab analysis. Since we wanted chemical profiles of tributaries, water samples from tributaries were always passed on to the U of Maine for lab analysis regardless of field pH. For comparison purposes, lab samples were also collected from nearby river mainstems on days when tributaries were sampled.

Lab analysis included the same parameters as for previous years, plus fluoride, which is known to interact with forms of aluminum. As before, stormwater and meltwater high flow events in the spring were analyzed for turbidity and total suspended solids (TSS) whenever there was obvious cloudiness in the water.

Some baseflow and fall stormwater samples were planned for 2002. Because of the strong runoff season in the spring, our financial resources were exhausted by mid-April. No lab samples were collected in the summer. Only two samples (one from Tunk Stream and one from the Pleasant River) were taken during the fall.

Summer and fall chemical profiling was limited to field data (pH, DO and temperature) and to the deployments of automated environmental probes ("data sondes"). Six Yellow Springs Instruments (YSI) data sondes were deployed during the summer and fall of 2002. Two were deployed in the Sheepscot River. Four sondes were deployed downeast. These units were placed in tributaries of the Machias River (Old Stream, Big Springy Brook, and Sam Hill Brook) and in Venture Brook (a tributary of the Dennys River).

III. Results for 2002:

A. River Mainstems:

Data for stream flows from the USGS website show that although the drought continued in 2002 (Bangor Daily News, 2002), the spring and fall rain totals and river stages were essentially normal in most of the state (Figure 1). Natural organic acids (DOC) are abundant in all of the salmon rivers (Table 1). These natural acids come from the decomposition of organic matter in soils and wetlands. According to the classification system of Kahl et al (1989), all of Maine's salmon rivers would be classified as having "moderate" DOC levels. This is true even during spring high flows when many chemical species are relatively diluted. According to this classification system, surface waters with DOC values less than 5 mg/L are "low DOC", 5-30 mg/L are "moderate," and over 30 mg/L are "high" DOC systems. DOC is important because it is a natural source of acidity in Maine surface waters, and because it binds with heavy metals such as aluminum and mercury. Aquatic organisms do not generally take up toxic metals when they are bound in this organic form. Tunk Stream, which is not an official salmon river, had the lowest DOC content in this year's stormwater samples (2.11-8.64 mg/L).

For most of the salmon rivers, turbidity and TSS were very low in 2002. The exceptions are the Sheepscot, Cove Brook, and one early sample from the Narraguagus (Table 1). The turbidity values observed in the Sheepscot and Narraguagus Rivers (turbidity range 0-17 NTU and TSS range 0-39 mg/L) will cause short-term reductions in feeding rates for salmon parr (Newcombe & Jensen, 1996). The highest turbidities were found in Cove Brook (turbidity range 3.7-30 NTU and TSS range 3-76 mg/L) will likewise interfere with feeding success. The very highest TSS values can lead to mild gill irritation and respiratory stress for 24-hour exposures. This can become a moderate stress if the conditions last for more than 24 hours. Unlike last year when high turbidity lasted for 6 weeks in Cove Brook, muddy runoff in 2002 was associated with individual rainstorms or melt events. In general, the bottom of Cove Brook was visible again within 48 hours after a passing storm. When no turbidity or TSS data is given for a given sample, the reader should assume there was no obvious cloudiness in the water and that no sample was taken.

Total and dissolved aluminum were abundant in stormwater events on the all of the salmon rivers. This is a natural consequence of our acidic soils. High aluminum content is expected of stormwater since high flows suspend fine particles. Unlike last year when moderate pH and positive ANC's kept aluminum bound in organic forms, pH values below 6.0 and some zero or negative ANC's led to relatively high exchangeable Al (range 0-106 ug/L). Any exchangeable Al is a concern. Values above 5 ug/L become increasingly toxic to fish (Brocksen et al, 1992). Aluminum toxicity is a complex interaction of pH, the exchangeable Al concentration, and the Ca concentration (Baker & Christensen, 1991).

In contrast to 2001, this year's field season detected significant episodic acidification events in the downeast salmon rivers. These events affected many tributaries and even some river mainstems (Table 1). For much of the spring field season, field pH measurements taken from along Route 9 showed that the river mainstems and largest tributaries (the Narraguagus, Mopang Stream, Machias R, and Old Stream) remained above pH 5.8 most of the time. Field and lab measurements showed acidic episodes occurred primarily in three river mainstems, namely Tunk Stream (sampled at Rt. 182), the Pleasant River (at Columbia Falls), and the Narraguagus River (sampled in Cherryfield or Rt. 9) (Figures 2-4). The acidic episodes lasted throughout the sample period (from the middle of February to the middle of April). Tunk Stream experienced the most extreme pH values, but the Pleasant River was more acidic over more consecutive samples. The Narraguagus River experienced more moderate acidification. However, lab analysis shows that even the relatively moderate pH values may have significant exchangeable Al present (e.g., the Narraguagus R at Route 9 on March 5, pH = 5.74 with exchangeable Al = 25 ug/L and last year's sample from Rocky Brook pH = 5.72 with exchangeable Al = 96 ug/L). A single low pH value was found in the mainstem of the Machias R (pH = 5.44 at Holmes Falls on April 4 with 18 ug/L exchangeable Al).

Tunk Stream and Pleasant River experienced additional acidic episodes in the fall. Since our financial resources were exhausted, we have no details on the extreme values or how long they lasted. However, lows of pH 4.7 and 5.2 were measured on Tunk Stream and the Pleasant, respectively. Fish kills were observed on Tunk Stream, on October 17 and again on November 20. Both events followed large rainstorms (0.6 inches of rain on October 14 and another 1.0 inches on October 17, then 3.1 inches of rain and melting snow on November 17 and 18 based on precipitation measured in Machias). Fish kills were not observed on the nearby Pleasant or Narraguagus Rivers during these storms. The Narraguagus R had a pH of 6.0. Both fish kills were young-of-the-year alewives that were emigrating from Tunk Stream to the estuary. Fish pathology reports from both kills were provided by the state Dept of Inland Fisheries and Wildlife pathologist Russell Danner (see Appendix). The cause of death was asphyxiation and is consistent with acid rain toxicity. Eroded, deformed, and bleeding gills were observed in both cases. Due to the use of an alcohol preservative, no bacterial and viral screening was done on the first kill. Analysis of the second kill found no bacterial or viral agents.

B. Tributary Profiles:

Seasonal acidic episodes and sometimes significant exchangeable Al were observed in many tributaries. These included: East Little River and West Little River (Pleasant R), Big Springy Brook, New Stream, Pembroke Stream (Machias), Bear Brook, Honeymoon Brook, Dead Stream - First Lake, and Dead Stream - Boles Lake (Old Stream), and Rocky Brook (E Machias). The lowest observed pH values were pH 4.6 (observed in Rocky Brook (E Machias) West Little River (Pleasant) and Big Springy Brook (Machias). Some tributaries are sources of non-point source pollution (NPS) inputs. The influence of NPS inputs are most obvious in Cove Brook and the Sheepscot R. Discussions of individual rivers follows.

1. Cove Brook:

Baker Brook is the single most important tributary on Cove Brook. Cove and Baker Brooks both experienced significant muddiness during high flow events. In contrast to last year, the worst turbidity was short-lived. While the worst turbidity lasted for 2 months last year, in 2002 the stream bottom was visible within 48 hours after a storm. Cove Brook and its largest tributary are similar in their high pH, ANC, high Ca, moderate DOC, seasonal turbidity and TSS, and other parameters.

2. Sheepscot R:

Sampling on the Sheepscot R concentrated on tributaries of the West Branch. Due to NPS pollution issues, especially seasonal turbidity, high bacteria concentrations, and many low summer DO events, the DEP has identified the West Branch as needing a total maximum daily load (TMDL) analysis under the Clean Water Act. Our tributary profiles will assist in those TMDL determinations.

All of the sampled tributaries of the West Branch had noticeable seasonal turbidity. Griffin, Hewett, and Choat Brooks were more turbid than the others. Surprisingly, the main branch of the Sheepscot and the West Branch were more turbid than any of the sampled tributaries. This may represent resuspension of sediments already in the system. The Sheepscot River Watershed Coalition has many years of experience with NPS pollution mitigation projects. Our data set does not have a long enough history to evaluate the success of these projects. However, it is reasonable to conclude they have had a positive effect on water quality. All of the sampled tributaries of the Sheepscot have relatively high pH and ANC. These values are generally comparable to the river mainstem. Branch and Meadow Brooks have higher pH, ANC and Ca than the other tributaries. Palermo Brook has lowest DOC.

Unfortunately, no data was recovered from the two data sonde deployments in the Sheepscot watershed. These deployments failed due to operator error (the sondes did not begin logging).

3. Pleasant R:

Both the East and Western Little Rivers have seasonal low pH (range 4.60-5.18), low or negative ANC, and exchangeable Al (12-38 ug/L). On the single sample date (February 28), the chemistry of the river mainstem was found to be less extreme than these two important tributaries. Thus, the East and Western Little Rivers are sources of relatively soft and acidic water. Western Little R has more DOC than the mainstem (18.8 mg/L as opposed to 14.4 mg/L in the mainstem).

4. Narraguagus R:

Baker Brook, Sinclair Brook, Bobcat Brook, Humpback Brook, Gould Brook, Barrel Brook, the West Branch of the mainstem, and Pork Brook on the West Branch of the Narraguagus River experienced spring-time acidic episodes. Pork Brook experienced the lowest pH (5 .17) and had the highest exchangeable Al (33 ug/L). Pork Brook used to be known for its productive trout fishery (Ron Brokaw), but has now been greatly affected by beaver activity. Baker Brook had the highest DOC (12.8 mg/L).

5. Machias R:

All of the sampled tributaries of the Machias River and Old Stream experienced seasonal low pH and relatively high exchangeable Al, except for Lanpher Brook. Pembroke Stream and Big Springy Brook have good trout habitat (Ron Brokaw, Nate Pennell, personal communications). Big Springy Brook used to have Atlantic salmon spawning near the confluence with the Machias River (Nate Pennell, personal communication). Both streams have seasonally very low pH, low or negative ANC, high DOC, and low Ca. Dead Stream - First Lake and Dead Stream - Boles Lake have high DOC but are not as acidic during high flow events. All of these streams except Lanpher Brook have exchangeable Al (range 15-68 ug/L). The impact of acidic tributaries on the larger streams is obvious (note the pH = 5.4 and exchangeable Al of 18 ug/L on the Machias R at Holmes Falls on April 4 and pH = 5.8 and exchangeable Al of 7 ug/L on Old Stream at the 83-000 logging road bridge also April 4). In contrast, Lanpher Brook is a source of ANC, base cations, and helps support higher pH on the mainstem.

Figures 5-7 present data sonde recordings for Old Stream, Big Springy Brook and Sam Hill Brook for this summer and fall. These recordings have not yet been corrected for periods when the units were removed from the water for calibration or for data that was lost due to low flows or battery failures. Old Stream (Figure 5) maintained circumneutral pH values throughout the summer. The cyclic nature of diurnal pH variation is obvious in the summer, but is lost as the season progresses and water temperature drops. This is due to the effect of cold water on photosynthesis and respiration in the fall. The pH of Old Stream dropped to about 5.8 in the fall with the return of October rains. In grab samples from this spring, Old Stream had significant exchangeable Al (7 & 33 ug/L on two different days) at pH 5.8. The longer scale pH fluctuations (weekly and monthly variations) have an inverse relationship with water depth (and flows). Water temperatures peaked in July and August. There are several summer heat events where even the nighttime temperatures were above 20 degrees C for a few consecutive days. This is a significant heat stress for salmon. The DO calibration lasted for only a day or so in June and July, but lasted for several weeks in August and September. This is probably due to variations in the quality of the DO probe membranes. The DO drifting lower each consecutive day and then to zero, but showing high DO values again on a calibration day is instrument error. It is not actual environmental data.

Big Springy Brook (Figure 6) is one of the most acidic bodies of water observed in our study. A single grab sample from April 4 had a pH of 4.6 and exchangeable Al of 56 ug/L. The sonde recording shows that low pH (pH < 5.5) continued into June. If this acidic episode began in mid February (like it did for Tunk Stream and the Pleasant), then acidic conditions lasted four months in spring 2002. Later this summer, the pH varied between 6.0 and 6.5 during baseflow conditions. Then with the return of fall rains, the pH plummeted to pH 4.2. The pH stayed below pH 5.5 for another 6 weeks in the fall. It is surprising that the fall pH is just as extreme as was observed in the spring in spite of the flows being lower in the fall. Big Springy Brook used to be known to local sport fishermen for its trout and salmon (Nate Pennell and Ron Brokaw, personal communications). Big Springy Brook maintained fairly moderate temperatures even in the heat of the summer and during low flow conditions.

Sam Hill Brook (Figure 7) is a source of cold water and moderate pH. The pH ranged mostly 6.0 to 7.0. The strong diurnal fluctuation in pH is unusual and suggests that the water chemistry is greatly influenced by daily cycles in metabolic processes (photosynthesis and respiration) and by evapotranspiration. As happened with the other sonde deployments, the performance of the DO probe is disappointing. However, in early September DO appears to go to zero at night. If this is real, then it might be due to the low flows during this period (August 2002 experienced the lowest recorded rainfall ever for this month in Maine). Potential nighttime DO depletion during summer low flows should be field checked during the 2003 field season.

IV. Discussion:

The toxicity of low pH events depends on the magnitude of the pH drop, the length of exposure, and the chemical interactions between Al, Ca, DOC, and F. While most of the river mainstems and larger tributaries maintained pH values close to 6.0 or above, examples cited above show that exchangeable Al (0-96 ug/L) can be associated with moderate pH (5.7-6.0). Moderate acidification episodes lasting at least 2 months were observed in Tunk Stream, Pleasant R and the Narraguagus R with additional and shorter-term events this fall in Tunk Stream and the Pleasant. Short-term acidification events were observed in the spring in the Machias R and Old Stream.

As expected, tributaries are more strongly affected than larger streams and rivers. Of the tributaries profiled this spring. 12 out of 13 tributaries to the Machias R, and 4 out of 8 on the Narraguagus R have seasonally acidic conditions below pH 5.8. Extreme acidification episodes lasted possibly four months this spring in Big Springy Brook with an additional 6 weeks of even lower pH in the fall. The sonde data from Big Springy Brook is the only time series that we currently have from acid sensitive tributaries in the downeast rivers. More time series are clearly needed. If other tributaries experienced acidic episodes that lasted for months this spring and then for several weeks this fall, then the combination of low pH, medium-to-high exchangeable Al, and low Ca would be a significant challenge for salmon and other fish.

In a review of the available literature, Baker & Christensen (1991) suggest that the presence or absence of fish may not be determined by the average or median conditions, but by the extreme conditions that occur during critical life stages. Often population extinctions occur due to recruitment failures, not from outright fish kills. For salmon, the most sensitive life stages are the newly fertilized eggs in the fall and the new hatchlings, up to the eye-up stage, in the springtime (Brocksen et al., 1992). In a review of the available literature, Baker and Christensen (1991) list threshold pH values for salmon embryos (5.5) and for fry (5.4-5.5). These thresholds are exceeded in Tunk Stream, the Pleasant R, and for many tributaries. Spring and fall are the time of year where acidic events have been observed in the downeast rivers and the timing coincides with salmon spawning and fry emergence.

It is surprising that Venture Brook had a small acidification event in the fall of 2001, the driest year on record. The fall acidification event in Big Spring Brook seems disproportionate to the 2002 fall flows. In Nova Scotia, acidic episodes occur primarily in the spring and fall, but can occur any time of year (Clair et al, 2001). Pine Martin Brook (the smallest brook studied) only had acidic events in the fall. The authors hypothesized this might have something to do with the large amount of wetlands (30%) in the watershed. Soil acidity was thought to contribute significantly to the acidic episodes in the fall. McEvoy (1989) suggests that in New England seasonal low pH and high Al and DOC occur as water is forced to flow through shallow acidic soil horizons during spring thaw and again in the fall as soils become saturated by fall rains. The limited data that we have from fall, suggest that fall acid events may be more common and more severe than the runoff volume alone might suggest.

Aluminum is most toxic when it occurs as free inorganic monomeric Al, which is measured in laboratory conditions as "exchangeable Al." The highest exchangeable Al values are found in Tunk Stream, Bear Brook, Big Springy Brook, Pembroke Stream (in the Machias drainage), and Rocky Brook (E Machias R). Values for exchangeable Al ranged 4-106 ug/L. Exposure of salmon smolts held for 5-16 days at pH 5.47 with 96 ug/L exchangeable Al showed osmotic stress (Magee et al, 2001) and difficulty smolting successfully. In laboratory experiments with Atlantic salmon smolts exposed to different pH and Al levels, with Ca ranging 0.72-1.33 mg/L, Kroglund & Staurnes (1999) report that no mortalities occurred when pH > 5.8 and exchangeable Al is 15-20 ug/L or less. Mortalities were observed in all groups with pH < 5.8, and exchangeable Al 30-90 ug/L. These are ranges that have been observed in the downeast rivers.

Calcium levels are very important in ameliorating toxic conditions below pH 6.0. At lower pH values, the threshold for calcium to support whole-body electrolytes was 2.8 mg/L (Wood et al, 1990). Calcium concentrations above this level and especially above 4.0 mg/L are effective in counteracting Al toxicity (Brocksen et al, 1992). Our downeast rivers are generally too dilute to offer this protection (Ca range 0.87-3.19 mg/L in high flows).

DOC values above 5 mg/L help ameliorate Al toxicity by binding Al in an organic complex. Fortunately, moderate DOC levels are almost universal in the salmon rivers. The lowest DOC values were observed in Tunk Stream. This may be significant. Increases in water clarity with acid rain inputs have been observed in field surveys and whole-lake experimental manipulations (Baker & Christensen, 1991). Tunk Stream has the lowest ANC and is the most sensitive to additional acid inputs. Although Tunk Stream is not one of the official salmon rivers, Tunk Stream has supported salmon as recently as the early 1980's. If Tunk Stream is becoming clearer (if DOC declining) then it may be a sign that the watershed is becoming more acidic.

Fluoride levels are low in our rivers, and are generally essentially zero. Except for rare circumstances, fluoride may not play an important role in Al toxicity in our rivers.

Our findings are comparable to those of Haines & Akielaszek (1984) where they surveyed these same Maine salmon rivers in the early 1980's. They found that pH depressions below pH 6 were occurring rarely in river mainstems, but may sometimes dip into the low 5's (pH 5.3 was observed in the Machias R). Likewise in the early 1980's smaller streams, especially first- and second-order streams were observed with seasonal pH values as low as 4.7 during spring melt/runoff periods. Our data shows there has been no improvements in the last 20 years.

According to Newcomb & Jensen (1996), the moderate turbidity and TSS values experienced in 2002 in the Maine salmon rivers are mildly stressful for Atlantic salmon fry and parr as long as the exposure lasts no more than 48 hours. The effect is primarily on feeding with some mild gill irritation for TSS values around 20 mg/L. The highest TSS values (around 80 mg/L) are a moderate stress as long as the conditions last no more than 48 hours. When moderate turbidities (TSS range 20-80 mg/L) last for days and weeks, as they did in 2001 in Cove Brook, the cumulative feeding and respiratory stresses have a major physiological impact and the transported sediments can result in loss of habitat (Newcombe & Jensen, 1996).

V. Plans for 2003:

A. More Stormwatcr Sampling: The plans for 2003 depend on the availability of funds. While baseflow conditions have a fairly stable and predictable water chemistry, stormwater is extremely variable. Variation occurs within an individual storm, from one storm to another, and from one year to the next. Since the water quality problems are mostly high flow issues, more sampling of high runoff events is planned in 2003. More time series are needed to evaluate the magnitude and duration of problem conditions. The data sondes will be moved to new tributaries this spring.

B. More Sampling in the Fall: Some acidic events clearly take place in the fall and may be disproportionate compared to flow data. Time series data must include the fall in order to document pH extremes and duration.

C. Complete Tributary Profiles: The tributaries sampled in the spring of 2002 should be sampled during the summer baseflow period. It is useful to characterize both the average summer day-to-day conditions (baseflow) to the seasonal extremes (mostly spring and fall storm flows). Some critical life stages for salmon occur in the different conditions and some authors have hypothesized that the loss of a species often comes from failure at only one point in the life cycle.

One of the most important contributions tributaries make to river mainstems is water volume. Mopang Stream and Old Stream have flow gauges, but other tributaries do not. It would be helpful to have flow data from as many tributaries as possible. Relative flows could be easily compared by taking flow measurements during stable baseflow conditions.

D. More Emphasis on the Pleasant R: The Pleasant R has some of the most extreme pH values noticed in the mainstem of an official salmon river. In addition, the low pH events lasted for 2 months this spring, with additional shorter-term events in the fall. We need better time series and more information on tributaries.

Some potential new tributaries on the Pleasant R include: Taylor Brook, Colonel Brook, Bog Brook, Gosha Brook, and additional profiling of East and Western Little Rivers.

E. Take a Closer Look at the East Machias R: This watershed has not had much attention yet Some potential new tributaries for chemical profiling on the E Machias are: Northern Stream, Harmon Brook, Beaverdam Stream, Clifford Stream, Rocky Brook, and Northern and Southern Inlets to Rocky Lake (E Machias R).

F. Investigate Acid Mitigation Options: If we can agree that acid rain has been impacting our salmon rivers for more than 20 years, and that the situation is serious enough to be causing losses of fish, and that things are not getting better on their own, then we should be discussing mitigation options.

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Table 1. Water chemistry for spring 2002 field season. All lab analysis was done at the U of Maine George Mitchell Center for Environmental and Watershed Research. Samples are mostly stormwater or spring melt water, but a few samples were taken between storms and are labeled "spring baseflow."

River/Watershed	Sample Location	Sample Type, notes	Date	dissAl	AlOrg	Alx	Altotal	Ca	Ca	Mg	Mg	Na	Na	K	K	CaCO3 alk	ANC	Cl	Cl	NO3	NO3	SO4	SO4	F	pH	DOC	DOC
				µg/L	µg/L	µg/L	µg/L	mg/L	ueq/L	mg/L	ueq/L	mg/L	ueq/L	mg/L	ueq/L	mg/L	µeq/L	mg/L	µeq/L	mg/L	µeq/L	mg/L	µeq/L	mg/L		mg/L	ueq/L
Narraguagus R	Cherryfield at cannery	Rain on melting snow, 2" in Machias	02/11/2002	155	na	na	309	2.49	124.25	0.88	72.42	4.2	182.70	0.61	15.60	5.15	103	6.38	180	1.04	16.8	4.13	86	<0.08	6.56	8.29	33.16
Tunk Stream	Steuben, lower bridge	Rain on melting snow, 2" in Machias	02/11/2002	184	144	40	282	1.78	88.82	0.91	74.89	4.97	216.20	0.54	13.81	1.90	37.9	9.57	270	0.94	15.1	4.32	90	<0.08	5.81	7.85	31.40
Tunk Stream	Unionville bridge	Rain on melting snow, 2" in Machias	02/11/2002	121	81.9	39.1	199	1.38	68.86	0.56	46.09	3.43	149.21	0.63	16.12	1.59	31.8	6.74	190	0.51	8.3	3.36	70	<0.08	5.93	5.56	22.24
Tunk Stream	Route 182 bridge	Rain on melting snow, 2" in Machias	02/11/2002	135	82.9	52.1	164	1.31	65.37	0.54	44.44	3.23	140.51	0.56	14.32	1.58	31.6	6.38	180	0.35	5.7	3.27	68	<0.08	5.72	6.83	27.32
Tunk Stream	Tunk Lake outlet	Rain on melting snow, 2" in Machias	02/11/2002	24.7	16.5	8.2	29.6	0.97	48.40	0.37	30.45	2.63	114.41	0.33	8.44	0.74	14.7	4.96	140	0.21	3.4	3.27	68	<0.08	6.00	2.12	8.48
Cove Brook	Route 1A above the bridge	Light rain on snow, 0.7" in Machias	02/20/2002	50.2	na	na	75.8	13.1	653.69	2.37	195.05	7.72	335.82	1.13	28.91	28.75	575	18.79	530	1.72	27.8	10.09	210	<0.08	8.02	5.1	20.40
Cove Brook	Back Winterport Road culvert	Light rain on snow, 0.7" in Machias	02/20/2002	52.9	na	na	89.7	11.4	568.86	2.26	186.00	7.06	307.11	1.12	28.65	25.50	510	16.66	470	1.80	29.1	9.13	190	<0.08	7.97	5.41	21.64
Souadabscook Stream	Route 1A above the bridge	Light rain on snow, 0.7" in Machias	02/20/2002	60.1	na	na	209	13.1	653.69	2.76	227.15	11.5	500.25	0.94	24.05	25.80	516	26.94	760	1.23	19.8	10.09	210	<0.08	7.97	9.28	37.12
Cove Brook	Route 1A above the bridge	Light rain on melting snow	02/27/2002	76.3	na	na	495	8.07	402.69	1.69	139.09	5.72	248.82	1.32	33.77	17.25	345	13.12	370	2.32	37.5	7.68	160	<0.08	7.25	5.91	23.64
Cove Brook	Back Winterport Road culvert	Light rain on melting snow	02/27/2002	105	na	na	180	6.2	309.38	1.46	120.16	4.72	205.32	0.85	21.74	11.70	234	10.63	300	1.94	31.3	6.72	140	<0.08	6.87	5.55	22.20
Souadabscook Stream	Route 1A above the bridge	Light rain on melting snow	02/27/2002	86.9	na	na	479	11.5	573.85	2.4	197.52	11.3	491.55	1.03	26.35	22.55	451	26.59	750	1.80	29	8.65	180	<0.08	7.26	8	32.00
Sheepscot R	Route 126 gauge site	Light rain on melting snow	02/27/2002	174	na	na	691	4.16	207.58	1.05	86.42	2.82	122.67	1.2	30.70	6.75	135	6.03	170	1.35	21.8	6.72	140	<0.08	6.50	7.07	28.28
Sheepscot R	Route 126 gauge site	Light rain on snow, 1.25" for 2 days	02/28/2002	170	na	na	343	4.17	208.08	1.03	84.77	2.82	122.67	1.17	29.93	6.05	121	6.38	180	1.06	17.1	6.72	140	<0.08	6.50	8.42	33.68
Sheepscot R	West Branch at Howe Rd	Light rain on snow, 1.25" for 2 days	02/27/2002	159	na	na	501	4.59	229.04	0.98	80.65	2.81	122.24	1.17	29.93	7.40	148	5.67	160	1.67	26.9	7.20	150	<0.08	6.62	6.54	26.16
Sheepscot R	West Branch at Howe Rd	Light rain on snow, 1.25" for 2 days	02/28/2002	131	na	na	467	4.59	229.04	0.94	77.36	2.74	119.19	1.2	30.70	6.40	128	5.67	160	1.30	20.9	7.20	150	<0.08	6.56	8.72	34.88
Sheepscot R	Palermo Brook	Light rain on snow, 1.25" for 2 days	02/27/2002	66.7	na	na	135	4.84	241.52	0.83	68.31	2.71	117.89	1.23	31.46	8.85	177	5.32	150	1.15	18.6	6.72	140	<0.08	6.84	5.28	21.12
Sheepscot R	Palermo Brook	Light rain on snow, 1.25" for 2 days	02/28/2002	67.5	na	na	108	4.63	231.04	0.77	63.37	2.65	115.28	1	25.58	6.50	130	5.32	150	1.07	17.2	7.68	160	<0.08	6.85	5.27	21.08
Sheepscot R	Hewett Brook	Light rain on snow, 1.25" for 2 days	02/27/2002	151	na	na	456	5.14	256.49	0.99	81.48	2.47	107.45	1.09	27.88	7.25	145	5.32	150	1.97	31.8	7.20	150	<0.08	6.51	6.89	27.56
Sheepscot R	Hewett Brook	Light rain on snow, 1.25" for 2 days	02/28/2002	165	na	na	331	5.26	262.47	0.97	79.83	2.59	112.67	1.04	26.60	7.25	145	5.67	160	1.36	21.9	7.68	160	<0.08	6.50	7.78	31.12
Sheepscot R	Griffin Brook	Light rain on snow, 1.25" for 2 days	02/27/2002	152	na	na	468	4.21	210.08	0.97	79.83	2.83	123.11	1.25	31.98	7.85	157	5.67	160	1.13	18.2	6.24	130	<0.08	6.58	7.55	30.20
Sheepscot R	Griffin Brook	Light rain on snow, 1.25" for 2 days	02/28/2002	139	na	na	325	5.25	261.98	1.12	92.18	3.89	169.22	1.27	32.49	8.45	169	8.15	230	0.86	13.8	8.17	170	<0.08	6.62	8.71	34.84
Sheepscot R	Dearborn Brook	Light rain on snow, 1.25" for 2 days	02/27/2002	151	na	na	437	4.67	233.03	0.91	74.89	3.03	131.81	1.34	34.28	7.35	147	6.38	180	2.11	34	6.72	140	<0.08	6.56	7.52	30.08
Sheepscot R	Dearborn Brook	Light rain on snow, 1.25" for 2 days	02/28/2002	153	na	na	289	4.45	222.06	0.84	69.13	2.59	112.67	1.11	28.39	6.30	126	4.96	140	1.44	23.3	7.20	150	<0.08	6.50	8.65	34.60
Tunk Stream	Steuben, lower bridge	Light rain on snow, 1.25" for 2 days	02/28/2002	177	189	0	312	1.02	50.90	0.55	45.27	2.82	122.67	0.46	11.77	0.96	19.1	5.32	150	0.22	3.6	2.93	61	<0.08	5.26	8.88	35.52
Tunk Stream	Unionville bridge	Light rain on snow, 1.25" for 2 days	02/28/2002	118	96.9	21.1	141	0.88	43.91	0.37	30.45	2.24	97.44	0.34	8.70	0.85	17	3.90	110	0.08	1.3	2.45	51	<0.08	5.39	6.09	24.36
Tunk Stream	Route 182 bridge	Light rain on snow, 1.25" for 2 days	02/28/2002	98.8	73.1	25.7	108	0.87	43.41	0.36	29.63	2.2	95.70	0.37	9.46	0.01	0.2	3.54	100	0.07	1.2	2.50	52	0.08	4.86	6.19	24.76
Tunk Stream	Tunk Lake outlet	Light rain on snow, 1.25" for 2 days	02/28/2002	23.9	19.9	4	28.7	1.03	51.40	0.34	27.98	2.72	118.32	0.32	8.19	1.00	20	4.96	140	0.12	2	3.22	67	<0.08	6.00	2.22	8.88
East Machias R	Chase Mill Stream	Light rain on snow, 1.25" for 2 days	02/28/2002	36.8	na	na	106	3.19	159.18	0.76	62.55	3.49	151.82	0.38	9.72	5.00	100	8.51	240	0.35	5.7	3.99	83	<0.08	6.35	5.26	21.04
Easr Machias R	Beaverdam Stream	Light rain on snow, 1.25" for 2 days	02/28/2002	120	na	na	179	2.67	133.23	0.8	65.84	3.27	142.25	0.35	8.95	3.81	76.2	6.03	170	0.71	11.5	4.80	100	<0.08	6.16	8.72	34.88
Narraguagus R	Cherryfield at cannery	Light rain on snow, 1.25" for 2 days	02/28/2002	205	207	0	397	1.33	66.37	0.58	47.73	2.19	95.27	0.6	15.35	1.81	36.1	3.15	89	ND	<1.0	2.79	58	<0.08	5.59	10.8	43.20
Cove Brook	Route 1A above the bridge	Light rain on snow, 1.25" for 2 days	02/28/2002	106	na	na	374	5.34	266.47	1.21	99.58	4.83	210.11	1.04	26.60	10.20	204	9.93	280	1.66	26.8	5.76	120	<0.08	6.86	7.66	30.64
Cove Brook	Back Winterport Road culvert	Light rain on snow, 1.25" for 2 days	02/28/2002	114	na	na	209	4.26	212.57	1.12	92.18	4.18	181.83	1.04	26.60	8.55	171	8.15	230	1.71	27.6	4.80	100	<0.08	6.58	7.55	30.20
Souadabscook Stream	Route 1A above the bridge	Light rain on snow, 1.25" for 2 days	02/28/2002	94.4	na	na	265	9.53	475.55	2.02	166.25	8.92	388.02	0.9	23.02	18.20	364	21.27	600	1.65	26.6	8.17	170	<0.08	7.13	8.6	34.40
Pleasant R	Columbia Falls at WSRC	Light rain on snow, 1.25" for 2 days	02/28/2002	241	229	12	323	1.55	77.35	0.68	55.96	2.61	113.54	0.5	12.79	1.30	25.9	4.25	120	0.44	7.1	2.79	58	<0.08	5.18	14.2	56.80
Pleasant R	Eastern Little R	Light rain on snow, 1.25" for 2 days	02/28/2002	255	217	38	335	1.19	59.38	0.65	53.50	2.15	93.53	0.46	11.77	0.59	11.8	3.54	100	0.22	3.6	2.69	56	<0.08	4.88	14	56.00
Pleasant R	W Little River	Light rain on snow, 1.25" for 2 days	02/28/2002	244	214	30	275	1.12	55.89	0.63	51.85	1.85	80.48	0.52	13.30	0.01	0.2	2.80	79	0.35	5.7	2.55	53	<0.08	4.60	18.8	75.20
Cove Brook	Route 1A above the bridge	Rain on last snow, 2" in Stockton Spr	03/04/2002	114	na	na	358	4.82	240.52	0.96	79.01	4.13	179.66	0.71	18.16	9.75	195	8.15	230	1.20	19.4	5.76	120	<0.08	7.13	6.27	25.08
Cove Brook	Back Winterport Road culvert	Rain on last snow, 2" in Stockton Spr	03/04/2002	130	na	na	253	4.15	207.09	0.9	74.07	3.76	163.56	0.67	17.14	8.40	168	7.44	210	1.20	19.3	4.80	100	<0.08	6.88	6.41	25.64
Souadabscook Stream	Route 1A above the bridge	Rain on last snow, 2" in Stockton Spr	03/04/2002	104	na	na	193	7.55	376.75	1.57	129.21	6.86	298.41	0.72	18.42	14.90	298	16.31	460	1.22	19.6	7.20	150	<0.08	7.22	8.75	35.00
Narraguagus R	Route 9 bridge	Rain on last snow, 2" in Stockton Spr	03/05/2002	194	169	25	233	2.14	106.79	0.51	41.97	1.5	65.25	0.38	9.72	2.50	50	1.70	48	0.12	2	3.51	73	<0.08	5.74	12.8	51.20
Union R	W Branch at Route 9	Rain on last snow, 2" in Stockton Spr	03/05/2002	175	na	na	216	2.79	139.22	0.71	58.43	1.73	75.26	0.35	8.95	3.73	74.6	2.06	58	0.42	6.8	5.28	110	<0.08	6.26	11.8	47.20
Machias R	Old Stream at Route 9	Rain on last snow, 2" in Stockton Spr	03/05/2002	224	191	33	231	2.58	128.74	0.7	57.61	1.96	85.26	0.35	8.95	3.53	70.5	2.66	75	0.16	2.6	3.99	83	<0.08	5.90	16	64.00
Machias R	Mopang stream at Route 9	Rain on last snow, 2" in Stockton Spr	03/05/2002	119	104	15	119	1.53	76.35	0.45	37.04	1.73	75.26	0.38	9.72	2.35	47	2.02	57	0.11	1.7	2.93	61	0.09	5.76	10.2	40.80
Machias R	Machias camp, Route 9	Rain on last snow, 2" in Stockton Spr	03/05/2002	188	172	16	196	1.83	91.32	0.5	41.15	1.78	77.43	0.44	11.26	3.27	65.3	2.09	59	0.21	3.4	3.07	64	0.09	5.84	6.8	27.20
East Machias R	Rocky Brook	Rain on last snow, 2" in Stockton Spr	03/05/2002	215	178	37	210	1.89	94.31	0.56	46.09	2.81	122.24	0.26	6.65	0.10	2	4.96	140	0.07	1.1	3.94	82	<0.08	4.61	17	68.00
East Machias R	Gaddis Pool	Rain on last snow, 2" in Stockton Spr	03/05/2002	140	na	na	160	2.3	114.77	0.76	62.55	2.75	119.63	0.34	8.70	3.05	61	4.96	140	0.60	9.7	4.66	97	<0.08	6.00	9.47	37.88
East Machias R	Route 9 bridge	Rain on last snow, 2" in Stockton Spr	03/05/2002	111	na	na	115	2.46	122.75	0.68	55.96	2.35	102.23	0.29	7.42	4.25	85	3.90	110	0.17	2.7	3.55	74	<0.08	6.26	10.3	41.20
East Machias R	Beaverdam Stream	Rain on last snow, 2" in Stockton Spr	03/05/2002	145	124	21	157	1.63	81.34	0.57	46.91	2.3	100.05	0.28	7.16	1.05	21	3.54	100	0.10	1.6	3.94	82	<0.08	5.13	12.2	48.80
Narraguagus R	Baker Brook	High but falling river stage	03/14/2002	169	151	18	165	2.14	106.79	0.49	40.33	1.48	64.38	0.27	6.91	1.81	36.2	1.84	52	0.10	1.6	3.70	77	<0.08	5.35	12.8	51.20
Narraguagus R	Sinclair Brook	High but falling river stage	03/14/2002	147	125	22	146	1.12	55.89	0.46	37.86	1.52	66.12	0.27	6.91	1.13	22.6	1.84	52	0.11	1.7	3.46	72	<0.08	5.59	6.28	25.12
Narraguagus R	Bobcat Brook	High but falling river stage	03/14/2002	152	121	31	150	1.02	50.90	0.46	37.86	1.63	70.91	0.18	4.60	0.79	15.8	2.09	59	ND	<1.0	3.70	77	<0.08	5.34	5.77	23.08
Narraguagus R	Pork Brook	High but falling river stage	03/14/2002	186	153	33	184	1.07	53.39	0.35	28.81	1.74	75.69	0.21	5.37	1.08	21.6	1.81	51	0.08	1.3	2.35	49	0.11	5.17	10.1	40.40
Narraguagus R	Humpback Brook	High but falling river stage	03/14/2002	174	150	24	174	1.79	89.32	0.47	38.68	1.49	64.82	0.3	7.67	2.05	41	1.74	49	0.07	1.2	3.75	78	<0.08	5.66	9.77	39.08
Narraguagus R	Gould Brook	High but falling river stage	03/14/2002	158	136	22	184	1.85	92.32	0.43	35.39	1.5	65.25	0.32	8.19	2.27	45.3	1.63	46	0.07	1.2	3.60	75	<0.08	5.86	9.91	39.64
Narraguagus R	Barrell Brook	High but falling river stage	03/14/2002	68.9	58.9	10	69.9	1.52	75.85	0.36	29.63	1.51	65.69	0.32	8.19	3.40	67.9	1.49	42	0.12	2	2.50	52	<0.08	6.22	5.81	23.24
Narraguagus R	W Branch of the mainstem	High but falling river stage	03/14/2002	159	130	29	161	1.9	94.81	0.46	37.86	1.56	67.86	0.3	7.67	3.32	66.4	1.67	47	0.09	1.5	3.12	65	<0.08	6.17	8.81	35.24

Samples taken by DEP and Salmon River Watershed Councils

Sample analysis by U of Maine, George Mitchell Center for Environmental and Watershed Research

				Al dissol.	Al org.	Al exch.	Al total	Ca		Mg		Na		K		Alk	ANC	Cl		NO3		SO4		F	pH	DOC	
Tunk Stream	Steuben, lower bridge	Spring baseflow	03/20/2002	61.6	na	na	69.2	1.15	57.39	0.48	39.50	2.73	118.76	0.39	9.98	1.41	28.2	5.32	150	ND	<1.0	3.22	67	0.08	6.03	3.84	15.36
Tunk Stream	Unionville bridge	Spring baseflow	03/20/2002	39.3	na	na	46.7	1.02	50.90	0.4	32.92	2.51	109.19	0.37	9.46	0.30	6	4.96	140	ND	<1.0	3.07	64	0.1	5.16	3.15	12.60
Tunk Stream	Route 182 bridge	Spring baseflow	03/20/2002	29.8	na	na	38.1	0.96	47.90	0.37	30.45	2.42	105.27	0.34	8.70	1.15	22.9	4.25	120	ND	<1.0	3.07	64	0.1	5.81	3.16	12.64
Tunk Stream	Tunk Lake outlet	Spring baseflow	03/20/2002	23	na	na	29.7	0.91	45.41	0.35	28.81	1.99	86.57	0.38	9.72	0.73	14.6	3.54	100	0.13	2.1	3.41	71	0.09	5.83	2.11	8.44
Cove Brook	Route 1A above the bridge	Stormwater, 2.9 " in Columbia Falls	03/27/2002	72.9	na	na	223	7.82	390.22	1.51	124.27	5.79	251.87	0.73	18.67	18.20	364	13.12	370	0.89	14.3	6.72	140	<0.08	7.23	5.61	22.44
Souadabscook Stream	Route 1A above the bridge	Stormwater, 2.9 " in Columbia Falls	03/27/2002	87.6	na	na	174	9.51	474.55	1.93	158.84	9.97	433.70	0.65	16.63	20.05	401	23.40	660	0.59	9.5	6.72	140	<0.08	7.40	8.25	33.00
Ducktrap River	Route 52 gauge	Stormwater, 2.9 " in Columbia Falls	03/27/2002	91	na	na	116	2.33	116.27	0.68	55.96	2.98	129.63	0.41	10.49	3.50	69.9	6.38	180	0.22	3.5	4.66	97	<0.08	6.47	6.11	24.44
Narraguagus R	Route 9 bridge	High flows from 3/27	03/29/2002	135	na	na	149	2.15	107.29	0.47	38.68	3.22	140.07	0.31	7.93	3.45	69	6.38	180	0.12	1.9	3.36	70	<0.08	6.28	8.88	35.52
Canoe Brook, Pleasant R Lake	Route 9 bridge	High flows from 3/28	03/29/2002	85.5	na	na	92.7	1	49.90	0.37	30.45	1.73	75.26	0.23	5.88	2.11	42.2	2.02	57	0.16	2.6	3.55	74	<0.08	6.28	2.86	11.44
Machias R	Mopang stream at Route 9	High flows from 3/29	03/29/2002	71.9	na	na	83.5	1.31	65.37	0.35	28.81	1.51	65.69	0.31	7.93	3.16	63.1	1.91	54	0.07	1.2	2.59	54	0.08	6.23	7	28.00
Pleasant R	Little River, east	High flows from 3/30	03/28/2002	198	213	0	300	0.94	46.91	0.49	40.33	1.88	81.78	0.38	9.72	1.02	20.3	3.26	92	0.12	1.9	2.74	57	<0.08	5.05	12	48.00
Pleasant R	West Little River	High flows from 3/31	03/28/2002	191	199	0	259	0.83	41.42	0.43	35.39	1.53	66.56	0.27	6.91	0.37	7.3	1.99	56	0.17	2.7	2.26	47	<0.08	4.66	14	56.00
Pleasant R., Columbia Falls	Columbia Falls at WSRC	High flows from 3/32	03/28/2002	170	195	0	259	0.99	49.40	0.45	37.04	1.84	80.04	0.29	7.42	1.50	29.9	2.87	81	0.20	3.3	2.40	50	<0.08	5.22	10.9	43.60
Machias R	Holmes Falls bridge	Stormwater, 2" in last 5 days	04/04/2002	169	151	18	208	1.33	66.37	0.37	30.45	1.85	80.48	0.33	8.44	1.66	33.1	1.74	49	0.10	1.6	2.45	51	<0.08	5.44	11	44.00
Machias R	Bear Brook (OLD 16)	Stormwater, 2" in last 5 days	04/04/2002	242	174	68	256	1.02	50.90	0.43	35.39	1.89	82.22	0.32	8.19	1.22	24.4	1.63	46	ND	<1.0	2.79	58	<0.08	4.99	13	52.00
Machias R	Joe Hill Brook (OLD 19)	Stormwater, 2" in last 5 days	04/04/2002	113	93.6	19.4	110	1.17	58.38	0.38	31.27	1.83	79.61	0.11	2.81	0.39	7.8	1.91	54	ND	<1.0	3.46	72	<0.08	5.00	7.79	31.16
Machias R	Big Springy Brook (MAC 13)	Stormwater, 2" in last 5 days	04/04/2002	267	211	56	251	0.97	48.40	0.36	29.63	1.76	76.56	0.24	6.14	-0.48	-9.5	1.35	38	ND	<1.0	2.88	60	<0.08	4.61	17	68.00
Machias R	Holmes Brook (MAC 15)	Stormwater, 2" in last 5 days	04/04/2002	188	159	29	207	1.2	59.88	0.47	38.68	1.7	73.95	0.24	6.14	1.37	27.3	1.63	46	0.11	1.8	2.59	54	<0.08	5.19	11.6	46.40
Machias R	New Stream (MAC 27)	Stormwater, 2" in last 5 days	04/04/2002	217	174	43	227	1.19	59.38	0.42	34.57	2.74	119.19	0.23	5.88	0.86	17.2	3.54	100	0.10	1.6	3.12	65	<0.08	5.01	10.7	42.80
Machias R	Sam Hill Stream (OLD 17)	Stormwater, 2" in last 5 days	04/04/2002	126	98.7	27.3	125	1.3	64.87	0.39	32.10	1.9	82.65	0.27	6.91	1.01	20.1	1.84	52	0.06	1	3.41	71	<0.08	5.28	9.23	36.92
Machias R	Joe Meadow Brook (MAC 28)	Stormwater, 2" in last 5 days	04/04/2002	119	104	15	129	1.1	54.89	0.26	21.40	2.08	90.48	0.12	3.07	1.06	21.1	2.41	68	ND	<1.0	2.26	47	<0.08	5.20	8.54	34.16
Machias R	Old Stream at Bear Br. Road	Stormwater, 2" in last 5 days	04/04/2002	158	151	7	187	1.57	78.34	0.47	38.68	1.88	81.78	0.26	6.65	2.44	48.8	1.88	53	0.10	1.6	2.93	61	<0.08	5.86	9.88	39.52
Union R	Middle Branch at Route 9	Stormwater, 2" in last 5 days	04/04/2002	119	96.8	22.2	115	1.62	80.84	0.43	35.39	2.35	102.23	0.38	9.72	2.09	41.7	3.26	92	0.07	1.2	2.59	54	0.14	5.76	9.62	38.48
Machias R	Honeymoon Brook (OLD 22)	Spring baseflow	04/11/2002	134	86.4	47.6	149	2.13	106.29	0.59	48.56	7.96	346.26	0.38	9.72	1.38	27.6	12.05	340	ND	<1.0	3.94	82		5.73	7.75	31.00
Machias R	Pembroke Stream (MAC 29)	Spring baseflow	04/11/2002	283	177	106	279	1.07	53.39	0.38	31.27	3.49	151.82	0.26	6.65	-0.08	-1.5	3.90	110	ND	<1.0	2.88	60		4.86	14.6	58.40
Machias R	Lanpher Brook (MAC 9)	Spring baseflow	04/11/2002	116	na	na	117	3.14	156.69	0.49	40.33	1.76	76.56	0.41	10.49	6.40	128	1.52	43	ND	<1.0	3.70	77		6.59	7.64	30.56
Machias R	Dead Stream-First Lake (OLD 25)	Spring baseflow	04/11/2002	210	147	63	202	1.91	95.31	0.37	30.45	1.86	80.91	0.26	6.65	1.36	27.2	1.49	42	ND	<1.0	3.27	68		5.41	13.2	52.80
Machias R	Dead Stream-Boles Lake (OLD24)	Spring baseflow	04/11/2002	236	155	81	238	1.45	72.36	0.48	39.50	2.25	97.88	0.25	6.40	1.33	26.5	1.74	49	ND	<1.0	3.12	65		5.38	12.6	50.40
Pleasant R	Columbia Falls at WSRC	Stormwater, 2 day total 2.75"	04/15/2002	220	177	43	293	1.26	62.87	0.5	41.15	2.85	123.98	0.34	8.70	1.39	27.7	3.05	86	0.11	1.7	2.31	48	<0.08	5.36	13.7	54.80
Narraguagus R	Cherryfield at cannery	Stormwater, 2 day total 2.75"	04/15/2002	201	163	38	281	1.42	70.86	0.47	38.68	2.9	126.15	0.47	12.02	1.98	39.6	3.12	88	0.10	1.6	2.40	50	<0.08	5.86	11.4	45.60
Tunk Stream	Steuben, lower bridge	Stormwater, 2 day total 2.75"	04/15/2002	183	130	53	218	1.03	51.40	0.5	41.15	4.04	175.74	0.37	9.46	1.16	23.1	4.96	140	0.06	1	2.79	58	<0.08	5.59	8.64	34.56
Union R	Middle Branch at Route 9	Stormwater, 2 day total 2.75"	04/15/2002	135	99.4	35.6	137	1.79	89.32	0.44	36.21	2.8	121.80	0.37	9.46	2.62	52.4	2.94	83	ND	<1.0	2.40	50	0.12	5.86	11.3	45.20
Ducktrap River	Route 52 gauge	Stormwater, 2 day total 2.75"	04/16/2002	115	na	na	125	2.22	110.78	0.61	50.20	3.73	162.26	0.36	9.21	3.21	64.2	4.96	140	0.06	1	4.13	86	<0.08	6.41	7.21	28.84
Sheepscot R	Route 126 gauge site	Stormwater, 2 day total 2.75"	04/16/2002	120	na	na	247	3.78	188.62	0.8	65.84	3.54	153.99	0.79	20.21	6.25	125	5.32	150	0.21	3.4	5.76	120	<0.08	6.86	8.08	32.32
Sheepscot R	West Branch at Howe Rd	Stormwater, 2 day total 2.75"	04/16/2002	122	na	na	292	4.78	238.52	0.85	69.96	3.52	153.12	0.92	23.53	7.60	152	5.32	150	0.26	4.2	6.24	130	<0.08	6.82	9.04	36.16
Sheepscot R	Palermo Brook	Stormwater, 2 day total 2.75"	04/16/2002	55.8	na	na	108	5.36	267.46	0.86	70.78	3.58	155.73	0.95	24.30	9.90	198	4.61	130	0.18	2.9	7.20	150	<0.08	7.11	5.34	21.36
Sheepscot R	Meadow Brook	Stormwater, 2 day total 2.75"	04/16/2002	68.8	na	na	72.6	7.13	355.79	0.83	68.31	3.43	149.21	0.88	22.51	11.50	230	6.74	190	0.20	3.3	5.76	120	<0.08	6.78	7.85	31.40
Sheepscot R	Hewett Brook	Stormwater, 2 day total 2.75"	04/16/2002	153	na	na	242	6.58	328.34	1.06	87.24	4.18	181.83	1.13	28.91	11.00	220	7.09	200	0.22	3.6	7.20	150	<0.08	6.84	9.07	36.28
Sheepscot R	Choat Brook	Stormwater, 2 day total 2.75"	04/16/2002	167	na	na	899	3.07	153.19	0.67	55.14	2.5	108.75	0.53	13.56	3.59	71.8	3.19	90	0.09	1.5	4.80	100	<0.08	6.18	11.8	47.20
Sheepscot R	Griffin Brook	Stormwater, 2 day total 2.75"	04/16/2002	158	na	na	310	5.05	252.00	1.08	88.88	4.56	198.36	1.22	31.21	10.05	201	7.09	200	0.22	3.6	6.24	130	<0.08	6.89	9.53	38.12
Sheepscot R	Wingood Brook	Stormwater, 2 day total 2.75"	04/16/2002	251	na	na	348	2.92	145.71	0.91	74.89	3	130.50	0.77	19.70	4.50	90	3.90	110	0.27	4.3	5.28	110	<0.08	6.33	11.8	47.20
Sheepscot R	Branch Brook	Stormwater, 2 day total 2.75"	04/16/2002	30.7	na	na	30	8.85	441.62	0.96	79.01	5.03	218.81	1.17	29.93	14.05	281	10.28	290	ND	<1.0	8.17	170	<0.08	7.01	4.3	17.20
Sheepscot R	Dearborn Brook	Stormwater, 2 day total 2.75"	04/16/2002	144	na	na	256	5.07	252.99	0.88	72.42	3.33	144.86	1.05	26.86	8.75	175	4.96	140	0.22	3.6	5.76	120	<0.08	6.80	10.6	42.40
Pleasant R	Columbia Falls at WSRC	Stormwater, 2 day total 2.75"	04/17/2002	201	146	55	259	1.11	55.39	0.39	32.10	2.54	110.49	0.22	5.63	0.98	19.6	2.55	72	ND	<1.0	2.07	43	<0.08	5.24	14.1	56.40
Sheepscot R	Route 126 gauge site	Stormwater, 2 day total 2.75"	05/14/2002	111	na	na		4.21	210.08	0.88	72.42	3.53	153.56	1.02	26.09	10.30	206	5.67	160	0.24	3.8	5.28	110	<0.08	6.98	8.09	32.36
Sheepscot R	West Branch at Howe Rd	Stormwater, 2 day total 2.75"	05/14/2002	82.7	na	na		3.84	191.62	0.74	60.90	2.71	117.89	0.95	24.30	9.65	193	4.25	120	0.24	3.8	4.23	88	<0.08	7.01	6.29	25.16
Sheepscot R	Palermo Brook	Stormwater, 2 day total 2.75"	05/15/2002	49.6	na	na		4.76	237.52	0.8	65.84	2.97	129.20	1.03	26.35	11.65	233	3.90	110	0.13	2.1	6.24	130	<0.08	7.20	5.5	22.00
Sheepscot R	Meadow Brook	Stormwater, 2 day total 2.75"	05/14/2002	48.2	na	na		7.25	361.78	0.86	70.78	3.24	140.94	0.97	24.81	17.70	354	6.38	180	0.09	1.4	4.32	90	<0.08	6.92	7.52	30.08
Sheepscot R	Choat Brook	Stormwater, 2 day total 2.75"	05/14/2002	136	na	na		6.21	309.88	1.04	85.59	3.34	145.29	0.92	23.53	13.95	279	5.67	160	0.23	3.7	6.24	130	<0.08	6.98	9.76	39.04
Sheepscot R	Choat Brook	Stormwater, 2 day total 2.75"	05/14/2002	198	na	na		3.04	151.70	0.68	55.96	2.56	111.36	0.59	15.09	6.15	123	3.54	100	0.09	1.5	3.65	76	<0.08	6.45	12.4	49.60
Sheepscot R	Griffin Brook	Stormwater, 2 day total 2.75"	05/14/2002	138	na	na		4.58	228.54	0.98	80.65	3.61	157.04	1.08	27.63	12.20	244	5.32	150	0.23	3.7	5.28	110	<0.08	6.90	9.72	38.88
Sheepscot R	Wingood Brook	Stormwater, 2 day total 2.75"	05/14/2002	240	na	na		2.38	118.76	0.76	62.55	2.37	103.10	0.76	19.44	5.70	114	2.94	83	0.48	7.7	3.46	72	<0.08	6.41	12.5	50.00
Sheepscot R	Branch Brook	Stormwater, 2 day total 2.75"	05/15/2002	23.6	na	na		8.82	440.12	0.96	79.01	4.33	188.36	1.1	28.14	17.80	356	9.57	270	ND	<1.0	7.68	160	<0.08	7.01	4.11	16.44
Sheepscot R	Dearborn Brook	Stormwater, 2 day total 2.75"	05/14/2002	155	na	na		4.86	242.51	0.86	70.78	3.44	149.64	1.04	26.60	11.80	236	5.67	160	0.19	3.1	4.80	100	<0.08	6.82	10.1	40.40

Samples taken by DEP and Salmon River Watershed Councils

Sample analysis by U of Maine, George Mitchell Center for Environmental and Watershed Research

Total P	SPCond	TSS	Turbidity	Cation Sum	Anion Sum
µg/L	µSI/cm	mg/L	NTU		
nd		20.00	7.00	394.98	418.96
15	56.90	na	na	393.72	444.40
20	41.00	na	na	280.27	322.34
14	39.20	na	na	264.64	312.62
2.2	30.80	na	na	201.70	234.58
20	154.00	na	na	1213.47	1363.20
21	138.00	na	na	1090.62	1220.74
31	178.00	na	na	1405.13	1542.92
120	106.00	76.00	30.00	824.37	936.14
61	86.50	30.00	8.50	656.60	727.50
110	168.00	68.00	28.00	1289.27	1442.00
70	59.80	32.00	13.00	447.37	495.08
43	57.00	17.00	7.50	445.45	491.78
91	60.70	39.00	17.00	461.86	511.06
50	56.60	19.00	9.00	456.29	493.78
41	59.90	9.00	4.20	459.17	506.72
15	57.20	2.00	1.50	435.26	478.28
49	60.50	12.00	8.00	473.29	504.36
29	62.40	3.00	4.60	481.57	518.02
50	58.90	17.00	9.60	444.99	495.40
34	72.40	8.00	5.80	555.85	617.64
46	63.10	7.00	7.00	474.01	531.08
25	56.50	3.00	3.20	432.25	473.90
39	34.30	na	na	230.60	269.22
9.6	26.90	na	na	180.50	203.66
9.8	27.60	na	na	178.21	178.16
3.2	31.30	na	na	205.88	237.88
64	55.60	na	na	383.26	449.74
17	47.80	na	na	350.27	392.58
35	29.10	16.00	7.50	224.71	226.30
77	76.50	29.00	14.00	602.76	661.44
39	66.60	3.00	5.00	513.18	558.80
38	134.00	12.00	7.60	1052.84	1195.00
38	33.30	14.00	6.60	259.63	267.80
26	31.20	7.00	3.80	218.17	227.40
26	32.10	14.00	4.00	201.51	213.10
40	71.00	13.00	7.70	517.34	589.48
26	63.60	5.00	3.70	461.85	522.94
24	115.00	4.00	4.60	822.78	962.60
15	27.40	na	na	223.73	224.20
14	35.10	na	na	281.86	296.60
16	34.60	na	na	280.57	295.10
10	25.70	na	na	198.36	207.50
13	28.40	na	na	221.15	218.90
10	42.70	na	na	269.28	293.10
12	41.60	na	na	305.64	345.58
9.7	37.30	na	na	288.36	312.90
9.6	34.30	na	na	235.46	253.40
5.9	27.30	na	na	218.40	218.00
4.4	22.80	na	na	166.77	173.42
3.5	23.80	na	na	164.27	174.88
5.9	22.40	na	na	163.26	163.30
7.4	26.00	na	na	200.49	208.28
13	25.30	na	na	201.14	207.14
5.6	22.50	na	na	179.35	187.14
8.3	25.70	na	na	208.20	215.14

Samples taken by DEP and Salmon River Watershed Councils

Sample analysis by U of Maine, George Mitchell Center for Environmental and Watershed Research

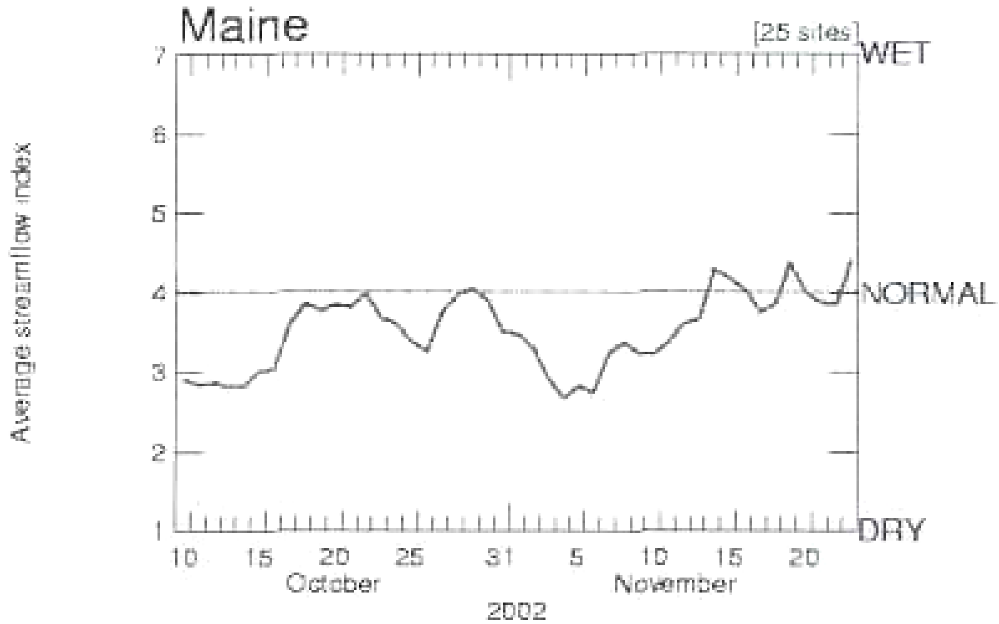
total P	Cond	TSS	Turbidity	Cations	Anions
7.9	31.90	na	na	225.62	260.56
5.3	32.50	na	na	202.47	222.60
4.4	30.20	na	na	192.32	219.54
2.8	26.20	na	na	170.50	196.14
31	101.00	13.00	6.10	785.03	910.74
23	140.00	6.20	6.00	1083.71	1243.50
10	43.50	na	na	312.35	374.84
11	40.90	na	na	293.97	356.42
5	21.10	na	na	161.49	187.24
6.2	22.10	na	na	167.79	200.30
15	26.90	na	na	178.73	219.20
17	24.80	na	na	150.27	169.00
16	25.40	na	na	173.89	207.80
12	22.20	na	na	185.73	178.70
10	23.30	na	na	176.69	180.40
5	23.20	na	na	172.08	164.96
7	28.80	na	na	160.73	156.50
11	22.30	na	na	178.65	175.50
10	29.40	na	na	219.02	226.60
8.5	23.40	na	na	186.52	181.02
7	21.80	na	na	169.84	170.26
11	23.30	na	na	205.45	203.92
7.6	27.80	na	na	228.17	227.38
9.3	62.60	na	na	510.82	480.60
6.8	25.70	na	na	243.13	226.90
5	29.12	na	na	284.06	278.56
13	24.00	na	na	213.32	190.00
7.6	24.10	na	na	216.13	190.90
17	27.20	na	na	236.70	218.20
14	26.70	na	na	247.71	224.80
12	34.10	na	na	277.75	256.66
8.6	28.60	na	na	256.80	230.60
10	39.50	na	na	332.44	320.04
17	51.90	3.20	2.10	428.66	430.72
20	59.20	5.40	3.20	485.13	472.36
9.7	61.20	1.10	0.70	518.27	502.26
7.6	68.10	0.00	0.30	595.81	574.70
19	74.60	1.40	3.10	626.32	609.88
25	36.90	12.00	1.60	330.64	310.50
20	69.20	2.10	3.00	570.45	572.72
18	42.20	1.10	2.10	370.80	361.50
8.3	92.90	0.00	0.30	769.36	758.20
18	57.00	1.50	2.10	497.13	481.00
nd	27.20	na	na	203.60	191.00
21	61.60	5.10	3.50	462.15	512.16
29	69.50	6.80	4.30	394.70	429.96
17	59.70	1.70	1.30	458.91	497.10
7.6	77.00	0.30	0.30	598.31	655.48
24	73.80	3.10	5.00	564.29	611.74
16	41.70	1.30	1.60	334.11	350.10
33	64.00	9.00	5.60	493.86	546.58
36	37.90	3.70	3.60	303.85	326.70
3.9	99.80	0.00	0.50	735.62	802.44
25	63.90	3.90	3.90	489.54	539.50

Samples taken by DEP and Salmon River Watershed Councils

Sample analysis by U of Maine, George Mitchell Center for Environmental and Watershed Research

Figure 1. Average stream flow conditions in Maine from USGS "Water Watch" website. Data i given for October and November 2002 as well as flows from 1999-2000.

Last 45 Days



Since July 2, 1999

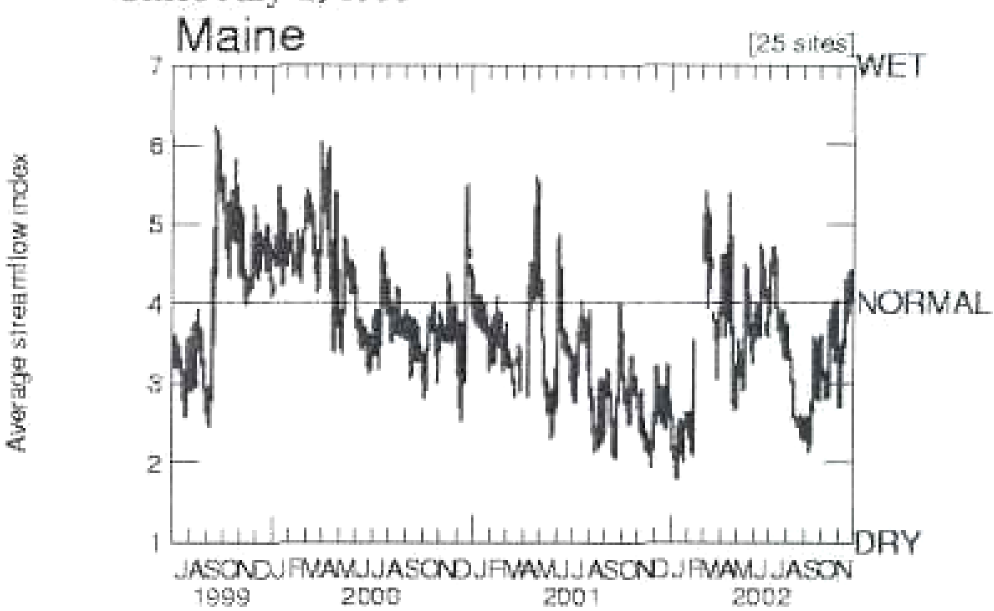


Figure 2. Field and lab pH data from Tunk Stream. All samples were taken from the bridge on Route 182 (the Black Woods Road). Hand written initials next to data points indicate the source of the data. MW is a field measurement by Mark Whiting. DS is a field measurement made by Dennis Shellabarger of the Friends of Tunk. UM is a lab pH by the George Mitchell Center.

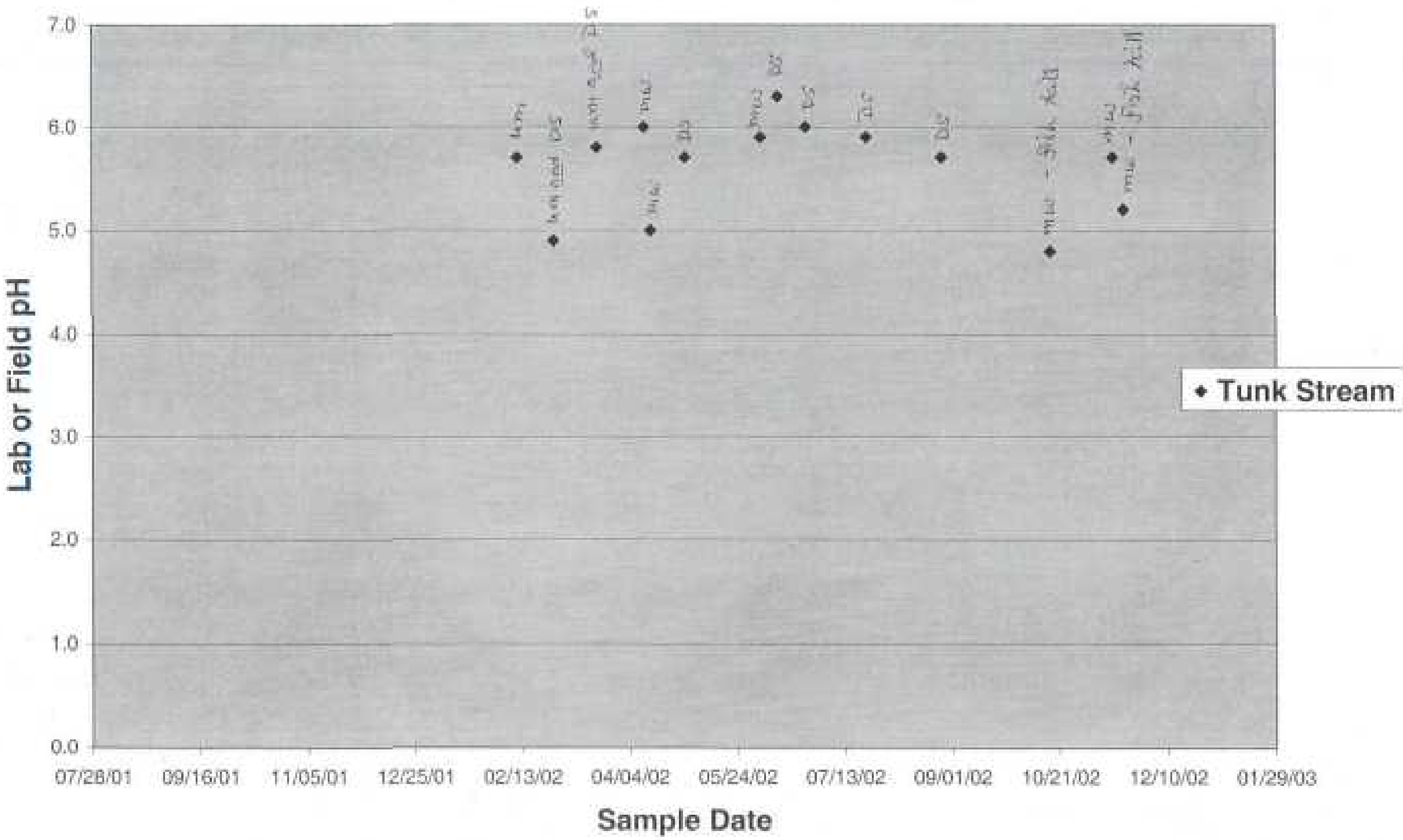


Figure 3. Field and lab pH data from the Pleasant River at Columbia Falls. Hand written initials next to data points indicate the sources of the data. MW is a field measurement by Mark Whiting. UMM is a field measurement by Prof. Alan Lewis's salmon biology class. JvdS is a field measurement from Jacob vandeSande. UM is a lab pH by the George Mitchell Center. The question mark is a value that appears to be unrealistic given the other data points.

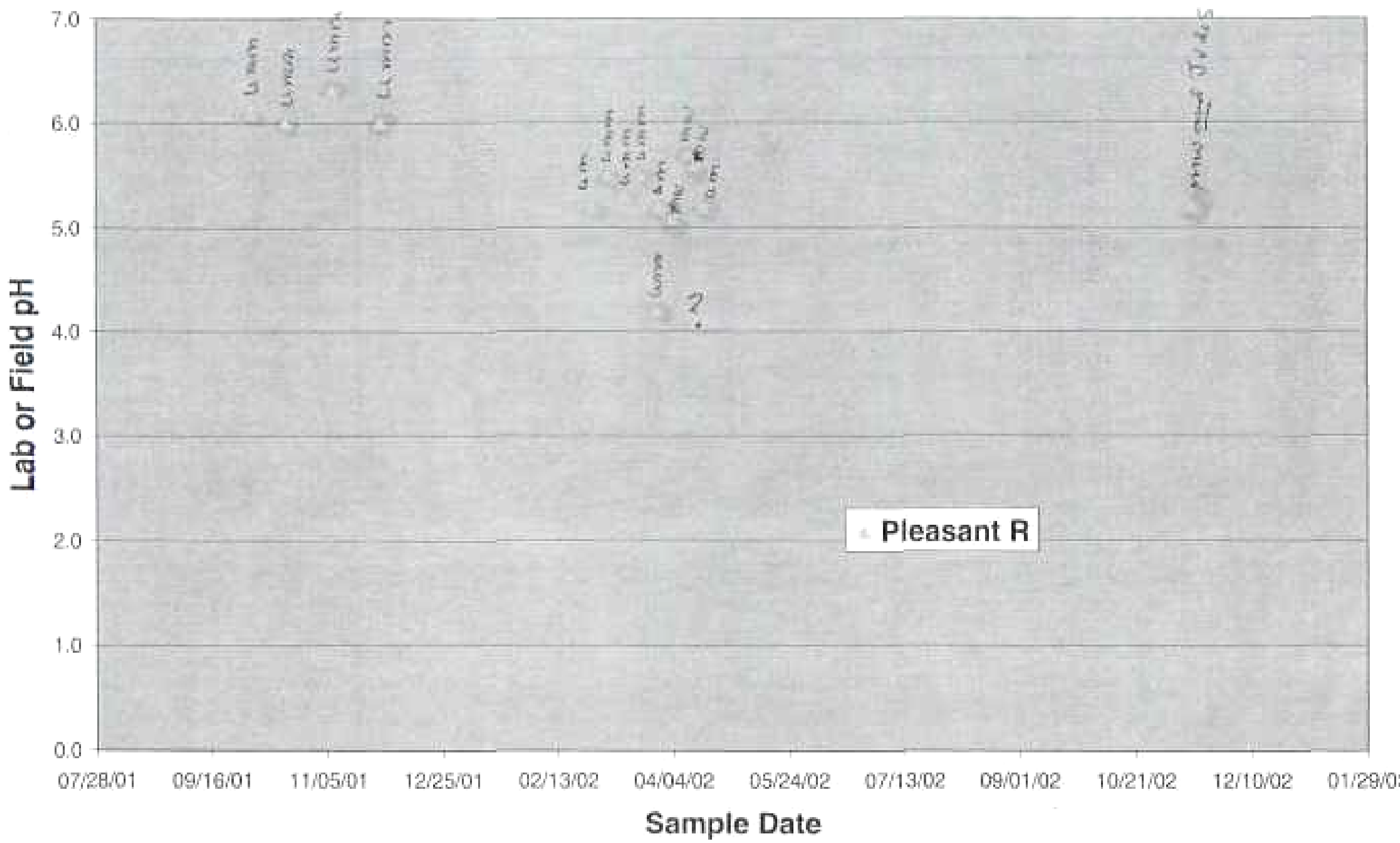


Figure 4. Field and lab pH data from the Narraguagus R. Most samples are from downtown Cherryfield, but three data points are from the bridge on Route 9 (these are marked by hand drawn circles around the data point). Initials indicate the sources of the data. MW is a field measurement by Mark Whiting. UMM is a field measurement by Prof. Alan Lewis' salmon biology class. UM is a lab pH from the George Mitchell Center. Question marks indicate values that appear to be unrealistic given the other available information.

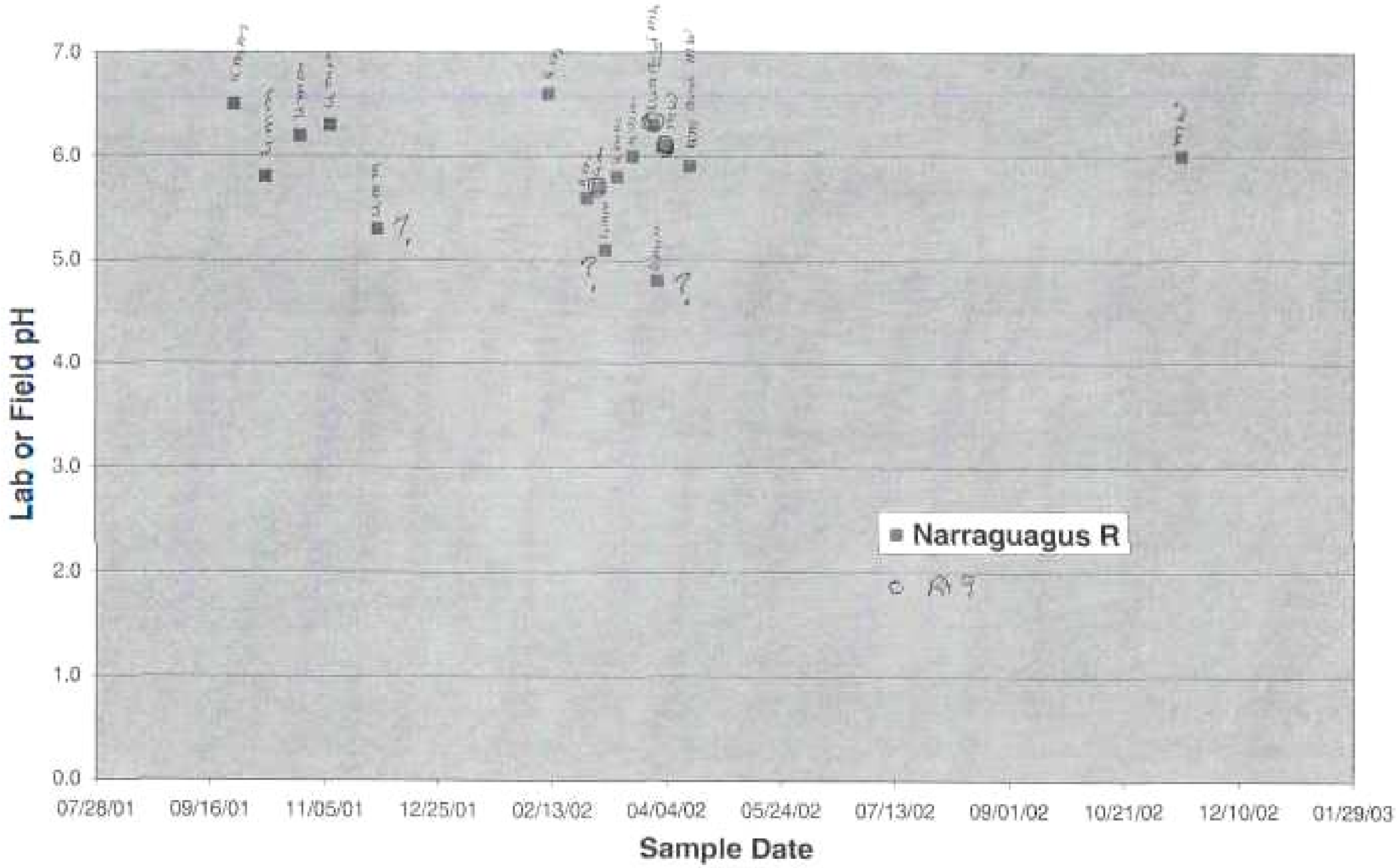


Figure 5. Data sonde recording for Old Stream.

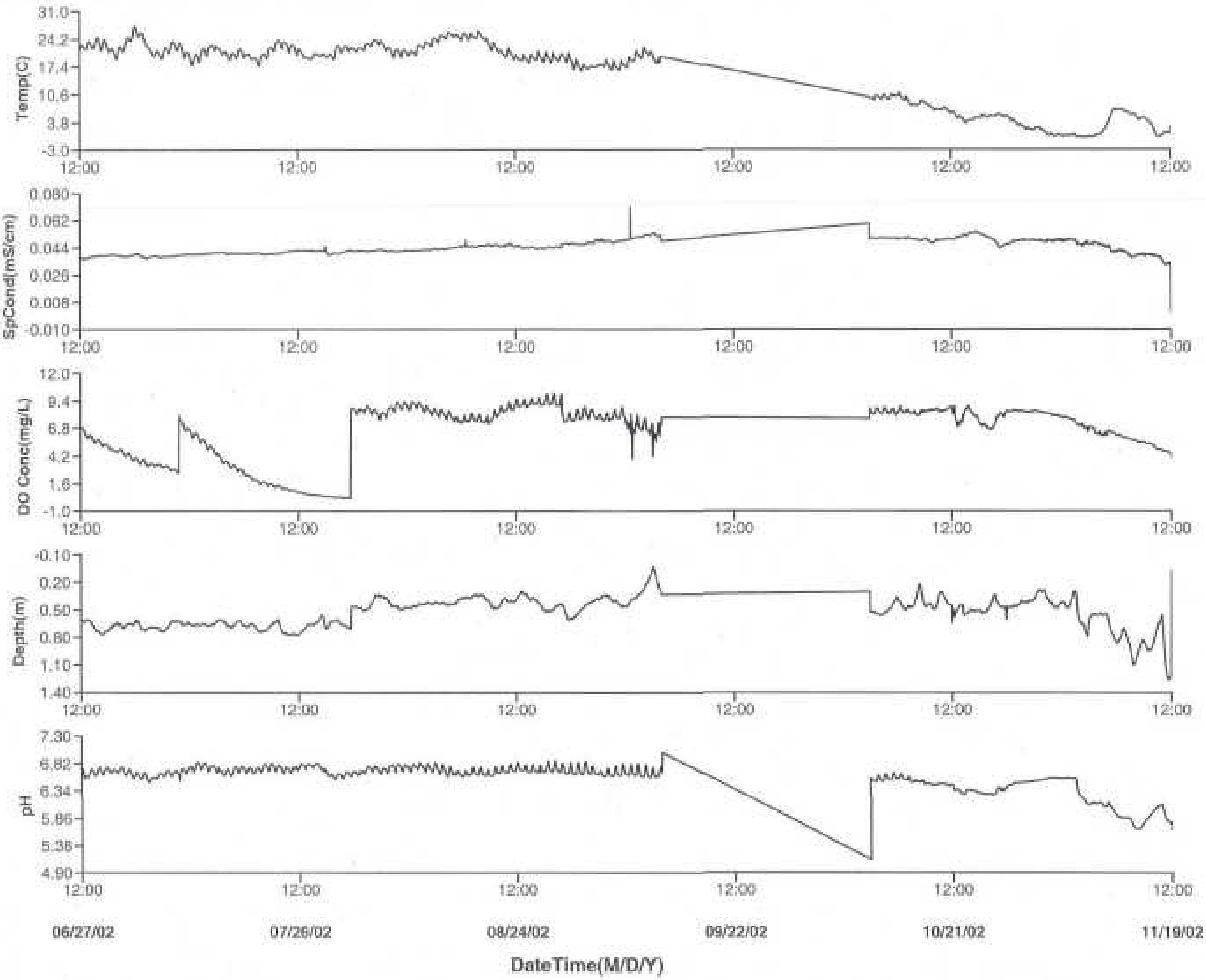


Figure 6. Data sonde recording for Big Springy Brook.

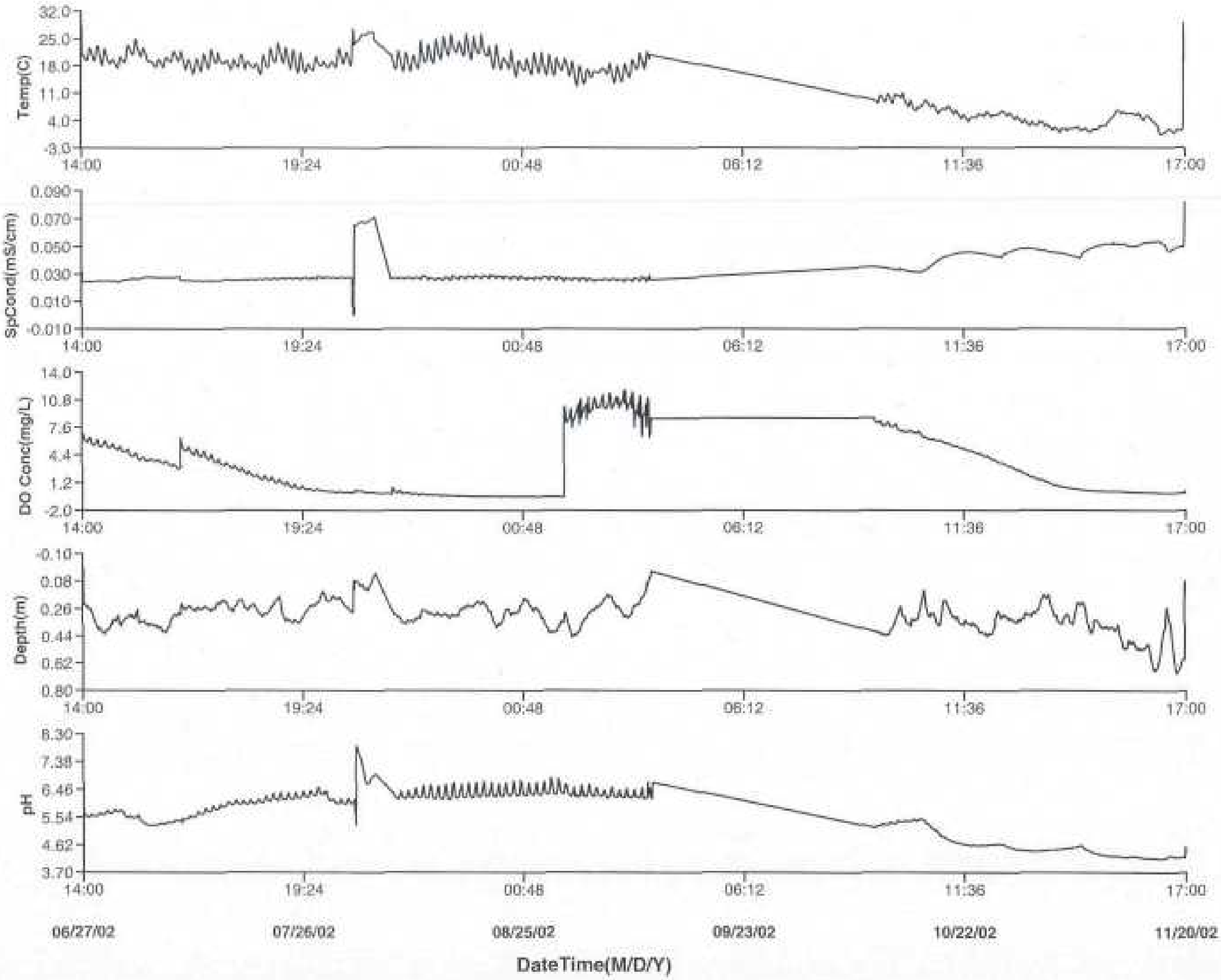


Figure 7. Data sonde recording for Sam Hill Brook.