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April 13, 2009

Chris Countie
Water Supply Manager
Pennichuck Water Works
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Nashua, NH 03064

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**RE: PENNICHUCK WATER WORKS
TRIBUTARY SAMPLING DATA**

Dear Mr. Countie:

The purpose of this letter report is to present the results of the tributary sampling program initiated in May 2007 and recommendations for changes to the program. The program began in conjunction with the preparation of a Watershed Restoration Plan for the Pennichuck Brook Water Supply Watershed and included dry and wet weather sampling of nine tributaries and recording of continuous tributary flows through the use of data loggers. Figure 1 shows the nine sampling locations.

Background

Pennichuck Water Works, in coordination with NRPC, has been collecting data from the watershed since 1991. Over this time, sampling locations and parameters have changed until around 2005, at which time a sampling program was developed for nine tributaries within the watershed and a specific set of parameters. This program was further refined in 2007 to include continuous flow monitoring and the collection of winter samples, beginning a more complete data set. This letter report focuses on the full data set collected beginning in 2007.

Monitoring Locations

The nine tributary sampling locations are shown on Figure 1 with descriptions provided in the following table.

Station	Description	Station	Description
01-BRB	Boire Field Brook, Tinker Road	01-WCH	South Merrimack Road Bridge
09-PEN	Holt Pond Dam	01-XWB	Unnamed Trib to Witches Brook
09T-PEN	Route 101A Bridge	02-WCH	Ames Road Bridge off Route 122
09-XPB	Unnamed Trib to Pennichuck Brook	12-PEN	Nevins Road Bridge
		01-MUD	Farley Road Bridge



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Data Collection

Monitoring activities presented in this report include those beginning in May of 2007 through December, 2008. During this time, CEI collected water quality and flow data to aid in determining the health of each tributary. Manual field measurements were taken during dry weather conditions on May 30, June 26, August 2, August 22, September 26, and October 31, 2007, as well as January 8, May 28, July 9, August 20, October 10, and December 8, 2007. On these dates, samples were taken for Total Coliform, E.coli, Nitrate-N, Ammonia-N, TKN, Total Phosphorus and Total Suspended Solids and sent for laboratory analysis. CEI also performed field analysis of pH, Conductivity, Dissolved Oxygen and Temperature. All data was tabulated and input into a water quality database.

Electronic data loggers were installed at all locations on May 21, 2007 to determine the relative contribution of each stream to Pennichuck Brook and to track long-term trends in flow. The surface water data loggers read and record water levels every 30 minutes. During previous monitoring efforts in 2005 and 2006, staff gauges were installed at the nine locations and stage-discharge relations were created based on field measurements. Using the stage-discharge equations, the water levels recorded by the data loggers can convert to an approximate flow for the river at each point in time. Data loggers were downloaded to a field laptop for analysis approximately every four to six weeks between June and December of each year.

Due to changes in stream profiles, new stage-discharge equations were developed for stations 01-WCH and 02-WCH throughout the 2007 and 2008 monitoring period. The original stage-discharge curves developed using the 2005 and 2006 data are still valid for all other streams, however, an adjustment was made to the stage-discharge equation for Station 01-MUD to avoid negative flows associated with lower water levels.

Data Results

The sampling data results were analyzed for trends and correlations, as well as any unexpected data outliers. Overall, stations 09-XPB, 09T-PEN, 01-BFB and 01-XWB showed the highest concentrations for each parameter analyzed. These stations also have the largest flows recorded. Station 09-PEN also had large flows, however did not show the same high concentrations as the other three stations.

Seasonal

Samples taken during the summer months in both 2007 and 2008 roughly correlate to one another. As expected, temperature rises during summer months along with turbidity, ammonia, phosphorus and bacteria levels. Turbidity levels should not exceed

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naturally occurring concentrations. A limit of 5 NTU is often used for drinking water standards. Turbidity readings were all less than 14 NTU, indicative of low levels.

Dissolved oxygen is inversely proportional to the above parameters as it tends to fall during warmer months and recover during colder periods. Dissolved oxygen surface water quality standards specify a minimum concentration of 5.0 mg/L. Samples from stations 09T-PEN, 01-MUD and 01-WCH violate standards numerous times while other stations are generally above 6.0 mg/L. Readings below 4.0 mg/L would be considered dangerous to aquatic organisms.

Sampling performed during winter months is more difficult to correlate as there were not as many samples taken. Additionally, some winter field data, particularly flow information, was unreliable because of instrument malfunction due to ice buildup.

Based on the information obtained during sampling, TSS, phosphorus, TKN, total coliform, E.coli and ammonia exhibit substantially higher than average levels as shown from the January, 2008 sample. As only one sample was taken during the winter months, it is difficult to draw correlations between this spike and how it is related to water quality at that time.

Wet and Dry Weather

An analysis of dry and wet weather data for nitrate, ammonia and TKN revealed that concentrations during dry weather were higher than wet weather in almost every occasion. This is possible as wet weather has larger volumes of water which would dilute concentrations, particularly in data collected after the first flush. An analysis of wet weather data shows a spike for ammonia and TKN and phosphorus during the same 2007 and 2008 June through August period as exhibited during dry weather. Wet weather sampling performed only twice a year is difficult to draw conclusions from due to limited data collection; however, it is useful to compare sites to one another to evaluate impacts of development on water quality.

Stream Flow

Flow results measured at all stations are roughly correlated to each other, as seen by similar rise and fall trends. The only exception is station 09-XPB which tends to be inversely related to the rest of station flows. There is no obvious cause of this; however this station may have been subject to a faulty data logger, as there are large sections of missing data throughout the 2007 and 2008 periods. Similarly, station 01-WCH is missing large portions of data during the sampling period due to multiple battery failures. The remaining seven stations have mostly complete data for 2007 and 2008.



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Total Phosphorus

Stations 09-XPB and 09T-PEN showed higher than average readings of phosphorus during the July, 2008 sampling event. While these two stations had elevated readings, all other stations had low readings, consistent with other readings taken during 2007 and 2008. As expected, data shows spikes in phosphorus correspond to high TSS readings and higher than normal flow. This is logical as phosphorus is largely contained in sediments flushed into the tributaries during storm events. Unlike ammonia and nitrate which flush quickly, TSS and phosphorus take longer to enter the waterbody.

While there is no numeric standard for phosphorus, the NHDES level of concern is 0.05 mg/L. In 1976, the EPA also recommended phosphorus limits of 0.05 mg/L for streams. Only naturally occurring phosphorus should be present, typically from 0.014 to 0.017 ppb under natural conditions. Levels of 0.015 mg/L in lakes and ponds are often set as a goal to support recreational uses of the water and decrease algae blooms.

TKN and TSS

TKN readings at all stations were relatively consistent during the 2007 through 2008 sampling rounds with the exception of two readings taken at stations 09-XPB and 09T-PEN during January of 2008. Readings at each station were between two and ten times higher than all other samples taken during both years. January, 2008 also showed high spikes of TSS levels at the same two stations. TSS readings were approximately eight to ten times higher than average background readings. As only a single winter sample was taken, there is not enough data to perform a satisfactory analysis of the data. TKN and TSS do not have numeric standards specified in the New Hampshire surface water quality standards. Some states set a TSS standard of 30 mg/L. Only four TSS readings exceeded this standard.

pH

pH appears relatively constant during the two year period with the exception of two outliers during August, 2007 and October, 2008. Results during these times were substantially lower than background conditions. Both dates are likely anomalies associated with equipment malfunctions and not representative of actual conditions. pH does not have a numeric standard specified, however concentrations should not exceed natural conditions. Near neutral pH values between 6 and 9 are desirable.

E.coli

E.coli readings are fairly consistent during the sampling period, with levels generally rising during summer months and falling during winter periods. There is one reading in May, 2008 at station 02-WCH that is approximately 15 times higher than average. This date also corresponds with a spike in total coliform. As all other samples taken on the same date were consistent with previous levels, there is insufficient data to draw a



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conclusion. This station should be monitored in the future for similar bacteria spikes. E.coli should not exceed 153 cts/100 mL for any single sample, based on numeric standards for Class A waters.

Conductivity

A conductivity reading taken in August, 2007 for station 01-XWB is also an outlier. The sample taken on that day was approximately eight times higher than average conditions, while no other stations showed a substantial increase. This is also an anomaly and could be due to an equipment problem. New Hampshire water quality standards do not specify a numeric standard for conductivity, however, a waterbody with conductivity greater than 2000 umhos/cm would be considered high in dissolved salts.

Nitrate and Ammonia

A single wet weather nitrate sample in July, 2008 resulted in a reading of 2.12 mg/L at station 01-WCH. All other nitrate readings during the 2007-2008 sampling round were less than 1 mg/L. This sample also corresponded with a small spike in ammonia and TKN. Spikes of these types could be due to anoxic conditions in the adjacent wetland area. Despite a single corresponding increase in ammonia and TKN, insufficient data exists to draw a conclusion as to nitrate impacts on Pennichuck Brook.

There are no numeric standards for nitrate. Only naturally occurring concentrations should be present. Average nitrate levels are approximately 1.0 mg/L, which is considered low. This average should be used as a benchmark for future samples. Large increases would be cause for concern. Ammonia concentrations are dependent on pH levels. When the pH is below 8.75, NH_4^+ dominates. Basic pHs above 9.75 can cause NH_3 to dominate, which is more toxic to aquatic species. Ammonia should be less than 0.64 mg/L as per New Hampshire water quality standards. All samples met water quality standards for ammonia.

Recommended Changes to the Monitoring Program

In order to make the most efficient use of time and funding, CEI recommends that the sampling of Nitrates be discontinued at all stations. Data obtained in 2007 and 2008 showed nitrate levels at less than 1 mg/L at all stations during all sampling events with the exception of the single abnormality as described in the previous section. Nitrate readings have consistently been below laboratory detection limits and are not thought to be cause for concern in the watershed.

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Additionally, CEI recommends the following changes to the monitoring program:

Existing Sampling Schedule	Proposed Sampling Schedule
February	February
April	March
May	April
June	July
July	August
August	September
September	November
October	
December	

The above schedule reduces the sampling to seven months a year as opposed to the original program of nine months a year. The purpose is to obtain more data in consecutive months while eliminating data points which have not shown a historic trend. The proposed monitoring schedule should produce better, more consistent data for analysis purposes.

If you have any questions or require any additional information, please do not hesitate to contact me at (800) 725-2550, ext. 308.

Sincerely,

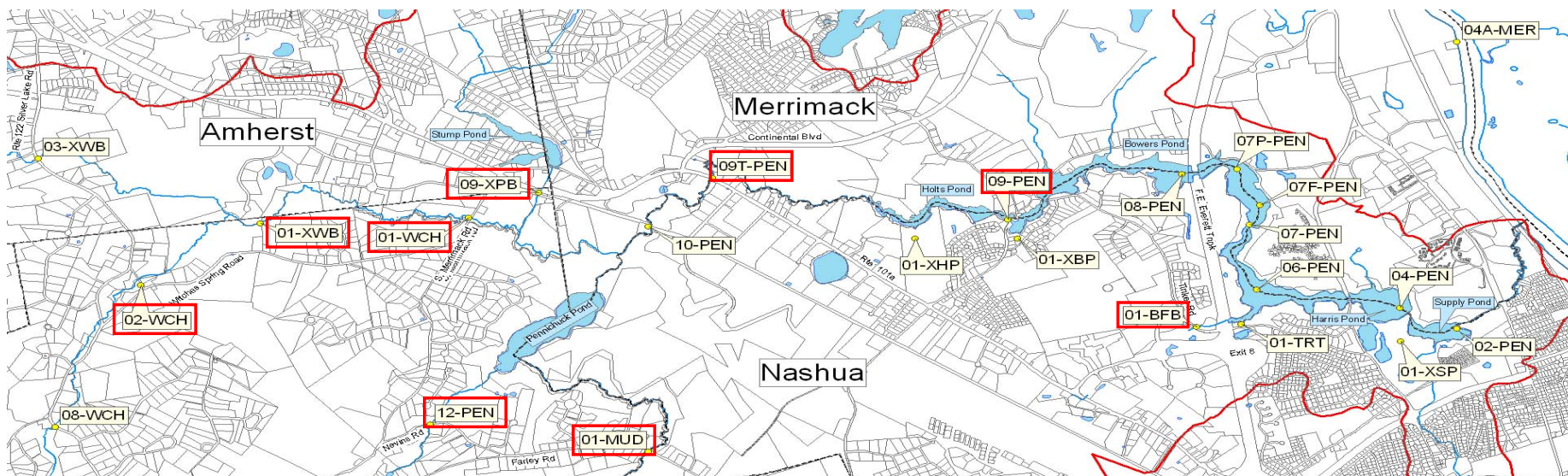
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Rebecca Balke, P.E.
Project Manager

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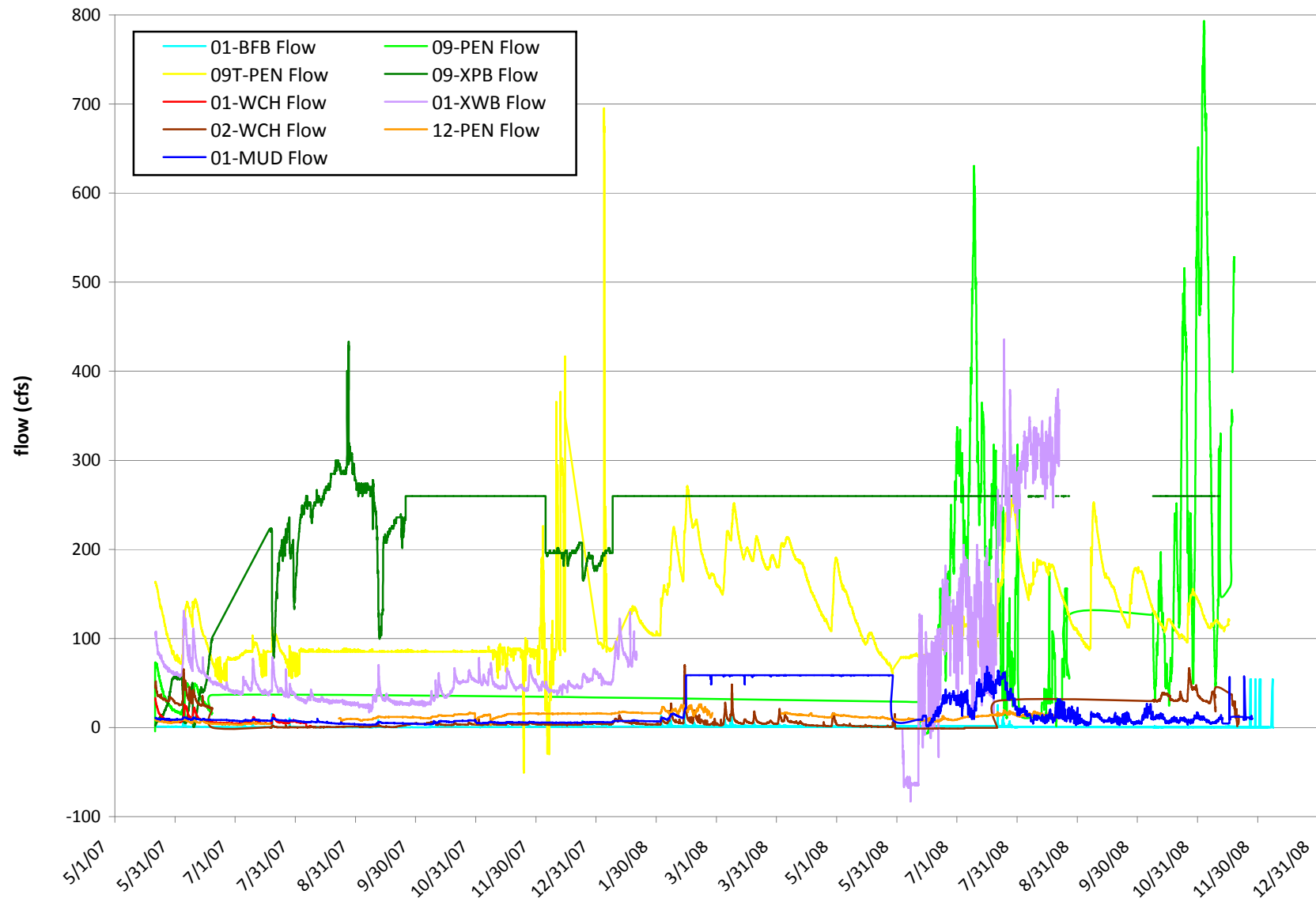
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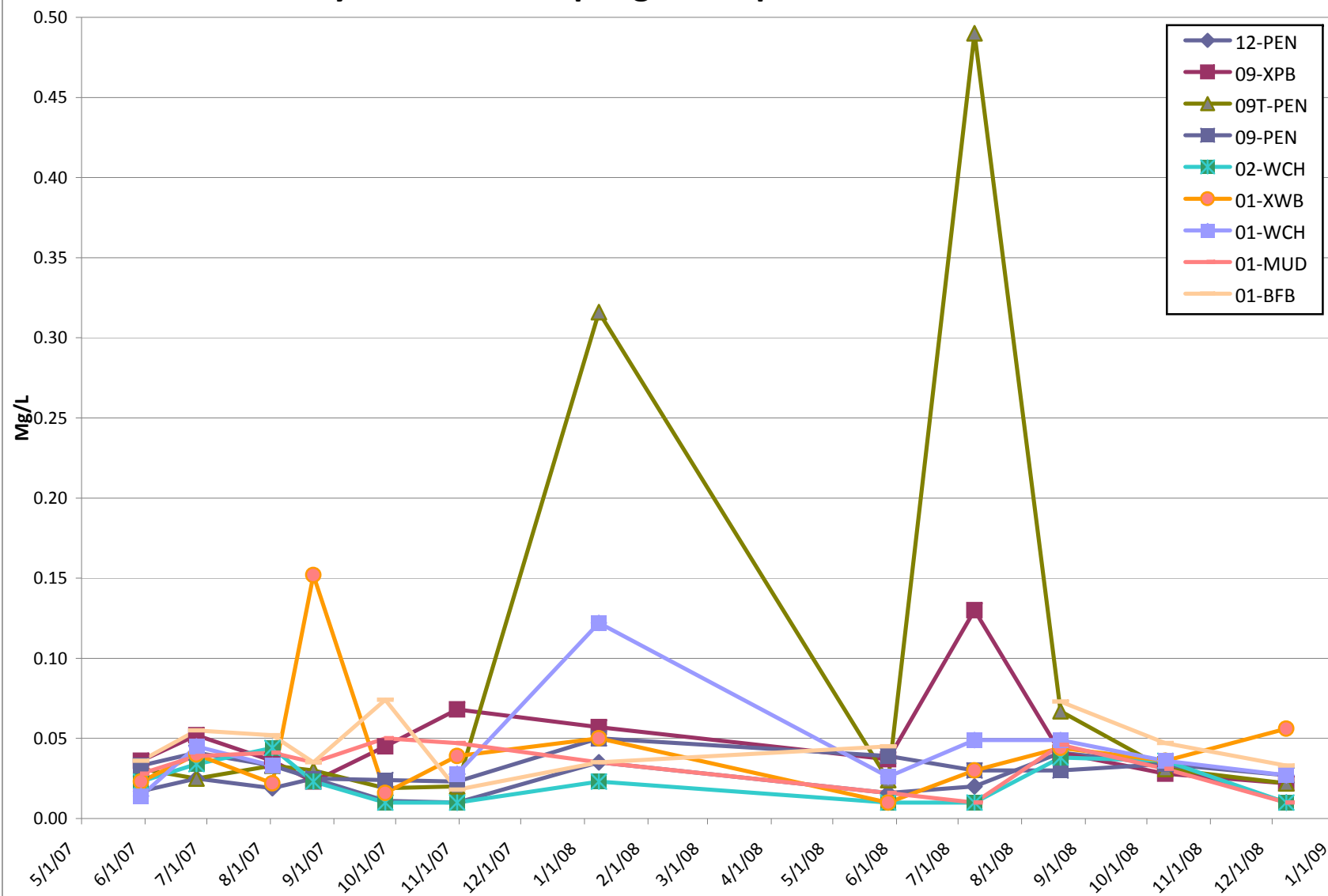
Old Name	New DES Name	Descriptions	Old Name	New DES Name	Descriptions
T-1	01-BFB	Boire Field Brook - Tinker Road	B1	07F-PEN	Bowers Pond - 700' US of Bowers
T-2	09-PEN	Holt Pond Dam	B2	08-PEN	Bowers Pond - Middle
T-3	09T-PEN	Route 101A Bridge	H1	04-PEN	Harris Pond - 100' US of Harris
T-4	09-XPB	Unnamed Trib to Pennichuck Brook	H2	06-PEN	Harris Pond - Middle
T-5	01-WCH	South Merrimack Road Bridge	R1	07P-PEN	Bowers Pond - 1/4 mile DS of E
T-6	01-XWB	Unnamed Trib to Witches Brook	R2	04A-MER	Merrimack River - Boat Launch
T-7	02-WCH	Ames Road Bridge off Route 122	S1	02-PEN	Supply Pond - 25' Upstream of
T-8	12-PEN	Nevins Road Bridge			
T-9	01-MUD	Farley Road Bridge			

FIGURE 1: Site Locations and Names

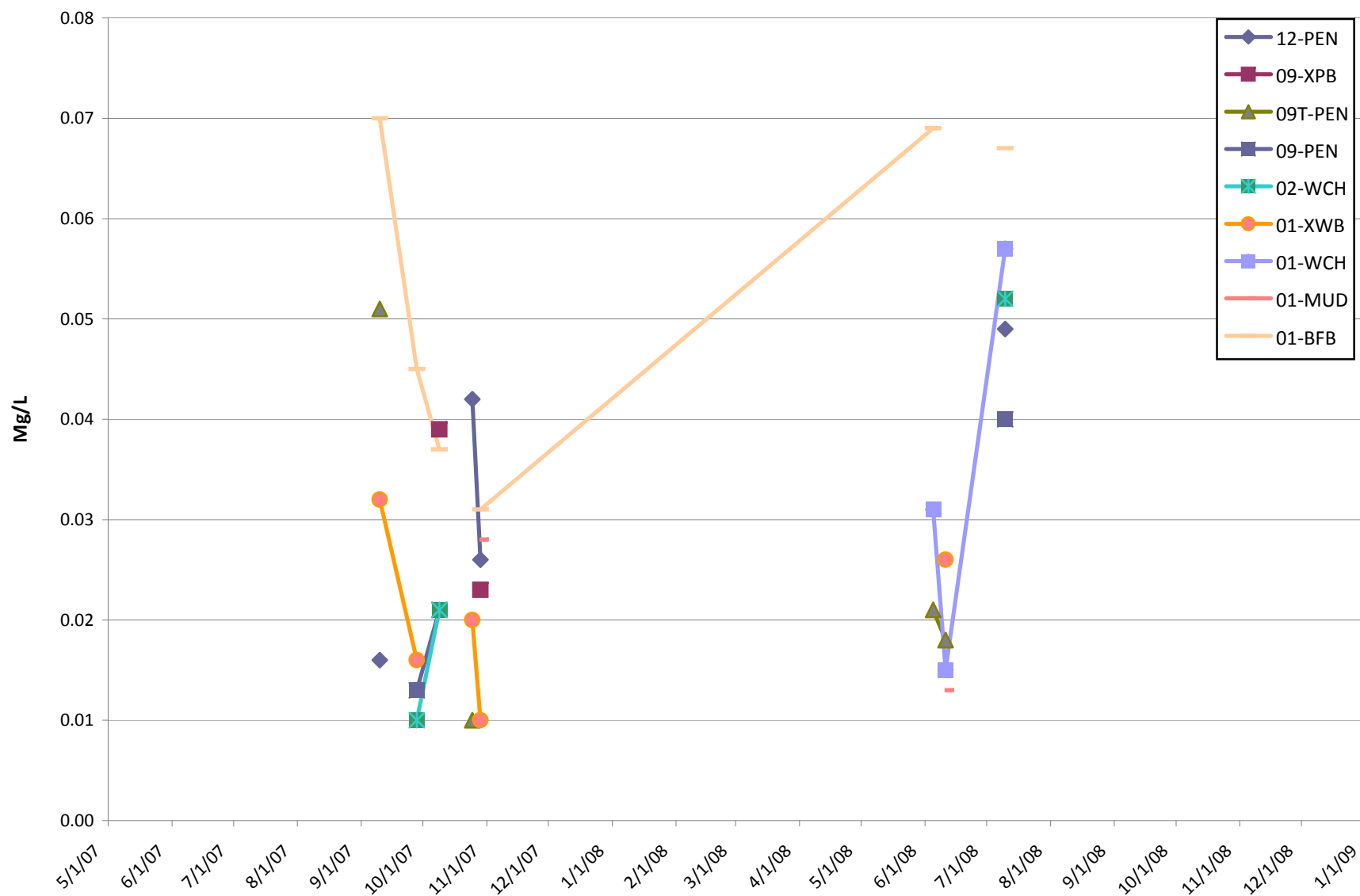
Tributary Flow Data for 2007-2008



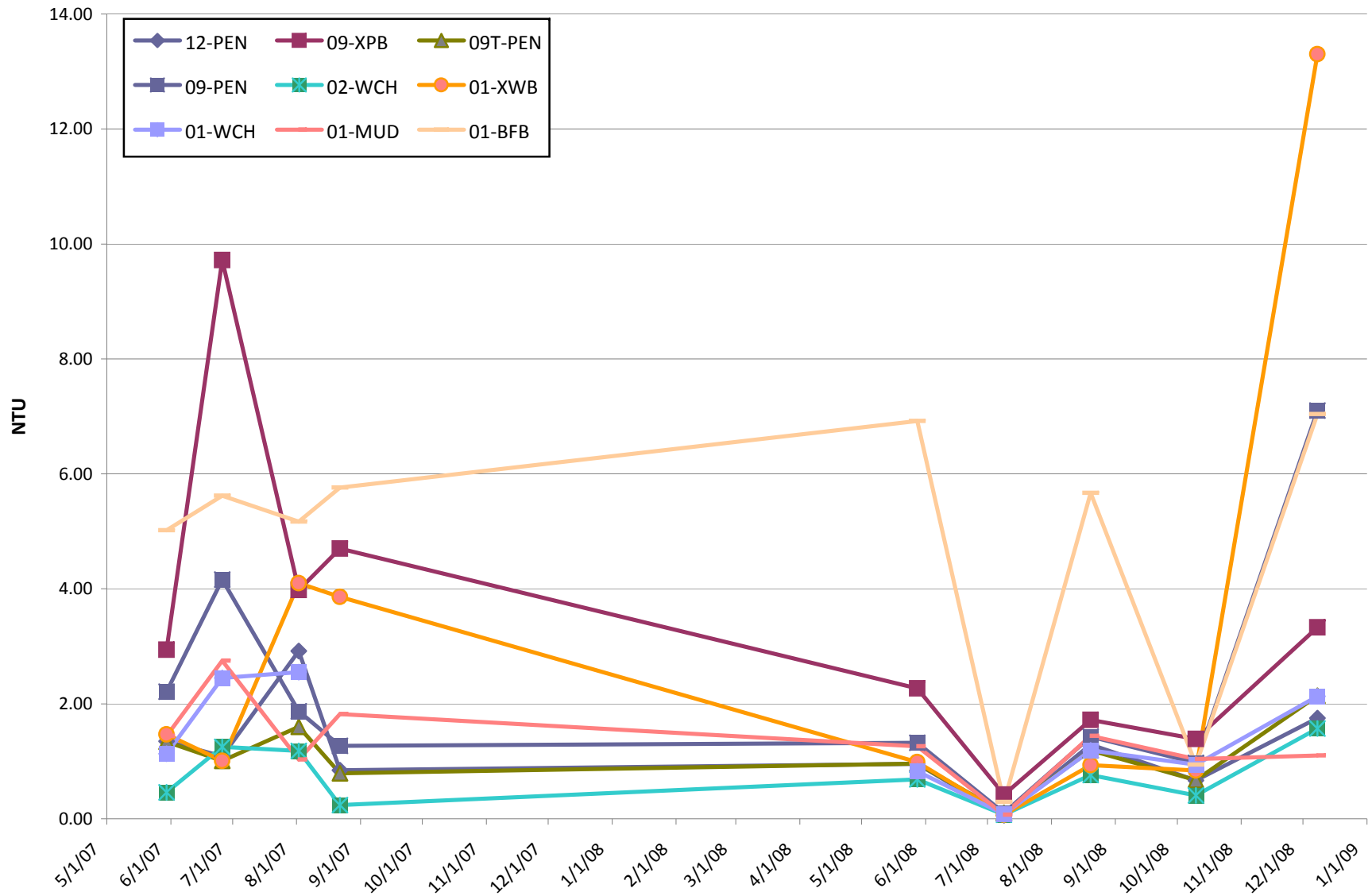
Dry Weather Sampling - Phosphorus Levels 2007-2008



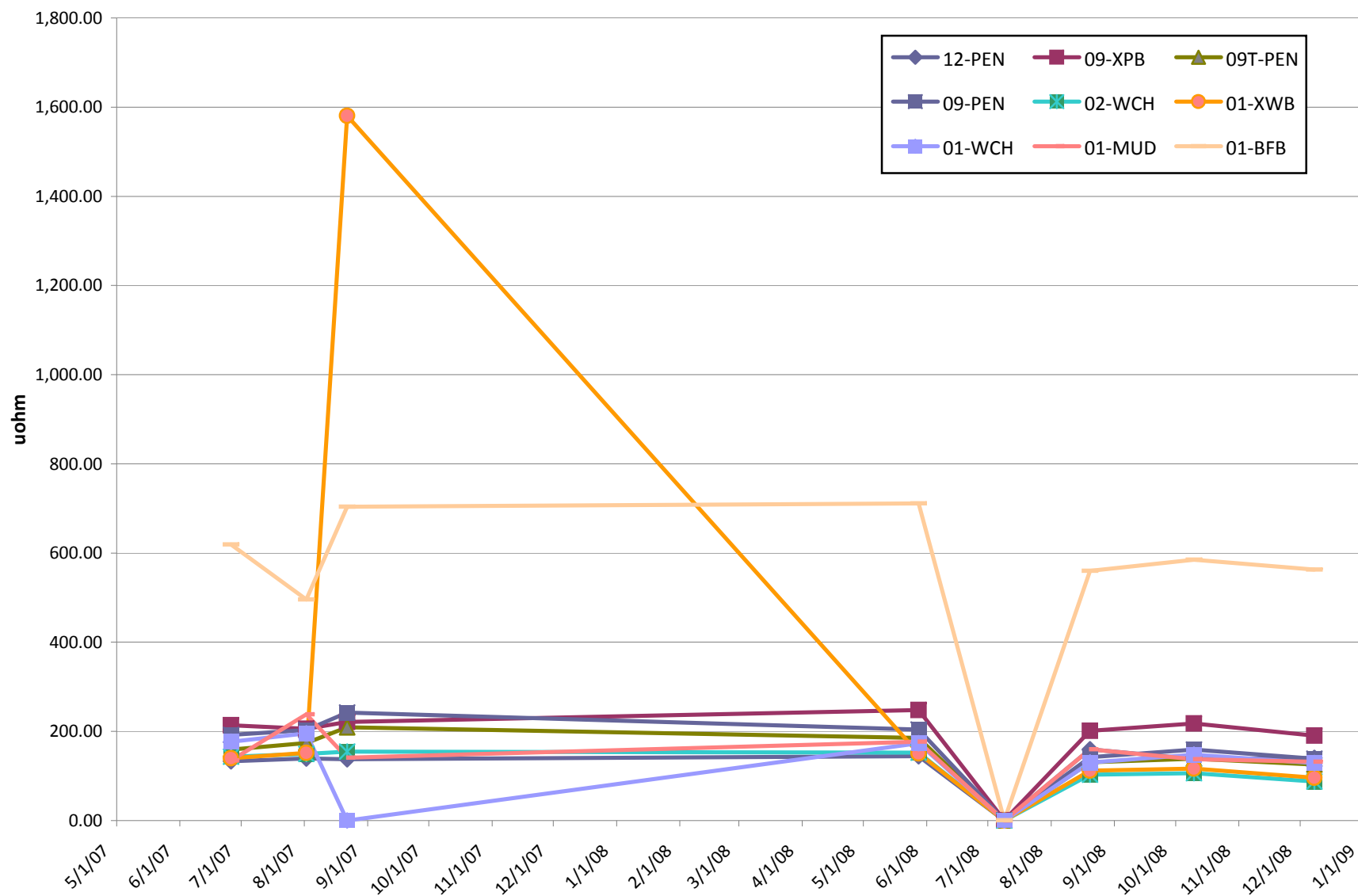
Wet Weather Sampling - Phosphorus Levels 2007-2008



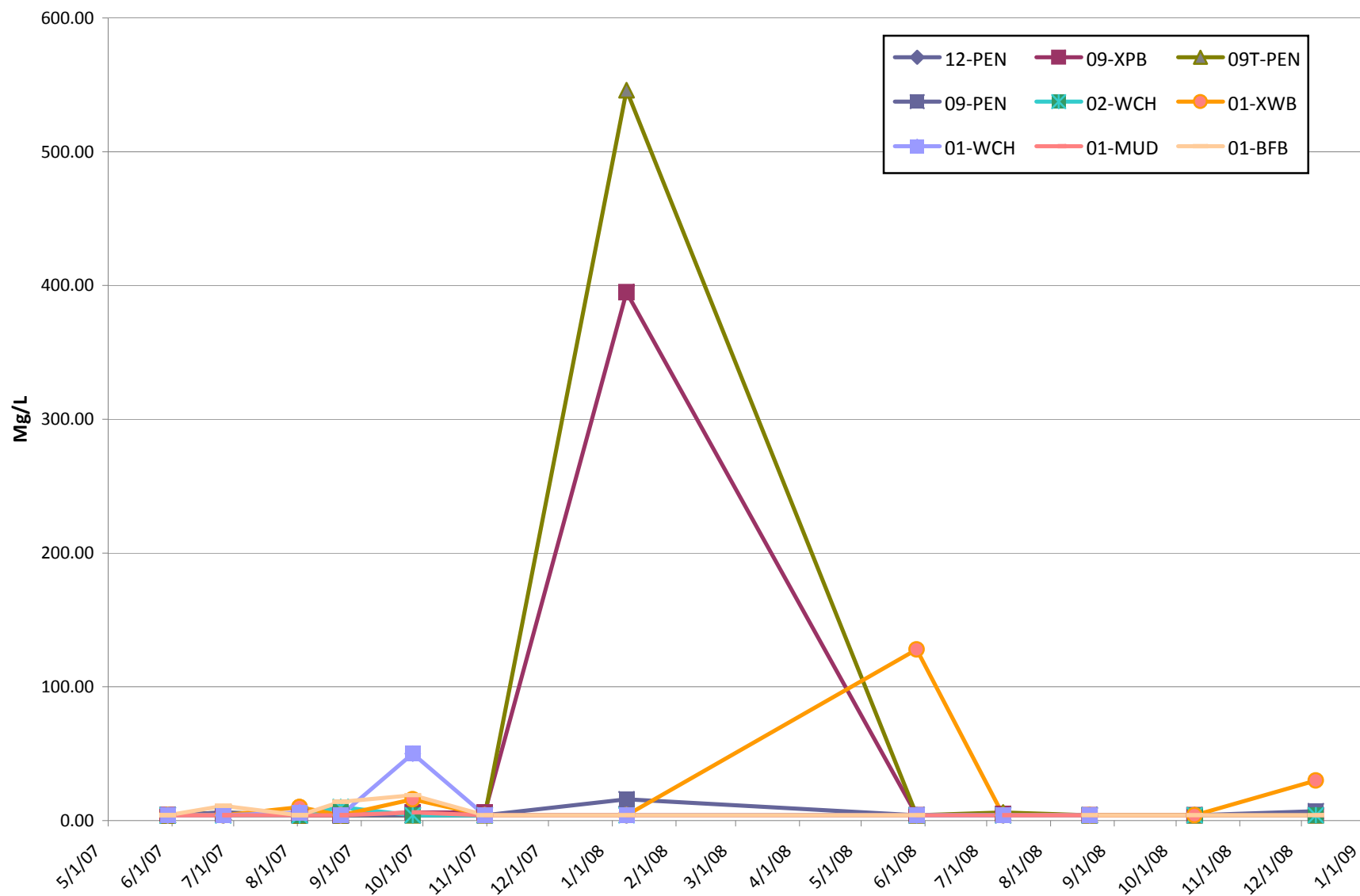
Dry Weather Sampling - Turbidity Levels 2007-2008



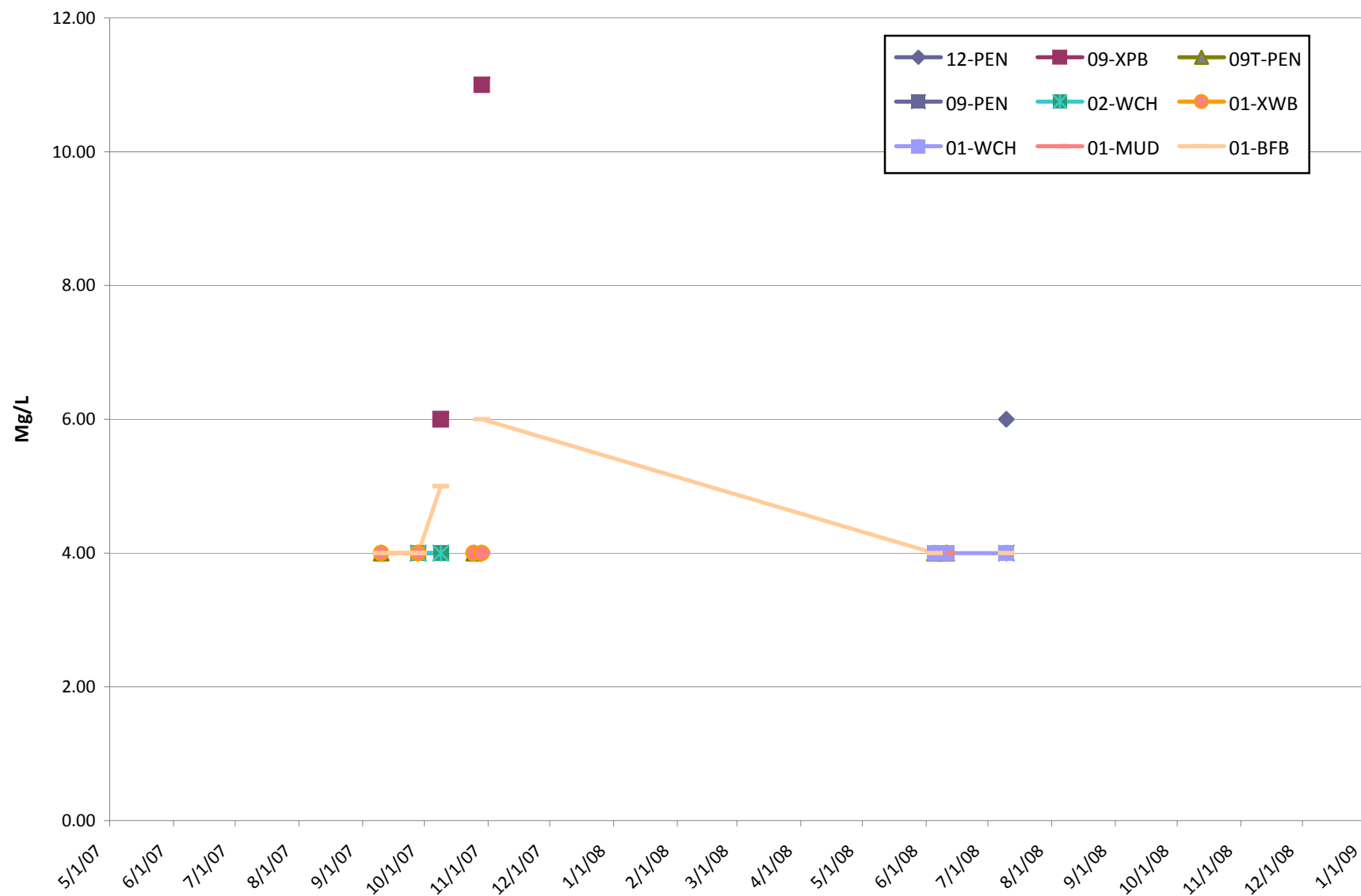
Dry Weather Sampling - Conductivity Levels 2007-2008



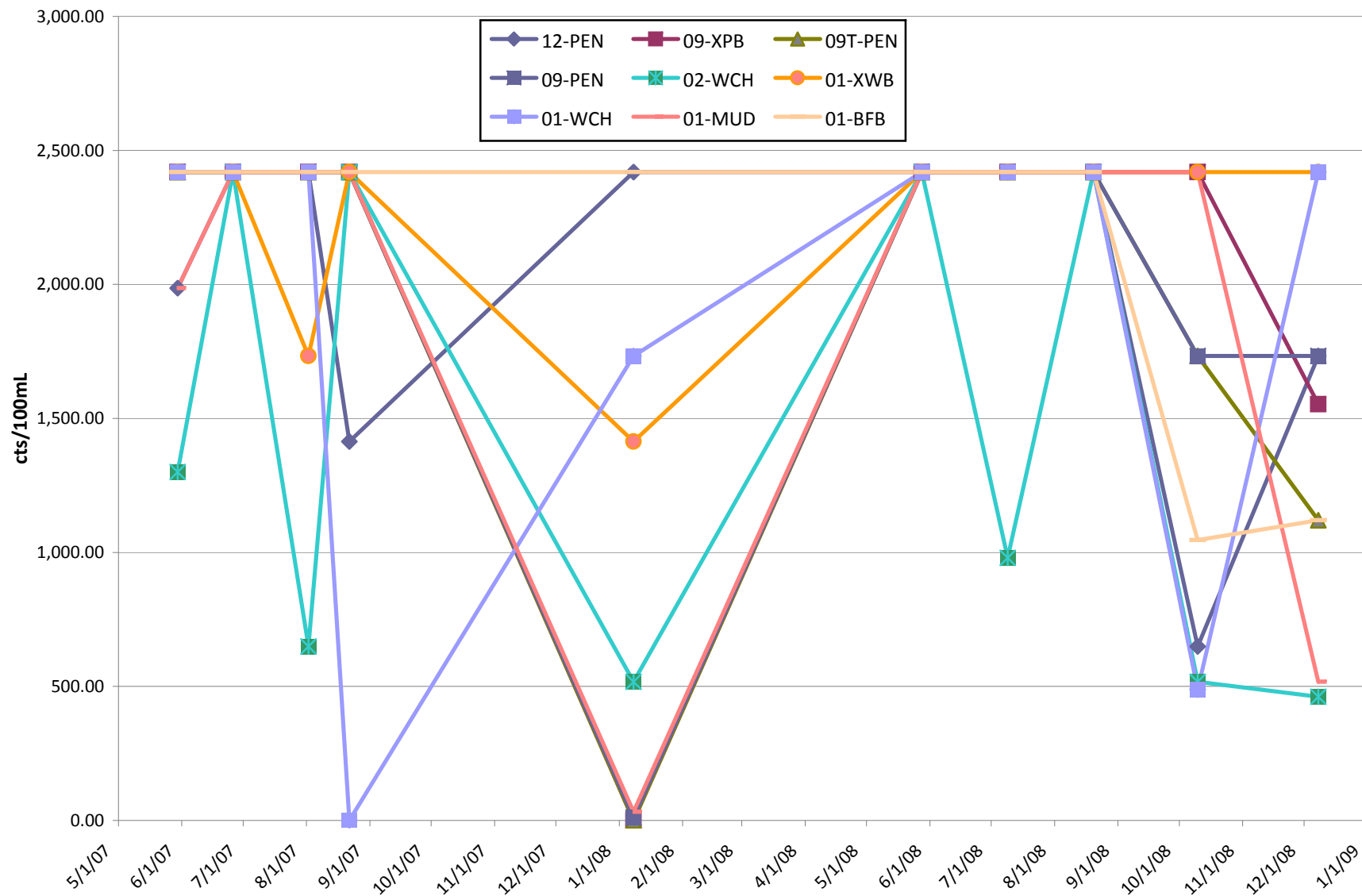
Dry Weather Sampling - TSS Levels 2007-2008



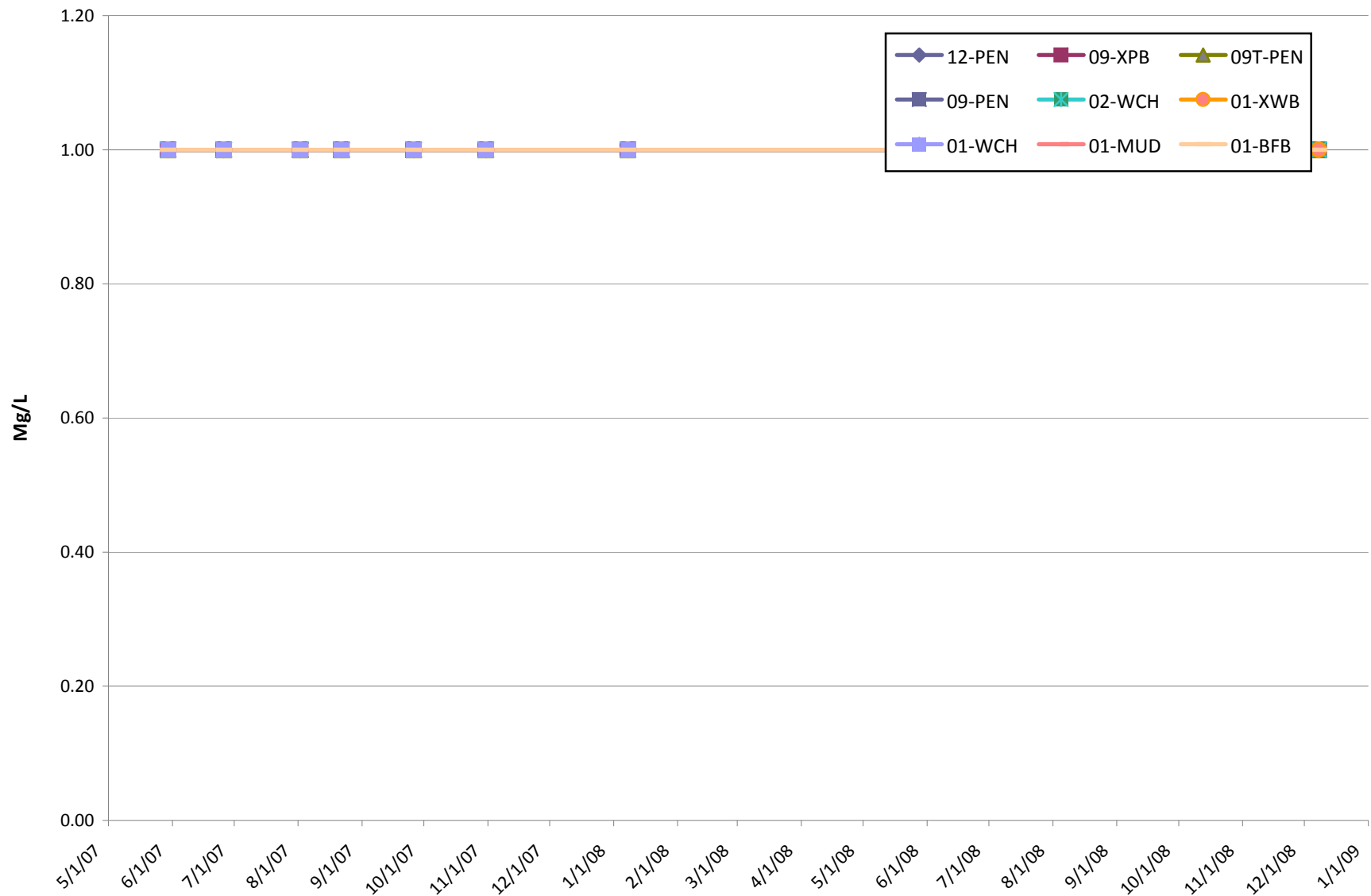
Wet Weather Sampling - TSS Levels 2007-2008



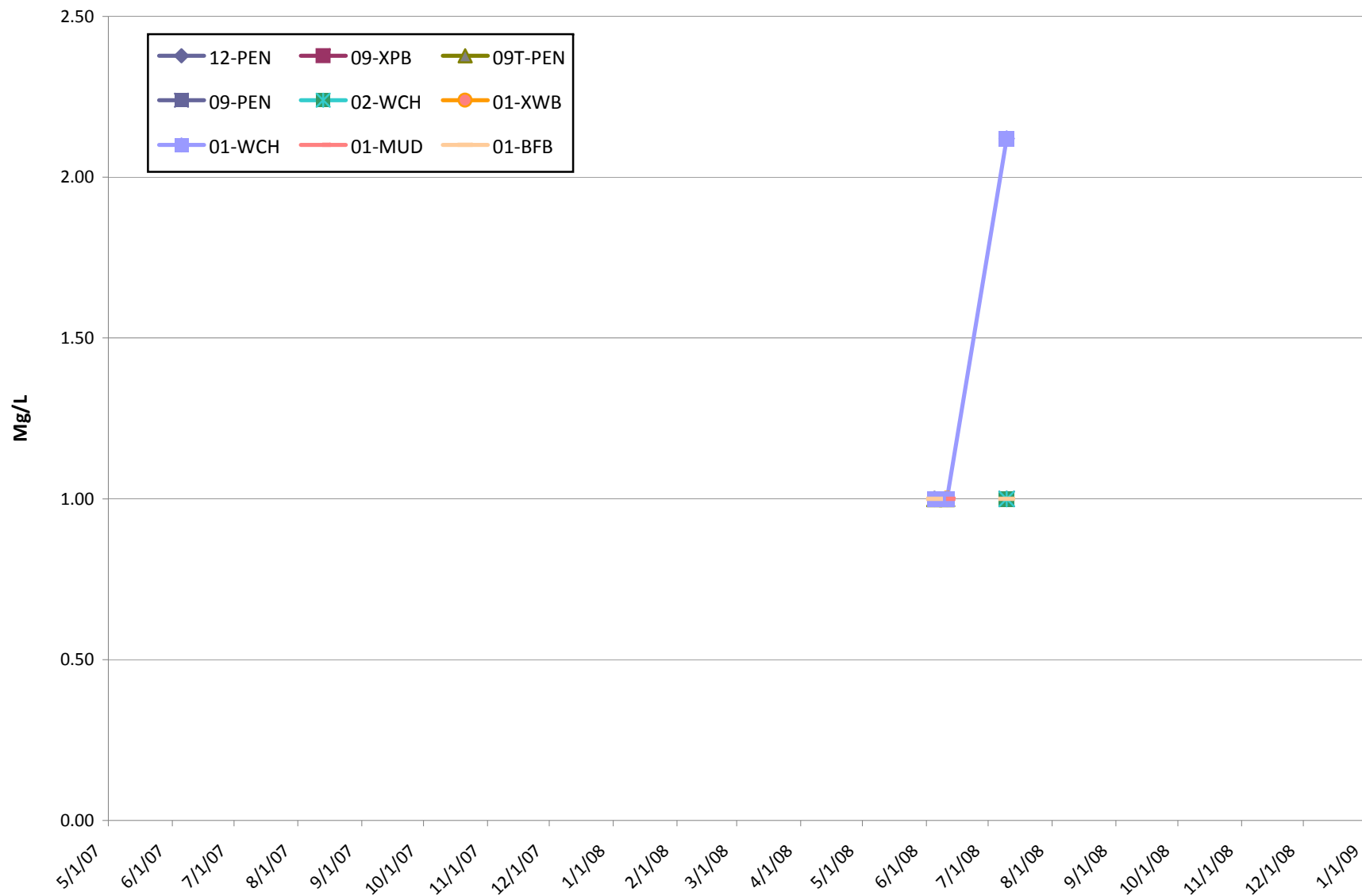
Dry Weather Sampling - Total Coliform Levels 2007-2008



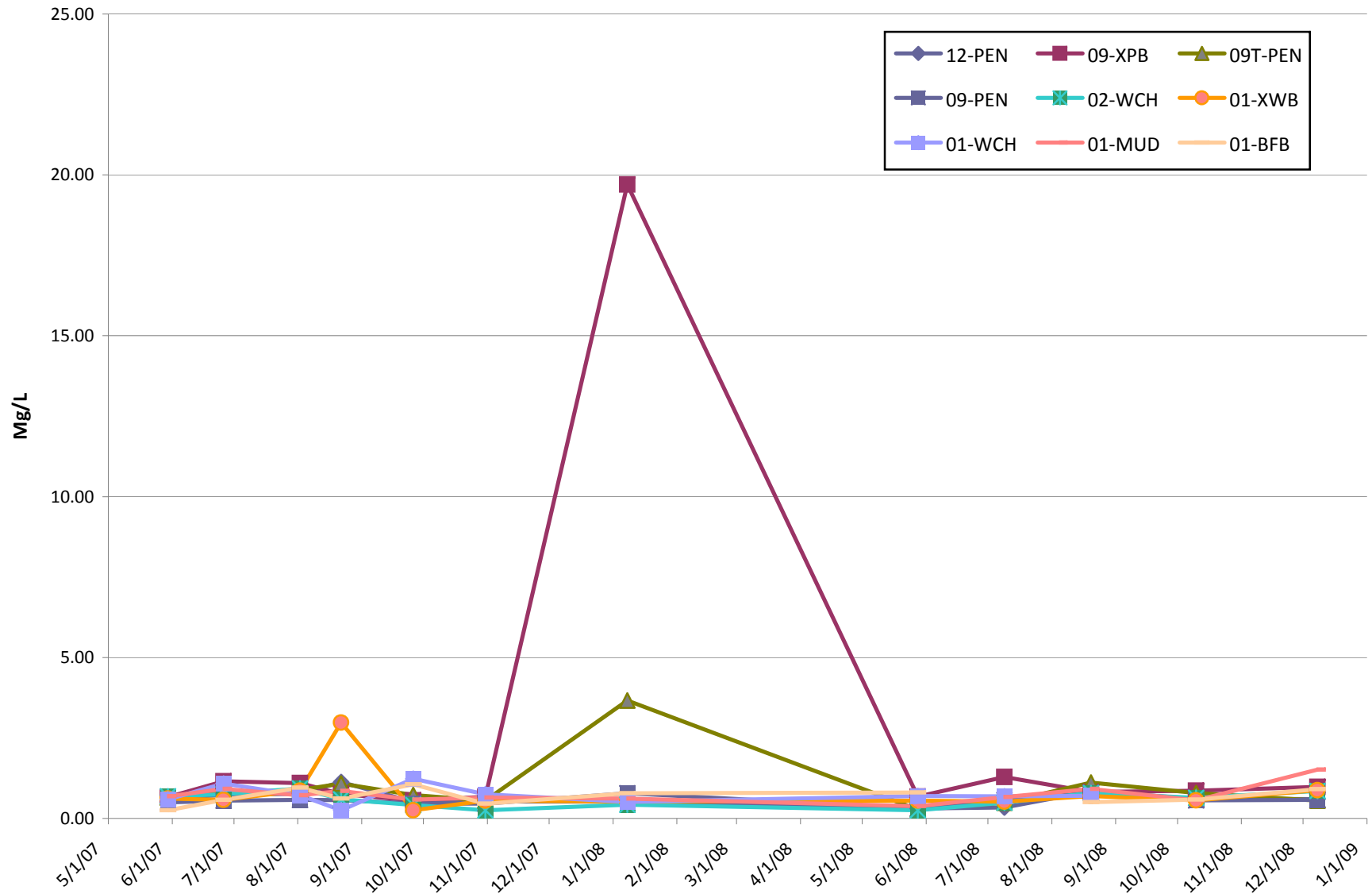
Dry Weather Sampling - Nitrate Levels 2007-2008



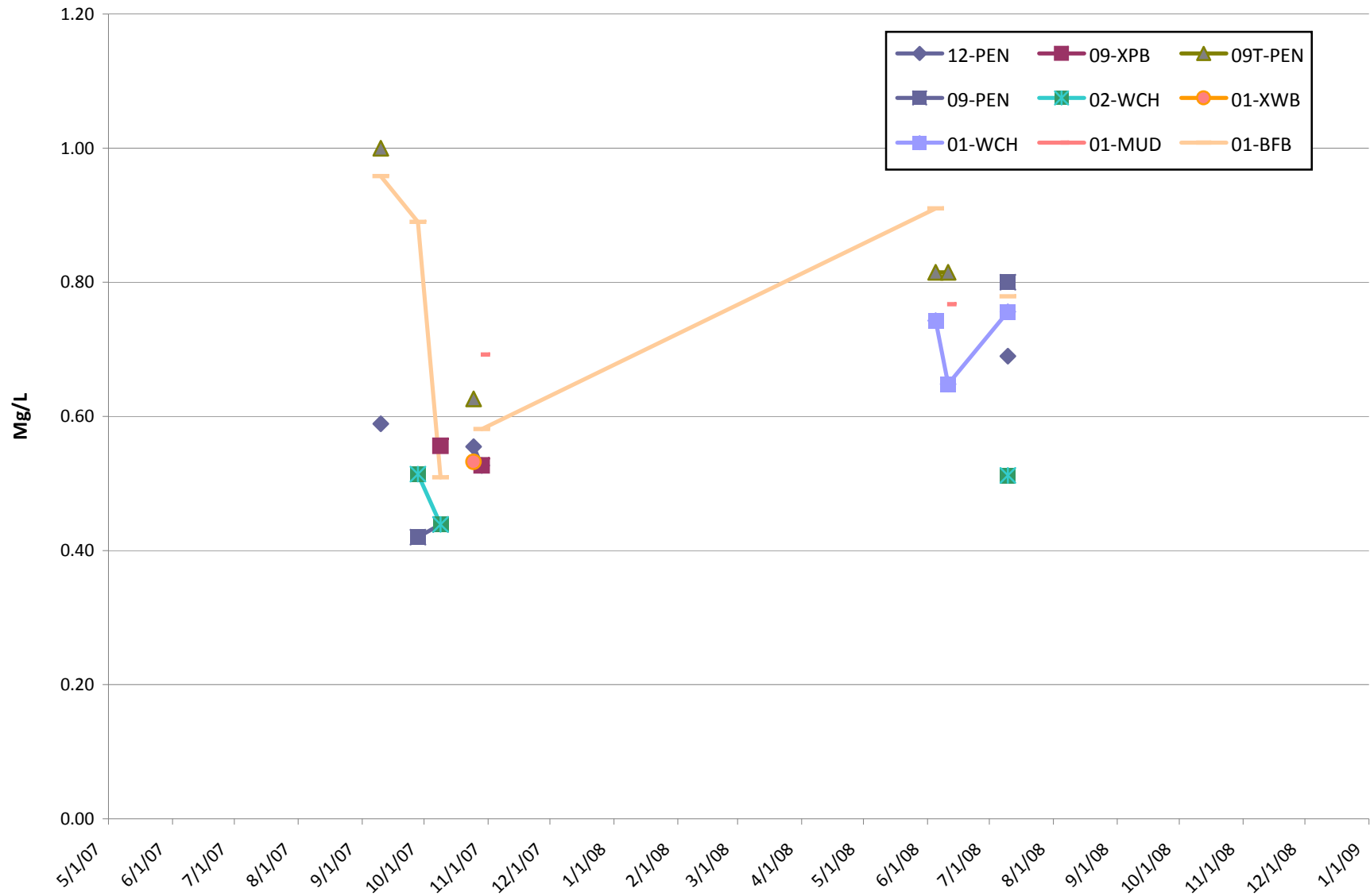
Wet Weather Sampling - Nitrate Levels 2007-2008



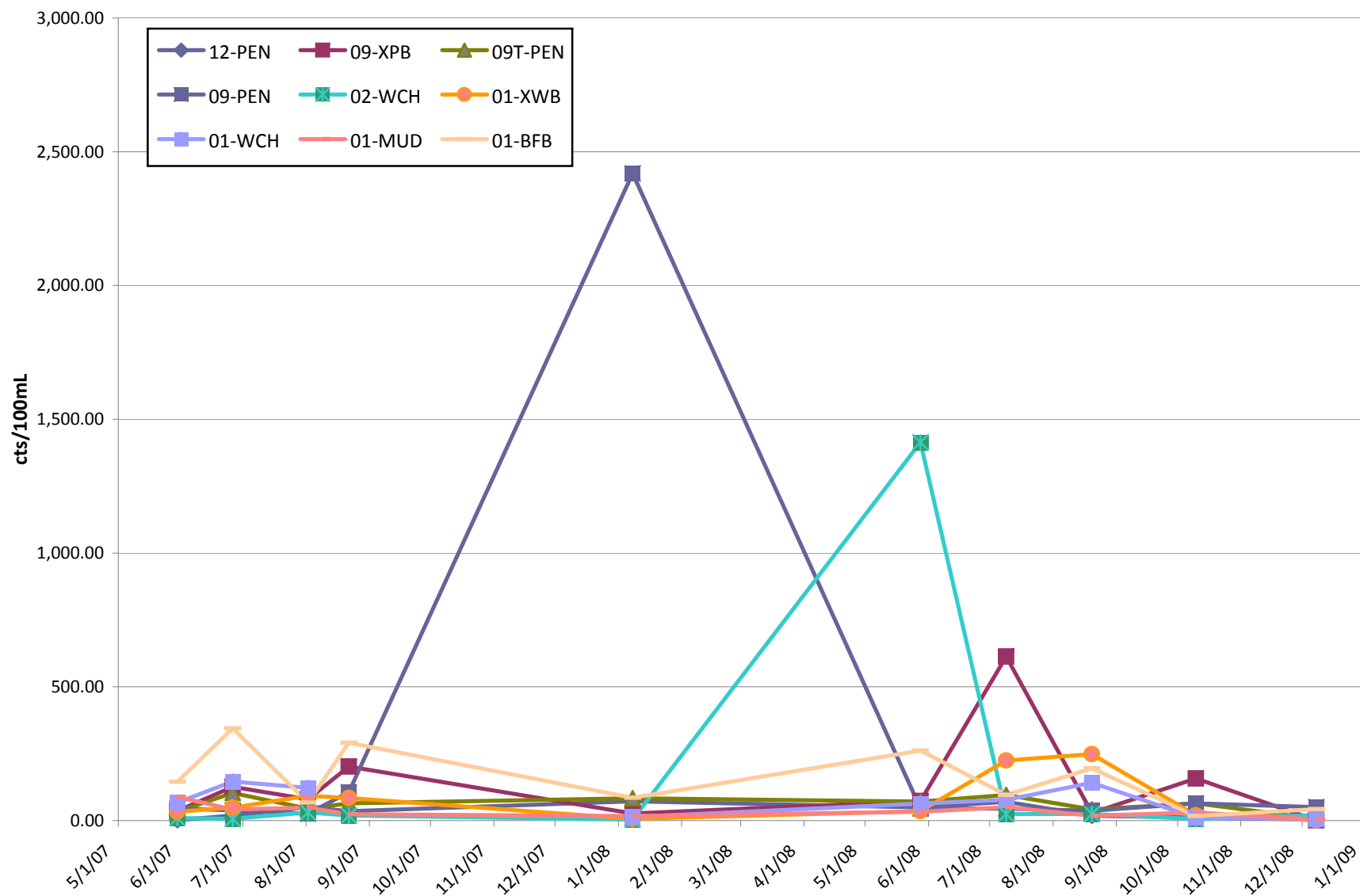
Dry Weather Sampling - Kjeldahl-N Levels 2007-2008



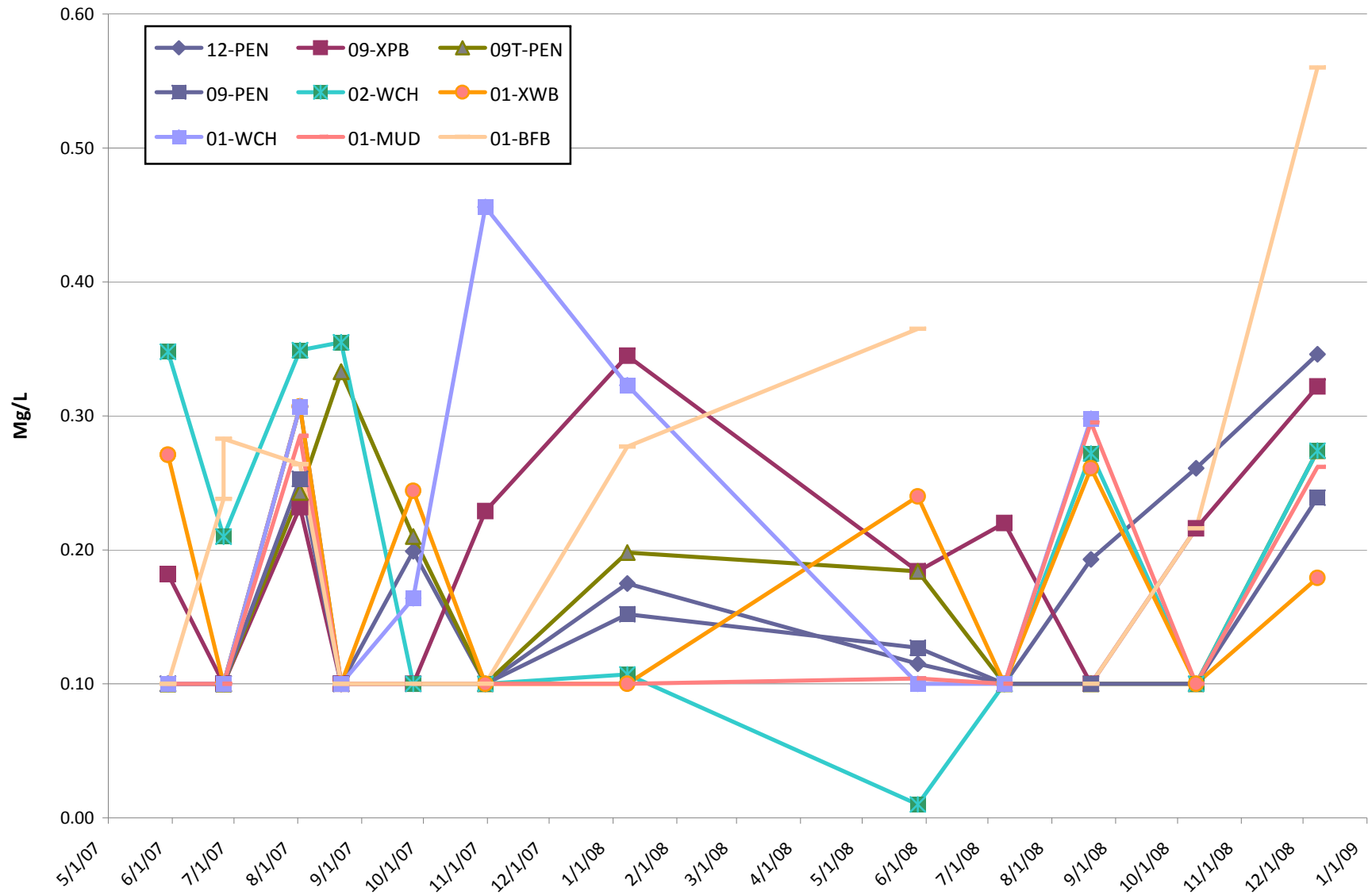
Wet Weather Sampling - Kjeldahl-N Levels 2007-2008



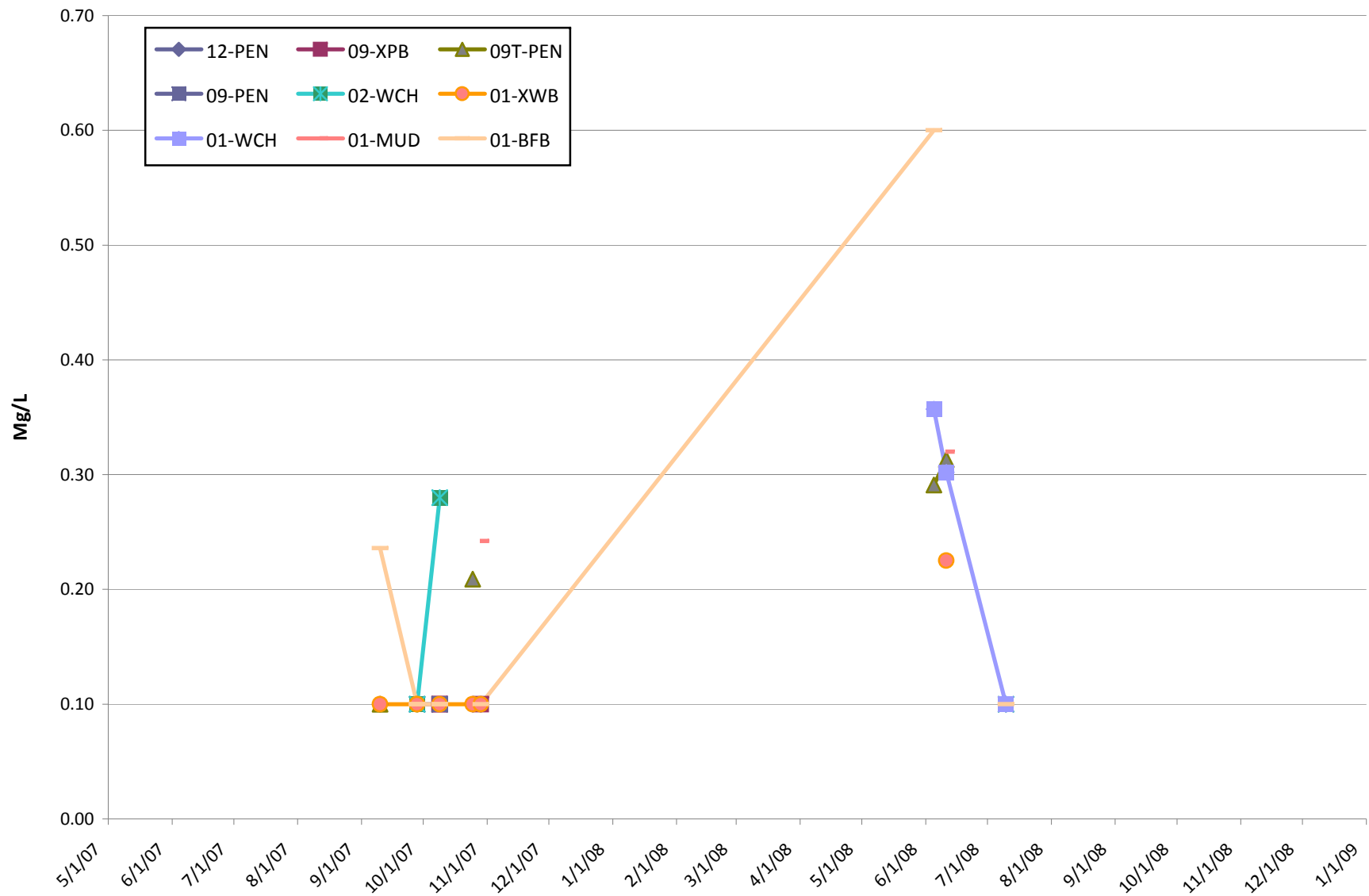
Dry Weather Sampling - E.Coli Levels 2007-2008



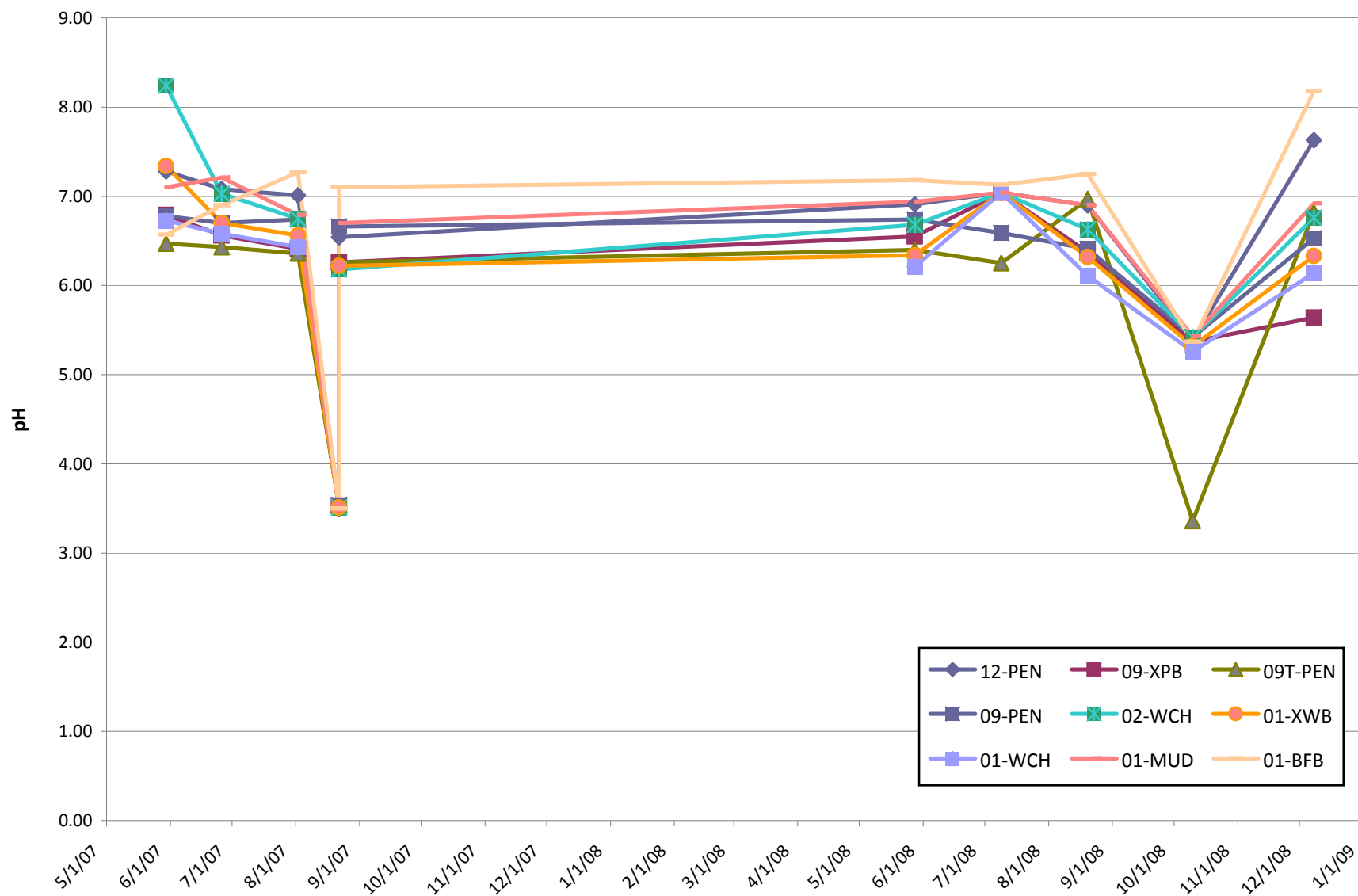
Dry Weather Sampling - Ammonia-N 2007-2008



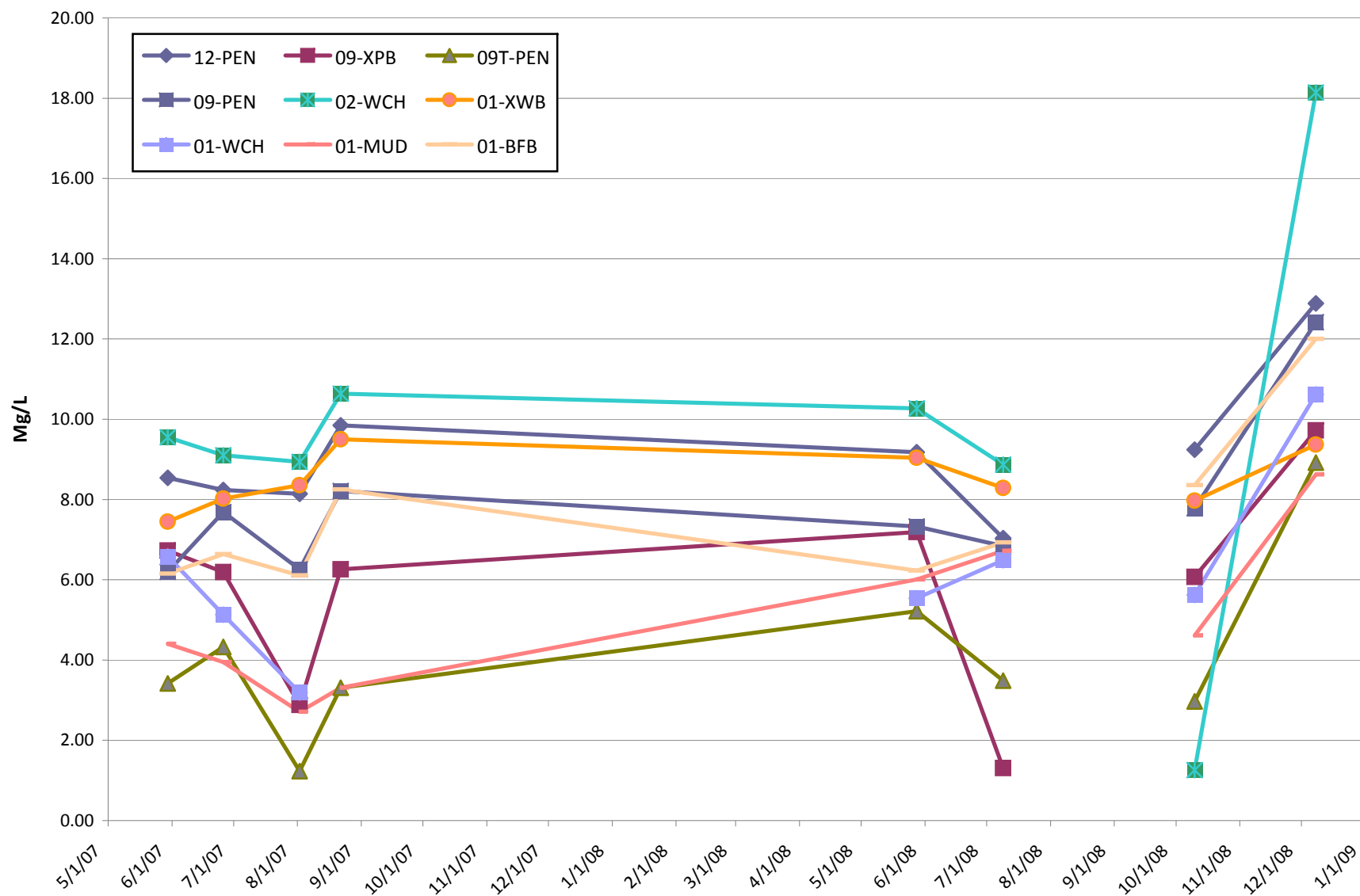
Wet Weather Sampling - Ammonia-N 2007-2008



Dry Weather Sampling - pH 2007-2008



Dry Weather Sampling - Dissolved Oxygen 2007-2008



Dry Weather Sampling - Temperature 2007-2008

