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December 28, 2012

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- Design
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Mr. Chris Countie
Water Supply Manager
Pennichuck Water Works
200 Concord Street
Nashua, NH 03064

RE: PENNICHUCK WATER WORKS
2007 – 2012 TRIBUTARY AND IN-POND SAMPLING DATA

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Dear Mr. Countie:

The purpose of this letter report is to present the results of the tributary sampling program performed May 2007 through December 2012 as well as any recommendations for changes to the program. This report also briefly presents the results of the in-pond sampling program conducted by Pennichuck Water Works.

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. No sampling was performed in 2009 due to a "freeze" on projects during ownership negotiations between Pennichuck Water Works and the City of Nashua. **Figure 1** shows the nine tributary sampling locations.

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- Watershed Restoration

Background

Pennichuck Water Works, in coordination with the Nashua Regional Planning Commission (NRPC), has been collecting data from the watershed since 1991. Over this time, sampling locations and parameters varied until around 2005, at which time a sampling program using a specific set of water quality parameters was developed for nine tributary and five pond sampling locations within the watershed. This program was further refined in 2007 to include continuous flow monitoring and the collection of winter samples at tributary locations, beginning a more complete data set. Since then, water quality sampling and tributary flow measurements have been ongoing, with modifications and adjustments made as needed. This letter report focuses on the full data set collected from 2007 through 2012.

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Monitoring Locations

The nine tributary sampling locations are shown on Figure 1 with descriptions provided in **Table 1**.

Table 1 – Tributary Sampling Locations

Station	Description	Station	Description
01-BFB	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 on Route 122
09-XPB	Unnamed Trib to Pennichuck Brook on 101A	12-PEN	Nevins Road Bridge
		01-MUD	Farley Road Bridge

In addition, Pennichuck Water Works has been collecting in-pond data at five locations since 2007. In-pond stations and locations are shown on Figure 1 with descriptions provided in **Table 2**.

Table 2 – In-Pond Sampling Locations

Station	Description	Sample Locations
07F-PEN	Bowers Pond - 700' US of Bower	Surface and Bottom
08-PEN	Bowers Pond - Middle	Surface and Bottom
04-PEN	Harris Pond - 100' US of Harris	Surface and Bottom
06-PEN	Harris Pond - Middle	Surface and Bottom
07P-PEN	Bowers Pond - 1/4 mile DS of E	Surface Only

Data Collection

Monitoring activities presented in this report include those beginning in May of 2007 through December 2012 and excluding 2009 as previously described. During this time, Comprehensive Environmental, Inc. (CEI) collected water quality and flow data to aid in determining the health of each tributary, while Pennichuck Water Works collected data from in-pond sampling locations.

Laboratory and Field Data

Water samples were analyzed by assorted laboratories during the sampling program, most recently Eastern Analytical, Inc. for Total Coliform, E.coli, Ammonia-N, TKN (kjeldahl-N), Total Phosphorus and Total Suspended Solids. Field analysis of pH, Conductivity, Dissolved Oxygen and Temperature is also conducted during sampling efforts. In addition to the above parameters, Pennichuck Water Works also collects samples from in-pond locations for analysis of alkalinity, chloride, chlorophyll, color, iron, manganese, nitrate, orthophosphate, and turbidity. Though all parameters are not analyzed as part of this report, all data was tabulated and input into a water quality database, continuously updated since 2007.

In 2012, dry weather samples were collected from tributaries on March 28th, April 26th, August 2nd and 27th, September 18th, October 25th, and November 26th / 29th. The last sampling round collected tributary data simultaneously with groundwater data as part of a groundwater monitoring program performed under a separate Scope of Work. In-pond samples were collected on May 17th and 31st, June 28th, July 19th, August 1st and 22nd, September 13th and 27th, and October 17th.

Although the 2012 Scope of Work stated that two wet weather sampling events would be performed at tributary locations, later discussions between CEI and Pennichuck Water Works eliminated these sampling efforts due to the following:

1. Lack of sufficient data to determine long-term trends;
2. Difficulty in obtaining full representative sample rounds (e.g., all locations on the same day); and
3. Satisfactory cost/benefit analysis.

Wet weather sampling is not anticipated to be part of future tributary sampling efforts, but samples can be used to target hot spots (e.g., high concentrations in streams).

Data Loggers

Electronic data loggers were installed at all tributary locations on May 21, 2007 to determine the relative contribution of each stream to Pennichuck Brook and to track long-term trends in flow. Data loggers have been replaced periodically over the years to address various issues such as mechanical failures and vandalism. As recommended in last year's report, data loggers were reconfigured in April 2012 to log once per hour rather than every 30 minutes in order to help preserve battery life.

Due to mechanical problems, two data loggers installed at locations 01-WCH and 01-MUD were replaced during the 2012 sampling program. Each station was only without a functional data logger for less than two months. Both failed data loggers were the "old" style, using a serial port and single 9-volt battery. An additional data logger at 09-XPB was replaced on September 12, 2012 due to ongoing erratic readings, leading to skewed flow data. All data loggers in place are now one of two "new" styles, using either a USB or wireless connection, and with substantially better battery life due to the use of two 9-volt batteries on the USB model, and extended use battery on the wireless models.

Staff Gauges and Stage/Discharge Relationships

During previous monitoring efforts in 2005 and 2006, staff gauges were installed at the nine tributary locations and stage-discharge relations were created based on field measurements. Staff gauges have also been relocated and/or replaced over the years due to vandalism, high stream flows, changing stream dynamics, and even a culvert reconstruction project. When a staff gauge location was altered in any way, a new stage-discharge relationship equation was developed for the new location. Using these equations, the water levels recorded by the data loggers can convert to an approximate flow for the river at each point in time. Data was downloaded to a field laptop for analysis approximately every six weeks and checked for obvious problems or errors.

Due to changes in stream profile at station 09T-PEN, the existing staff gauge was moved and a new stage-discharge equation was developed on September 12, 2012. The adjustment has been made for all data collected after this date. The remaining stage-discharge curves developed during previous years were used for all other locations and/or time periods. Periodic adjustments to flow equations may also be made when a data logger is taken out for repairs and/or replaced. In these cases, the original stage-discharge curves still apply and the adjustment is only made to reflect a change in elevation in the setting of the data logger. These adjustments are noted in the database table where all data is recorded.

Data Results

The sampling data results were analyzed for trends and correlations, as well as any unexpected data outliers. Overall, tributary stations 09-XPB and 01-BFB continue to show the highest concentrations, with 09-PEN, 09T-PEN, 01-XWB and 12-PEN following. In-pond bottom samples at 07F-PEN and 08-PEN typically have the highest concentrations. However, the overall trend line is decreasing with lower concentrations than in previous years.

Stream Flow

Flow results measured at all tributary stations are roughly correlated to each other, as seen by similar rise and fall trends. Data available for the year varied by location, however is substantially complete with the exception of 01-WCH and 01-MUD, which due to mechanical issues are missing approximately 8 weeks and 6 weeks of data, respectively. 09T-PEN is also missing approximately 2 weeks of data due to the installation of a new staff gauge. Data gaps are shown on the "Tributary Flow Data" figures for any missing or negative data, however, these data gap issues have been substantially reduced with the installation of new data loggers with larger or more efficient batteries as identified earlier.

Flow data for 09-XPB is present throughout all of 2012, however data obtained prior to September 12, 2012 is unreliable due to mechanical issues. The data logger has since been replaced and readings have returned to normal levels.

Seasonal

Samples taken during the summer months roughly correlate to one another. As expected, temperature rises during summer months, with tributary results closely mimicking in-pond surface samples. In-pond bottom samples indicate that spring and early summer water warming trends lag behind surface warming as expected. Ammonia, phosphorus and bacteria levels also rise during the summer months at both tributary and in-pond locations.

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. Readings below 4.0 mg/L would be considered dangerous to aquatic organisms. Samples from tributary stations 09T-PEN, 09-XPB, and 01-WCH fell below standards multiple times in 2012, consistent with previous years. Station 09-PEN also fell below standards again in 2012. Stations 01-MUD and 01-XWB both fell below standards for the first time in 2012 with results as low as 2.49 mg/L and 0.25 mg/L, respectively. There was an overall improvement in dissolved oxygen (DO) levels at all stations except for stations 09-PEN and 01-XWB from 2007 through 2012. Station 09-PEN shows a very slight decrease in dissolved oxygen levels; however 01-XWB shows a noticeable decrease over the same sampling period.

Dissolved oxygen levels at tributary stations are trending upward from 2007 through 2012, showing an improvement since the start of watershed restoration efforts as shown in **Figure 2**.

In-pond surface samples are above 4 mg/L, with the exception of station 04-PEN which was below from late August through the end of sampling efforts. Bottom samples briefly dip below 4 mg/L during the summer months at all locations, likely associated with stratification of the pond. With the exception of the surface samples collected at station 04-PEN, remaining stations show an improvement in dissolved oxygen levels.

Cold weather tributary sampling was performed in March and November 2012. Overall, cold weather concentrations are lower than the rest of the year, and there is no apparent trend or correlation with the high levels detected in January 2008.

Total Suspended Solids (TSS)

TSS represents suspended material in the water. It can smother benthic macroinvertebrates as it settles to river bottoms, correlates with high phosphorus loadings, and also result in decreased dissolved oxygen. TSS can also hide other pollutants, such as bacteria, complicating disinfection. High TSS levels may result from erosion of disturbed areas (e.g., construction sites) and of natural stream banks.

Dry weather TSS levels were low throughout the 2012 sampling period with no notable spikes. Historically, elevated levels of TSS have been associated with increased flows, which is to be expected as runoff washes sediments into the streams from surfaces and stream bank erosion. TSS does not have a numeric standard specified in the New

Hampshire surface water quality standards. Some states set a TSS standard of 30 mg/L, and all 2012 samples recorded from both tributary and in-pond locations were below this threshold. TSS levels in tributaries are declining since the start of the 2007 sampling program as shown on **Figure 3**, showing an overall improvement in water quality.

Total Phosphorus

Phosphorus is a nutrient essential to plants and in excess amounts can cause algal blooms, particularly in fresh water systems. Algal blooms increase oxygen during the day in turn decreasing oxygen at night, resulting in a net loss, and make water less attractive. Phosphorus can indicate the presence of sewage, animal waste, lawn fertilizer, erosion and may also come from natural wetlands.

The majority of both in-pond and tributary sampling results ranged from 0.01 mg/L to 0.04 mg/L. Tributary stations 09-XPB, 01-BFB, and 09-PEN showed the highest overall phosphorus concentrations during summer dry weather sampling events. However, the reading at station 09-XPB appears to be an anomaly, as the concentration greatly exceeds historical values and is approximately 10 times higher than readings at other stations performed at the same time. With the exception of 2011, tributary stations 09-XPB and 01-BFB typically show the highest concentrations throughout the sampling period, with this trend continuing into 2012. Station 09-PEN showed somewhat elevated concentrations, however did not grossly exceed previous results.

Overall, phosphorus levels in both the tributaries and ponds show a declining trend since 2007 and the start of the watershed restoration program as shown on **Figure 4** and **Figure 5**.

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. Ideally, only naturally occurring phosphorus should be present, typically from 0.014 mg/L to 0.017 mg/L 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. Although only three in-pond and two tributary samples collected during 2012 exceed 0.05 mg/L, many locations exceed the 0.015 mg/L concentration identified as natural conditions.

Total Kjeldahl Nitrogen (TKN)

Nitrogen is a nutrient essential for algae and other plant growth and excess amounts can lead to nuisance algae blooms. TKN represents organic nitrogen and ammonia nitrogen, which can indicate the presence of sewage, animal waste, fertilizer, erosion, or other types of pollution. For the first time since 2008, detectable levels of TKN were observed at tributary stations 01-BFB, 09T-PEN, 01-XWB, and 01-MUD. Levels were still very low, with all 2012 results less than 1 mg/L, and much less than those recorded in 2007 and 2008.

In-pond results were similar to tributary locations, with detectable levels observed an average of once per year at all locations. Results were also low, with only a single surface sample collected at station 08-PEN exceeding 1 mg/L during 2012. Trends appear consistent with previous sample years.

TKN does not have a numeric standard specified in the New Hampshire surface water quality standards.

Ammonia

As with TKN, ammonia is a nutrient that contributes to plant growth. Ammonia toxicity is dependent on pH levels. When the pH is below 8.75, $NH4^+$ dominates. Basic pH above 9.75 can cause NH3 to dominate, which is more toxic to aquatic species. Measurement of TKN and ammonia allows for estimation of organic nitrogen by subtracting the concentration of ammonia nitrogen from TKN. Ammonia should be less than 0.64 mg/L as per New Hampshire water quality standards. All tributary and in-pond samples continue to meet water quality standards for ammonia.

Escherichia Coliform Bacteria (*E.coli*)

E. coli represents bacteria associated with the fecal matter of warm-blooded animals. It is often used to determine whether water is safe for swimming and requires treatment for use as drinking water. It may indicate the presence of sewage or wildlife.

E.coli levels were generally higher during summer and fall months and lower during winter periods, consistent with historical data. A noticeable bacteria spike occurred on August 2, 2012, most noticeable at tributary stations 01-BFB (1,046 MPN/100 mL), 09-XPB (548 MPN/100 mL), 12-PEN (365 MPN/100 mL), and 09T-PEN (228 MPN/100 mL). Other tributary results are consistent with previous sampling years. Due to the large summer spike in bacteria, the overall trend of E.coli is approximately flat at all stations with the exception of 01-BFB which is trending upwards, primarily due to the large 1,046 MPN/100 mL reading. E.coli levels at tributary locations are improving slightly as indicated on **Figure 6** by a slight downward trend from 2007 through 2012.

In-pond E.coli levels were typically highest at bottom locations, particularly 07F-PEN, 09-PEN, and 04-PEN, consistent with 2011 results. As with tributary locations, the overall trend of E.coli is approximately flat from 2007 through 2012.

E.coli should not exceed 153 cts/100 mL for any single sample, based on numeric standards for Class A waters. With the exception of tributary samples from August 2,

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2012, and a single in-pond bottom sample from station 07F-PEN on May 31, 2012 the remainder of samples met the numeric threshold for Class A waters.

pH

pH measures the acidity of water and can affect biological processes in water important to aquatic life. It can also affect the treatment process for drinking water.

pH appears relatively consistent during the 2012 period, generally ranging between 6 and 7.5, further confirming that the extreme dips in pH identified at tributary locations in August of 2007 and October of 2008 are likely anomalies associated with equipment malfunctions. The Class A NH Surface Water Quality Standard for pH is between 6.5 and 8.0 unless naturally occurring.

Conductivity

Conductivity measures the total dissolved solids including free ion (charged particles) content in water and can indicate the presence of chlorides, and total dissolved solids including nitrates, sulfates, phosphates, and sodium, magnesium, calcium, iron, and aluminum ions. Possible sources include road salt, septic systems, wastewater treatment plants, urban/agricultural runoff or naturally occurring from surrounding geology. Polluted water usually has a higher conductivity than unpolluted water.

Tributary conductivity levels were relatively consistent between sampling stations in 2012 with a general rise in the summer and early fall, and decline in winter and spring. Levels are similar to those observed in 2007, 2008, and 2011, and less than 2010 results. 2012 in-pond readings were consistent with 2011 readings and the majority of earlier samples.

New Hampshire water quality standards do not specify a numeric standard for conductivity, however, a waterbody with conductivity greater than 2,000 umhos/cm would be considered high in dissolved solids. All samples from 2012 are substantially less than 2,000 umhos/cm.

Conclusions

Overall water quality is improving since the start of the 2007 watershed restoration program as shown by select water quality parameters in figures 2 through 6. Levels of total phosphorus, total suspended solids and E.coli are dropping, while dissolved oxygen is increasing in tributary locations, indicating an improvement in water quality.

Recommended Changes to the Tributary Monitoring Program

Pennichuck has been collecting streamflow data since 2007. The data was originally collected to help calibrate the model used in the 2008 Watershed Restoration Plan and

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continues to be collected to provide overall trend data and information for future modeling efforts. Sampling in 2012 was largely successful on all fronts. Data loggers performed largely as expected, and dry weather sampling was performed as scheduled.

Under current sampling methods, total coliform samples frequently reach the detection limit of 2,419.60 mpn/100 mL, providing little information on water quality. Due to the limited usefulness of the total coliform water quality parameter, it is recommended that sampling for total coliform be discontinued. Instead, it is recommended that locations be analyzed for fecal coliform, with the continued monitoring of E.coli.

CEI recommends that a minimum of two functioning data loggers be retained as backups at the beginning of 2013 for use as replacements should a field data logger be damaged or otherwise unusable. It is again recommended that malfunctioning or broken data loggers be sent for repair at the end of the sampling program, rather than during to maximize data collection while minimizing budget spent coordinating data logger repairs. If desired, reserve data loggers could be deployed to help identify any specific problems identified during field efforts.

If necessary, CEI can rely on staff gages at each station to determine flows on select sampling dates, allowing for correlation of flow to samples while data loggers are out. CEI will also grab periodic flow measurements using a velocity meter to ensure that the existing stage-discharge curves remain valid, with no significant changes to stream channel geometry. This will provide enough information to fill in data gaps associated with data logger issues at a more reasonable cost.

It is recommended that CEI continue to download data from field data loggers approximately every six weeks. Dry weather tributary sampling should continue as follows:

Table 2 – Proposed Dry Weather Sampling Schedule

2013 Month			
February	March	April	July
August	September	November	

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Sincerely,

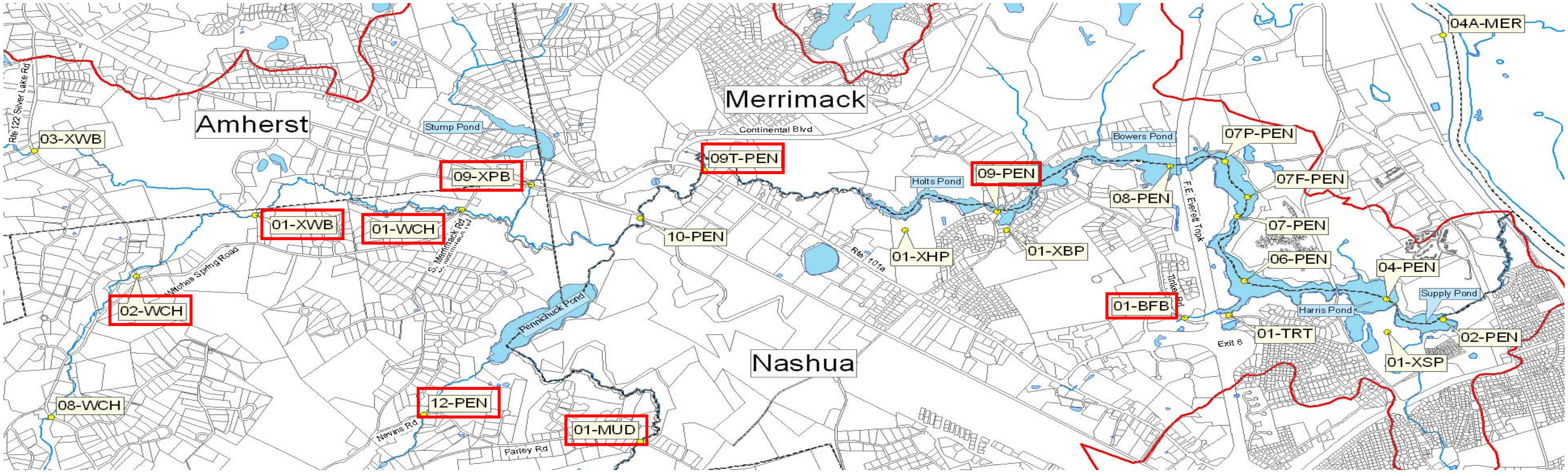
COMPREHENSIVE ENVIRONMENTAL INC.

Rebecca Balke

Rebecca Balke, P.E.
Project Manager

Attachments:

- Figure 1: Site Locations and Names
- Figure 2: Dissolved Oxygen Trends in Tributaries, 2007-2012
- Figure 3: TSS Trends in Tributaries, 2007-2012
- Figure 4: Phosphorus Trends in Tributaries, 2007-2012
- Figure 5: Phosphorus Trends for In-Pond Locations, 2007-2012
- Figure 6: E.coli Trends in Tributaries, 2007-2012
- Supporting Graphs
  - Tributary Flow Data Graphs;
  - 2007-2012 Tributary and In-Pond Trendline Graphs for:
    - Tributary Flow Data;
    - Dissolved Oxygen;
    - Temperature;
    - Total Suspended Solids;
    - Total Phosphorus;
    - TKN;
    - Ammonia-N;
    - E.coli;
    - Total Coliform;
    - pH; and
    - Conductivity.



Old Name	New DES Name	Descriptions		
T-1	01-BFB	Boire Field Brook - Tinker Road		
T-2	09-PEN	Holt Pond Dam		
T-3	09T-PEN	Route 101A Bridge		
T-4	09-XPB	Unnamed Trib to Pennichuck Brook		
T-5	01-WCH	South Merrimack Road Bridge		
T-6	01-XWB	Unnamed Trib to Witches Brook		
T-7	02-WCH	Ames Road Bridge off Route 122		
T-8	12-PEN	Nevins Road Bridge		
T-9	01-MUD	Farley Road Bridge		

Old Name	New DES Name	Descriptions			
B1	07F-PEN	Bowers Pond - 700' US of Bowers			
B2	08-PEN	Bowers Pond - Middle			
H1	04-PEN	Harris Pond - 100' US of Harris			
H2	06-PEN	Harris Pond - Middle			
R1	07P-PEN	Bowers Pond - 1/4 mile DS of E			
R2	04A-MER	Merrimack River - Boat Launch			
S1	02-PEN	Supply Pond - 25 ' Upstream of			

FIGURE 1: Site Locations and Names

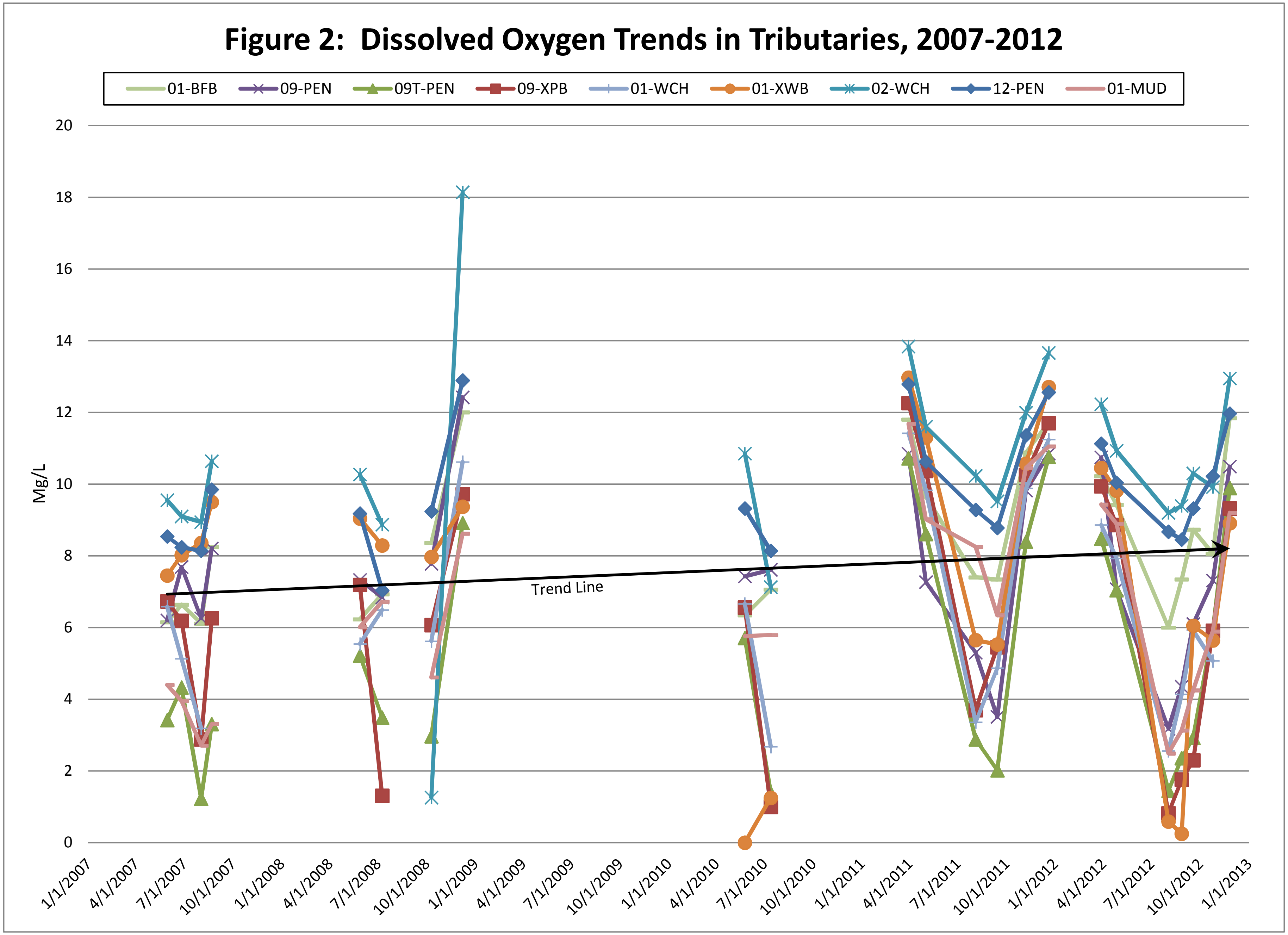
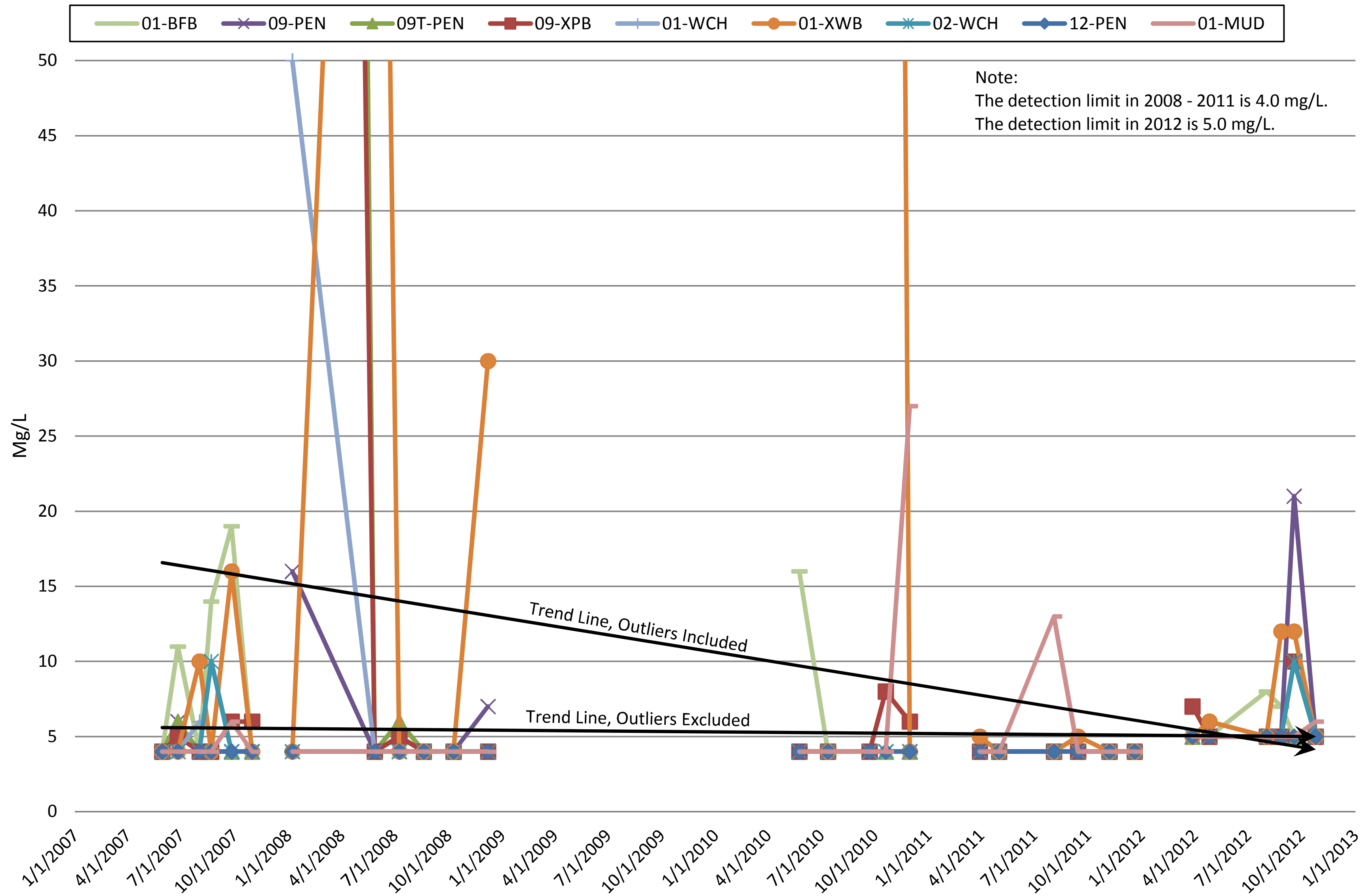


Figure 2: Dissolved Oxygen Trends in Tributaries, 2007-2012
01-BFB
09-PEN
09T-PEN
09-XPB
01-WCH
01-XWB
02-WCH
12-PEN
01-MUD
Mg/L
0
2
4
6
8
10
12
14
16
18
20
Trend Line
1/1/2007
4/1/2007
7/1/2007
10/1/2007
1/1/2008
4/1/2008
7/1/2008
10/1/2008
1/1/2009
4/1/2009
7/1/2009
10/1/2009
1/1/2010
4/1/2010
7/1/2010
10/1/2010
1/1/2011
4/1/2011
7/1/2011
10/1/2011
1/1/2012
4/1/2012
7/1/2012
10/1/2012
1/1/2013

Figure 3: TSS Trends in Tributaries, 2007-2012

(Outliers >50 mg/L Not Shown)



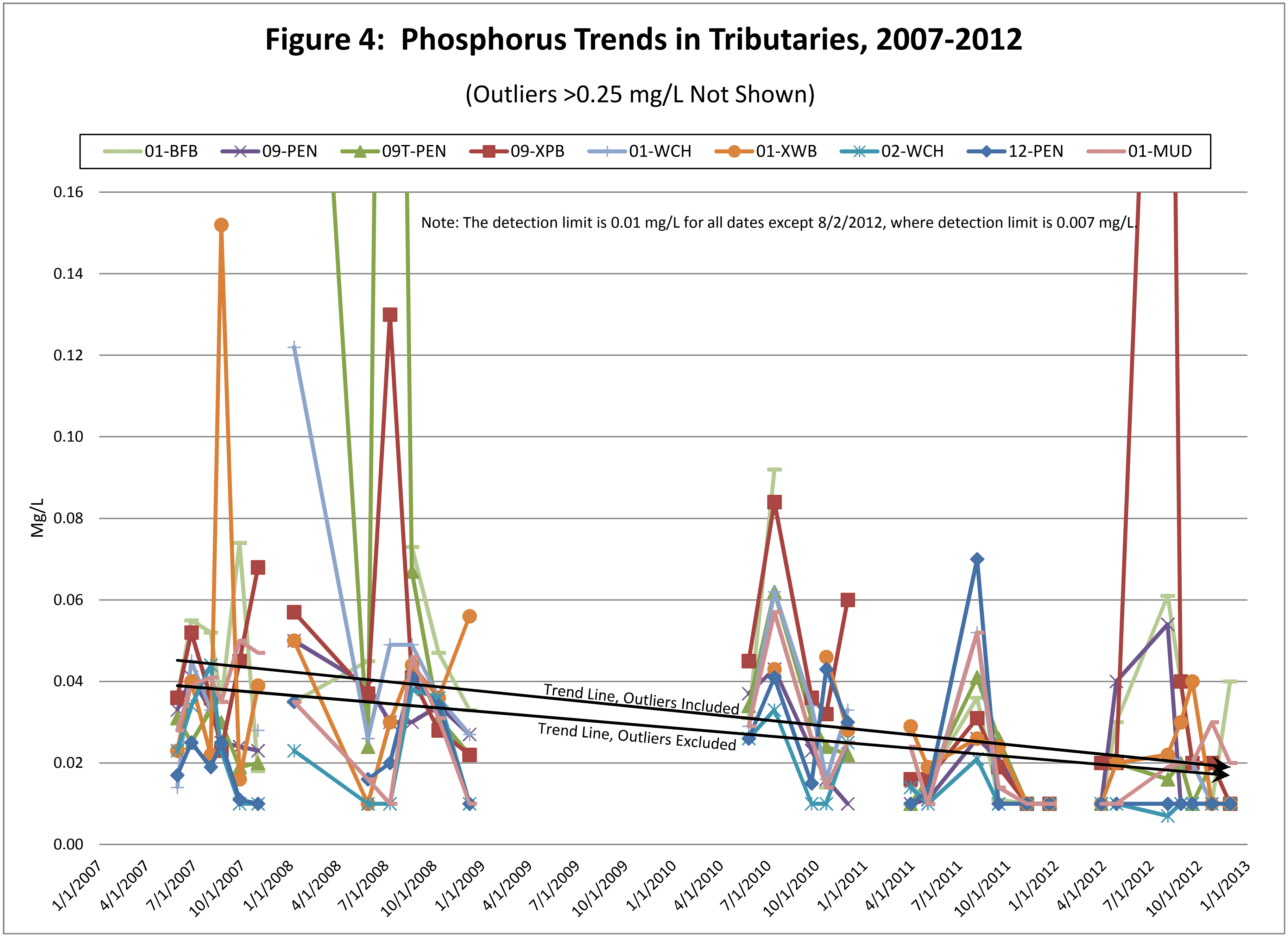


Figure 4: Phosphorus Trends in Tributaries, 2007-2012
(Outliers >0.25 mg/L Not Shown)
01-BFB
09-PEN
09T-PEN
09-XPB
01-WCH
01-XWB
02-WCH
12-PEN
01-MUD
Note: The detection limit is 0.01 mg/L for all dates except 8/2/2012, where detection limit is 0.007 mg/L.
Trend Line, Outliers Included
Trend Line, Outliers Excluded
Mg/L
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
1/1/2007
4/1/2007
7/1/2007
10/1/2007
1/1/2008
4/1/2008
7/1/2008
10/1/2008
1/1/2009
4/1/2009
7/1/2009
10/1/2009
1/1/2010
4/1/2010
7/1/2010
10/1/2010
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10/1/2012
1/1/2013

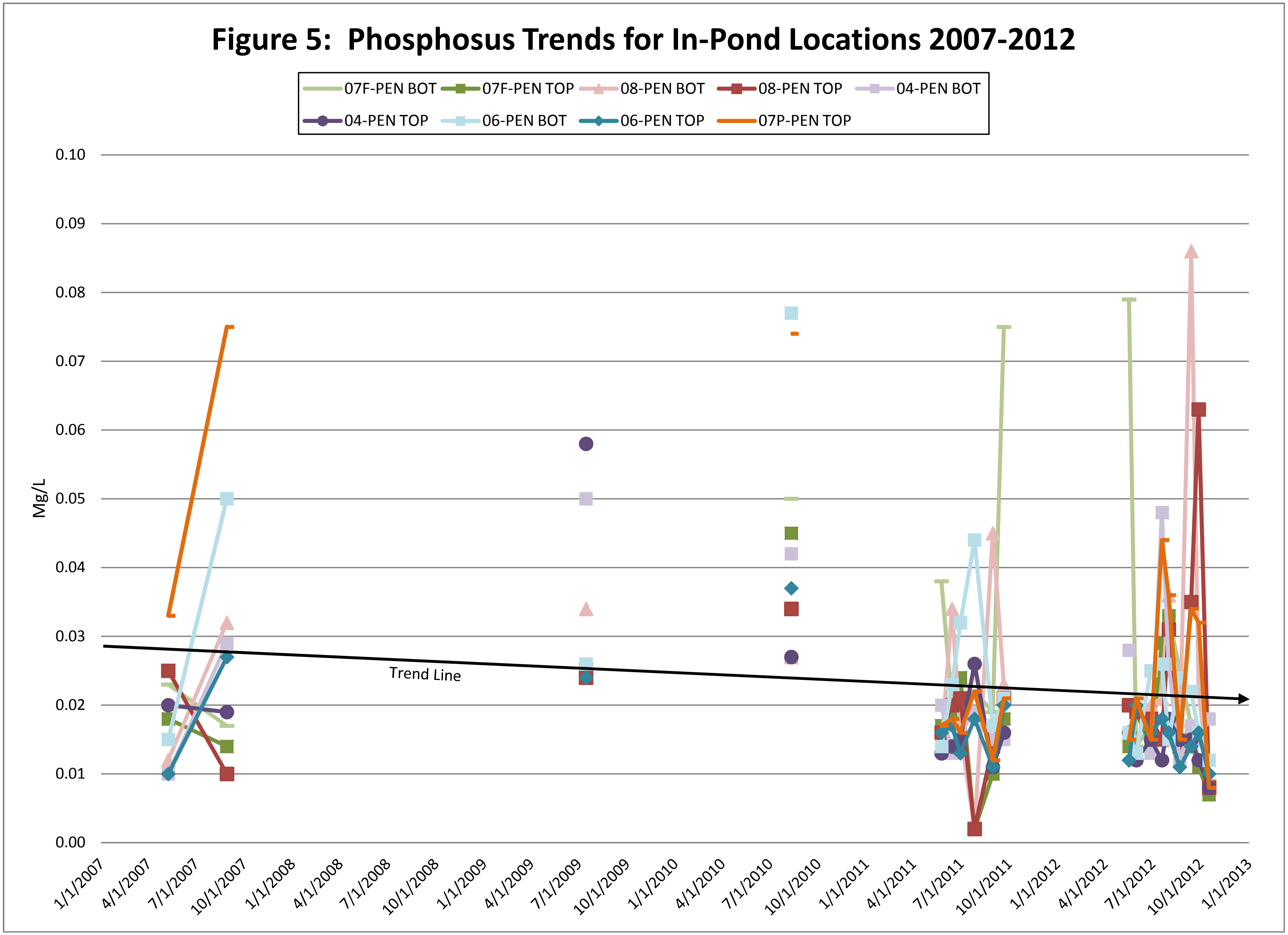
Figure 5: Phosphosus Trends for In-Pond Locations 2007-2012
07F-PEN BOT
07F-PEN TOP
08-PEN BOT
08-PEN TOP
04-PEN BOT
04-PEN TOP
06-PEN BOT
06-PEN TOP
07P-PEN TOP
Mg/L
0.10
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
Trend Line
1/1/2007
4/1/2007
7/1/2007
10/1/2007
1/1/2008
4/1/2008
7/1/2008
10/1/2008
1/1/2009
4/1/2009
7/1/2009
10/1/2009
1/1/2010
4/1/2010
7/1/2010
10/1/2010
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10/1/2012
1/1/2013

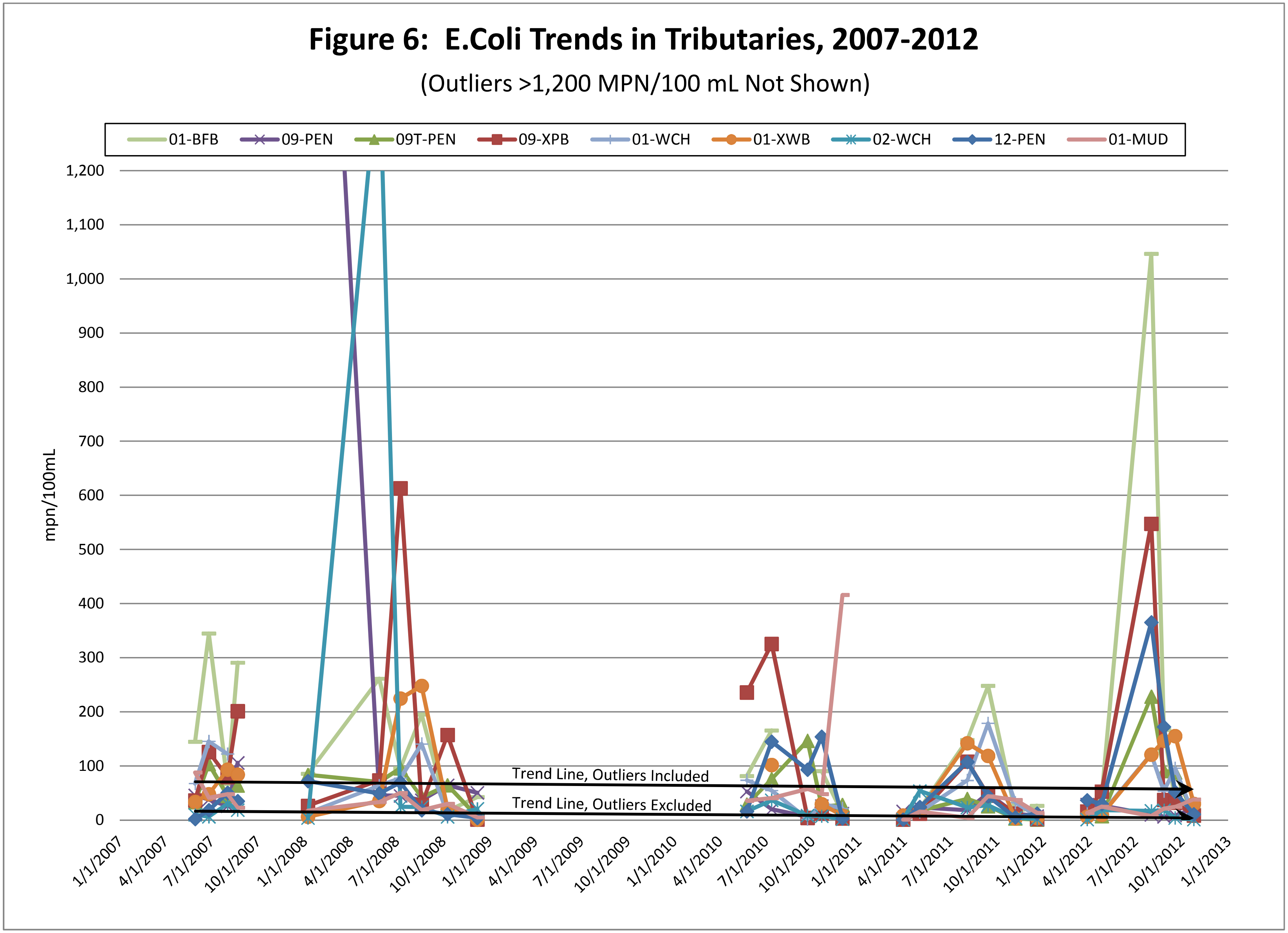

Figure 6: E.Coli Trends in Tributaries, 2007-2012
(Outliers >1,200 MPN/100 mL Not Shown)
01-BFB
09-PEN
09T-PEN
09-XPB
01-WCH
01-XWB
02-WCH
12-PEN
01-MUD
mpn/100mL
1,200
1,100
1,000
900
800
700
600
500
400
300
200
100
0
Trend Line, Outliers Included
Trend Line, Outliers Excluded
1/1/2007
4/1/2007
7/1/2007
10/1/2007
1/1/2008
4/1/2008
7/1/2008
10/1/2008
1/1/2009
4/1/2009
7/1/2009
10/1/2009
1/1/2010
4/1/2010
7/1/2010
10/1/2010
1/1/2011
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7/1/2011
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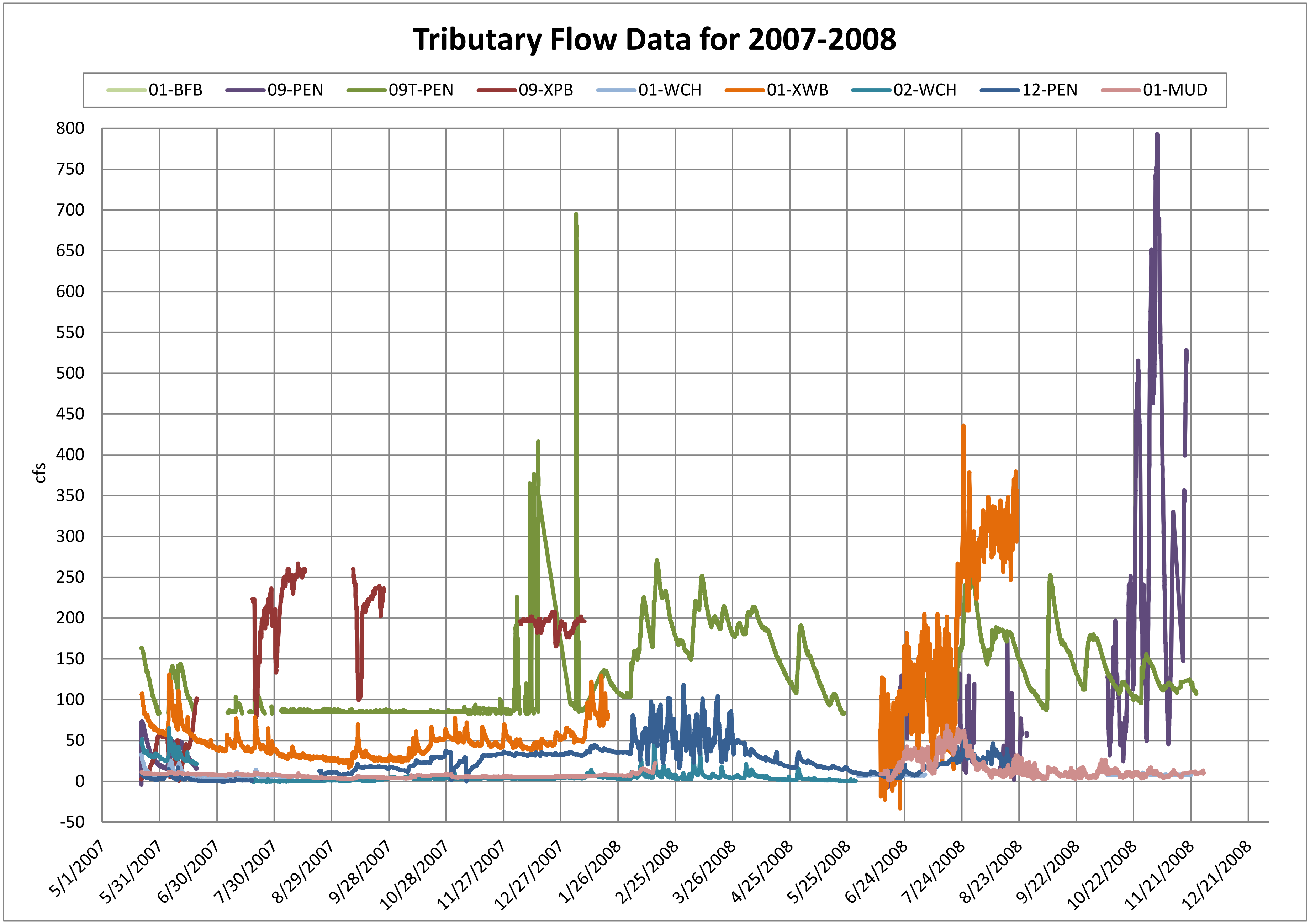
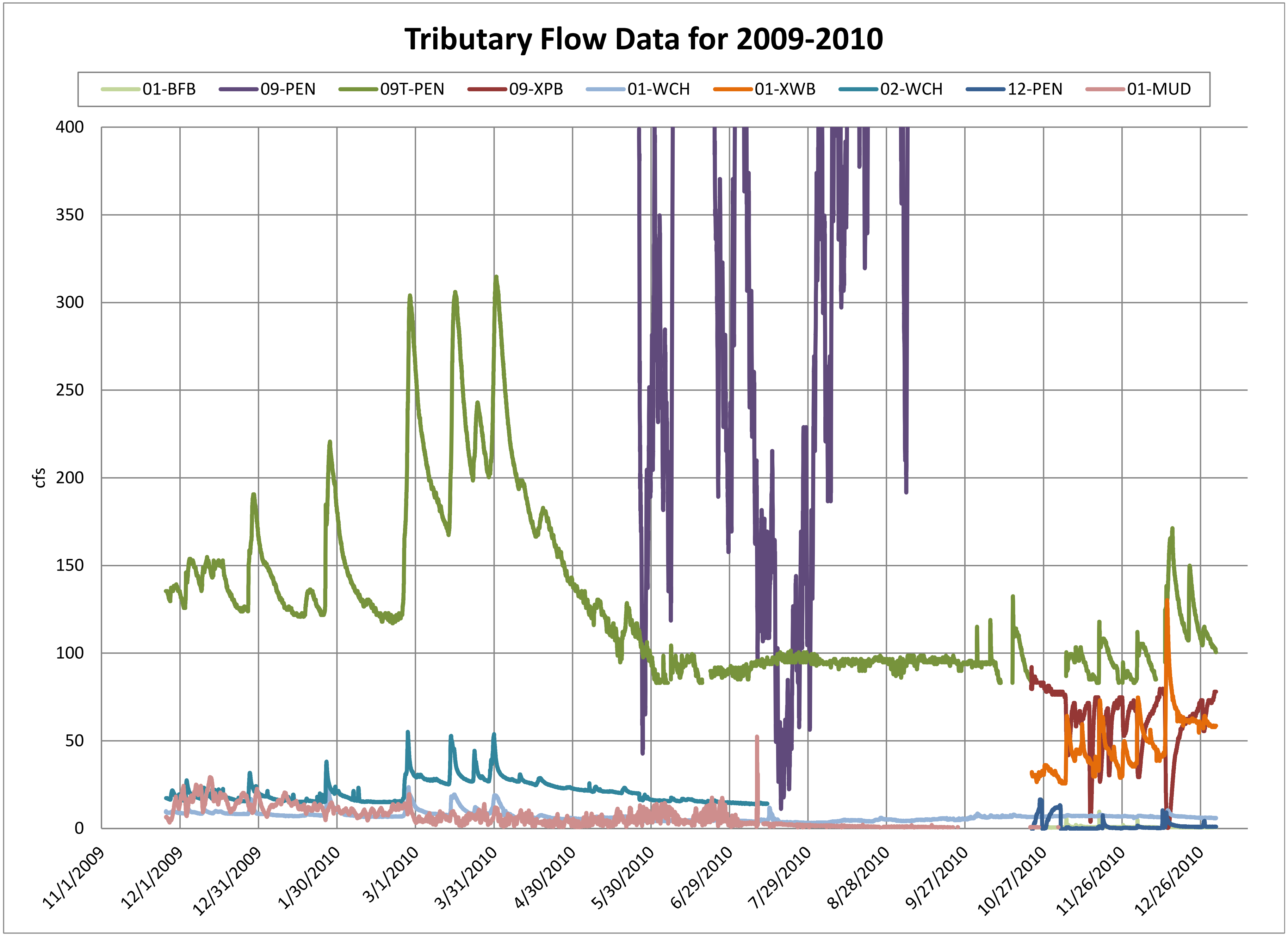
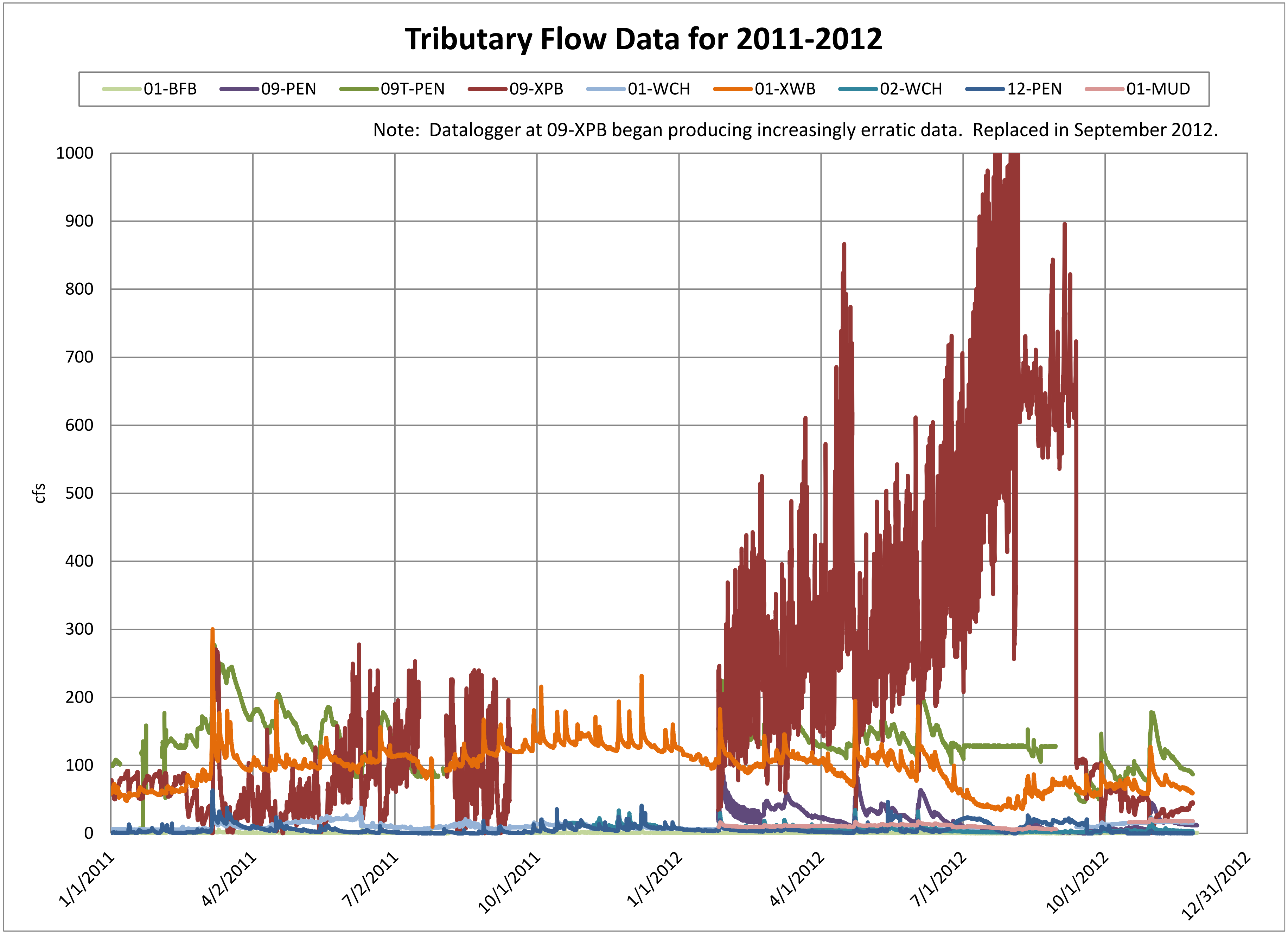
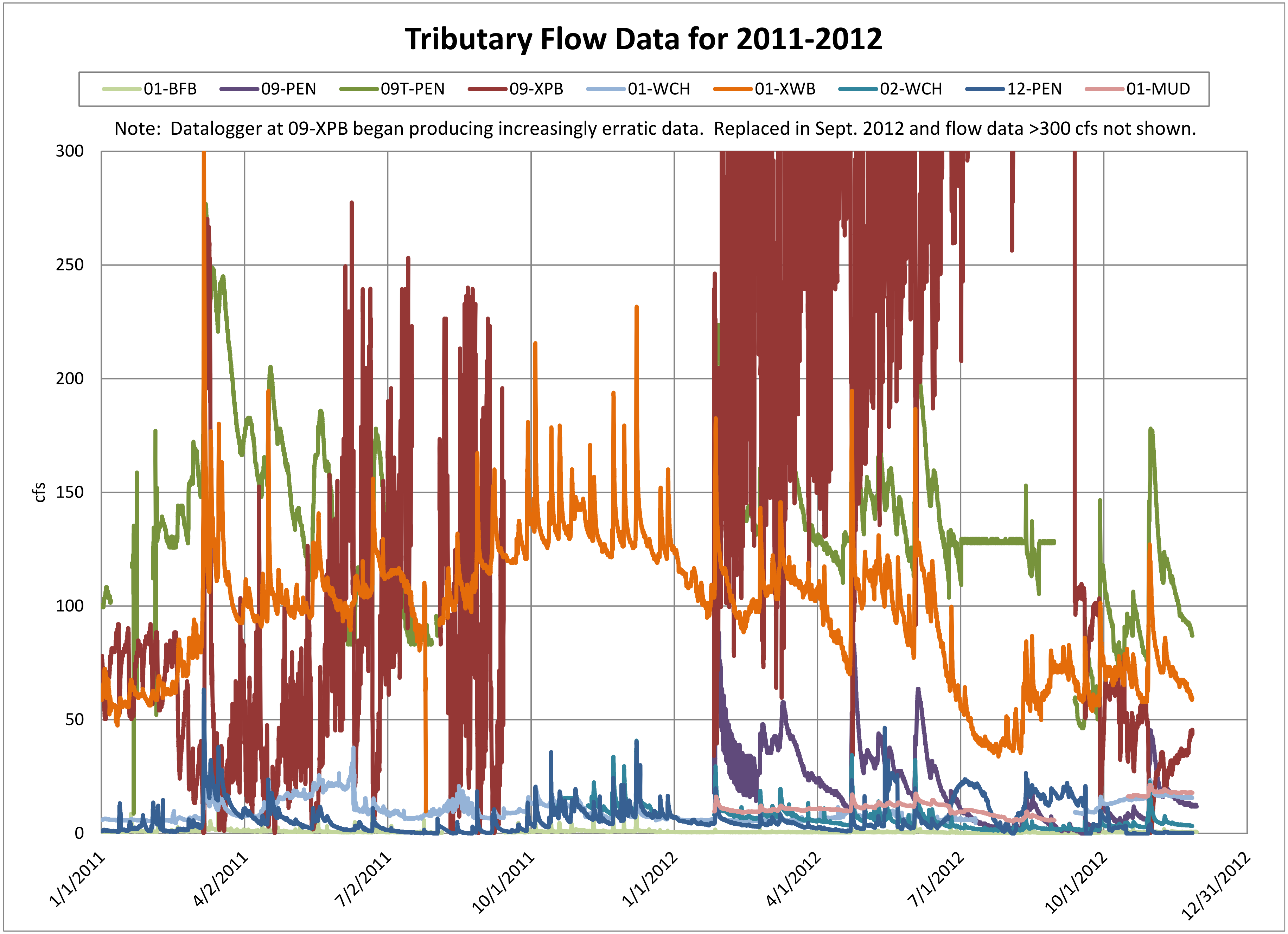
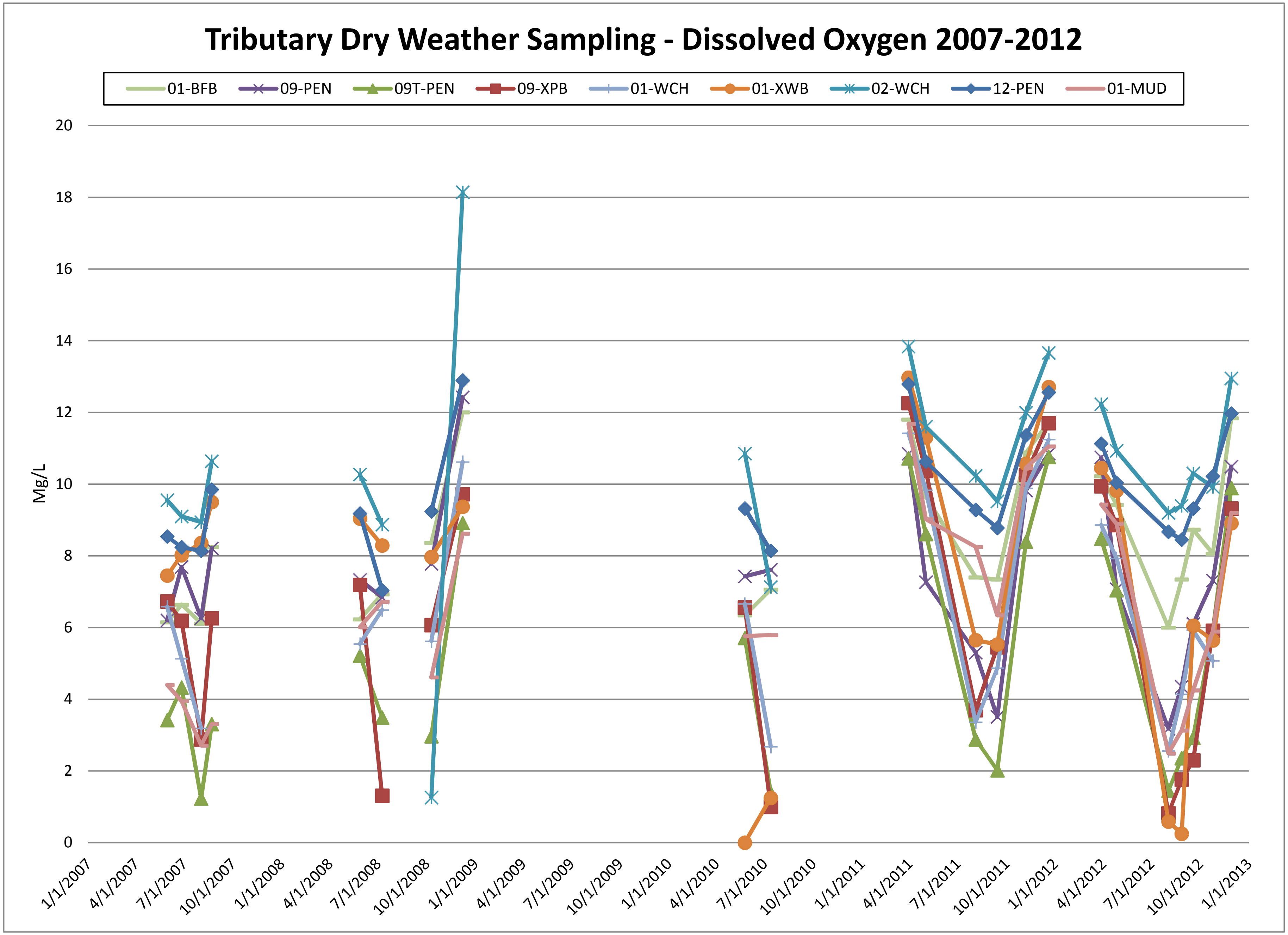
1/1/2012
4/1/2012
7/1/2012
10/1/2012
1/1/2013


Tributary Flow Data for 2007-2008
01-BFB
09-PEN
09T-PEN
09-XPB
01-WCH
01-XWB
02-WCH
12-PEN
01-MUD
cfs
800
750
700
650
600
550
500
450
400
350
300
250
200
150
100
50
0
-50
5/1/2007
5/31/2007
6/30/2007
7/30/2007
8/29/2007
9/28/2007
10/28/2007
11/27/2007
12/27/2007
1/26/2008
2/25/2008
3/26/2008
4/25/2008
5/25/2008
6/24/2008
7/24/2008
8/23/2008
9/22/2008
10/22/2008
11/21/2008
12/21/2008

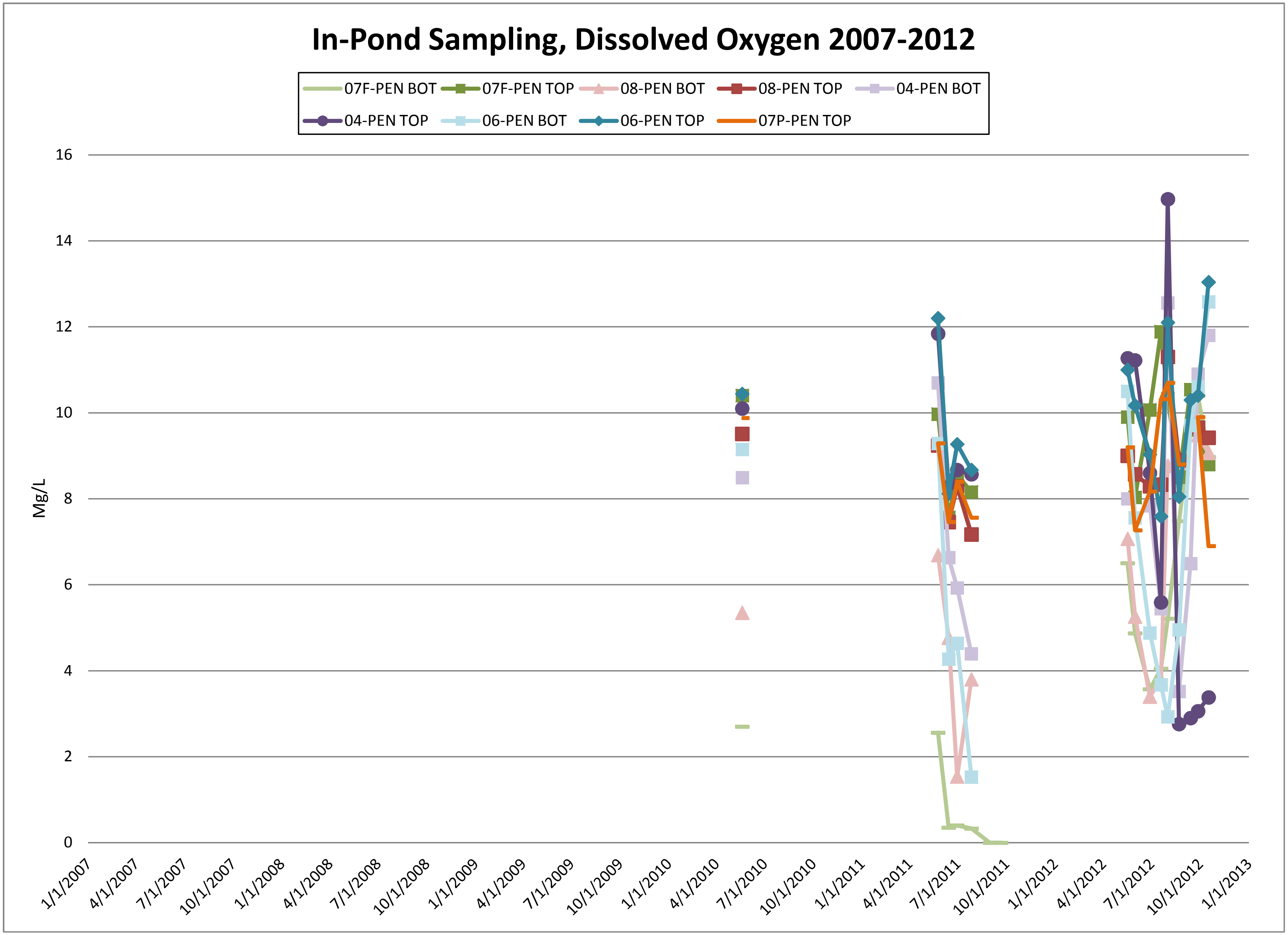

Tributary Flow Data for 2009-2010
01-BFB
09-PEN
09T-PEN
09-XPB
01-WCH
01-XWB
02-WCH
12-PEN
01-MUD
cfs
400
350
300
250
200
150
100
50
0
11/1/2009
12/1/2009
12/31/2009
1/30/2010
3/1/2010
3/31/2010
4/30/2010
5/30/2010
6/29/2010
7/29/2010
8/28/2010
9/27/2010
10/27/2010
11/26/2010
12/26/2010

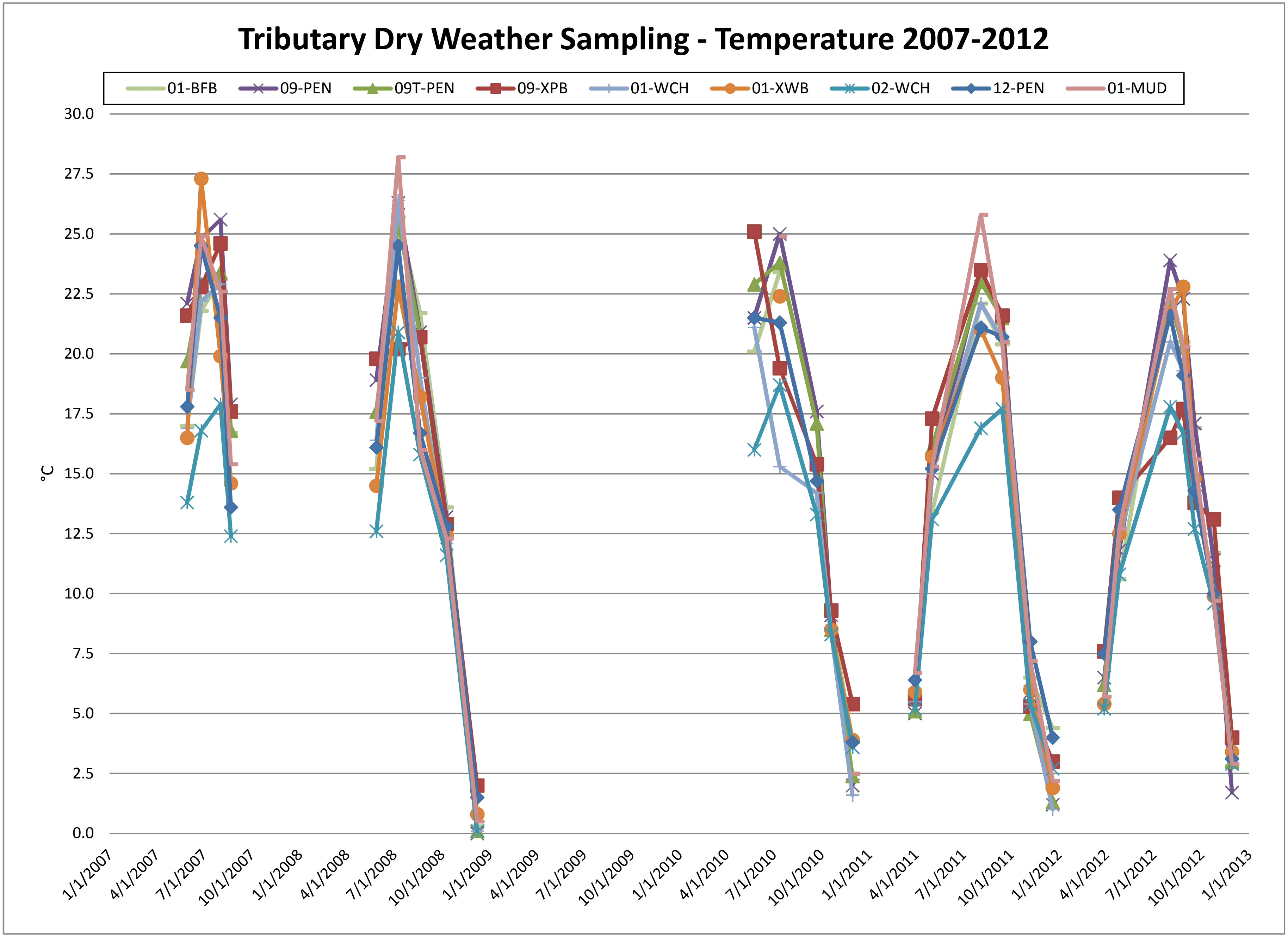

Tributary Flow Data for 2011-2012
01-BFB
09-PEN
09T-PEN
09-XPB
01-WCH
01-XWB
02-WCH
12-PEN
01-MUD
Note: Datalogger at 09-XPB began producing increasingly erratic data. Replaced in September 2012.
cfs
1000
900
800
700
600
500
400
300
200
100
0
1/1/2011
4/2/2011
7/2/2011
10/1/2011
1/1/2012
4/1/2012
7/1/2012
10/1/2012
12/31/2012

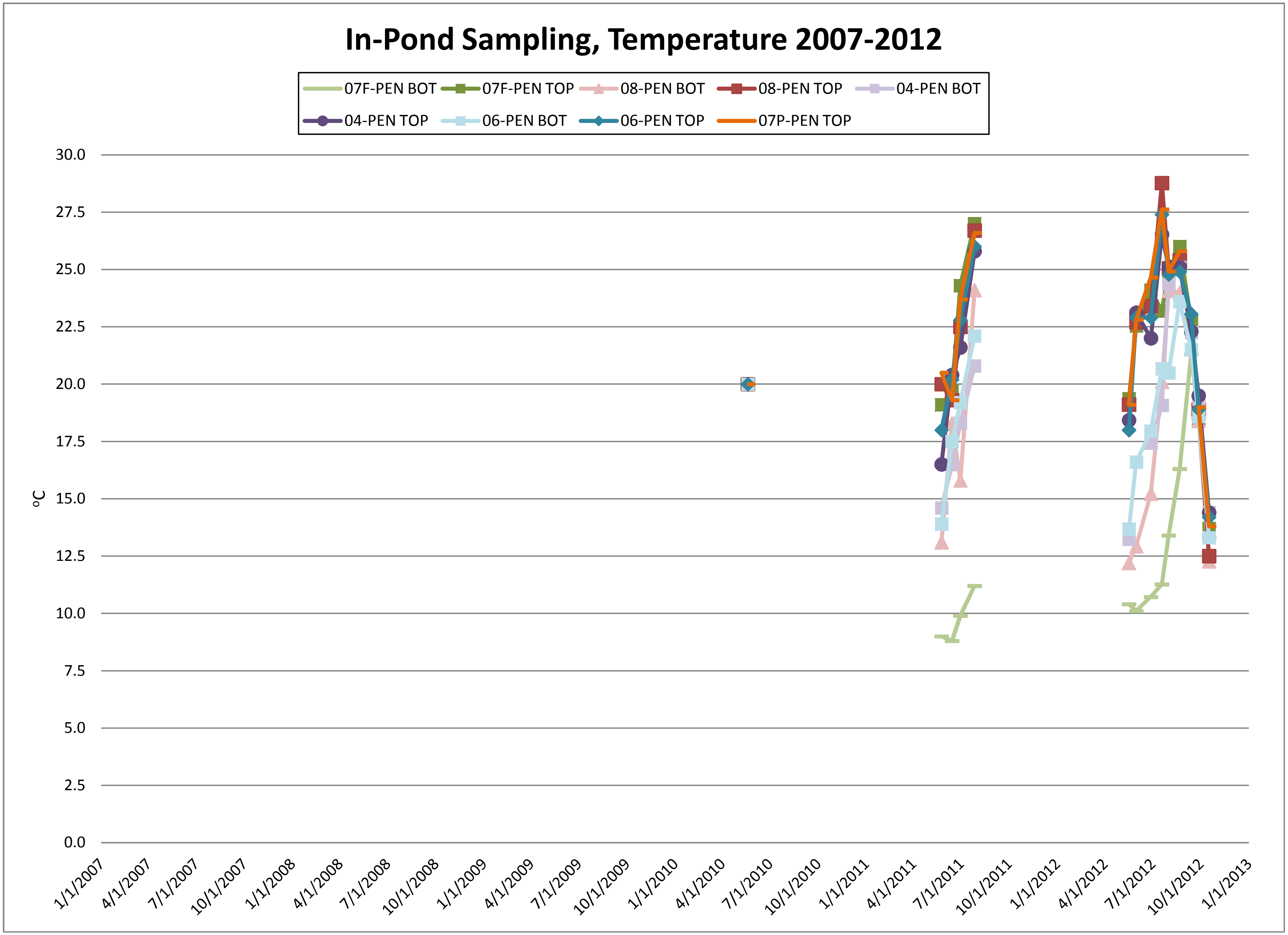

Tributary Flow Data for 2011-2012
01-BFB
09-PEN
09T-PEN
09-XPB
01-WCH
01-XWB
02-WCH
12-PEN
01-MUD
Note: Datalogger at 09-XPB began producing increasingly erratic data. Replaced in Sept. 2012 and flow data >300 cfs not shown.
cfs
0
50
100
150
200
250
300
1/1/2011
4/2/2011
7/2/2011
10/1/2011
1/1/2012
4/1/2012
7/1/2012
10/1/2012
12/31/2012



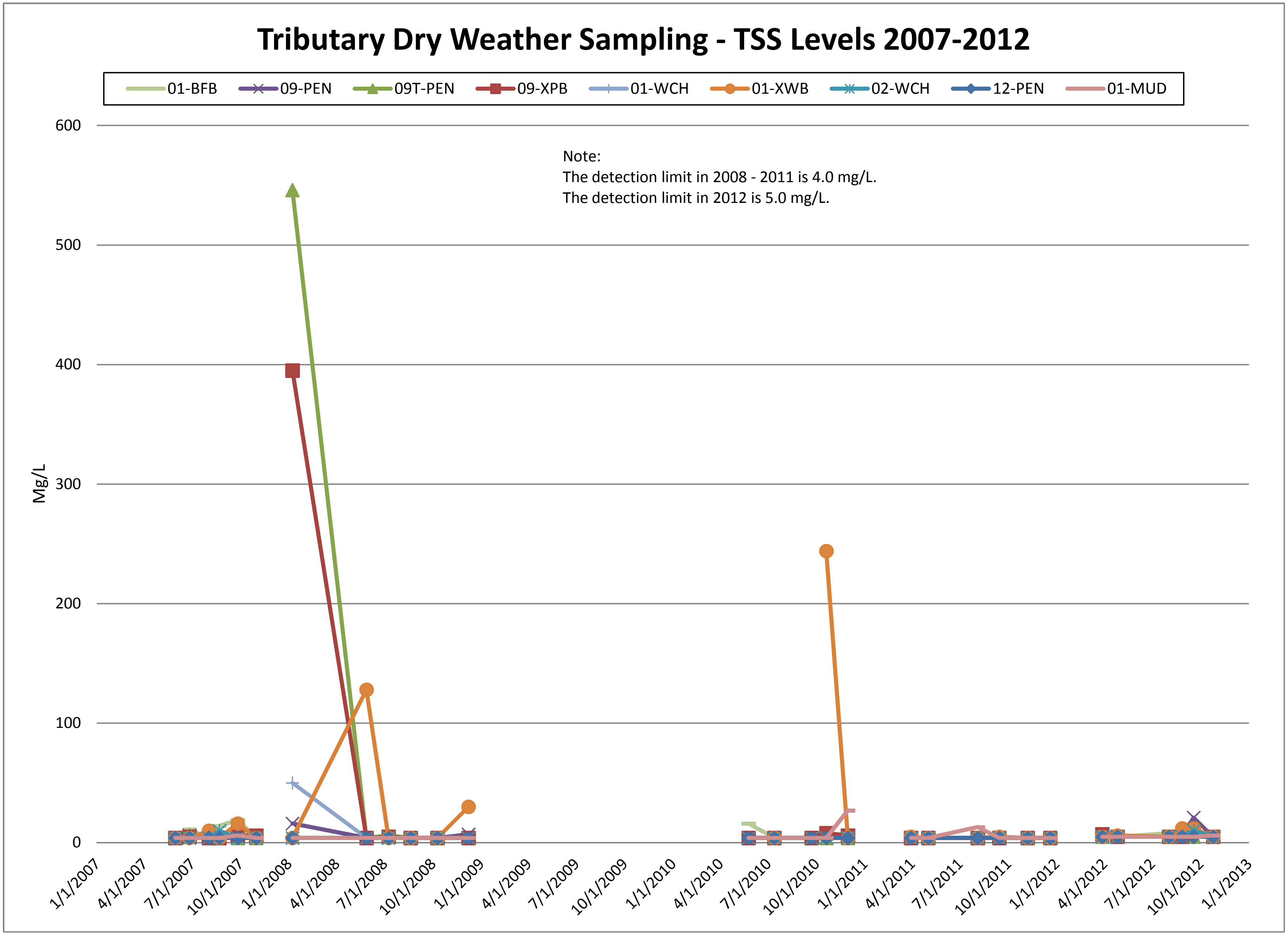
Tributary Dry Weather Sampling - Dissolved Oxygen 2007-2012
01-BFB
09-PEN
09T-PEN
09-XPB
01-WCH
01-XWB
02-WCH
12-PEN
01-MUD
Mg/L
20
18
16
14
12
10
8
6
4
2
0
1/1/2007
4/1/2007
7/1/2007
10/1/2007
1/1/2008
4/1/2008
7/1/2008
10/1/2008
1/1/2009
4/1/2009
7/1/2009
10/1/2009
1/1/2010
4/1/2010
7/1/2010
10/1/2010
1/1/2011
4/1/2011
7/1/2011
10/1/2011
1/1/2012
4/1/2012
7/1/2012
10/1/2012
1/1/2013


In-Pond Sampling, Dissolved Oxygen 2007-2012
07F-PEN BOT
07F-PEN TOP
08-PEN BOT
08-PEN TOP
04-PEN BOT
04-PEN TOP
06-PEN BOT
06-PEN TOP
07P-PEN TOP
Mg/L
16
14
12
10
8
6
4
2
0
1/1/2007
4/1/2007
7/1/2007
10/1/2007
1/1/2008
4/1/2008
7/1/2008
10/1/2008
1/1/2009
4/1/2009
7/1/2009
10/1/2009
1/1/2010
4/1/2010
7/1/2010
10/1/2010
1/1/2011
4/1/2011
7/1/2011
10/1/2011
1/1/2012
4/1/2012
7/1/2012
10/1/2012
1/1/2013

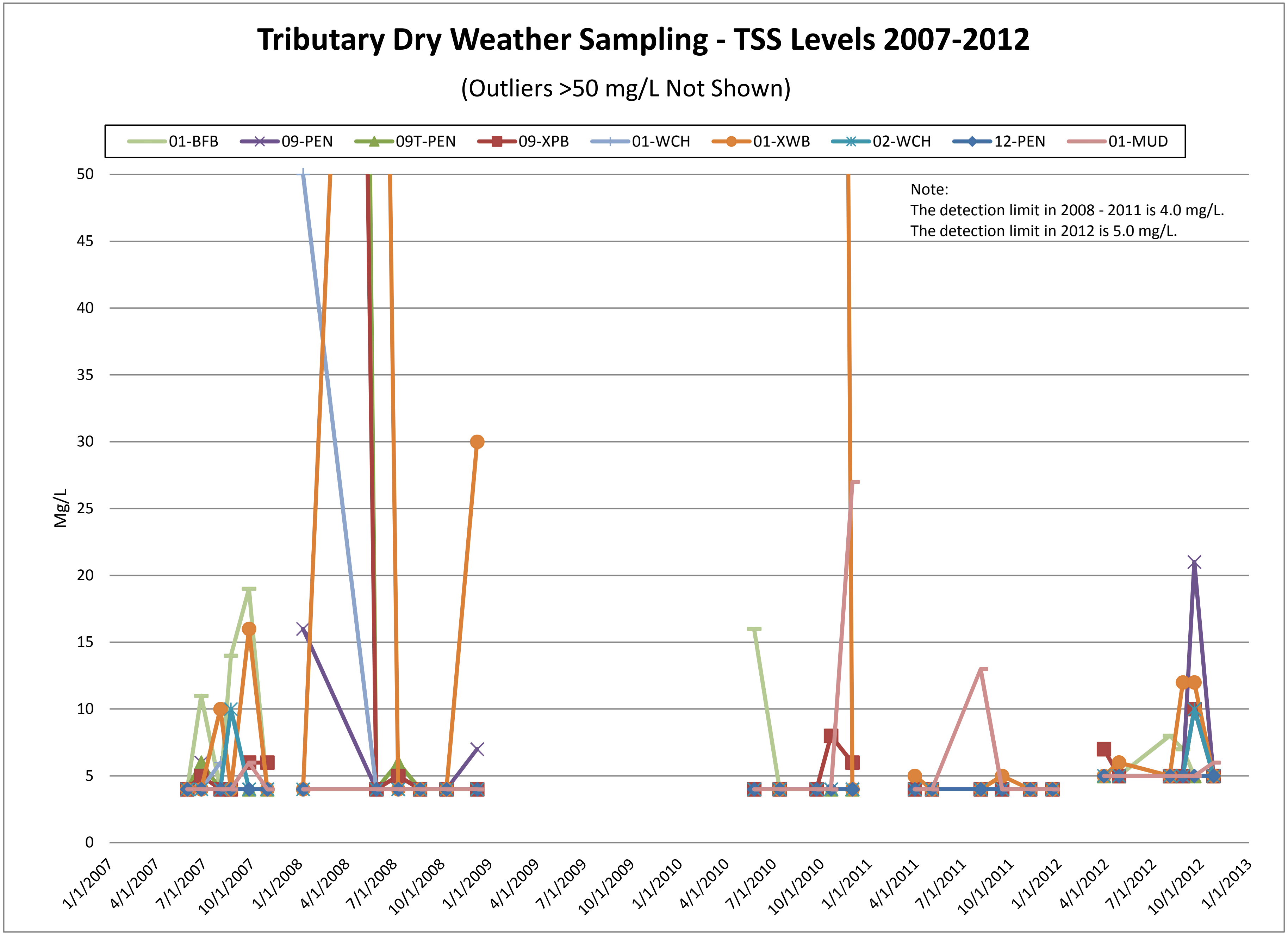

Tributary Dry Weather Sampling - Temperature 2007-2012
01-BFB
09-PEN
09T-PEN
09-XPB
01-WCH
01-XWB
02-WCH
12-PEN
01-MUD
°C
30.0
27.5
25.0
22.5
20.0
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
1/1/2007
4/1/2007
7/1/2007
10/1/2007
1/1/2008
4/1/2008
7/1/2008
10/1/2008
1/1/2009
4/1/2009
7/1/2009
10/1/2009
1/1/2010
4/1/2010
7/1/2010
10/1/2010
1/1/2011
4/1/2011
7/1/2011
10/1/2011
1/1/2012
4/1/2012
7/1/2012
10/1/2012
1/1/2013



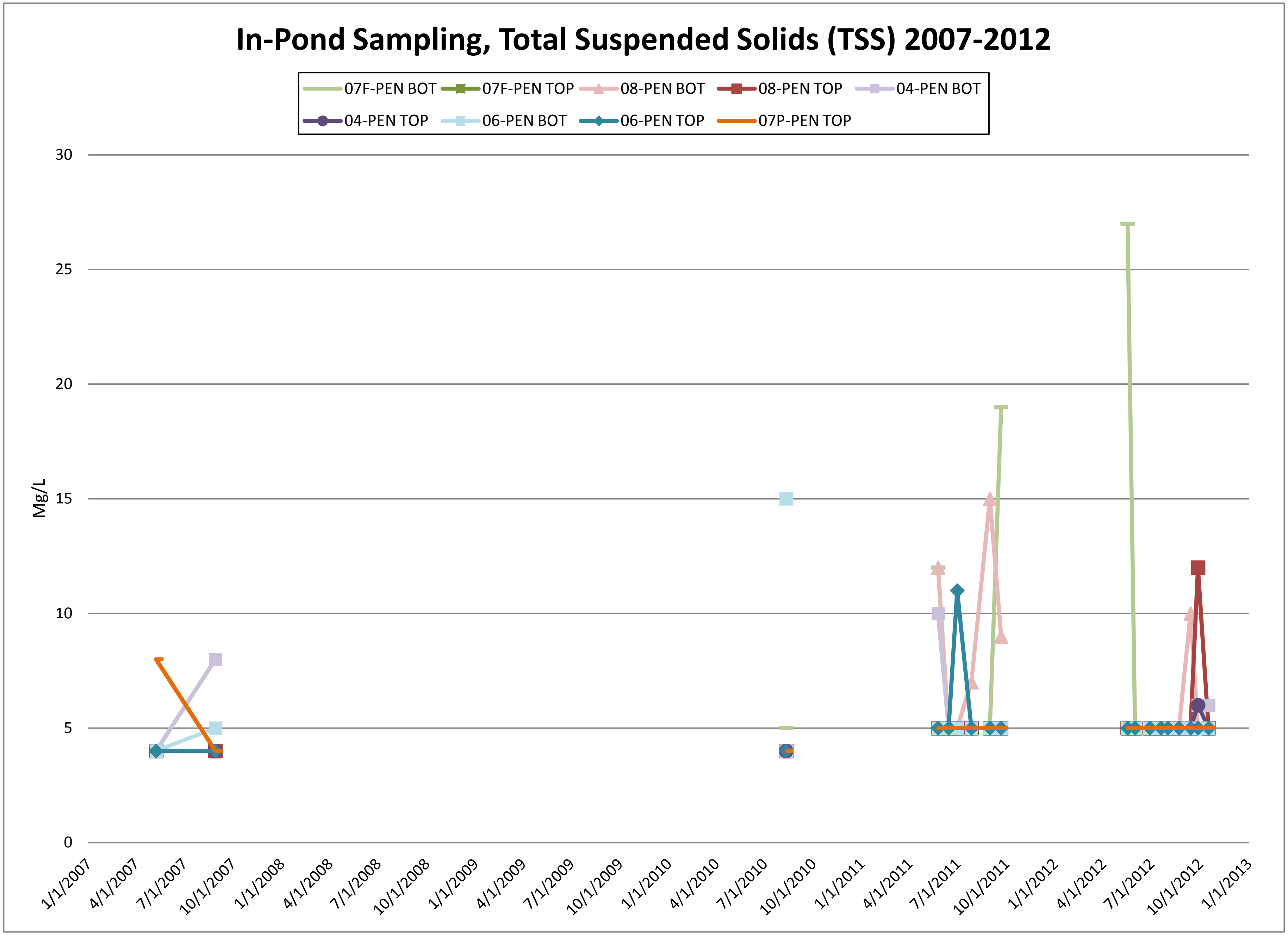
In-Pond Sampling, Temperature 2007-2012
07F-PEN BOT
07F-PEN TOP
08-PEN BOT
08-PEN TOP
04-PEN BOT
04-PEN TOP
06-PEN BOT
06-PEN TOP
07P-PEN TOP
°C
30.0
27.5
25.0
22.5
20.0
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
1/1/2007
4/1/2007
7/1/2007
10/1/2007
1/1/2008
4/1/2008
7/1/2008
10/1/2008
1/1/2009
4/1/2009
7/1/2009
10/1/2009
1/1/2010
4/1/2010
7/1/2010
10/1/2010
1/1/2011
4/1/2011
7/1/2011
10/1/2011
1/1/2012
4/1/2012
7/1/2012
10/1/2012
1/1/2013



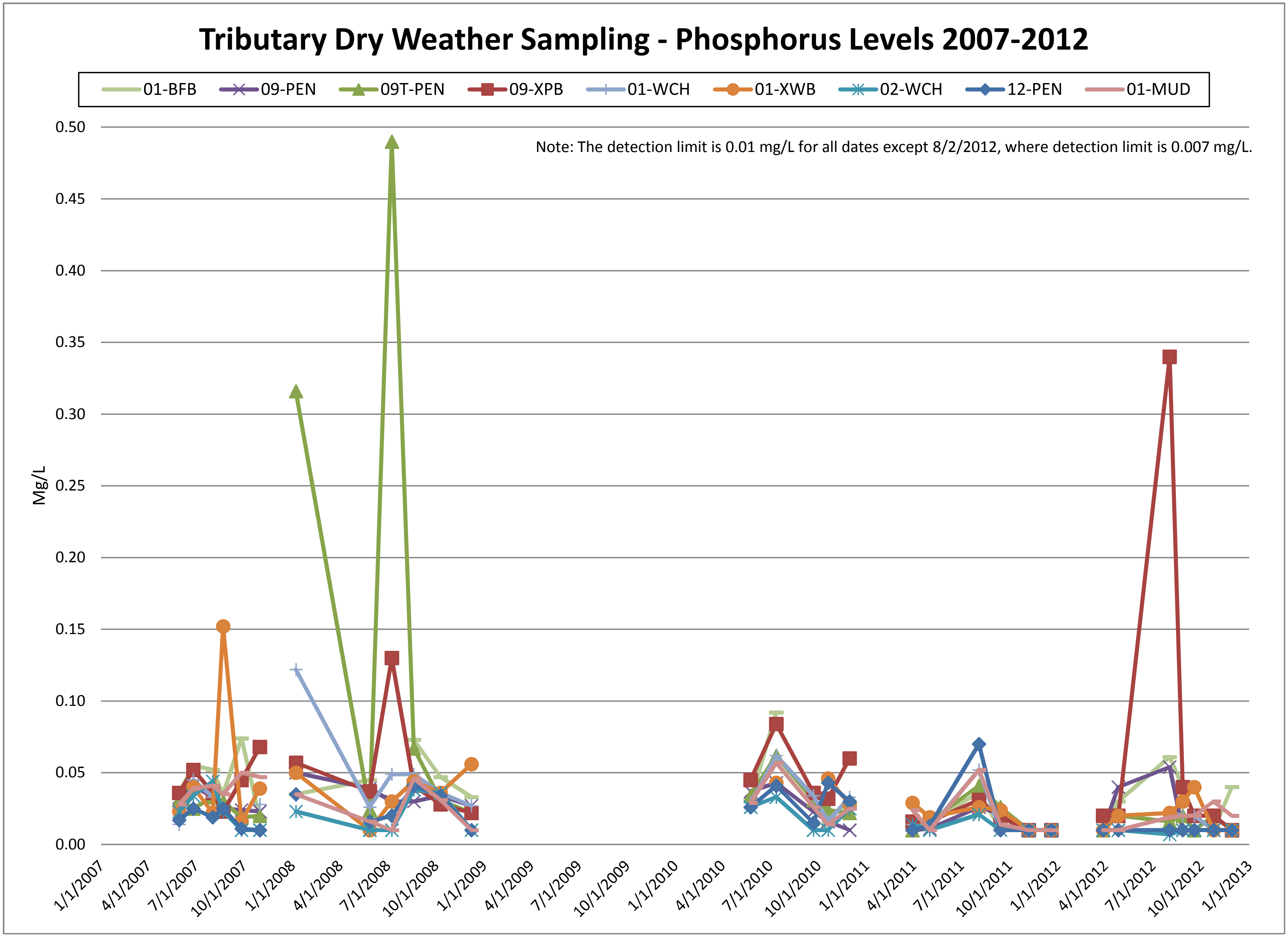
Tributary Dry Weather Sampling - TSS Levels 2007-2012
01-BFB
09-PEN
09T-PEN
09-XPB
01-WCH
01-XWB
02-WCH
12-PEN
01-MUD
Note:
The detection limit in 2008 - 2011 is 4.0 mg/L.
The detection limit in 2012 is 5.0 mg/L.
Mg/L
600
500
400
300
200
100
0
1/1/2007
4/1/2007
7/1/2007
10/1/2007
1/1/2008
4/1/2008
7/1/2008
10/1/2008
1/1/2009
4/1/2009
7/1/2009
10/1/2009
1/1/2010
4/1/2010
7/1/2010
10/1/2010
1/1/2011
4/1/2011
7/1/2011
10/1/2011
1/1/2012
4/1/2012
7/1/2012
10/1/2012
1/1/2013

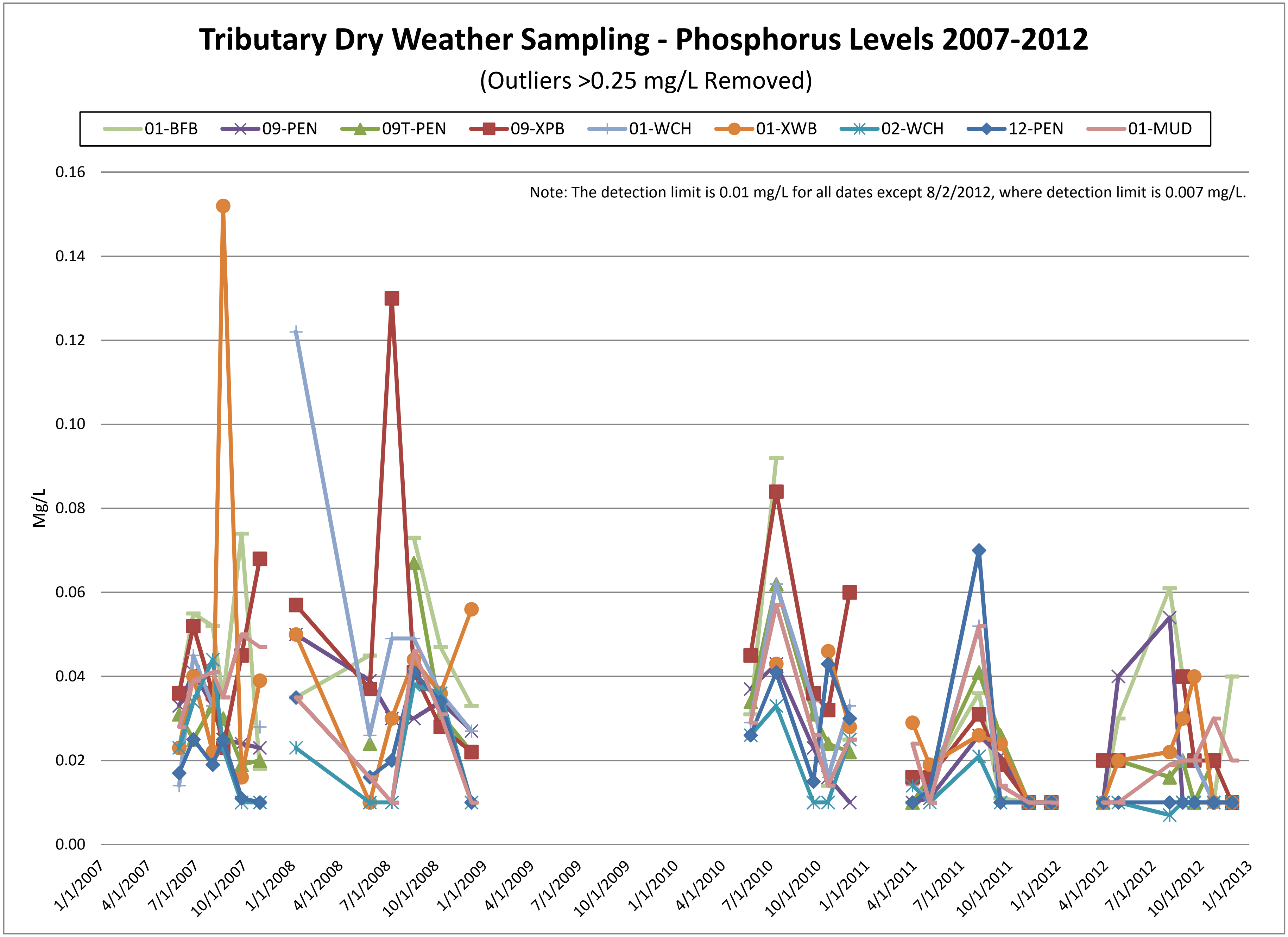


Tributary Dry Weather Sampling - TSS Levels 2007-2012
(Outliers >50 mg/L Not Shown)
01-BFB
09-PEN
09T-PEN
09-XPB
01-WCH
01-XWB
02-WCH
12-PEN
01-MUD
Note:
The detection limit in 2008 - 2011 is 4.0 mg/L.
The detection limit in 2012 is 5.0 mg/L.
Mg/L
0
5
10
15
20
25
30
35
40
45
50
1/1/2007
4/1/2007
7/1/2007
10/1/2007
1/1/2008
4/1/2008
7/1/2008
10/1/2008
1/1/2009
4/1/2009
7/1/2009
10/1/2009
1/1/2010
4/1/2010
7/1/2010
10/1/2010
1/1/2011
4/1/2011
7/1/2011
10/1/2011
1/1/2012
4/1/2012
7/1/2012
10/1/2012
1/1/2013

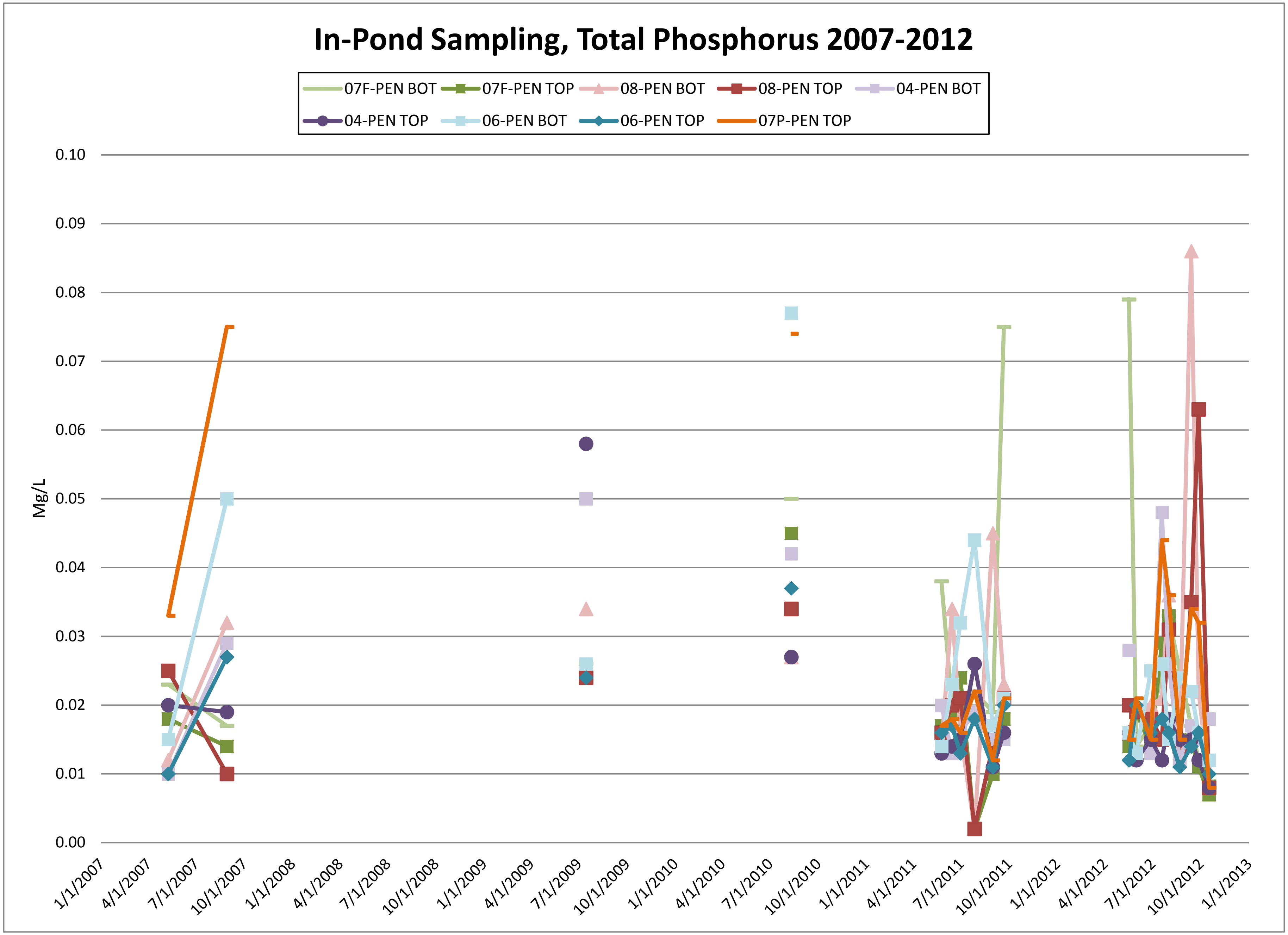


In-Pond Sampling, Total Suspended Solids (TSS) 2007-2012
07F-PEN BOT
07F-PEN TOP
08-PEN BOT
08-PEN TOP
04-PEN BOT
04-PEN TOP
06-PEN BOT
06-PEN TOP
07P-PEN TOP
Mg/L
0
5
10
15
20
25
30
1/1/2007
4/1/2007
7/1/2007
10/1/2007
1/1/2008
4/1/2008
7/1/2008
10/1/2008
1/1/2009
4/1/2009
7/1/2009
10/1/2009
1/1/2010
4/1/2010
7/1/2010
10/1/2010
1/1/2011
4/1/2011
7/1/2011
10/1/2011
1/1/2012
4/1/2012
7/1/2012
10/1/2012
1/1/2013

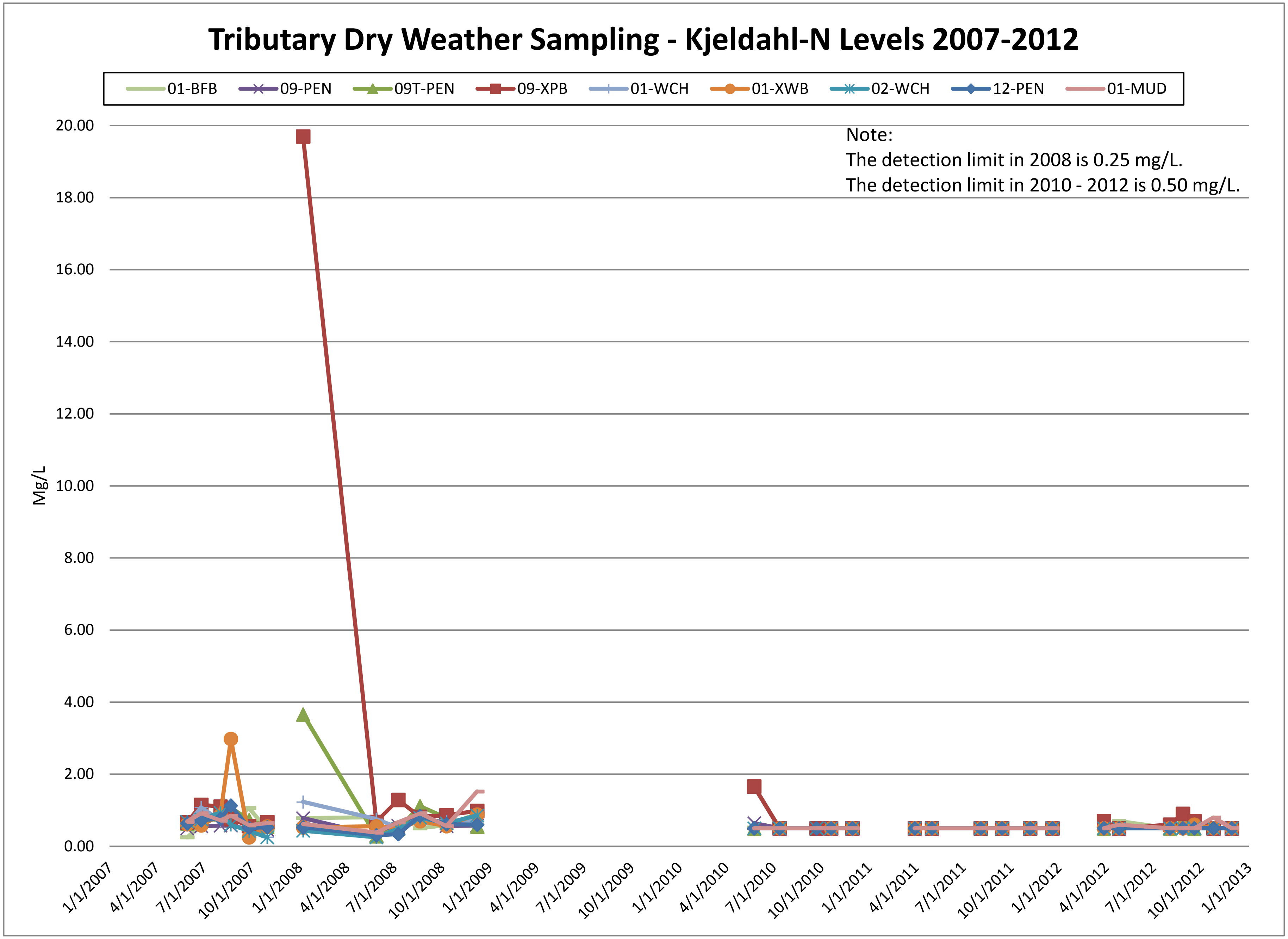

Tributary Dry Weather Sampling - Phosphorus Levels 2007-2012
01-BFB
09-PEN
09T-PEN
09-XPB
01-WCH
01-XWB
02-WCH
12-PEN
01-MUD
Note: The detection limit is 0.01 mg/L for all dates except 8/2/2012, where detection limit is 0.007 mg/L.
Mg/L
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
1/1/2007
4/1/2007
7/1/2007
10/1/2007
1/1/2008
4/1/2008
7/1/2008
10/1/2008
1/1/2009
4/1/2009
7/1/2009
10/1/2009
1/1/2010
4/1/2010
7/1/2010
10/1/2010
1/1/2011
4/1/2011
7/1/2011
10/1/2011
1/1/2012
4/1/2012
7/1/2012
10/1/2012
1/1/2013

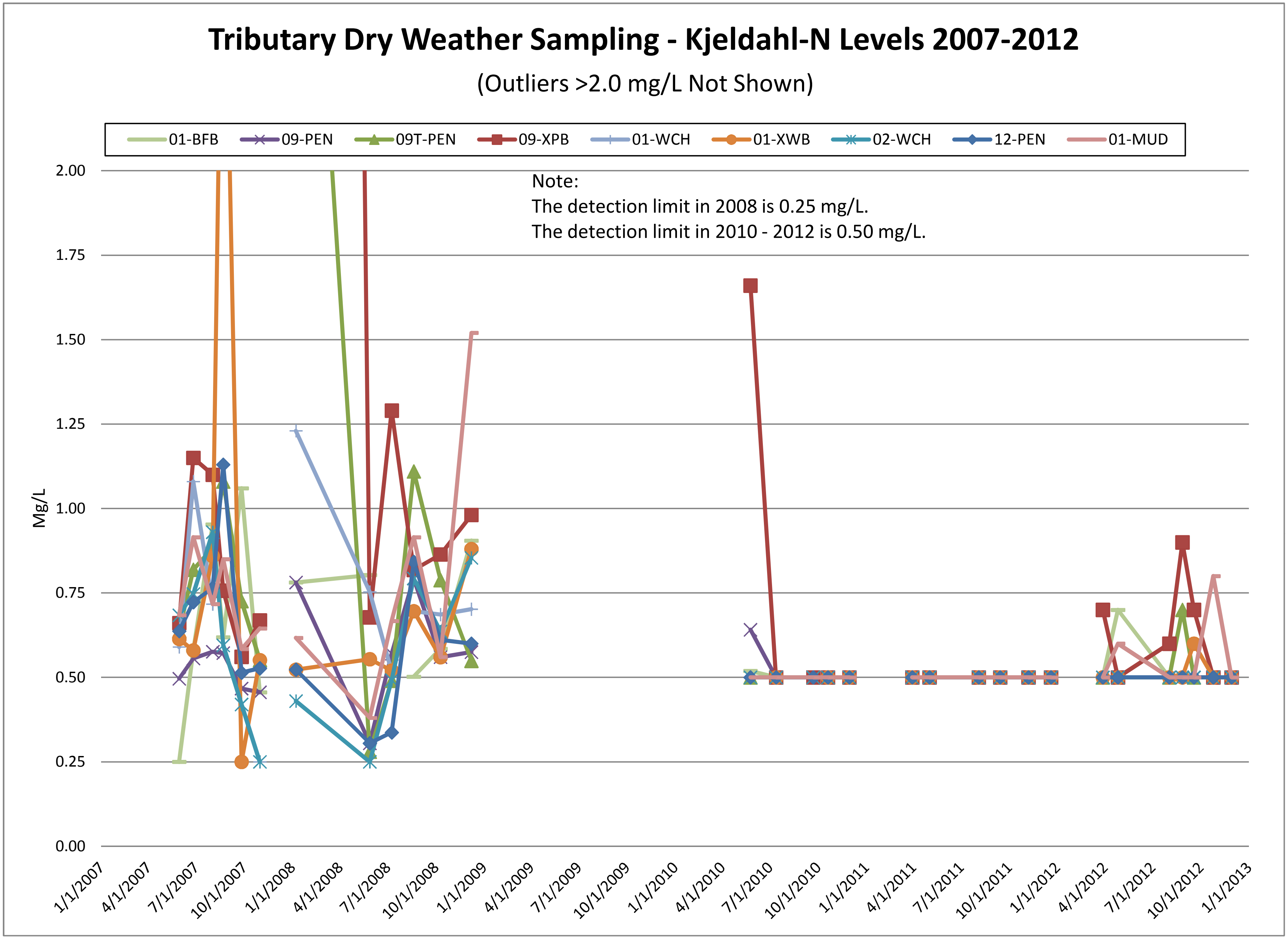


Tributary Dry Weather Sampling - Phosphorus Levels 2007-2012
(Outliers >0.25 mg/L Removed)
01-BFB
09-PEN
09T-PEN
09-XPB
01-WCH
01-XWB
02-WCH
12-PEN
01-MUD
Note: The detection limit is 0.01 mg/L for all dates except 8/2/2012, where detection limit is 0.007 mg/L.
Mg/L
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
1/1/2007
4/1/2007
7/1/2007
10/1/2007
1/1/2008
4/1/2008
7/1/2008
10/1/2008
1/1/2009
4/1/2009
7/1/2009
10/1/2009
1/1/2010
4/1/2010
7/1/2010
10/1/2010
1/1/2011
4/1/2011
7/1/2011
10/1/2011
1/1/2012
4/1/2012
7/1/2012
10/1/2012
1/1/2013

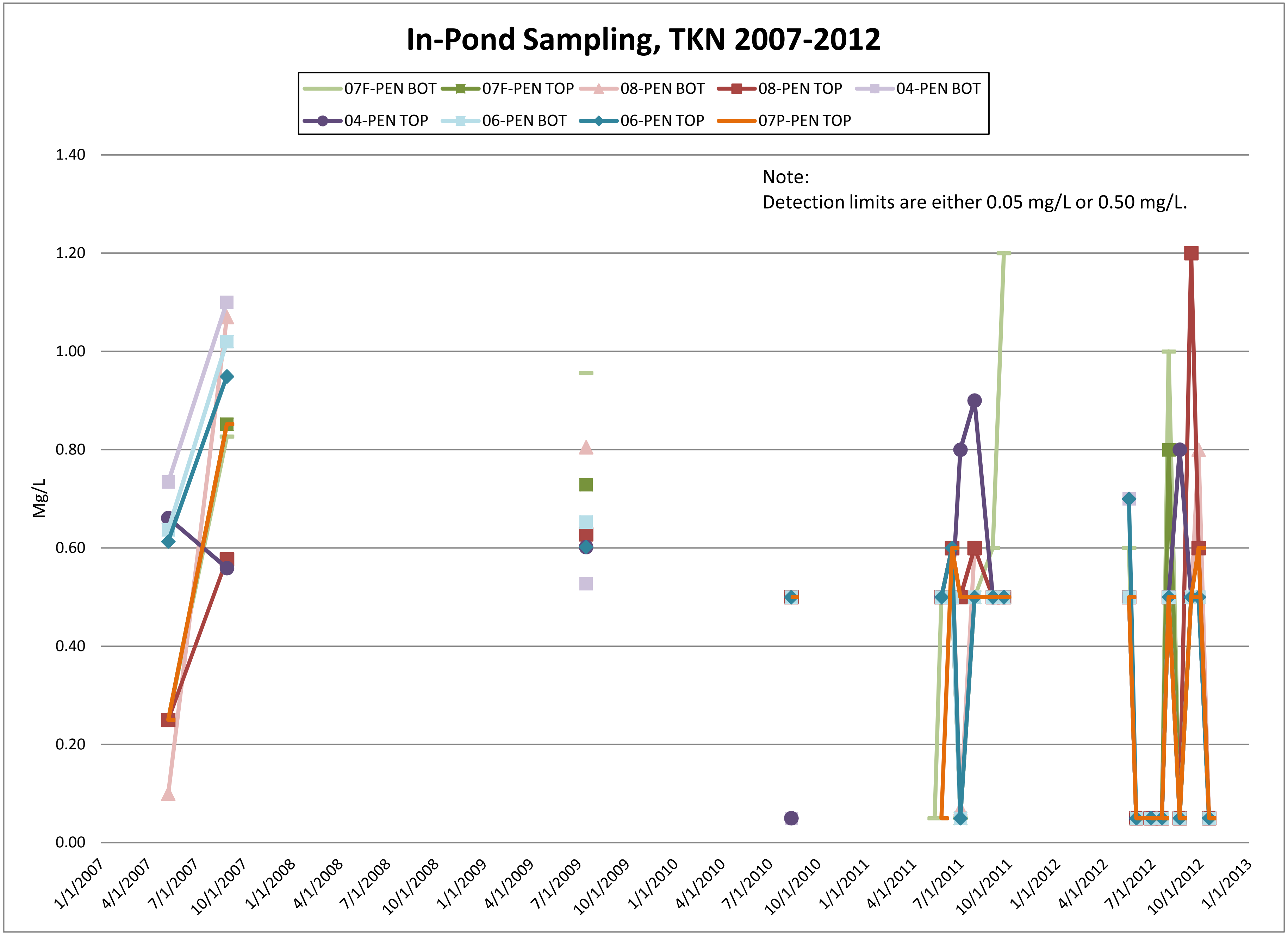


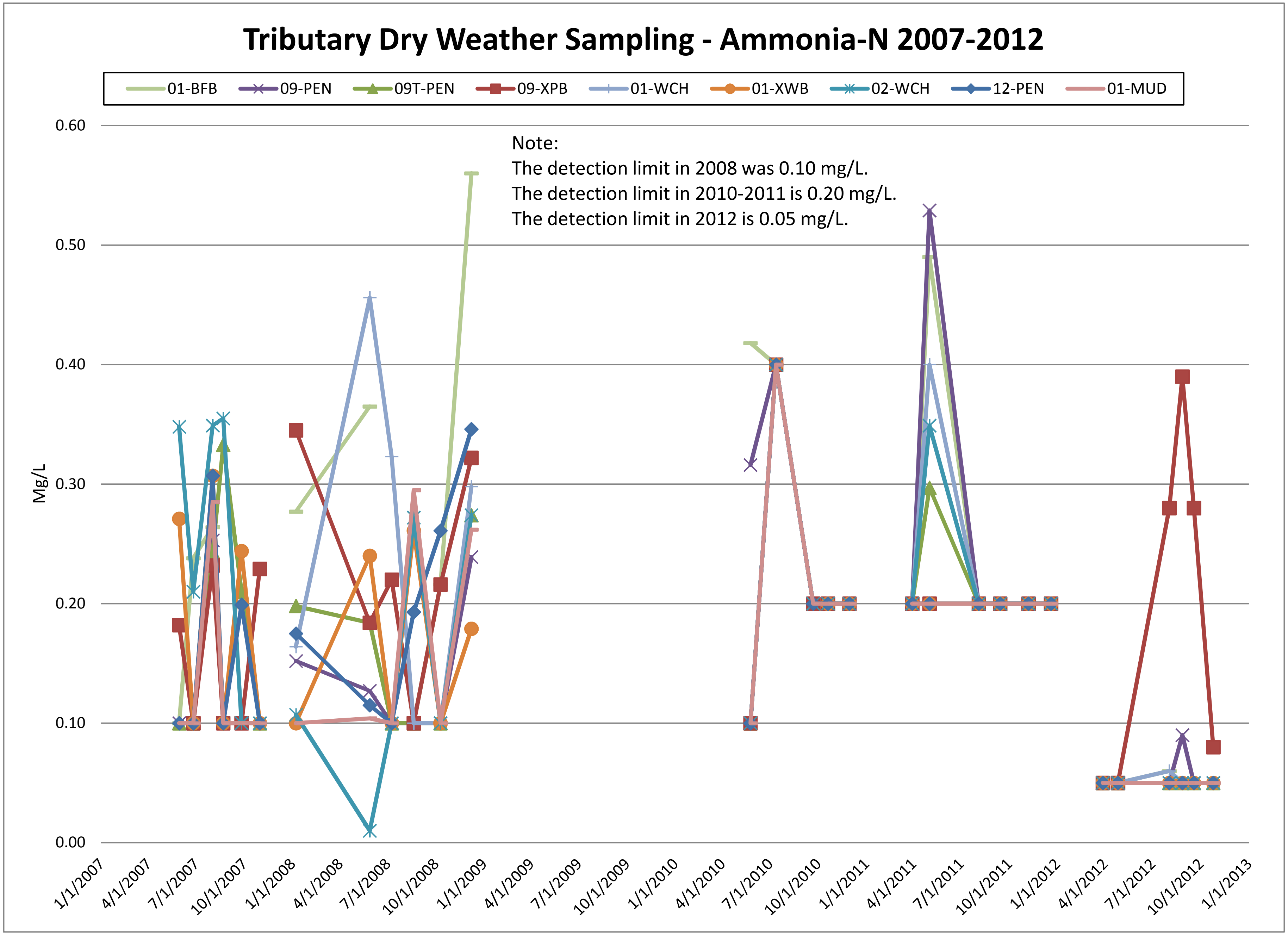
In-Pond Sampling, Total Phosphorus 2007-2012
07F-PEN BOT
07F-PEN TOP
08-PEN BOT
08-PEN TOP
04-PEN BOT
04-PEN TOP
06-PEN BOT
06-PEN TOP
07P-PEN TOP
Mg/L
0.10
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
1/1/2007
4/1/2007
7/1/2007
10/1/2007
1/1/2008
4/1/2008
7/1/2008
10/1/2008
1/1/2009
4/1/2009
7/1/2009
10/1/2009
1/1/2010
4/1/2010
7/1/2010
10/1/2010
1/1/2011
4/1/2011
7/1/2011
10/1/2011
1/1/2012
4/1/2012
7/1/2012
10/1/2012
1/1/2013


Tributary Dry Weather Sampling - Kjeldahl-N Levels 2007-2012
01-BFB
09-PEN
09T-PEN
09-XPB
01-WCH
01-XWB
02-WCH
12-PEN
01-MUD
Note:
The detection limit in 2008 is 0.25 mg/L.
The detection limit in 2010 - 2012 is 0.50 mg/L.
Mg/L
20.00
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
1/1/2007
4/1/2007
7/1/2007
10/1/2007
1/1/2008
4/1/2008
7/1/2008
10/1/2008
1/1/2009
4/1/2009
7/1/2009
10/1/2009
1/1/2010
4/1/2010
7/1/2010
10/1/2010
1/1/2011
4/1/2011
7/1/2011
10/1/2011
1/1/2012
4/1/2012
7/1/2012
10/1/2012
1/1/2013

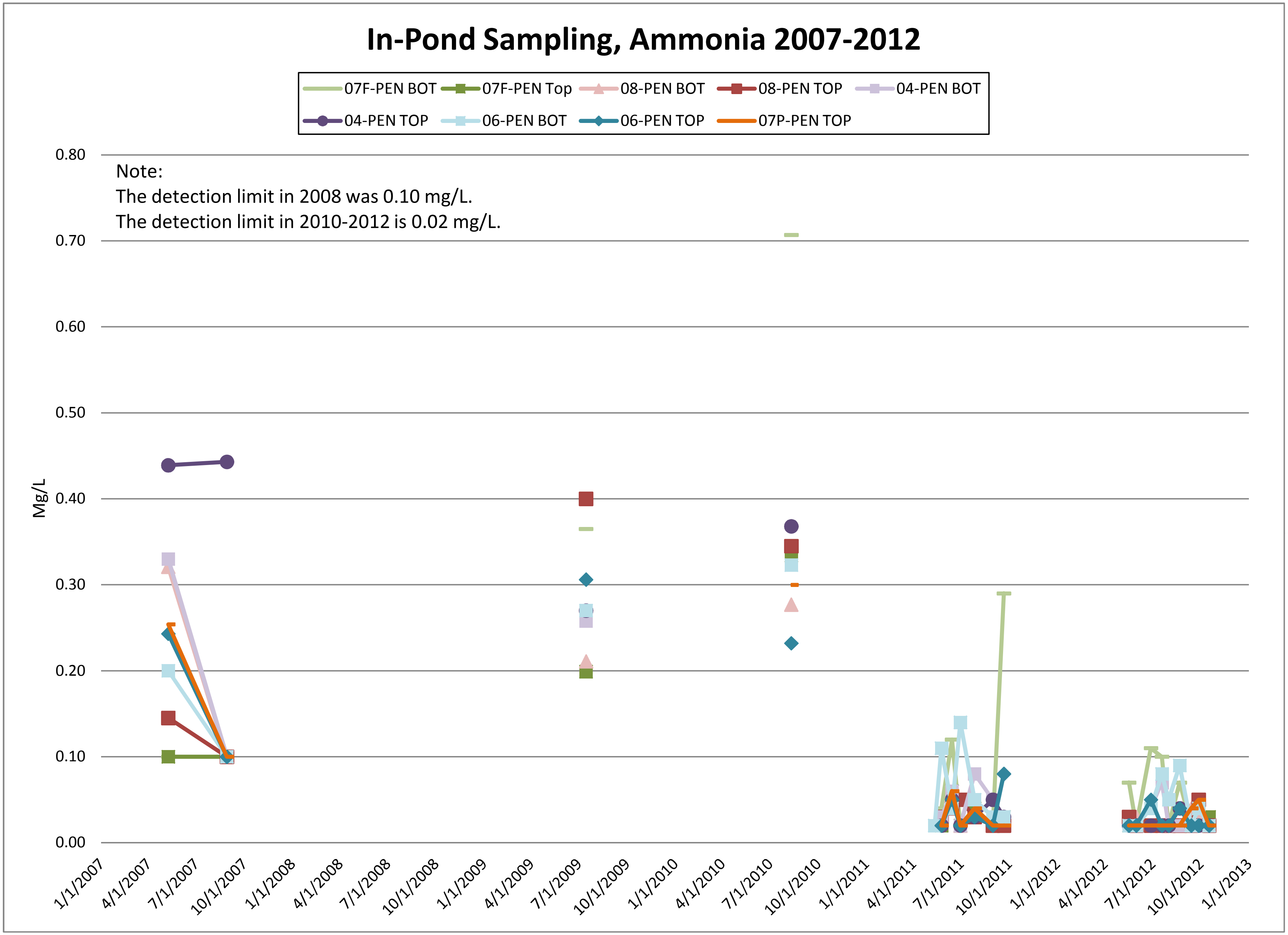


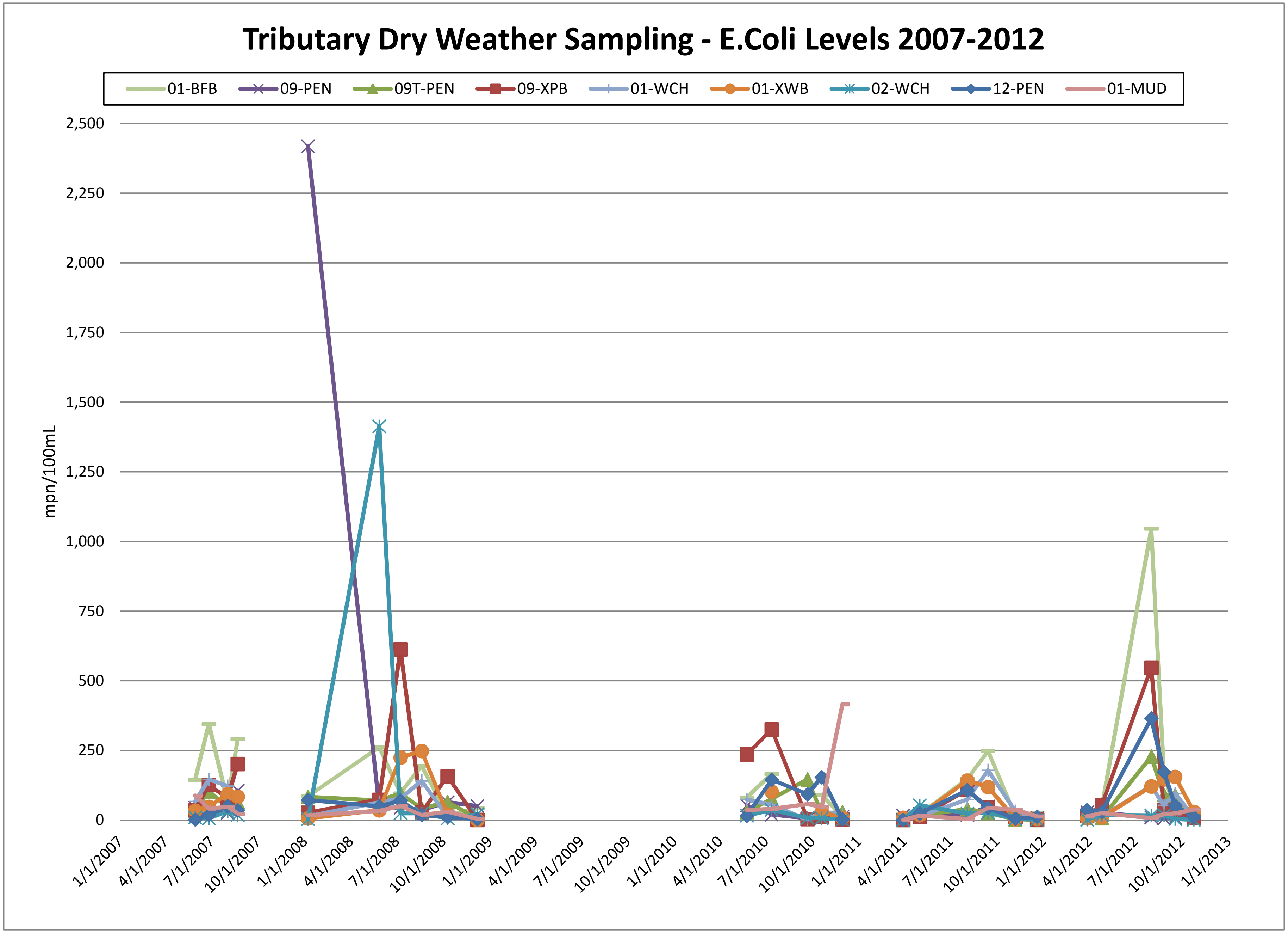
Tributary Dry Weather Sampling - Kjeldahl-N Levels 2007-2012
(Outliers >2.0 mg/L Not Shown)
01-BFB
09-PEN
09T-PEN
09-XPB
01-WCH
01-XWB
02-WCH
12-PEN
01-MUD
Note:
The detection limit in 2008 is 0.25 mg/L.
The detection limit in 2010 - 2012 is 0.50 mg/L.
Mg/L
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
1/1/2007
4/1/2007
7/1/2007
10/1/2007
1/1/2008
4/1/2008
7/1/2008
10/1/2008
1/1/2009
4/1/2009
7/1/2009
10/1/2009
1/1/2010
4/1/2010
7/1/2010
10/1/2010
1/1/2011
4/1/2011
7/1/2011
10/1/2011
1/1/2012
4/1/2012
7/1/2012
10/1/2012
1/1/2013

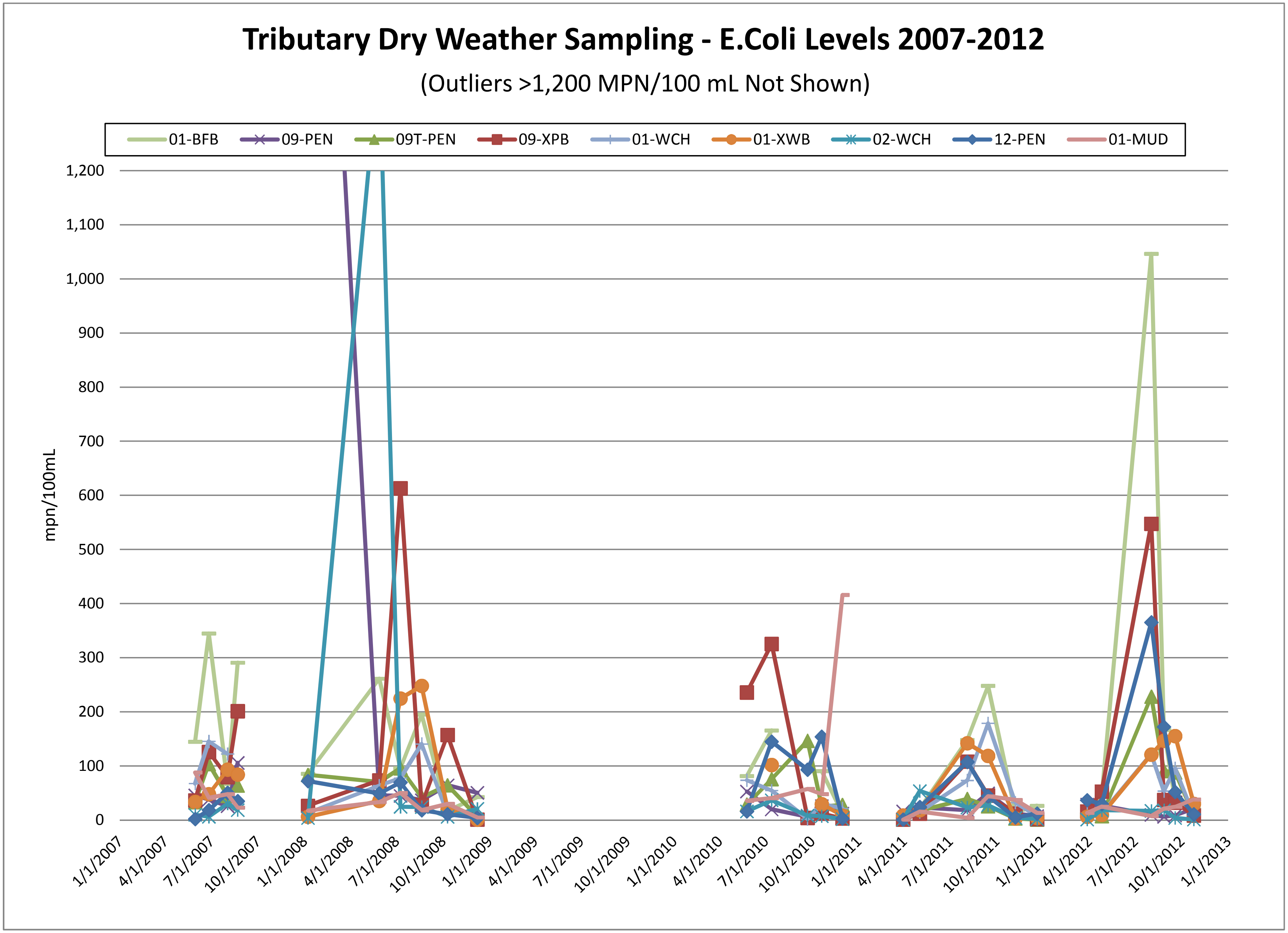

In-Pond Sampling, TKN 2007-2012
07F-PEN BOT
07F-PEN TOP
08-PEN BOT
08-PEN TOP
04-PEN BOT
04-PEN TOP
06-PEN BOT
06-PEN TOP
07P-PEN TOP
Note:
Detection limits are either 0.05 mg/L or 0.50 mg/L.
Mg/L
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
1/1/2007
4/1/2007
7/1/2007
10/1/2007
1/1/2008
4/1/2008
7/1/2008
10/1/2008
1/1/2009
4/1/2009
7/1/2009
10/1/2009
1/1/2010
4/1/2010
7/1/2010
10/1/2010
1/1/2011
4/1/2011
7/1/2011
10/1/2011
1/1/2012
4/1/2012
7/1/2012
10/1/2012
1/1/2013

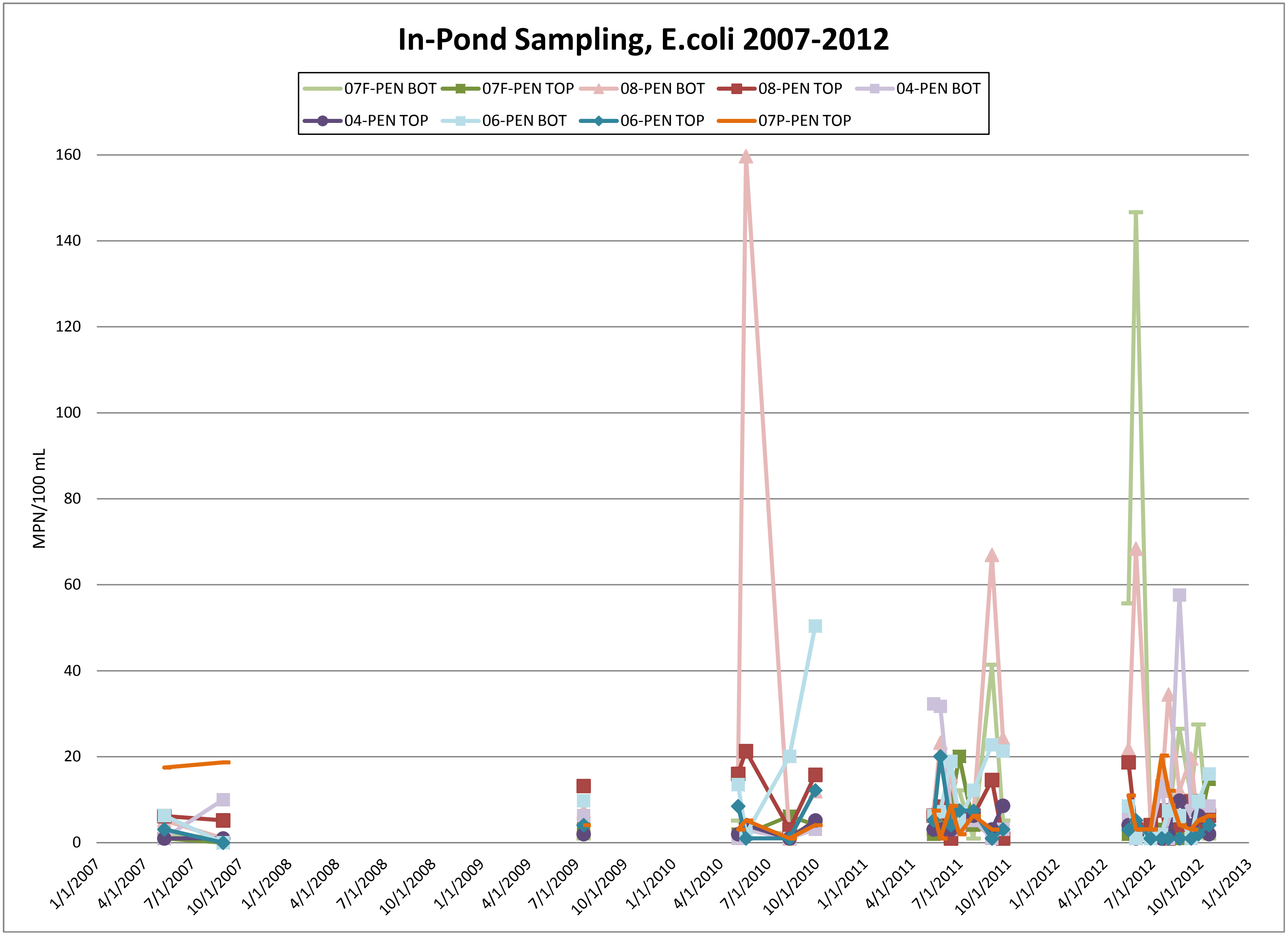


Tributary Dry Weather Sampling - Ammonia-N 2007-2012
01-BFB
09-PEN
09T-PEN
09-XPB
01-WCH
01-XWB
02-WCH
12-PEN
01-MUD
Note:
The detection limit in 2008 was 0.10 mg/L.
The detection limit in 2010-2011 is 0.20 mg/L.
The detection limit in 2012 is 0.05 mg/L.
Mg/L
0.60
0.50
0.40
0.30
0.20
0.10
0.00
1/1/2007
4/1/2007
7/1/2007
10/1/2007
1/1/2008
4/1/2008
7/1/2008
10/1/2008
1/1/2009
4/1/2009
7/1/2009
10/1/2009
1/1/2010
4/1/2010
7/1/2010
10/1/2010
1/1/2011
4/1/2011
7/1/2011
10/1/2011
1/1/2012
4/1/2012
7/1/2012
10/1/2012
1/1/2013

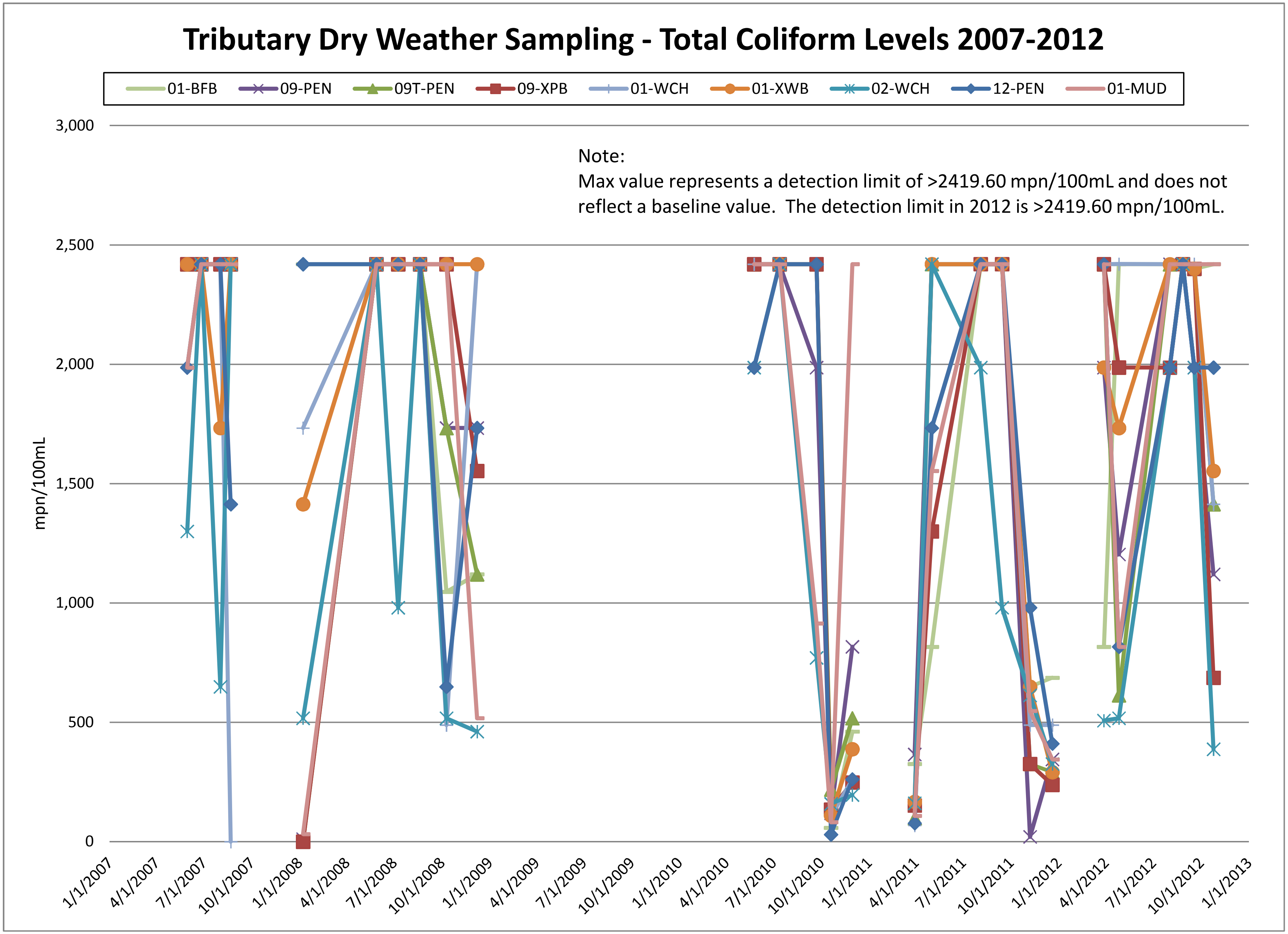

In-Pond Sampling, Ammonia 2007-2012
07F-PEN BOT
07F-PEN Top
08-PEN BOT
08-PEN TOP
04-PEN BOT
04-PEN TOP
06-PEN BOT
06-PEN TOP
07P-PEN TOP
Note:
The detection limit in 2008 was 0.10 mg/L.
The detection limit in 2010-2012 is 0.02 mg/L.
Mg/L
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
1/1/2007
4/1/2007
7/1/2007
10/1/2007
1/1/2008
4/1/2008
7/1/2008
10/1/2008
1/1/2009
4/1/2009
7/1/2009
10/1/2009
1/1/2010
4/1/2010
7/1/2010
10/1/2010
1/1/2011
4/1/2011
7/1/2011
10/1/2011
1/1/2012
4/1/2012
7/1/2012
10/1/2012
1/1/2013


Tributary Dry Weather Sampling - E.Coli Levels 2007-2012
01-BFB
09-PEN
09T-PEN
09-XPB
01-WCH
01-XWB
02-WCH
12-PEN
01-MUD
mpn/100mL
2,500
2,250
2,000
1,750
1,500
1,250
1,000
750
500
250
0
1/1/2007
4/1/2007
7/1/2007
10/1/2007
1/1/2008
4/1/2008
7/1/2008
10/1/2008
1/1/2009
4/1/2009
7/1/2009
10/1/2009
1/1/2010
4/1/2010
7/1/2010
10/1/2010
1/1/2011
4/1/2011
7/1/2011
10/1/2011
1/1/2012
4/1/2012
7/1/2012
10/1/2012
1/1/2013

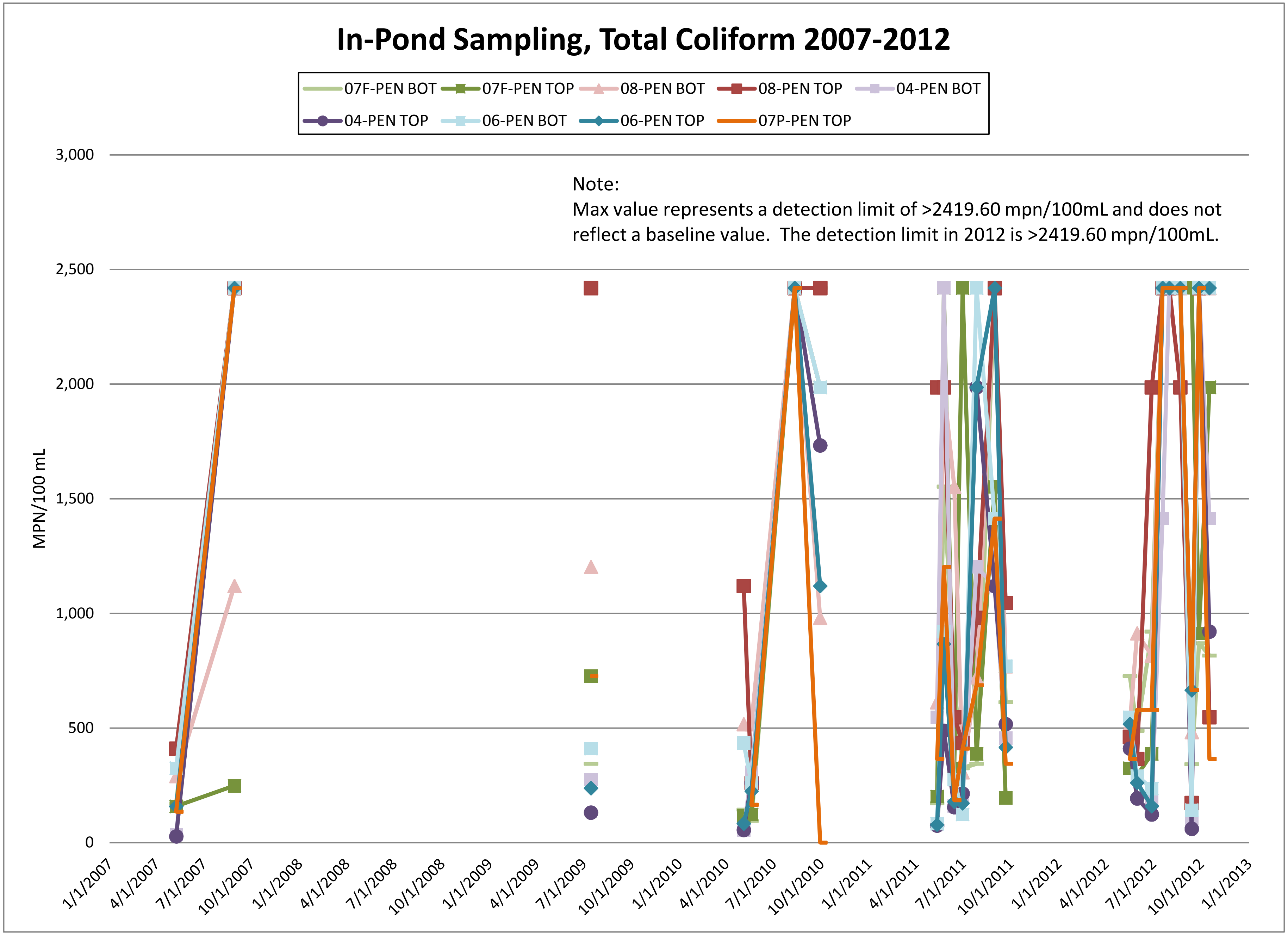

Tributary Dry Weather Sampling - E.Coli Levels 2007-2012
(Outliers >1,200 MPN/100 mL Not Shown)
01-BFB
09-PEN
09T-PEN
09-XPB
01-WCH
01-XWB
02-WCH
12-PEN
01-MUD
mpn/100mL
1,200
1,100
1,000
900
800
700
600
500
400
300
200
100
0
1/1/2007
4/1/2007
7/1/2007
10/1/2007
1/1/2008
4/1/2008
7/1/2008
10/1/2008
1/1/2009
4/1/2009
7/1/2009
10/1/2009
1/1/2010
4/1/2010
7/1/2010
10/1/2010
1/1/2011
4/1/2011
7/1/2011
10/1/2011
1/1/2012
4/1/2012
7/1/2012
10/1/2012
1/1/2013



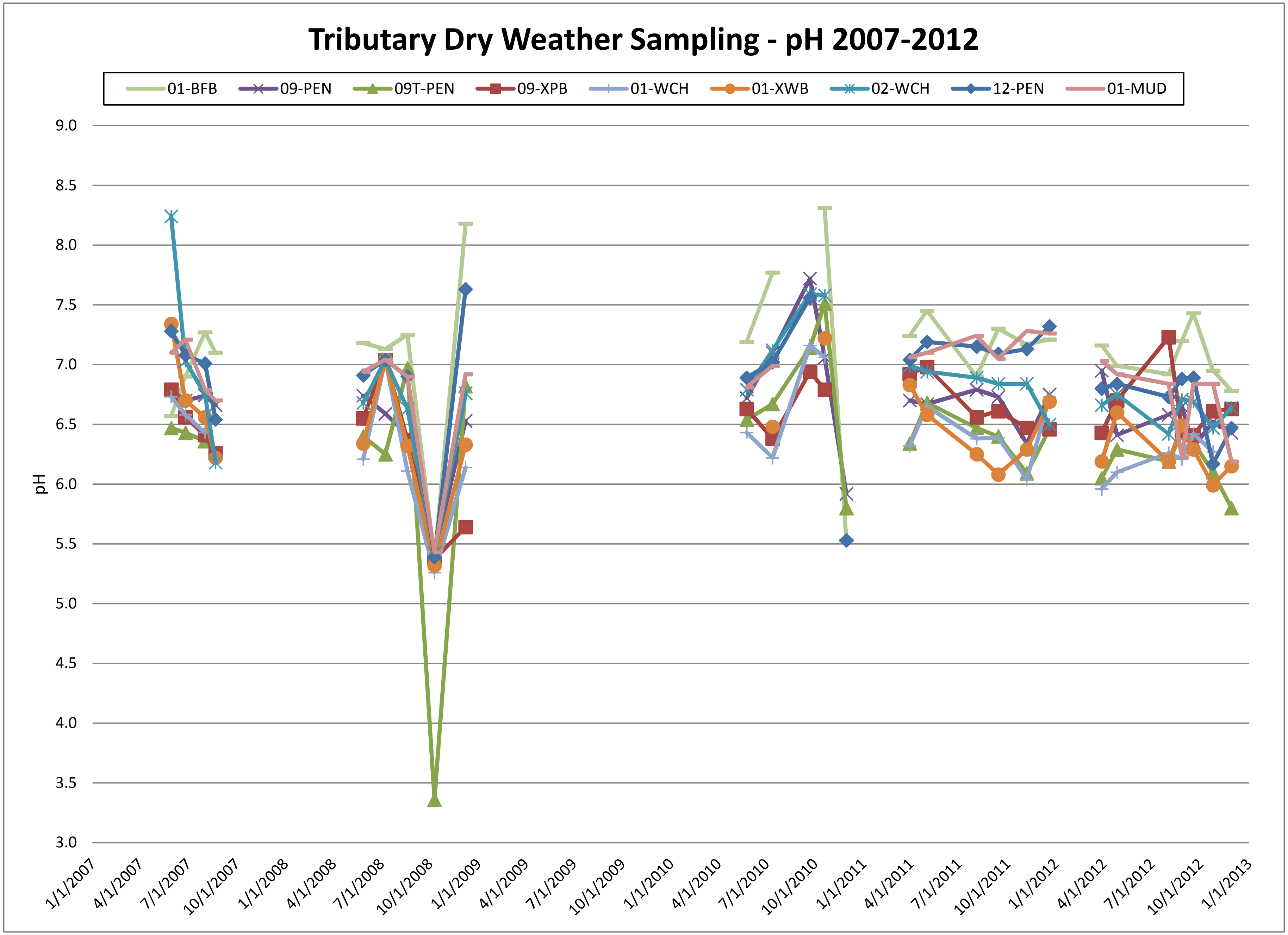
In-Pond Sampling, E.coli 2007-2012
07F-PEN BOT
07F-PEN TOP
08-PEN BOT
08-PEN TOP
04-PEN BOT
04-PEN TOP
06-PEN BOT
06-PEN TOP
07P-PEN TOP
MPN/100 mL
0
20
40
60
80
100
120
140
160
1/1/2007
4/1/2007
7/1/2007
10/1/2007
1/1/2008
4/1/2008
7/1/2008
10/1/2008
1/1/2009
4/1/2009
7/1/2009
10/1/2009
1/1/2010
4/1/2010
7/1/2010
10/1/2010
1/1/2011
4/1/2011
7/1/2011
10/1/2011
1/1/2012
4/1/2012
7/1/2012
10/1/2012
1/1/2013



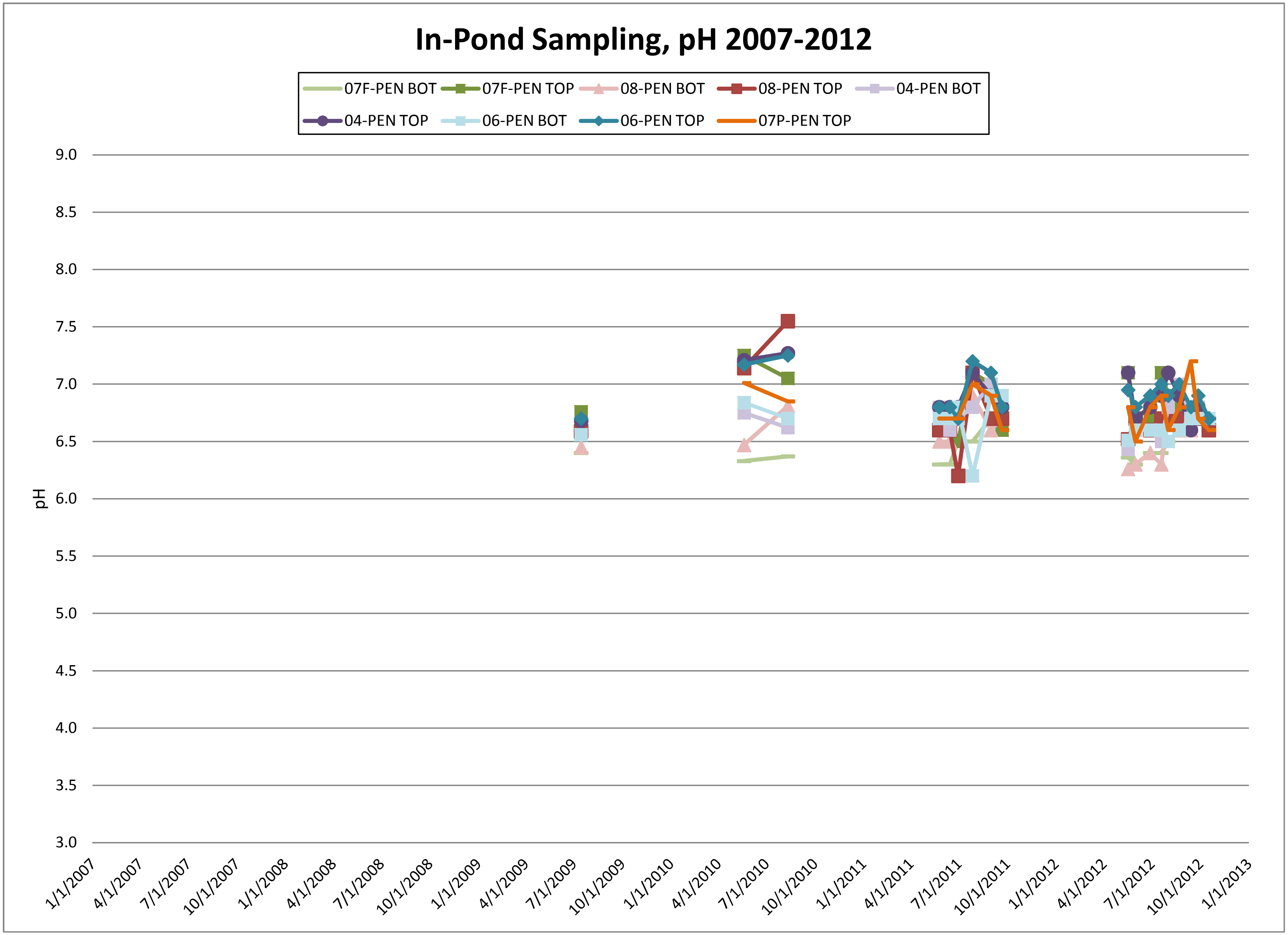
Tributary Dry Weather Sampling - Total Coliform Levels 2007-2012
01-BFB
09-PEN
09T-PEN
09-XPB
01-WCH
01-XWB
02-WCH
12-PEN
01-MUD
3,000
2,500
2,000
1,500
1,000
500
0
mpn/100mL
Note:
Max value represents a detection limit of >2419.60 mpn/100mL and does not reflect a baseline value. The detection limit in 2012 is >2419.60 mpn/100mL.
1/1/2007
4/1/2007
7/1/2007
10/1/2007
1/1/2008
4/1/2008
7/1/2008
10/1/2008
1/1/2009
4/1/2009
7/1/2009
10/1/2009
1/1/2010
4/1/2010
7/1/2010
10/1/2010
1/1/2011
4/1/2011
7/1/2011
10/1/2011
1/1/2012
4/1/2012
7/1/2012
10/1/2012
1/1/2013



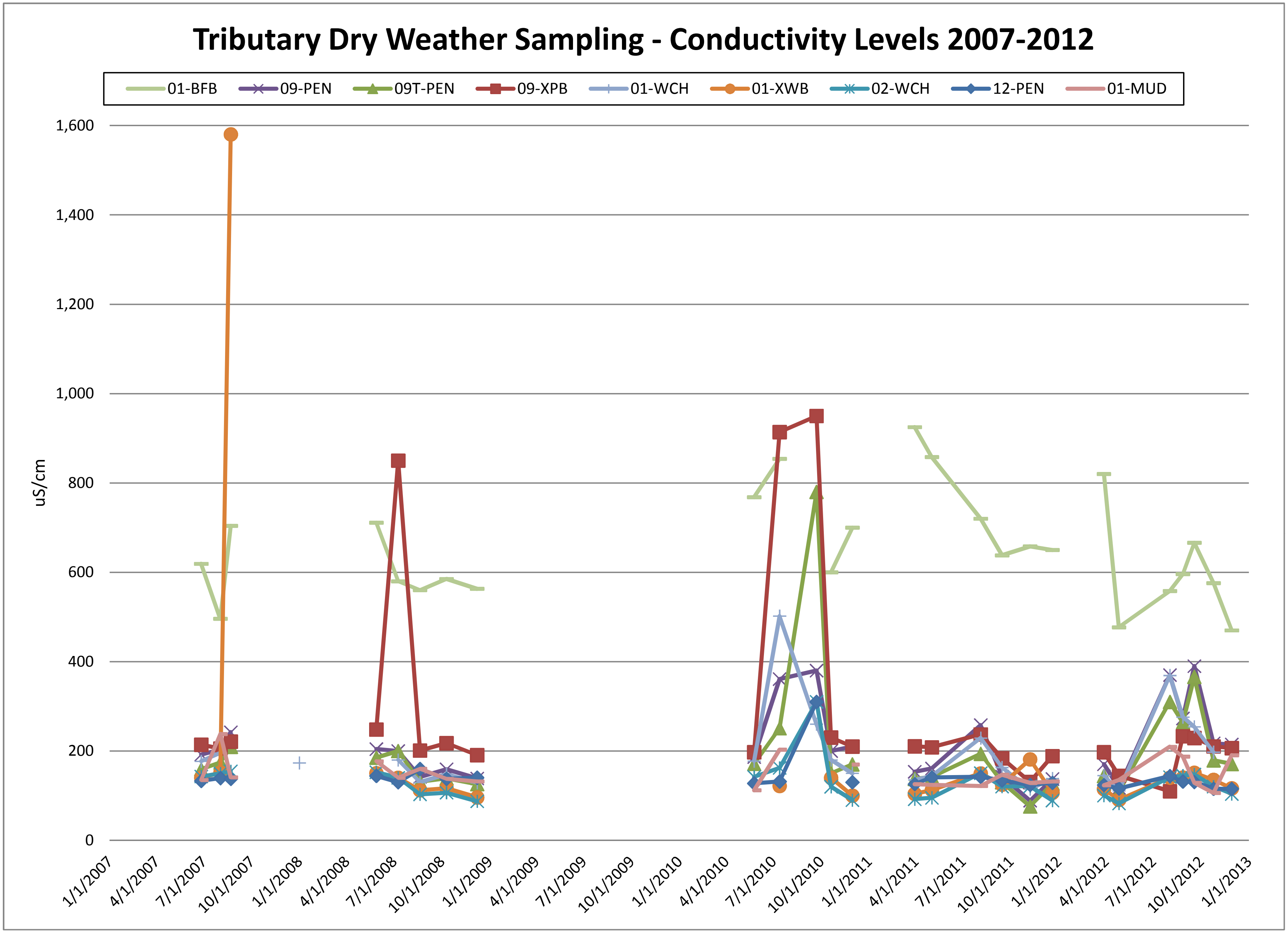
In-Pond Sampling, Total Coliform 2007-2012
07F-PEN BOT
07F-PEN TOP
08-PEN BOT
08-PEN TOP
04-PEN BOT
04-PEN TOP
06-PEN BOT
06-PEN TOP
07P-PEN TOP
Note:
Max value represents a detection limit of >2419.60 mpn/100mL and does not reflect a baseline value. The detection limit in 2012 is >2419.60 mpn/100mL.
MPN/100 mL
3,000
2,500
2,000
1,500
1,000
500
0
1/1/2007
4/1/2007
7/1/2007
10/1/2007
1/1/2008
4/1/2008
7/1/2008
10/1/2008
1/1/2009
4/1/2009
7/1/2009
10/1/2009
1/1/2010
4/1/2010
7/1/2010
10/1/2010
1/1/2011
4/1/2011
7/1/2011
10/1/2011
1/1/2012
4/1/2012
7/1/2012
10/1/2012
1/1/2013



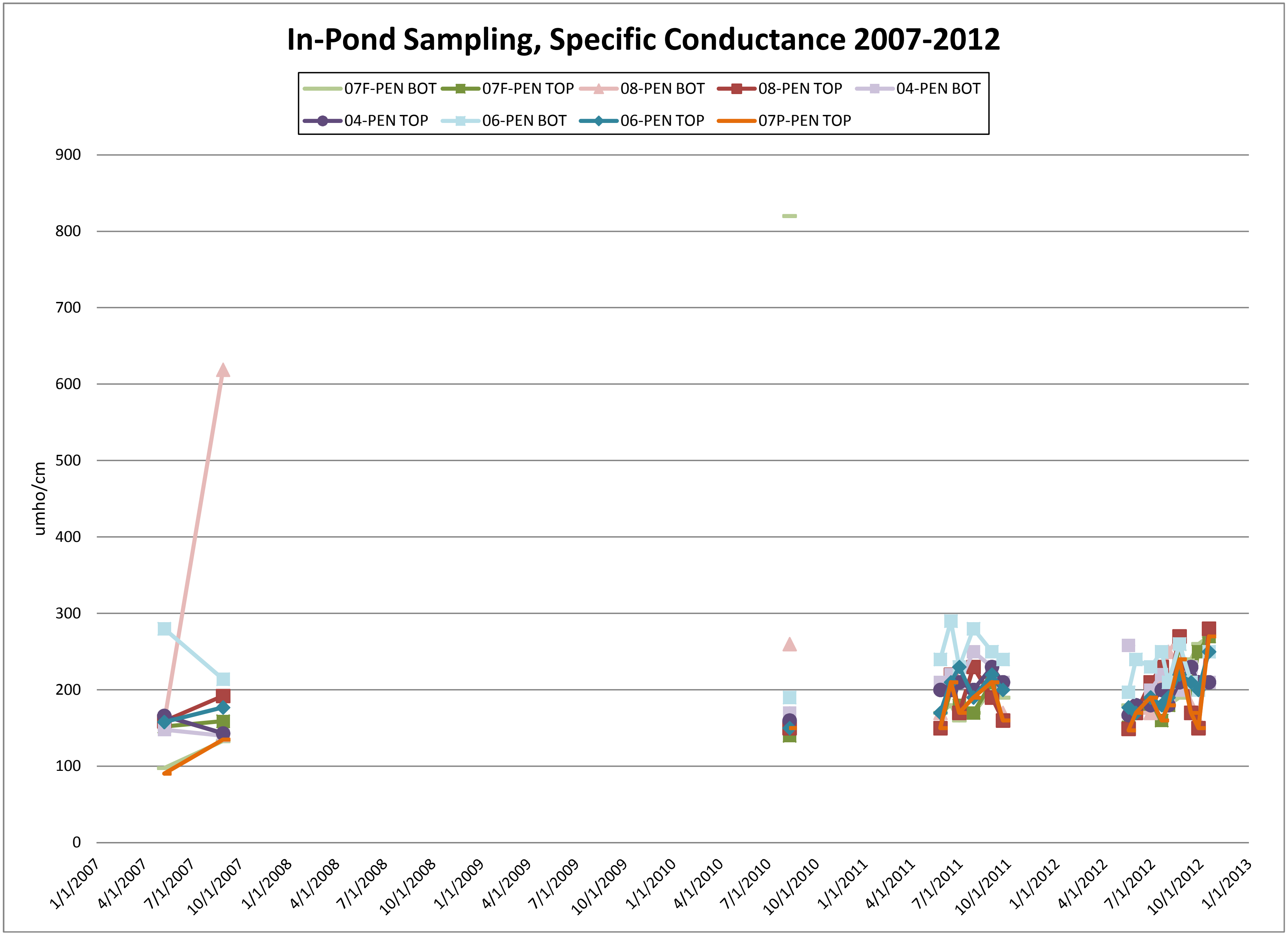
Tributary Dry Weather Sampling - pH 2007-2012
01-BFB
09-PEN
09T-PEN
09-XPB
01-WCH
01-XWB
02-WCH
12-PEN
01-MUD
pH
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
1/1/2007
4/1/2007
7/1/2007
10/1/2007
1/1/2008
4/1/2008
7/1/2008
10/1/2008
1/1/2009
4/1/2009
7/1/2009
10/1/2009
1/1/2010
4/1/2010
7/1/2010
10/1/2010
1/1/2011
4/1/2011
7/1/2011
10/1/2011
1/1/2012
4/1/2012
7/1/2012
10/1/2012
1/1/2013



In-Pond Sampling, pH 2007-2012
07F-PEN BOT
07F-PEN TOP
08-PEN BOT
08-PEN TOP
04-PEN BOT
04-PEN TOP
06-PEN BOT
06-PEN TOP
07P-PEN TOP
pH
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
1/1/2007
4/1/2007
7/1/2007
10/1/2007
1/1/2008
4/1/2008
7/1/2008
10/1/2008
1/1/2009
4/1/2009
7/1/2009
10/1/2009
1/1/2010
4/1/2010
7/1/2010
10/1/2010
1/1/2011
4/1/2011
7/1/2011
10/1/2011
1/1/2012
4/1/2012
7/1/2012
10/1/2012
1/1/2013



Tributary Dry Weather Sampling - Conductivity Levels 2007-2012
01-BFB
09-PEN
09T-PEN
09-XPB
01-WCH
01-XWB
02-WCH
12-PEN
01-MUD
uS/cm
1,600
1,400
1,200
1,000
800
600
400
200
0
1/1/2007
4/1/2007
7/1/2007
10/1/2007
1/1/2008
4/1/2008
7/1/2008
10/1/2008
1/1/2009
4/1/2009
7/1/2009
10/1/2009
1/1/2010
4/1/2010
7/1/2010
10/1/2010
1/1/2011
4/1/2011
7/1/2011
10/1/2011
1/1/2012
4/1/2012
7/1/2012
10/1/2012
1/1/2013


In-Pond Sampling, Specific Conductance 2007-2012
07F-PEN BOT
07F-PEN TOP
08-PEN BOT
08-PEN TOP
04-PEN BOT
04-PEN TOP
06-PEN BOT
06-PEN TOP
07P-PEN TOP
umho/cm
900
800
700
600
500
400
300
200
100
0
1/1/2007
4/1/2007
7/1/2007
10/1/2007
1/1/2008
4/1/2008
7/1/2008
10/1/2008
1/1/2009
4/1/2009
7/1/2009
10/1/2009
1/1/2010
4/1/2010
7/1/2010
10/1/2010
1/1/2011
4/1/2011
7/1/2011
10/1/2011
1/1/2012
4/1/2012
7/1/2012
10/1/2012
1/1/2013