PENNSYLVANIA
AMERICAN WATER

DBP Control in a Sludge Blanket Water Treatment Clarification Process Using Pretreatment Chloramination

Presented by:

Stan Szczepanek and Sandy Weiss

PENNSYLVANIA AMERICAN WATER

Our Company

- **Subsidiary of American Water Works Co. Inc.**
- **Roots date back to early 1800s, Incorporated in 1904**
- **Largest regulated water and wastewater service provider in PA**
- **Serving approximately 2.2 million people in 36 counties**
- **More than 1,000 employees**
- **Customer base:**
  - 638,000 water customers
    - 92% residential
    - 7% commercial
    - 1% industrial/other
  - 17,000 wastewater customers

PENNSYLVANIA AMERICAN WATER

Our Pennsylvania Infrastructure

Source of Supply

- 92% surface water
- 7% groundwater
- 1% purchased water

- 54 regulated dams
- 121 groundwater well sources

Treatment Facilities

- 36 surface water plants
  - 30 facilities received Directors Award from Partnership for Safe Water
- 6 wastewater plants
- Serving 17 percent of the Commonwealth's population

Storage & Transmission

- 279 water storage tanks
- 253 booster pumping stations

Distribution System

- 10,115 miles of water and sewer pipe

Water Capacity

- 202 MGD average daily delivery

Wastewater Capacity

- 11.2 MGD permitted

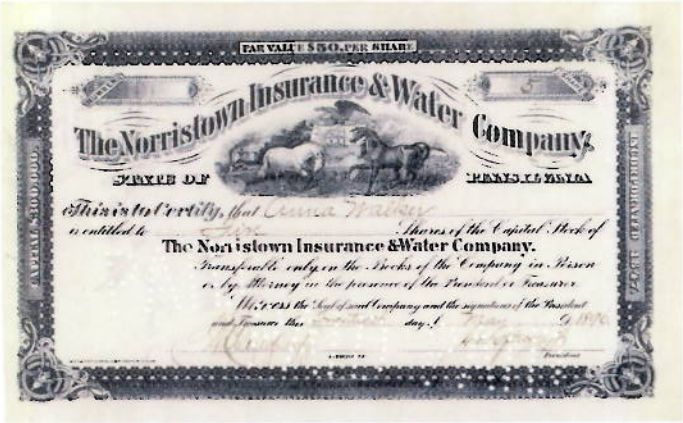
PENNSYLVANIA AMERICAN WATER

Norristown Water Treatment Plant - Overview

- Primary source of supply: Schuylkill River
- Plant's design capacity: 18 MGD
- Average daily delivery: 10.5 MGD
- Population served: 90,000-plus
- Booster stations: 8
- Storage tanks: 8 with 9.1 MG total storage
- Employees: 11 full time
- Directors Award: Received 10-year Partnership for Safe Drinking Directors Award in 2011

PENNSYLVANIA AMERICAN WATER

Historic Retrospect of the Norristown Treatment Plant



- Founded as The Norristown Insurance & Water Co. in 1847
- Initially water was unfiltered
- In 1875, the intake was relocated over a natural spring in the river to clear turbidity during rain events
- The first filters were installed in 1901
- Chlorination was started during the second decade of the 20th century
- American Water Works Co. bought The Norristown Water Co. in 1962
- Second plant built on the site in 1966

PENNSYLVANIA AMERICAN WATER

1996 Groundbreaking

- A new $50 million plant is phased in over 5 years retiring two older structures
- Plant upgrades included:
  - Super Pulsators replace conventional clarification/ sedimentation basins
  - Potassium Permanganate is added for Fe/Mn & T/O control
  - Plant becomes zero discharge
  - Sludge thickened and pressed on site

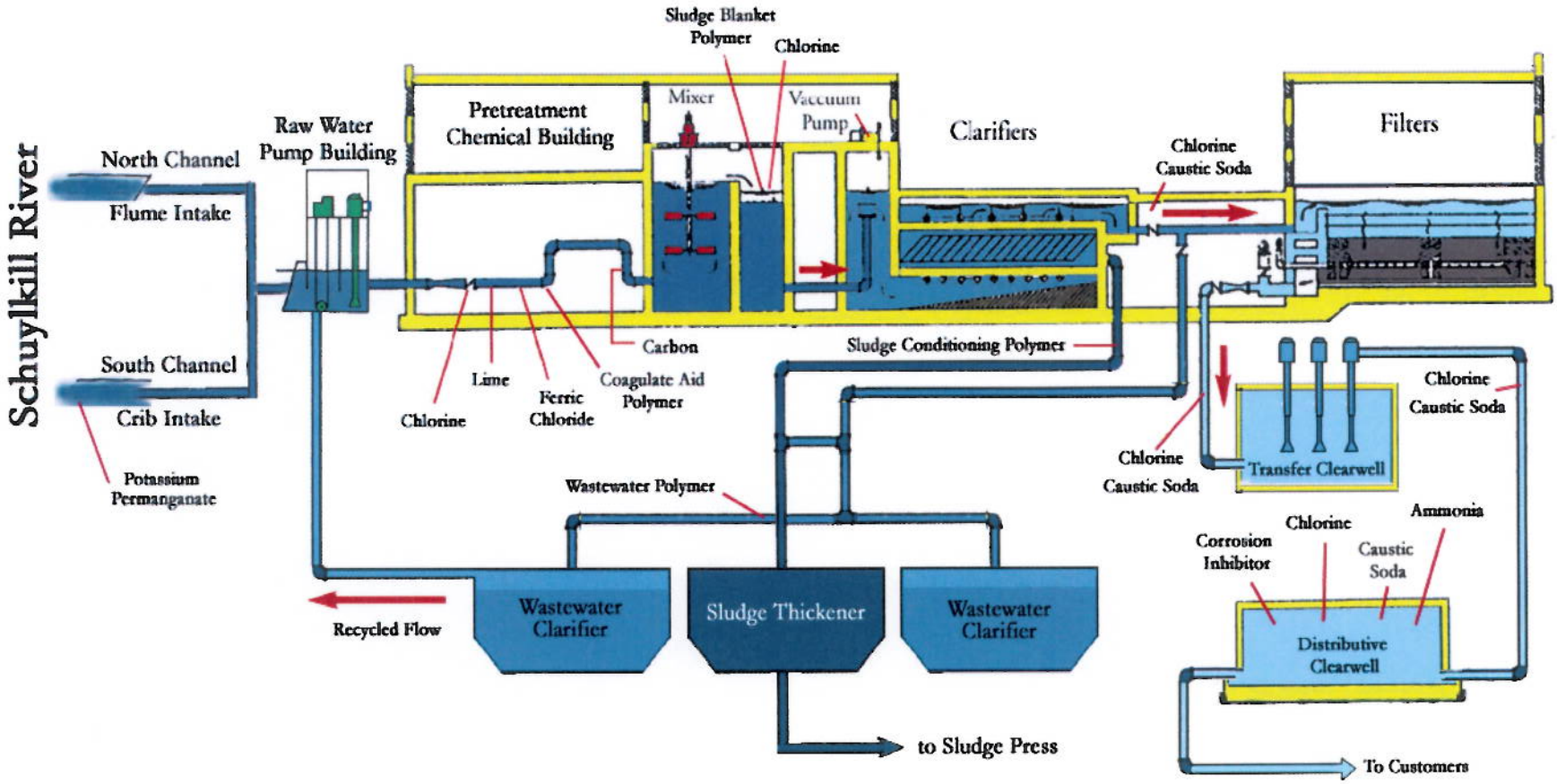
PENNSYLVANIA AMERICAN WATER

Norristown Water Treatment Plant – Treatment Process

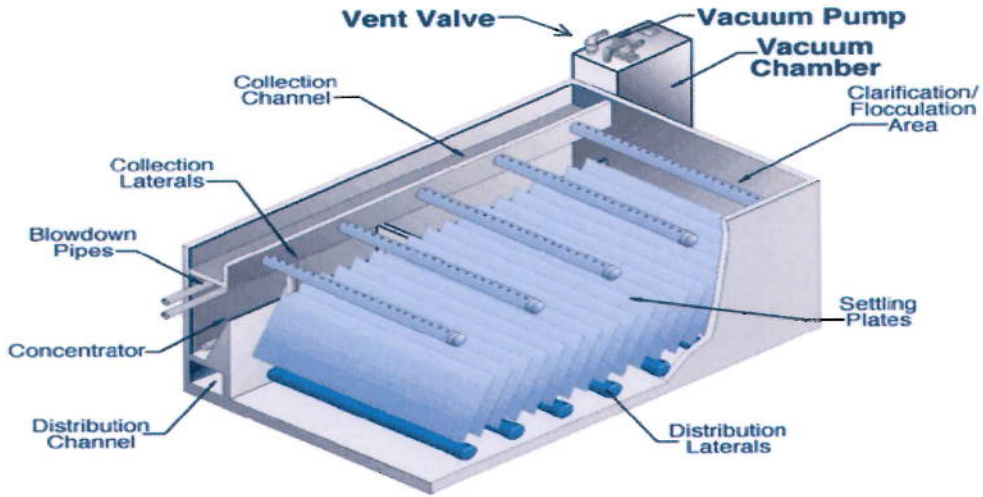
- **Clarification:**
  - Four Superpulsator® units for clarification
  - Ferric chloride is the primary coagulant
- **Filtration:**
  - Seven granular activated carbon filters
- **Disinfection:**
  - Gas chlorine applied prior to Superpulsators and after filtration
  - Chlorine contact time (CT) is met primarily in post filtration treatment
  - Gaseous ammonia is used to form monochloramine prior to distributing the water from the treatment plant
- **Aesthetics:**
  - Potassium permanganate is added for oxidation of iron and manganese

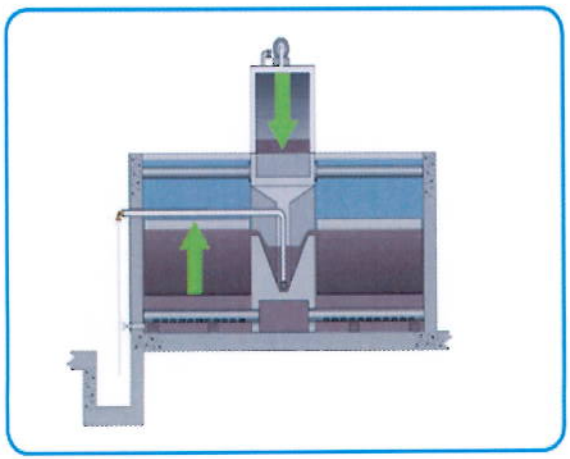
PENNSYLVANIA AMERICAN WATER

Norristown Water Treatment Plant Schematic

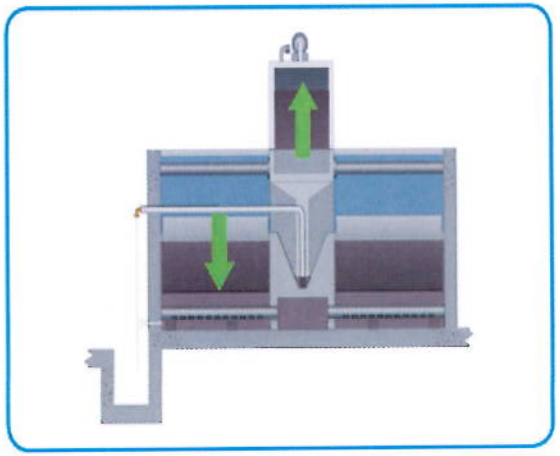


Superpulsator Schematic





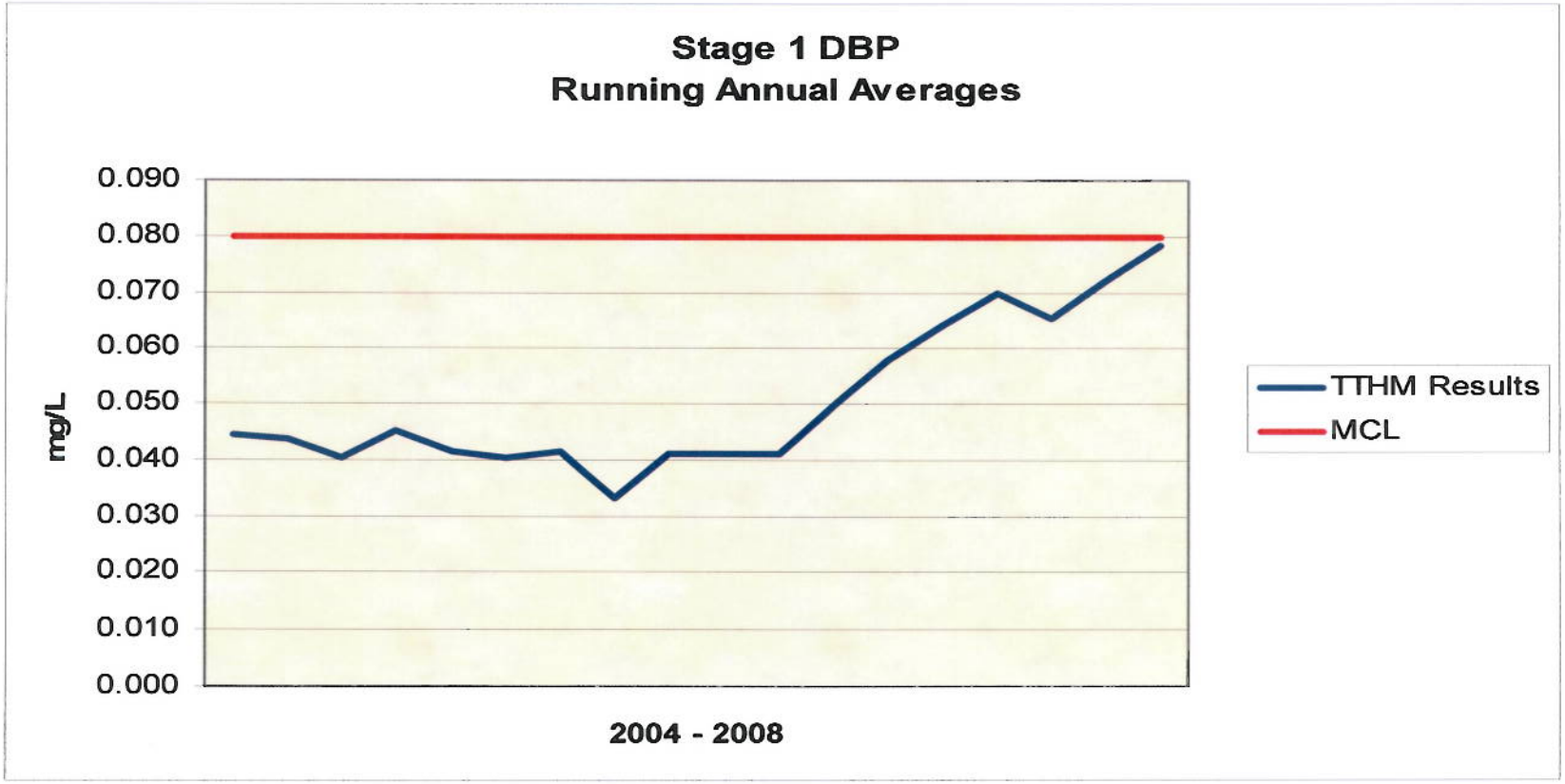
VACUUM
BLANKET EXPANSION



VACUUM
BLANKET CONTRACTION

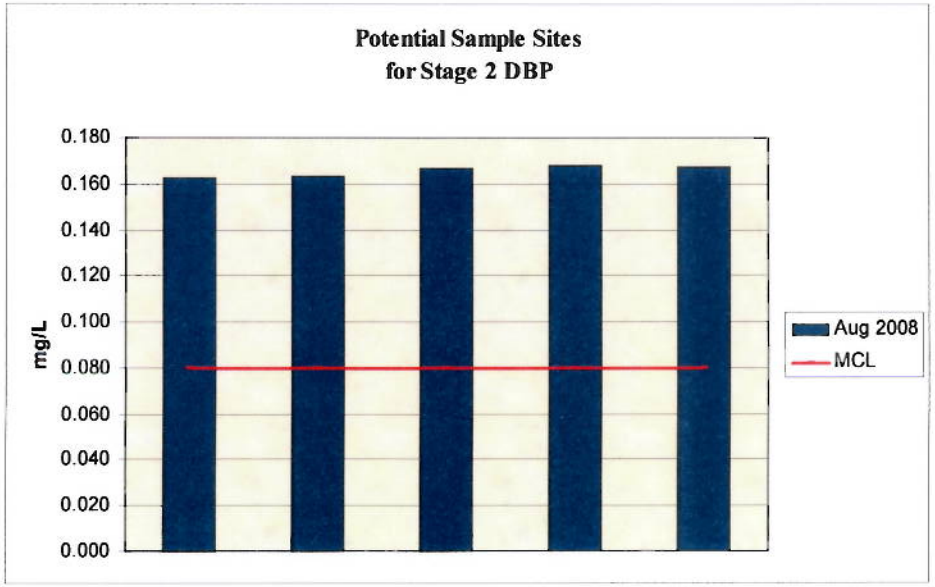
PENNSYLVANIA AMERICAN WATER

Treatment Challenge – Increasing TTHM Levels



Stage 2 DBP Rule

- **Established meeting compliance requirements at each sample location (LRAA)**
- **New high TTHM sites to be used for compliance determination**
- **For Norristown:**
  - Compliance sampling begins October 2012
  - Treatment changes were required to meet new regulations



PENNSYLVANIA AMERICAN WATER

Taking measures to lower TTHMs

- Conducted mini trials throughout 2009
- Found majority of TTHM formations were being created in the Superpulsators
- Moved pre-chlorine from feeding directly into the Superpulsators to post clarification
- In September of 2009, we conducted a small scale trial by applying chloramines to the inlet of one of the four Superpulsator clarifiers (SP #4)
  - Comparative TTHM samples were collected from Superpulsators # 3 and #4
  - Results showed a significant drop in TTHM formation in the Superpulsator #4 with the ammonia addition

PENNSYLVANIA AMERICAN WATER

Looking at the Data

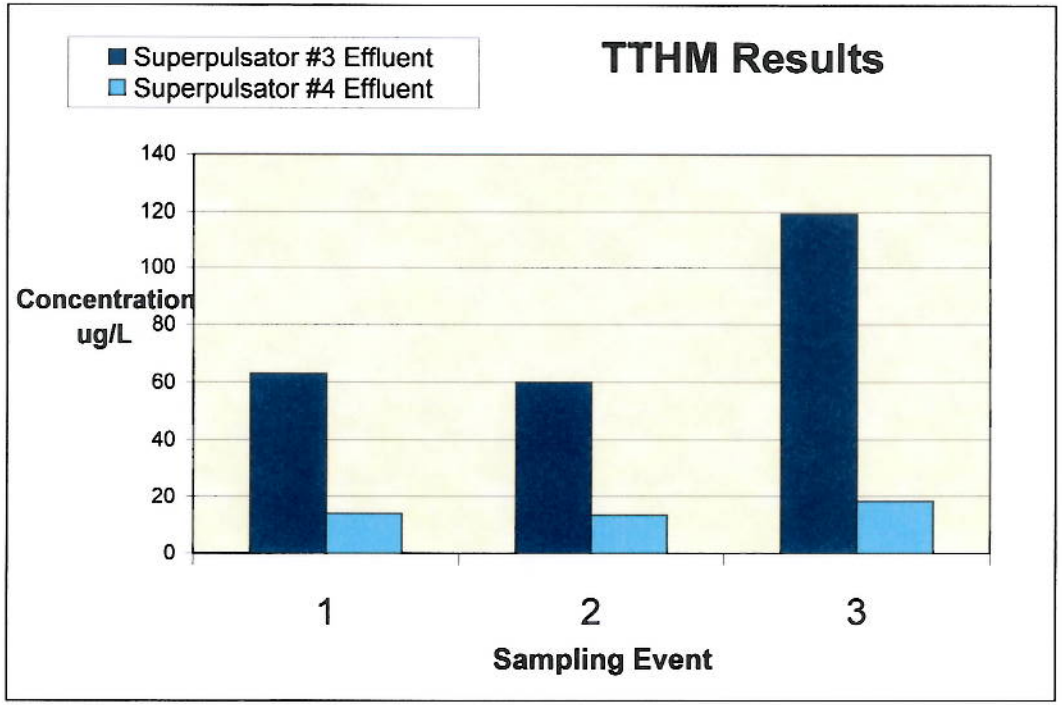
Process Changes					
Series #	Chlorine Feed at Top of Filters	Chlorine Feed prior to Superpulsators	Ferric Chloride Dose	Potassium Permanganate Dose	Powdered Activated Carbon Feed
1	X		25 mg/l	0.6 mg/l	0.0 mg/l
2	X		25 mg/l	0.6 mg/l	2.0 mg/l
3	X		35 mg/l	0.6 mg/l	2.0 mg/l
4		X	35 mg/l	0.6 mg/l	2.0 mg/l
5		X	25 mg/l	0.6 mg/l	2.0 mg/l
6		X	25 mg/l	0.6 mg/l	5.0 mg/l

TTHM Results (ug/L)				
Series #	Superpulsator Effluent	Filter Effluent	Transfer Clearwell	Plant Effluent
1	0.8	16.9	14.5	24.6
2	0.8	14.9	15.8	22.2
3	1.6	18.2	15.7	25.4
4	23.6	24.2	29.9	30.9
5	29.1	30.2	32.0	37.8
6	38.7	39.2	42.7	48.9

PENNSYLVANIA AMERICAN WATER

Graphical Depiction of Small Scale Trial

TTHM Results (ug/L)					
Sampling Event	Date	Superpulsator #3 Plant Control - Free Chlorine Applied	Superpulsator #4 Trial Unit- Chloramine Applied	Combined Filter Effluent	Plant Effluent
1	9/4/2009	63	13.8	67.1	95.6
2	9/8/2009	59.7	13.6	75.5	77
3	9/14/2009	119	18.1	94.6	102



PENNSYLVANIA AMERICAN WATER

Norristown Prechloramination Full Plant Trial 2010

- A full plant trial was conducted from July 13 through Oct. 13 2010 which added 30% Liquid Ammonium Sulfate (LAS) prior to the Superpulsators.
- The LAS product is AQUA AIDE-40TM which is NSF 60 Certified. AQUA AIDE is manufactured by GAC Chemical Corporation. The product is diluted to a 30% solution and distributed through Coyne Chemical Company.
- The time frame chosen to conduct a full plant trial was during the 3rd quarter where water temperatures are traditionally the warmest and TTHM formations are traditionally the highest.
- KMnO4 was used to oxidize soluble manganese and iron in lieu of free chlorine.

PENNSYLVANIA AMERICAN WATER

Sample Analysis Conducted

- Parameters monitored were iron and manganese levels, chlorine and ammonia ratios, total and free chlorine, monochloramines, total and free ammonia, and TTHM concentrations.
- HPC samples were analyzed on a weekly basis to monitor the Superpulsator blankets and individual filters to check for septic conditions.
- Filter effluent samples were analyzed for Nitrate to watch for possible plant process nitrification.
- All other plant processes remained the same including achieving break point chlorination prior to the 2.6 MG clearwell thus meeting all required contact times.

PENNSYLVANIA AMERICAN WATER

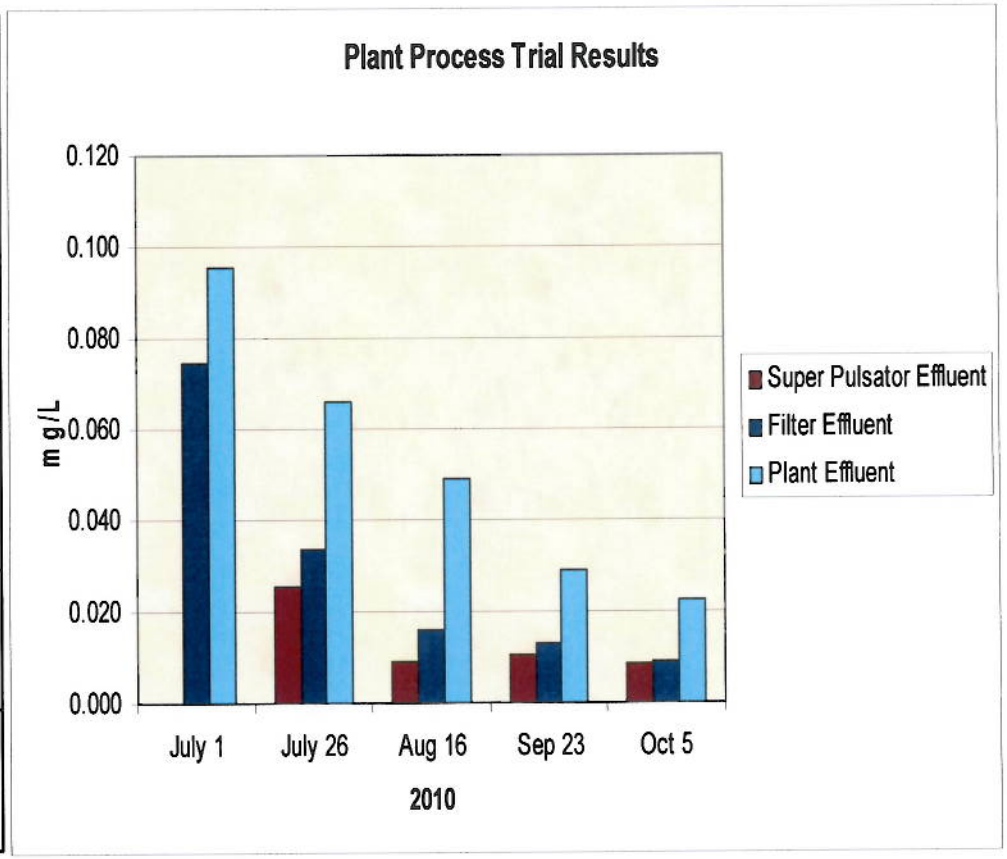
ChemScan Analyzer Demo

- In a joint cooperative, ASA Analytics provided a ChemScan Chloramination Online Analyzer with 2 sample lines for an on-site demonstration.
- 5-week trial
- Measured Free Ammonia, Total Ammonia, Monochloramine and Total Chlorine.
- Capable of testing two separate sample streams:
  - Superpulsator effluent
  - Plant effluent

PENNSYLVANIA AMERICAN WATER

2010 Full Plant Trial TTHM Results

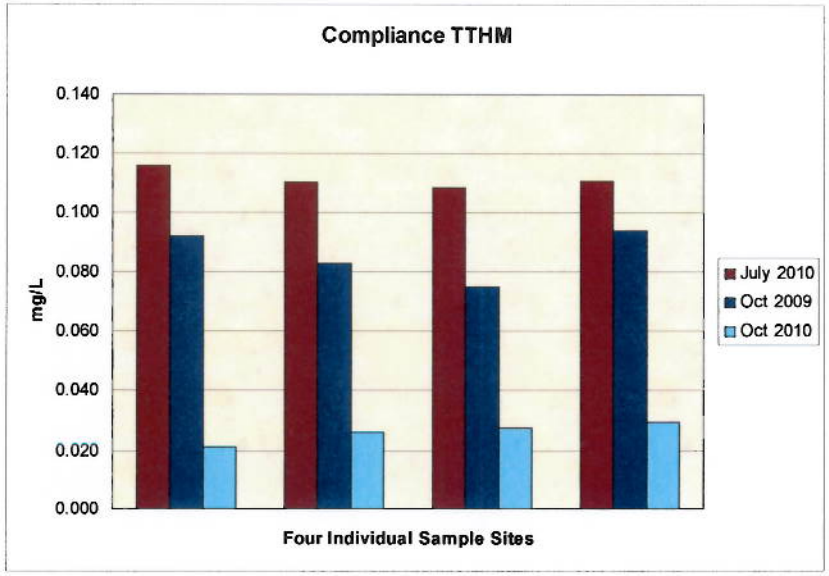
Sampling Date	Superpulsator Effluent	Filter Effluent	Plant Effluent
7/1/2010 Prior to the trial	--	0.0746	0.0953
7/26/2010 During the trial	0.0253	0.0337	0.0659
8/16/2010 During the trial	0.0090	0.0159	0.0490
9/23/2010 During the trial	0.0106	0.0129	0.0292
10/5/2010 During the trial	0.0087	0.0091	0.0225

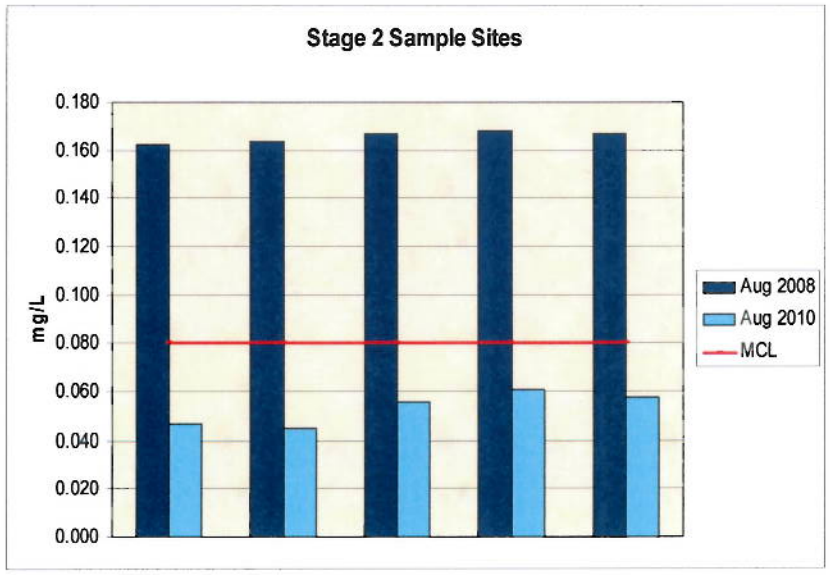


PENNSYLVANIA AMERICAN WATER

Additional Supporting Information

- The graph on the left shows Norristown's traditional compliance samples collected July 2010, Oct 2009, and Oct 2010. Comparing two sampling quarters in the same year and comparing the same sampling quarter in two different years.
- The graph on the right shows the possible Stage 2 sites collected in 2008 compared to the same locations sampled in 2010 during the trial.





PENNSYLVANIA AMERICAN WATER

Challenges Faced During the 2010 Trial

- Hottest summer and one of the driest on record.
- No flow pacing. Chemical feed changes based on residual. Operators maintained a 1.50 Total Chlorine residual.
- Chloramine/manganese interferences with the DPD free chlorine method.
- Need to elevate ferric feed to increase organic removal.
- Manganese issues
  - Traditional lower pH ranges utilized by the plant were not sufficient enough to oxidize manganese.
  - Tropical Storm Nicole drops 5.5 inches of rain in 12 hours.

PENNSYLVANIA AMERICAN WATER

What We Evaluated

1. Is chloramine application prior to the Superpulsators effective at preventing the sludge blankets from becoming septic?
2. Can manganese levels be controlled throughout the plant process without the use of pre-chlorinated free chlorine?
3. If chloraminated water is applied for an extended period of time, does it change the bacterial quality of the GAC filters?
4. Measure the effects of nitrification in the treatment plant.
5. Will prechloramination impact ability of GAC filters to remove HAA5s?

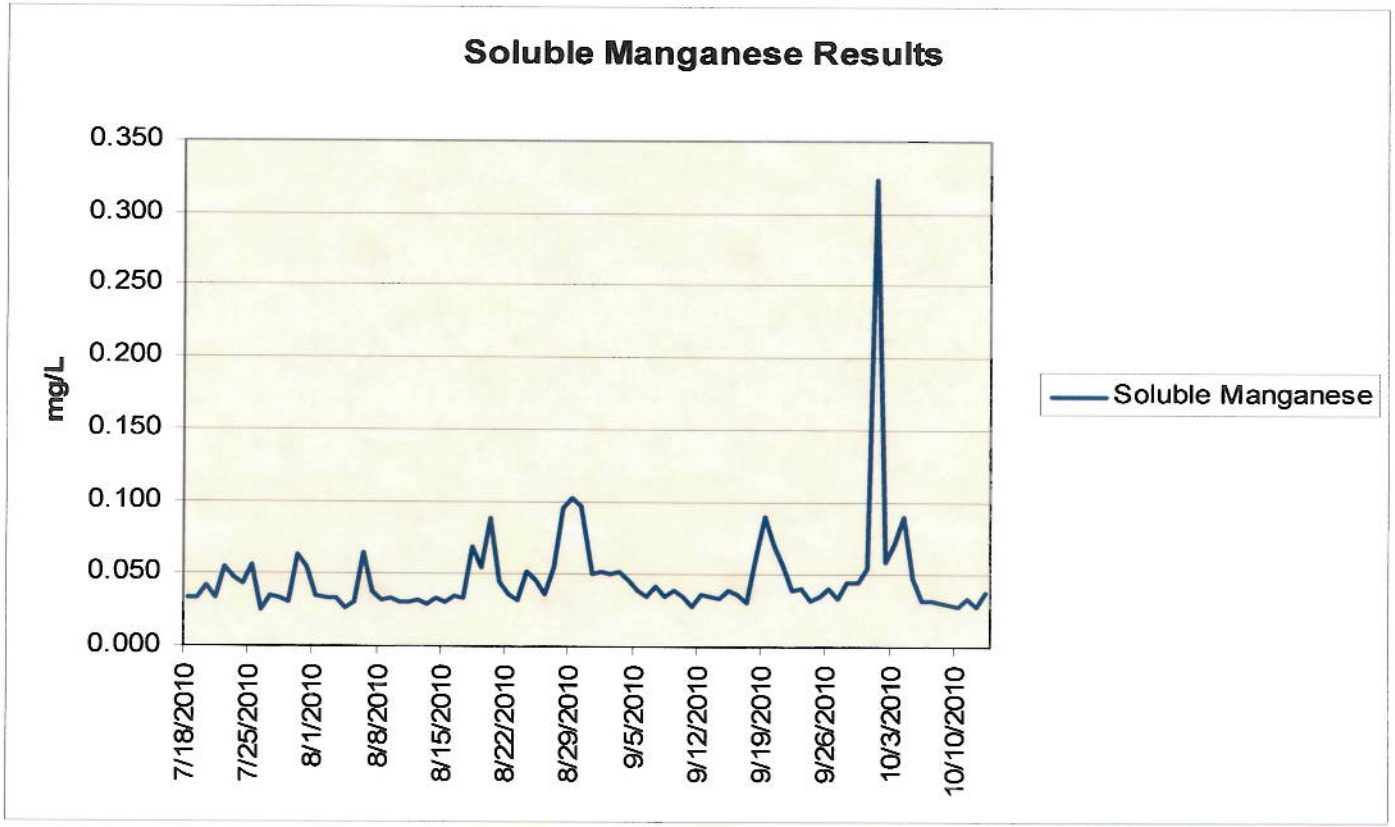
PENNSYLVANIA AMERICAN WATER

1. Is chloramine application prior to the Superpulsators effective at preventing the sludge blankets from becoming septic?

- Two analyses were performed which included soluble manganese and HPC.
- Soluble manganese was analyzed on the Superpulsator effluent every 4 hours.
- Soluble manganese levels remain consistently low showing no evidence of septic conditions being formed in the sludge blankets.
- The Superpulsator effluent HPC analysis was conducted to give additional confirmation in determining septic conditions in the sludge blankets. The range of counts found on the HPC plate ranged from 40 Most Probable Number (MPN) down to < 2 MPN which is dramatic evidence that the chloramine disinfectant residual maintained was sufficient to prevent septic conditions from forming.

PENNSYLVANIA AMERICAN WATER

Superpulsator Effluent Soluble Manganese Results



- **NOTE: 0.323 mg/L spike found on October 1 was due to tropical storm Nicole which affected the Norristown area between September 30 and October 1. The raw water manganese levels peaked at a level of 1.86 mg/L at 0400.**

2. Can manganese levels be controlled throughout the plant process without the use of pre-chlorinated free chlorine?

- Pre-trial: On average, the raw water manganese results are 0.250 mg/L to 3.0 mg/L
- During the trials, manganese levels were monitored throughout the entire plant process including raw water, Superpulsator effluent, combined filter effluent and plant effluent through a combination of Total and Soluble manganese tests.
- Prior to the application of the LAS, the Norristown plant would control the oxidation of manganese through the pre-treatment free chlorine.
- During the trial, an alternate way to treat for the high levels of manganese was to increase the pH to approximately 7.2 s.u. in addition to optimizing the potassium permanganate.

PENNSYLVANIA AMERICAN WATER

3. If chloraminated water is applied for an extended period of time, does it change the bacterial quality of the GAC filters?

- The individual filter effluent water was used to analyze for HPC to monitor bacterial growth.
- The GAC filter's bacterial quality, measured through the MPN counts of the HPC, changes with the number of hours on the filter itself.
- The greater the number of hours, the greater the HPC counts
- Once the filter was backwashed and put into service HPC counts recorded were minimal.

PENNSYLVANIA AMERICAN WATER

4. Does it increase the levels of Nitrates in the plant?

- A combined filter effluent sample was tested for nitrate 7 times over the trial period to monitor the plant process for indications of nitrification due to the added loadings of ammonia in the process.
- The first nitrate sample, collected July 26, resulted in a concentration of 3.00 mg/L and the last sample collected had a result of 3.15 mg/L. The highest recorded nitrate result was from July 20 which resulted in a concentration of 3.80 mg/L.
- The deviations recorded are minimal with nitrate levels fluctuating up and down and not continually increasing in concentrations.

PENNSYLVANIA AMERICAN WATER

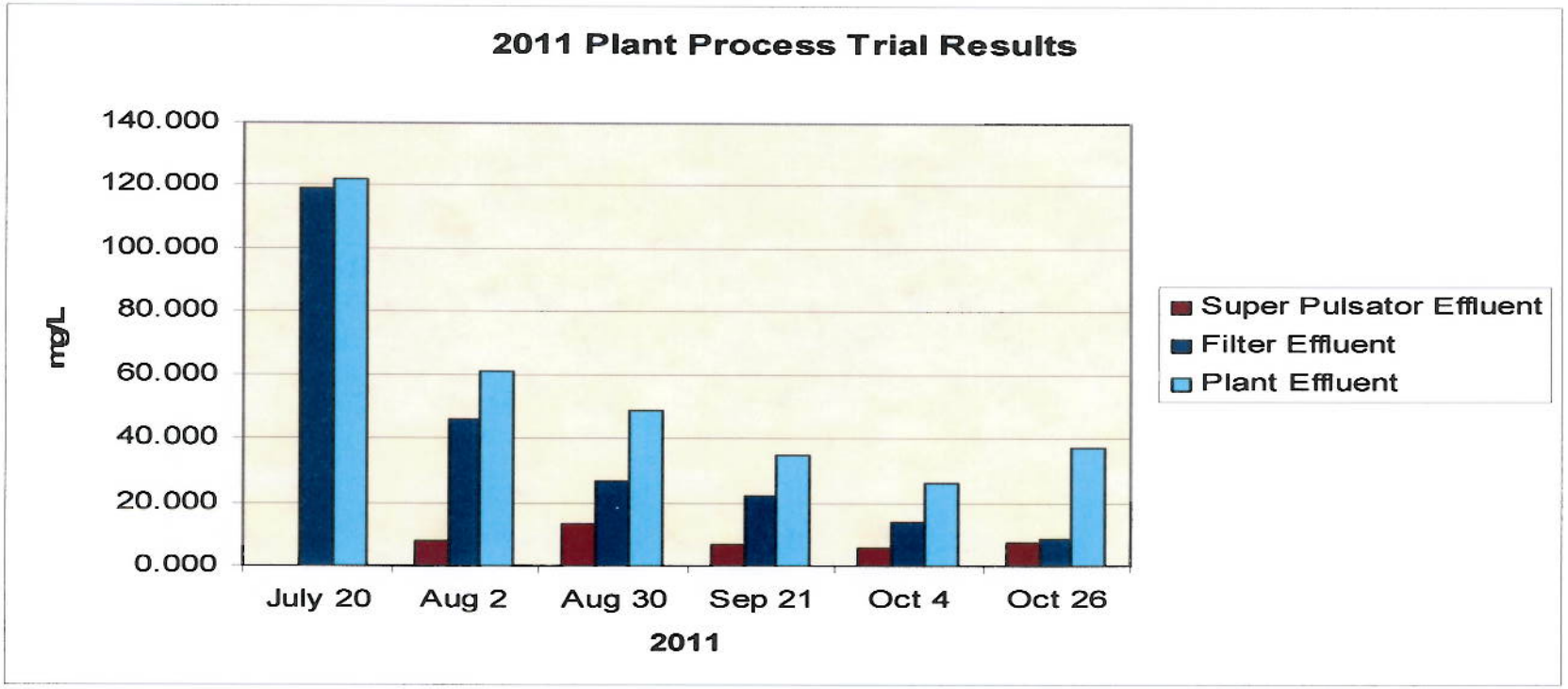
5. Will prechloramination impact ability of GAC filters to remove HAA5s?

- Since the GAC filters were installed and put into service in 2000, the highest HAA5 running annual average (RAA) was 15.2 ug/L in 2008.
- During the trial, the four Stage 1 compliance samples were collected and analyzed October 6. The average HAA5 result of those four sites was 4.5 ug/L.
- Lastly, Stage 2 DBP samples were collected in August 2010. The HAA5 results from 2010 were compared to the HAA5 results collected in August of 2008. In 2008, the highest HAA5 single result was 14.0 ug/L with an average HAA5 result of 5.8 ug/L, while in 2010 the highest HAA5 single result was 10.6 ug/L with an average HAA5 result of 6.5 ug/L.
- All HAA5 results document prechloramination has no affect on the ability of the GAC filters to remove HAA5 contaminants.

PENNSYLVANIA AMERICAN WATER

2011 In-House Plant Trial Samples

- The 2011 Trial officially began July 24, 2011 and ended October 26, 2011.
- The first sampling conducted on July 20 is prior to the start of the trial.



PENNSYLVANIA AMERICAN WATER

Challenges Faced During the 2011 Trial

- **Very hot end of spring beginning of summer and August was one of the wettest months on record. A total of 14.4 inches in one month!**
- **Hurricane Irene hits Norristown August 28, 2011**
- **Still no flow pacing. Chemical feed changes based on residual. Operators maintained a 1.50 Total Chlorine residual.**
- **Need to elevate ferric feed to increase organic removal.**
- **Manganese issues**
  - Traditional lower pH ranges utilized by the plant were not sufficient enough to oxidize manganese.

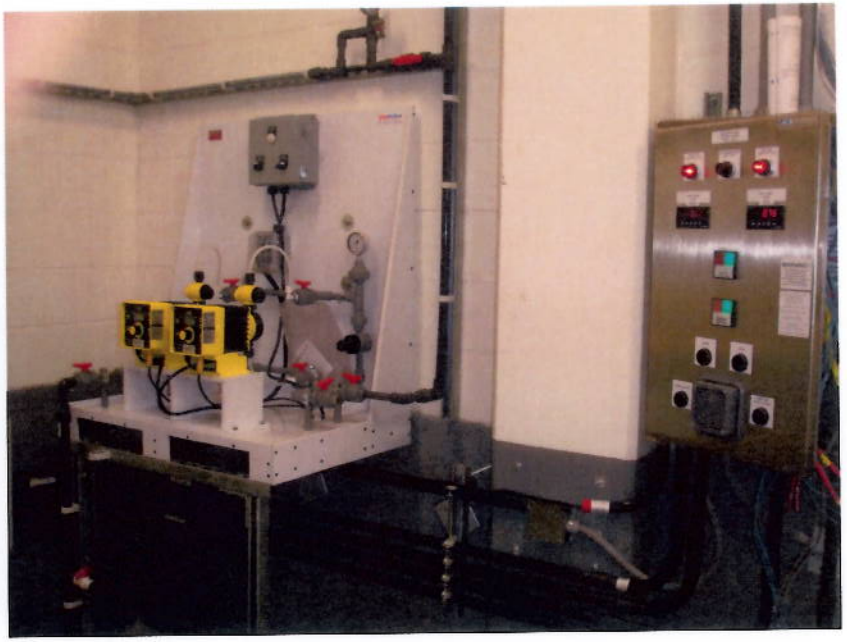
PENNSYLVANIA AMERICAN WATER

Moving Forward

- Equipment purchased to feed LAS through a permanent chemical feed system.
- Utilization of an onsite bulk tank.
- Purchased the Chemscan online chloramination analyzer.
- Received approval for operating permit amendment to feed LAS.
- LAS should begin feeding sometime in May.

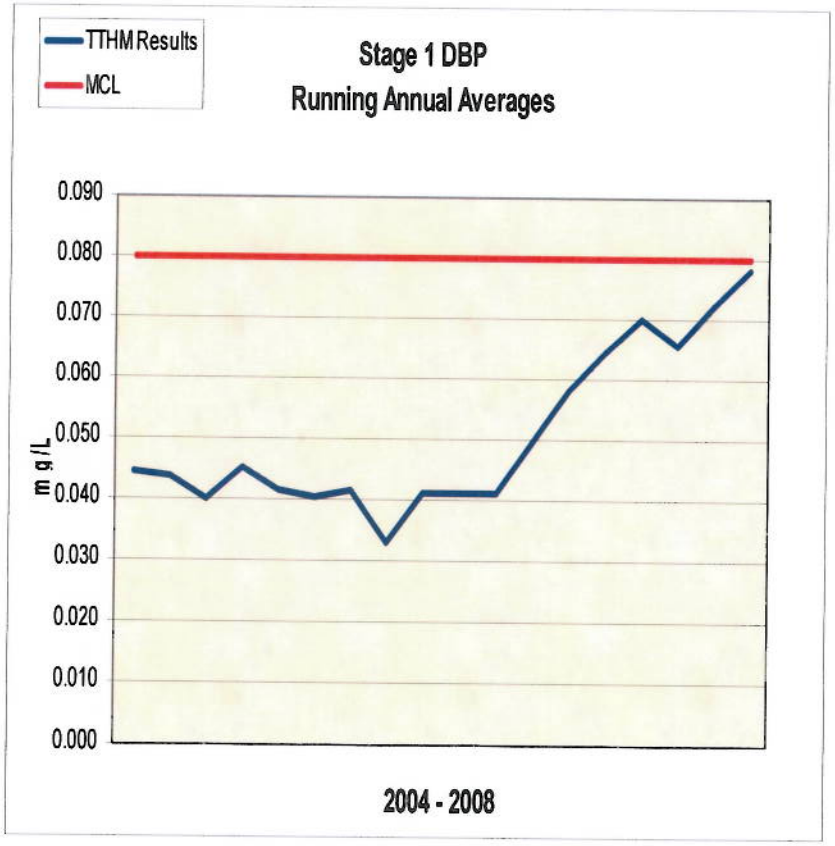
PENNSYLVANIA AMERICAN WATER

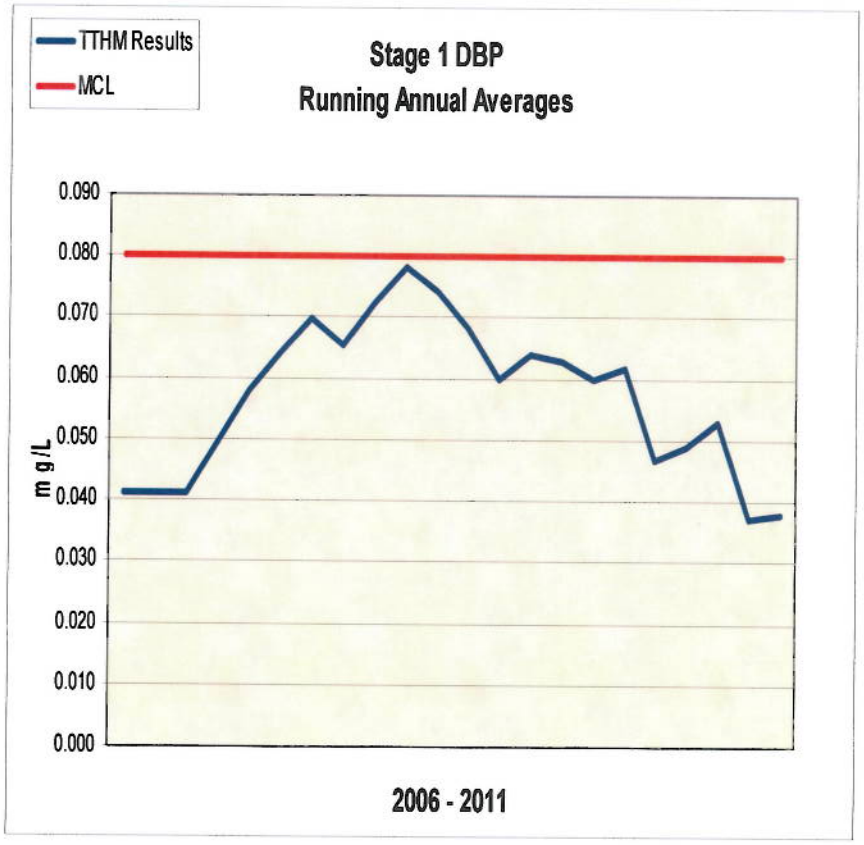
Permanent LAS Feed System – Day Tank and Feed Pumps



PENNSYLVANIA AMERICAN WATER

Where We Were… And Where We Are Now!





Current RAA ..... 0.040 mg/L !!!!!!!!!!!!