PPPL
PRINCETON
PLASMA PHYSICS
LABORATORY

Implementation of PAA at PPPL

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Contents

Background

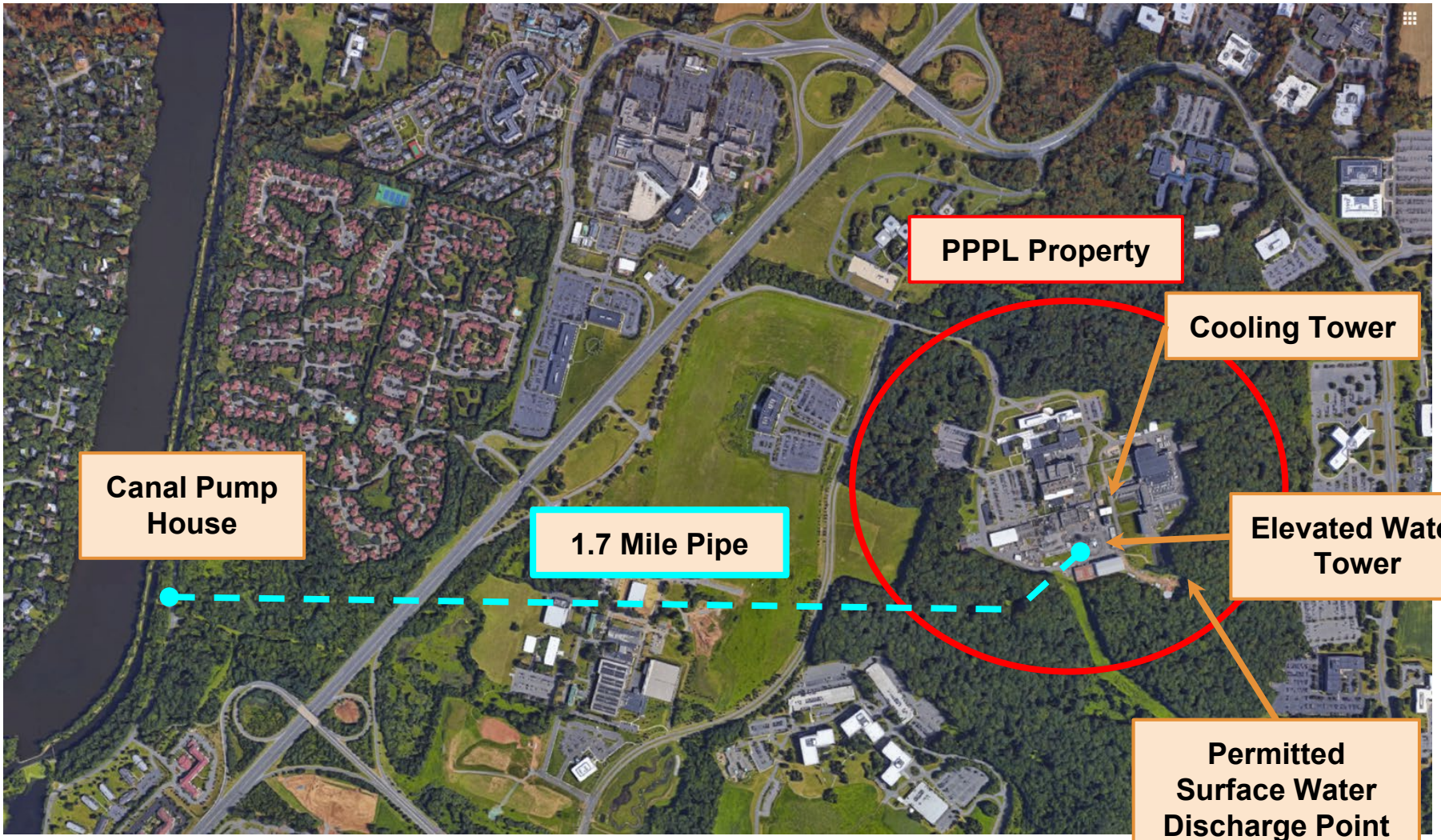
- U.S. Department of Energy National Laboratory operated by Princeton University
- Small-About 500 employees
- 88 acres
- Plainsboro, NJ
- Founded in 1950s

Background

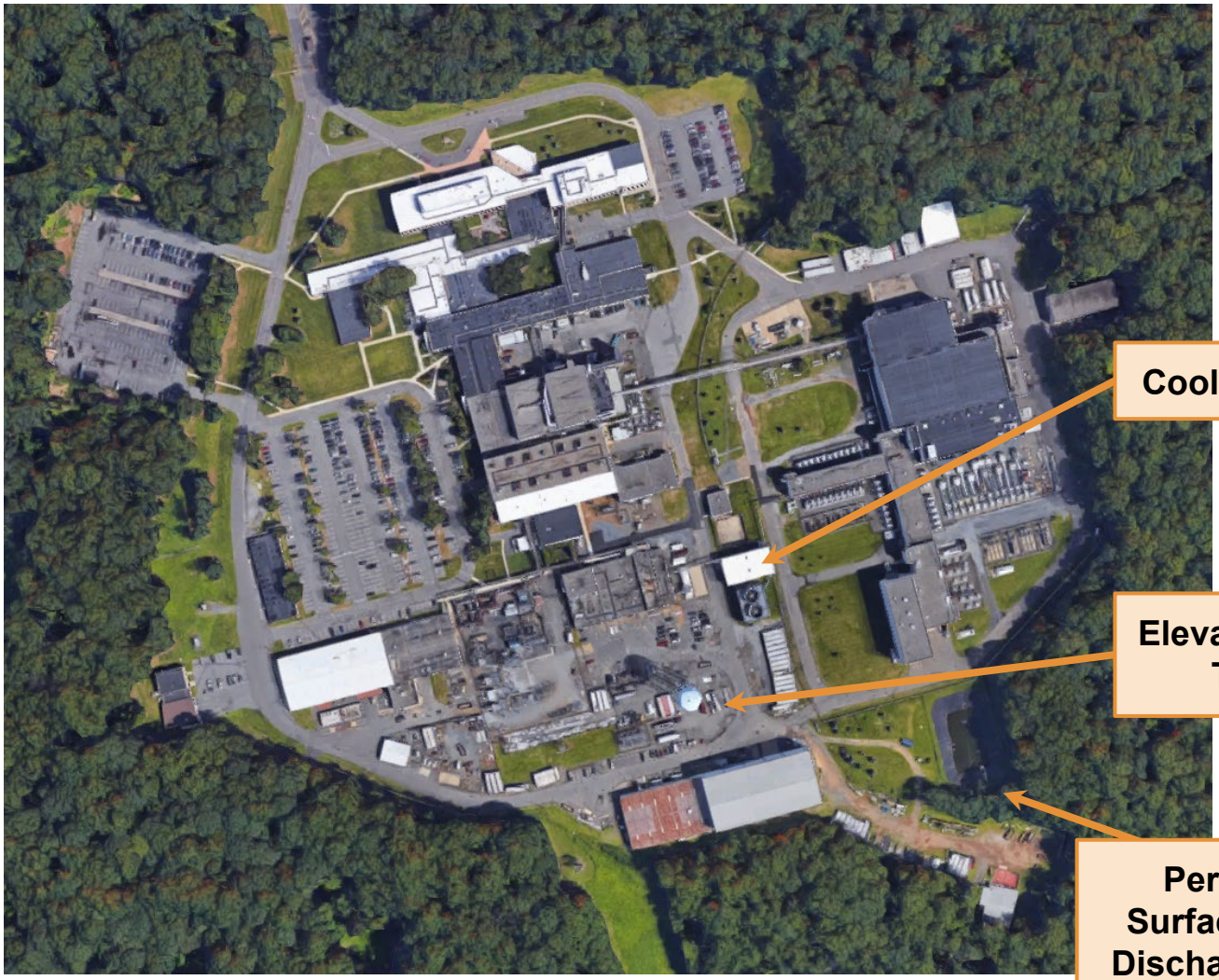
Background

- Chlorine was used as primary biocide for water treatment, we were faced with finding an alternative
- Peracetic Acid (PAA) solution is now the primary biocide
- Retrofitted two chemical injection locations, the canal pump house and cooling tower
- 3 year project to implement the chemical at PPPL
- PAA NJDEP monitoring study completed and final permission to use chemical in Spring 2019

Area Map


PPPL Property
Cooling Tower
Canal Pump House
1.7 Mile Pipe
Elevated Water Tower
Permitted Surface Water Discharge Point

PPPL Map


Cooling Tower
Elevated Water Tower
Permitted Surface Water Discharge Point

Composition of PAA

Substances

Mixture

PRODUCT as SOLD

Name	Product identifier	% (w/w)	Classification (GHS-US)
Water	(CAS No) 7732-18-5	50 - 70	Not classified
Hydrogen peroxide	(CAS No) 7722-84-1	20 - 30	Ox. Liq. 1, H271 Acute Tox. 4 (Oral), H302 Acute Tox. 4 (Dermal), H312 Acute Tox. 4 (Inhalation: vapour), H332 Skin Corr. 1A, H314 STOT SE 3, H335 Aquatic Acute 3, H402 Aquatic Chronic 3, H412
Acetic acid	(CAS No) 64-19-7	5 - 10	Flam. Liq. 3, H226 Skin Corr. 1A, H314 Eye Dam. 1, H318 Aquatic Acute 3, H402
Peroxyacetic acid	(CAS No) 79-21-0	5 - 10	Flam. Liq. 3, H226 Org. Perox. D, H242 Acute Tox. 4 (Oral), H302 Acute Tox. 4 (Dermal), H312 Acute Tox. 4 (Inhalation), H332 Skin Corr. 1A, H314 Aquatic Acute 1, H400

Driver

Driver

- Between 2012 and 2018, PPPL's Chlorine Produced Oxidants (CPO) permit limit was 0.1 mg/L (daily maximum)
- In 2016 NJDEP advised PPPL that new permit CPO limit would be lowered to 0.016 mg/L daily maximum
- PPPL explored system interventions like high frequency pulse-chambers and UV treatment
- Decided on PAA because of environmental benefits (breaks down quickly), minimal changes in systems and operations, and NJDEP and our subcontractor were willing to support us during the process

Driver

New NJPDES permit requirements

Table III - A - 1: Surface Water DMR Limits and Monitoring Requirements

PHASE: 1-Interim **PHASE Start Date: 07/01/2019** **PHASE End Date: 06/30/2022**

Parameter	Sample Point	Limit	Limit	Units	Limit	Limit	Limit	Units	Frequency	Sample Type
Chlorine Produced Oxidants	Effluent Gross Value	*****	*****	*****	*****	0.011 Monthly Average	0.016 Daily Maximum	MG/L	1/Month	Grab
January thru December	MDL	***	***		***	0.02	0.02			
Peracetic Acid	Effluent Gross Value	*****	*****	*****	*****	REPORT Monthly Average	REPORT Daily Maximum	MG/L	1/Month	Grab
January thru December	QL	***	***		***	***	***			
Temperature, oC	Effluent Gross Value	*****	*****	*****	*****	REPORT Monthly Average	30 Daily Maximum	DEG.C	1/Month	Grab
January thru December	QL	***	***		***	***	***			
Oxygen Demand,Chem. (High Level) (COD)	Effluent Gross Value	*****	*****	*****	*****	REPORT Monthly Average	50 Daily Maximum	MG/L	1/Month	Grab
January thru December	QL	***	***		***	***	***			
Petroleum Hydrocarbons	Effluent Gross Value	*****	*****	*****	*****	10 Monthly Average	15 Daily Maximum	MG/L	1/Month	Grab
January thru December	QL	***	***		***	***	***			
Phosphorus, Total (as P)	Effluent Gross Value	REPORT Monthly Average	REPORT Weekly Average	KG/DAY	*****	REPORT Monthly Average	REPORT Weekly Average	MG/L	1/Month	Grab
January thru December	QL	***	***		***	***	***			

Driver

2016 CPO Results		2017 CPO Results	
0.020	Exceedance	0.030	Exceedance
0.040	Exceedance	0.000	
0.040	Exceedance	0.030	Exceedance
0.080	Exceedance	0.000	
0.030	Exceedance	0.010	
0.150	Exceedance	0.070	Exceedance
0.000		0.080	Exceedance
0.140	Exceedance	0.000	
0.000		0.040	Exceedance
0.030	Exceedance	0.050	Exceedance
0.090	Exceedance	0.030	Exceedance
0.060	Exceedance	0.000	

10 Exceedances in 2016 and 8 Exceedances in 2017 if new limit existed

D-Site Cooling Tower Modifications

Previous Chlorine Feed System in D-Site Cooling Tower

PAA Installation

- Moved chemical tanks and metering pumps to be closer to injection points
  - Install PAA tank and metering pump
- Moved and reconfigured the pumping sample loop and controller
- Reassess chemical transfer, purchased new Finish Thompson drum pumps, new hoses, and quick connect (dripless) fittings.

Move Chemical Injection Location

BEFORE

AFTER

- Secondary containment

Install plumbing and Pumps

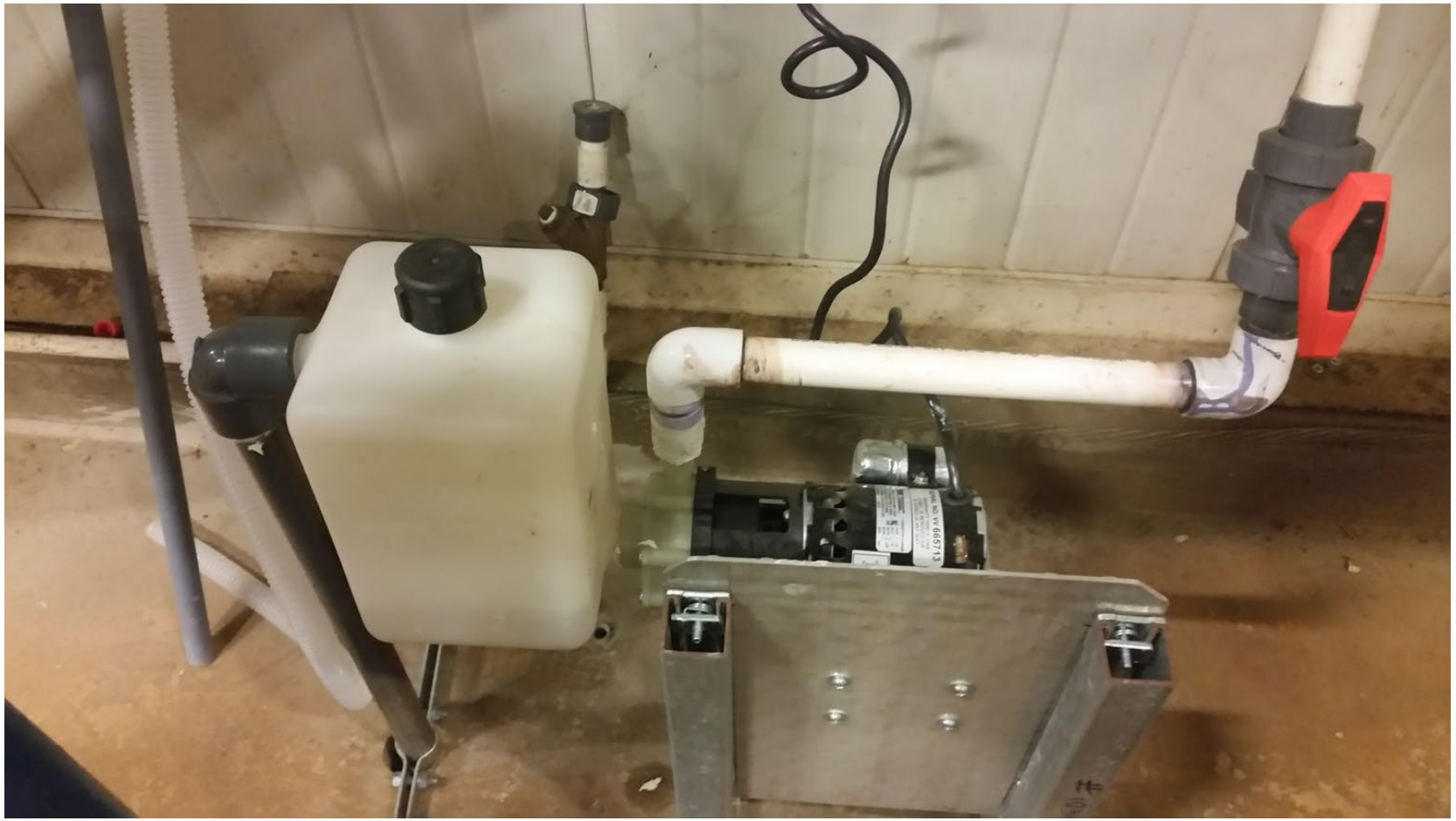
- Move to South-West end of building
- Install new style metering pump with gas venting capability.
- Install Vent to exterior of Building

Move and Reconfigure Sample Loop and Controller

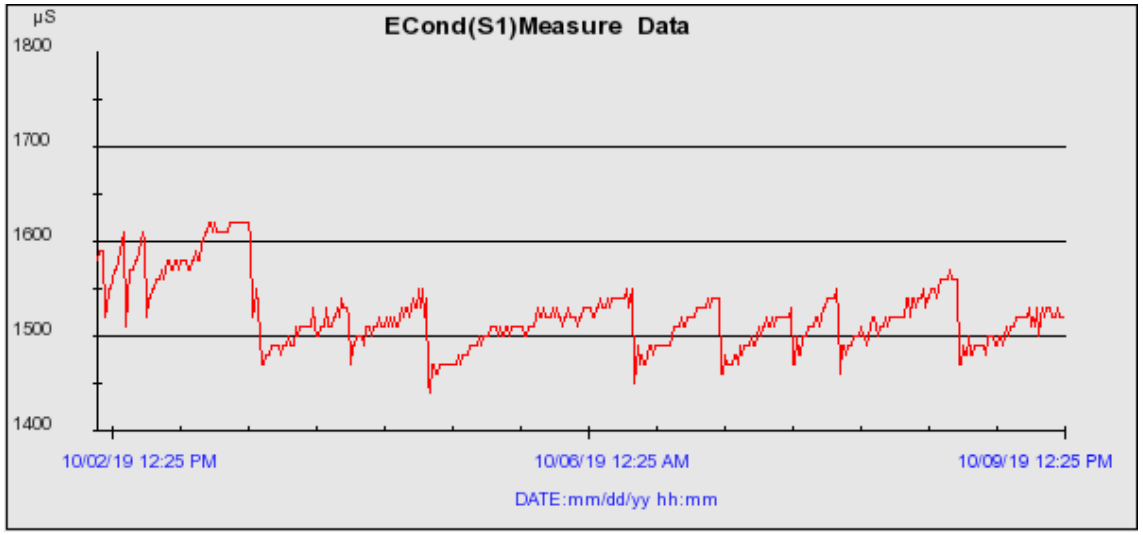
BEFORE

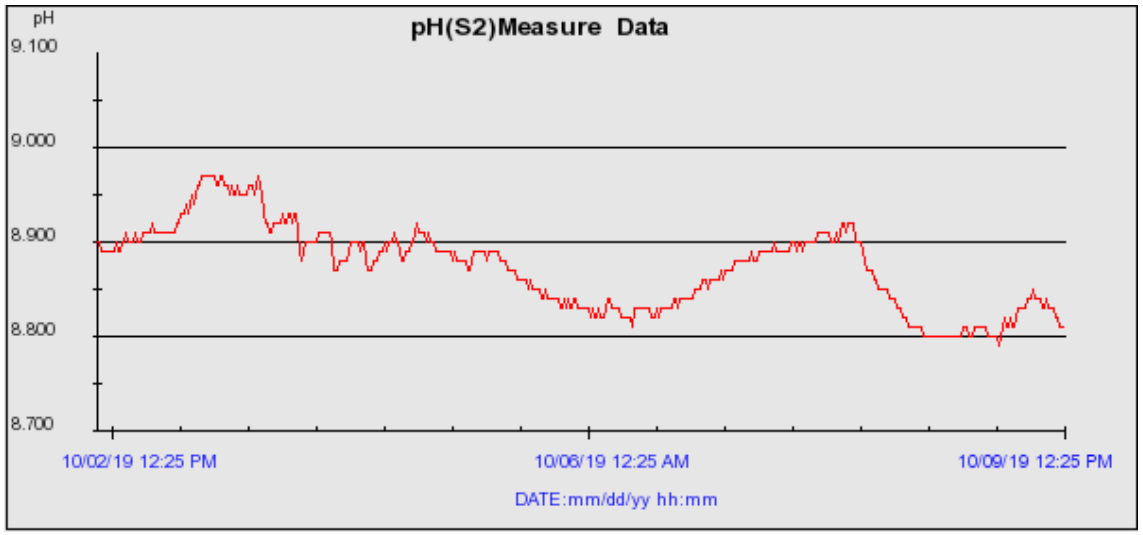
Move and Reconfigure Sample Loop and Controller

Sample Loop Pump



Controller Trending





Controller Metrics

Chemical	PAA Mixture Canal	PAA Mixture Cooling Tower	Antimicrobial #2 Cooling Tower	pH Controller Cooling Tower	Corrosion Inhibitor Cooling Tower
Controller Parameter	Constant when canal pump runs (~20 minutes/day)	4x daily for 60 minutes each	Once Weekly (Fridays 6 pm) for 100 minutes	Setpoint 8.1 (timeout after 190 minutes)	36 minutes every 3 hours
Pump Parameter	Max 0.6 GPH 150 PSI	Max 2.0 GPH 105 PSI	Max 1.0 GPH 60 PSI	Max 3.2 GPH 30 PSI	Max 2.0 GPH 105 PSI
Pump Setting	350 spm 0.58 GPH	100 spm 0.55 GPH	60 spm 0.16 GPH	50 spm (0.44 GPH)	100 spm 0.55 GPH
Weekly Volume	1.36 Gallons (0.08 Gallon PAA)	15.4 Gallons* (7.19 pounds PAA)**	0.27 Gallons	12.32 Gallons	2.57 Gallons

***Example:**
Pump has maximum output of 2.0 GPH at 360 strokes per minute (SPM). Current frequency is 100 SPM or 27.8% of maximum. Therefore the current output is *0.55 GPH*. Daily run time is 40 minutes or 0.67 hours.

0.55 x 0.67 = 0.37 GPD or 2.57 Gallons per week

**** There is only 5% concentration of PAA in chemical**

Canal Pump House Modifications

Installation at Canal

- Canal water pump operates based on level in elevated storage tank, we only add chemical while the pump is running
- Isolated and removed current chlorine injection system
  - Ensured flow to Emergency shower and corrosion inhibitor tank remains.
- Install new tank and metering pump.
  - Power new pump identical to previous electrical control
- Add back-flow connector and connect poly-flo tubing.
- Vented tank to outdoors

Install New Tank and Walchem Pump

BEFORE

AFTER

- Changed to horizontal tank.

Chemical Injection Location

Sampling, Monitoring, and Analysis

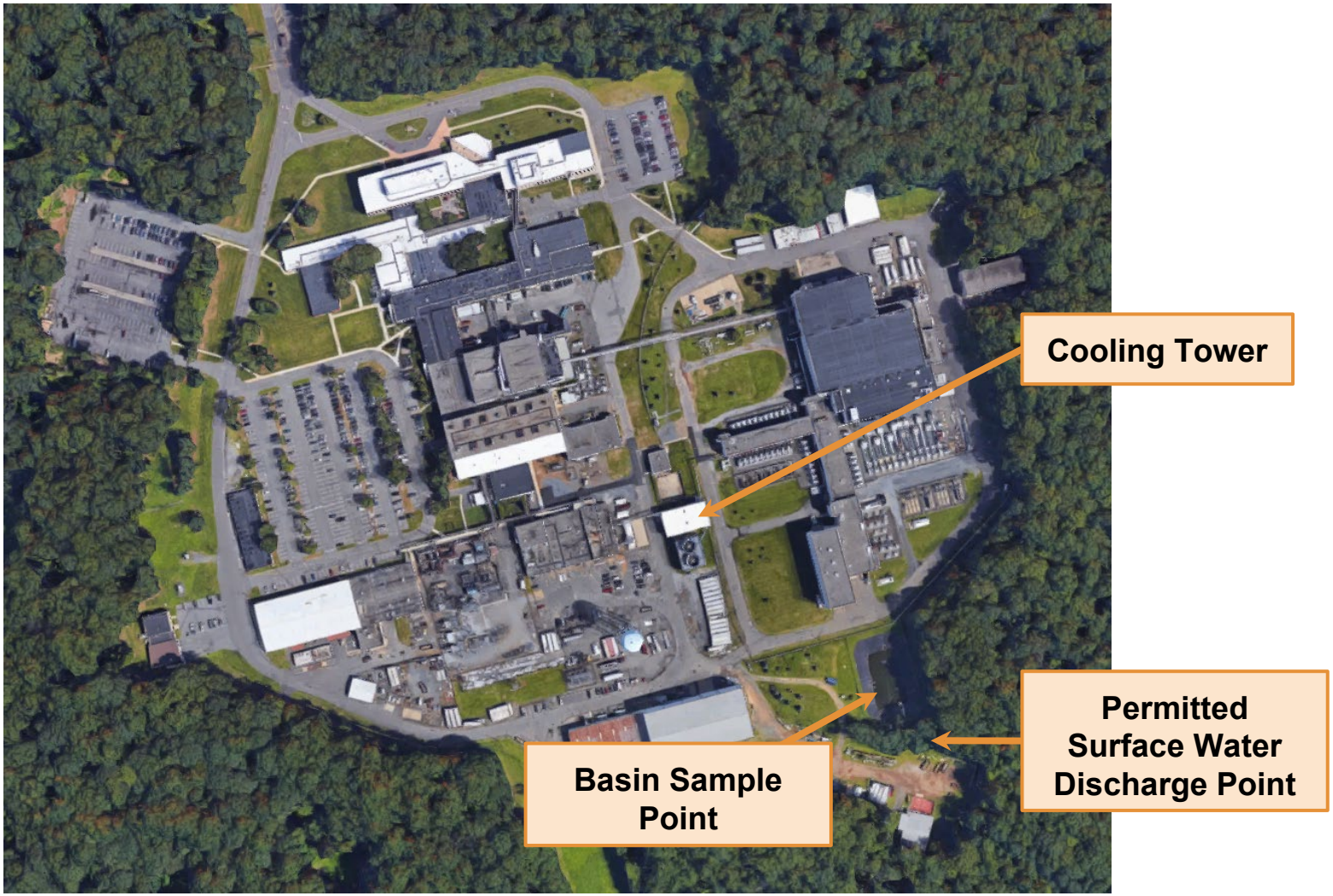
Analysis Protocol

- PPPL utilizes EPA Method 330.5 (Total Residual Chlorine) to immediately analyze for residual Peracetic Acid.
- This method is proportional to PAA, with the difference being the quantity of DPD Reagent and correction factor of 1.07.
- PPPL is a NJDEP certified laboratory for Analyze Immediately parameters including chlorine(PAA), pH, and temperature.
- PPPL needed NJDEP permission to use this method because it's not in 40 CFR 136
- Instruments and equipment used to gather, generate, or measure analyze immediately samples are inspected and calibrated in accordance with the manufacturer's specifications and internal procedures.

NJDEP Study

- NJDEP Study started with a two week baseline period
- Followed by a monitoring phase that lasted for 6 weeks, sampling twice a week, giving a total of 12 samples.
- There were two sample points for this study; one located inside the cooling tower and the other located in the retention basin, before our discharge.
- The study allowed NJDEP and PPPL to ascertain the feasibility of PAA disinfection.

Sample Points Map



NJDEP Study Baseline Results

Site Cooling Tower Baseline Injection Summary						
Parameter	**pH (SU)**	**Temperature (°C)**	**Total Chlorine (mg/L)**	**Dissolved Oxygen (mg/L)**	**TSS (mg/L)**	**COD (mg/L)**
Original Permit Limit	6 MMI & 9 MMA	30 DM	0.1 DMA & MA	N/A	50 DMA	50 DMA
Minimum	7.56	16.5	0.03	8.27	< 4.0	< 20.0
Maximum	8.49	18.1	0.07	9.31	< 4.0	27.1
Average	7.92	17.4	0.05	8.69	< 4.0	21.8
MMI = Monthly Minimum, MMA = Monthly Maximum, DMA = Daily Maximum, MA = Monthly Average						

Basin Outflow Pre-PAA Injection Summary					
Parameter	**pH (SU)**	**Temperature (°C)**	**DO (mg/L)**	**TSS (mg/L)**	**COD (mg/L)**
Original Permit Limit	6 MMI & 9 MMA	30 DM	N/A	50 DMA	50 DMA
Minimum	6.87	9.6	10.23	< 4	< 20
Maximum	7.63	11.4	11.25	56.5	< 20
Average	7.31	10.6	10.71	17.3	< 20
MMI = Monthly Minimum, MMA = Monthly Maximum, DMA = Daily Maximum, MA = Monthly Average					

NJDEP Study Results

- The results showed little discrepancy in dissolved oxygen, total suspended solids, chemical oxygen demand, pH, and temperature between the baseline study and the monitoring study

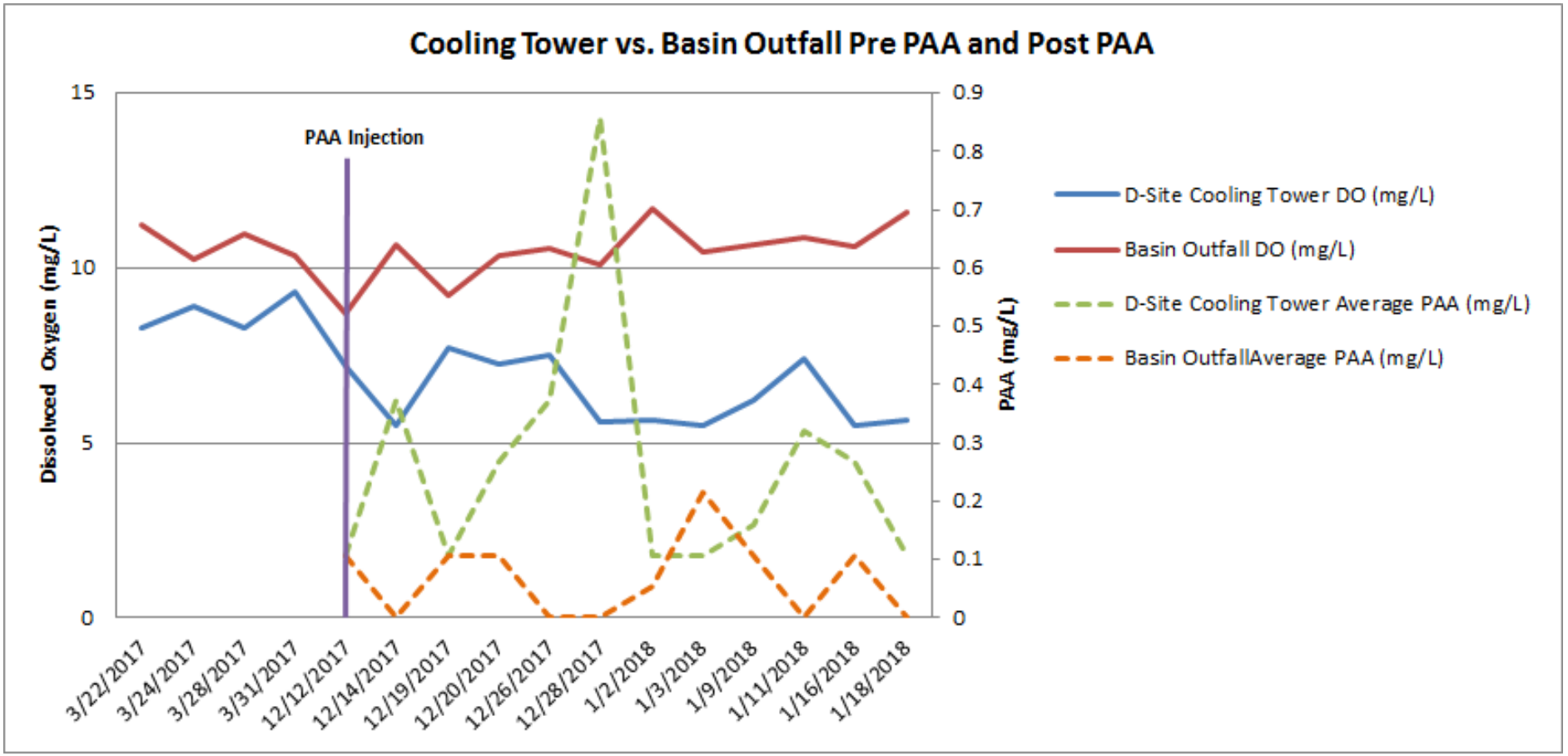
- PPPL maintained average of 0.270 mg/L residual PAA in the cooling tower, the average at the basin outflow was 0.08 mg/L

Summary of Study Results

D-Site Cooling Tower PAA Injection Summary						
Parameter	**pH (SU)**	**Temperature (C)**	**PAA (mg/L)**	**DO (mg/L)**	**TSS (mg/L)**	**COD (mg/L)**
Minimum	7.02	18.0	0.107	5.51	<4.0	<20.0
Maximum	8.40	22.9	0.856	7.73	23.7	23.1
Average	7.71	20.7	0.270	6.40	6.4	20.3

Basin Outflow PAA Injection Summary						
Parameter	**pH (SU)**	**Temperature (C)**	**PAA (mg/L)**	**DO (mg/L)**	**TSS (mg/L)**	**COD (mg/L)**
Minimum	6.27	4.2	0.000	8.72	<4.0	<20.0
Maximum	8.37	11.3	0.214	11.71	<4.0	<20.0
Average	NA	6.8	0.080	10.44	<4.0	<20.0

NJDEP Study Results



Safety and PPE

Required PPE

All PPE purchased is compatible with chemicals

- Goggles
- Faceshield
- Apron
- Neoprene gloves
- Sleeves
- Work boots

Chemical Transfer and Drum Rinsing

- Drum transfer pumps used to transfer chemical from temporary storage location to tanks
- Quick disconnects installed on tanks to prevent spills and exposures during chemical transfer
- Tubes and hardware are compatible with chemicals
- SOP and JHA created for chemical transferring
- Upon completion, tubes are flushed and drums are triple rinsed

SOP for Chemical Transfer

SAFETY OPERATING PROCEDURE

Finish Thompson Electric Drum Pump

DO NOT use this pump unless you are an Authorized User. This SOP is specific to the pumping of chemicals at Cooling Tower Pump House.

Safety glasses and face shields must be worn while pumping.

Long and loose hair must be contained.

Sturdy footwear must be worn at all times in work areas.

Protective clothing must be worn. Apron and arm sleeves.

PRE-OPERATIONAL SAFETY

1. **This is a 2 Person operation.**
2. BEFORE using or servicing your pump, please make sure to wear the proper clothing, eye protection and follow standard safety procedures when handling corrosive or personally harmful materials
3. NEVER use this pump for pumping or mixing flammable or combustible material.
4. Check workspaces and walkways to ensure no slip/trip-hazards are present. Ensure well lit.
5. Ensure you are familiar with the operation of the ON/OFF two speed switch. Make sure pump switch is in the center "O" OFF position prior to connecting to 120V power source.
6. Keep work area clear of all tools and materials.
7. ALWAYS use and store the pump and motor in an upright position.
8. Ensure you are not "Working Alone". A person is considered to be working alone when, for more than a few minutes at a time, they are not within earshot or visual contact with another employee ("companion") such that help could be made available in an emergency.
9. Electric motor - If the motor stops working and the reset button has popped out, press the switch to the OFF position "O". Review your application to make sure it is within the capabilities of the pump (reset button pops typically from an overloading situation). Allow the motor to cool down for at least 30 minutes and then press in the reset button located on the side of the motor handle. See figure 1.

Pumping chemical from 55 gallon drum to the chemical tank

1. Select the proper pump from the storage rack that is labelled for the chemical you are going to pump. Fill a 5 gallon pail with canal water and set near chemical drum to be pumped.
2. Check that the motor switch is in the center "O" OFF position, and then plug the power cord into an outlet.
3. Remove plastic bung in drum and insert the pump tube into the fluid to be dispensed and the discharge hose into the tank to be filled.
4. While holding the motor handle and hose, switch the motor to the "I" low speed. The fluid will begin to pump. If more flow is desired, switch the motor to the "II" high-speed setting. See figure 1 below.
5. Ensure tank receiving the chemical has adequate volume by monitoring the level gauge while pumping. Pump desired amount of chemical into tank, it is preferred that all 55 gallons are transferred. Turn off pump by placing motor switch in the center "O" OFF position, and then unplug the power cord from outlet.

This SOP does not necessarily cover all possible hazards associated with the machine and should be used in conjunction with other references
It is designed to be used as an adjunct to teaching Safety Procedures and to act as a reminder to users prior to machine use

Date of last review | | **Signature**

6. Drain any remaining chemical in hose by elevating pump and hose slightly to allow chemical to flow into tank. Raise pump out of chemical but not out of drum, allow to drain until no longer dripping.
7. Raise pump out of drum and insert into 5-gallon pail with canal water. Remove hose from tank and place in opening to cooling tower sump and secure. Pump 5 gallons of water through pump and hose to rinse. Allow to drain.
8. Place pump into storage receptacle and secure hose.
9. Place bung back into drum. When drum is empty contact ESD to remove drum.

HOUSEKEEPING

1. Keep any drums containing chemicals on spill pallet(s).
2. Always store pump and hose in storage rack.

POTENTIAL HAZARDS

■ Eye injuries ■ Skin injury from chemicals

FORBIDDEN

■ Pumping flammable or combustible liquids.

Figure 1

This SOP does not necessarily cover all possible hazards associated with the machine and should be used in conjunction with other references
It is designed to be used as an adjunct to teaching Safety Procedures and to act as a reminder to users prior to machine use

Date of last review | | **Signature**

Chemical Information Signs

Per-Ox

Peracetic Acid/Hydrogen Peroxide

Biocide #1

PPE AND CONTROLS: Neoprene gloves and protective eyewear. Cover exposed skin. Use faceshield when handling. Avoid prolonged contact.

HEALTH IMPACTS: Immediate contact may cause pain or irritation of skin eyes. Prolonged exposure to skin or eyes will cause injury. Ingestion or inhalation of large amounts will have serious adverse effects.

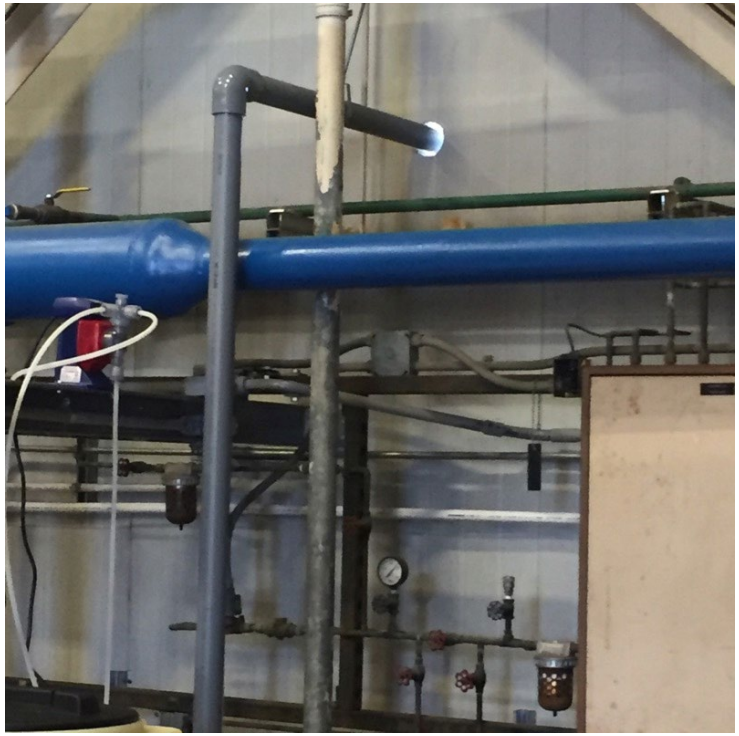
FIRST AID: Immediately flush with water if exposed to skin or eyes. If inhaled, move to fresh air.

SPILL RESPONSE: Contact ESU (x3333) and contain as much as possible using sorbents in spill kit.

Contact Information

Tom Ward x3593
Bill Gervasi x3592
Keith Rule x2329

Response: PAA Tank Engineering Controls



- Openings sealed
- CPVC pipe to vent fumes outdoors
- Blower fan placed next to tanks

Response: Air Monitoring and Respirators

- All work near open tanks required full face respirators with organic vapor/acid gas cartridges until permanent engineering controls in place
- Changed after engineering controls
- Monitored air during PAA transfer to determine exposure levels and results were below permissible exposure limits

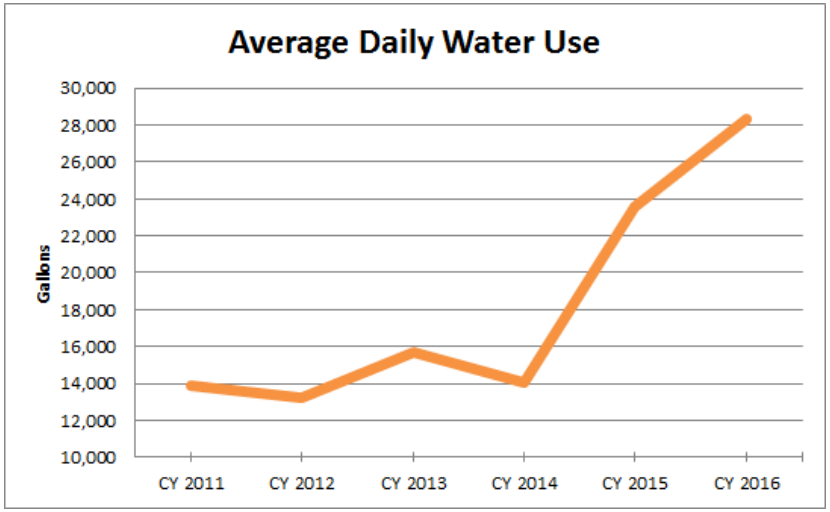
Challenges

Leak Discovered

- Despite meeting our objectives of installing the hardware for PAA and the rest of the chemicals, we are not able to attain target levels, despite constant injection and no blowdown cycles.
- A leak in the chilled water system was discovered that caused the system loop to lose water
- Large quantities of chemicals were being injected to overcome this issue, causing us to not be able to ascertain whether system was working

Canal Water Use

	A	B	C	D	E	F	G	H
1		CY 2011	CY 2012	CY 2013	CY 2014	CY 2015	CY 2016	CY 2017
2	Jan	0.068	0.271	0.225	0.128	0.155	0.509	0.554
3	Feb	0.069	0.147	0.250	0.187	0.147	0.657	0.552
4	Mar	0.087	0.390	0.241	0.399	0.115	0.648	0.567
5	Apr	0.173	0.173	0.396	0.380	0.468	0.534	0.497
6	May	0.376	0.235	0.253	0.569	1.079	1.457	
7	Jun	0.723	0.654	0.597	0.508	1.028	1.716	
8	Jul	0.978	0.975	1.232	0.827	1.419	1.114	
9	Aug	0.574	0.690	0.367	0.707	1.477	0.994	
10	Sep	0.555	0.549	1.429	0.467	1.085	0.912	
11	Oct	0.574	0.356	0.268	0.388	0.622	0.587	
12	Nov	0.555	0.161	0.276	0.316	0.501	0.655	
13	Dec	0.341	0.224	0.198	0.263	0.499	0.560	
14								
15	Total	5.073124	4.825	5.729284	5.1379	8.593593	10.34302	2.170
16								
17	Avg.daily	13,899	13,219	15,697	14,076	23,544	28,337	1,486
18								



Pumps Losing Prime

- Pumps lost prime due to off gassing of Acetic acid/PAA/H_2O_2
- Degassing valve installed to prevent issue but only partially worked
- Canal configuration switched to flooded suction
- Consumed technician time to troubleshoot

Fouling of Equipment

- Literature search indicates short half life of PAA over pH of 8.5.
- Cooling tower Basin Cleaning had not been done on two year schedule.
- Punched tubes on Chillers twice in summer season because approach temperature increased from 1-2 F to 8 F.

Fouling of Equipment

Chemical Shock Cooling Tower

Latest changes

- Shocked tower to due to biological growth in chiller heat exchangers
- We believe it is caused by pH levels affecting PAA efficacy.

Questions?

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Support Slides

Chemical Metrics

Manufacturer Name and Model	Per-Ox	AQUCAR DB-5	WI-2108	WI-4178	WI-2328 (Canal)
Chemical	Hydrogen Peroxide, Acetic Acid, Peracetic Acid*	2,2-Dibromo-3-nitrilopropionamide	Sodium Hydroxide solution	Corrosion Inhibitor Potassium Hydroxide solution	Corrosion Inhibitor (canal) TetraSodium Hexameta-phosphate
Use	Antimicrobial #1	Antimicrobial #2	pH Controller	Corrosion Inhibitor	Corrosion Inhibitor
Target Range	0.25 - 1 ppm PAA	N/A	8.0 - 8.5 pH	2 - 4 ppm Molybdate	5-15 ppm Phosphate
Injection Setpoint	3x daily, 60 minutes each	3x weekly, 30 minutes each	8.0 with 0.1 deadband	15 minutes every 6 hours	When canal pump starts

*50-70% Water, 20-30% Hydrogen Peroxide, 5-10% Acetic Acid, 5-10% Peracetic Acid

Isolate Chlorine Storage and Delivery

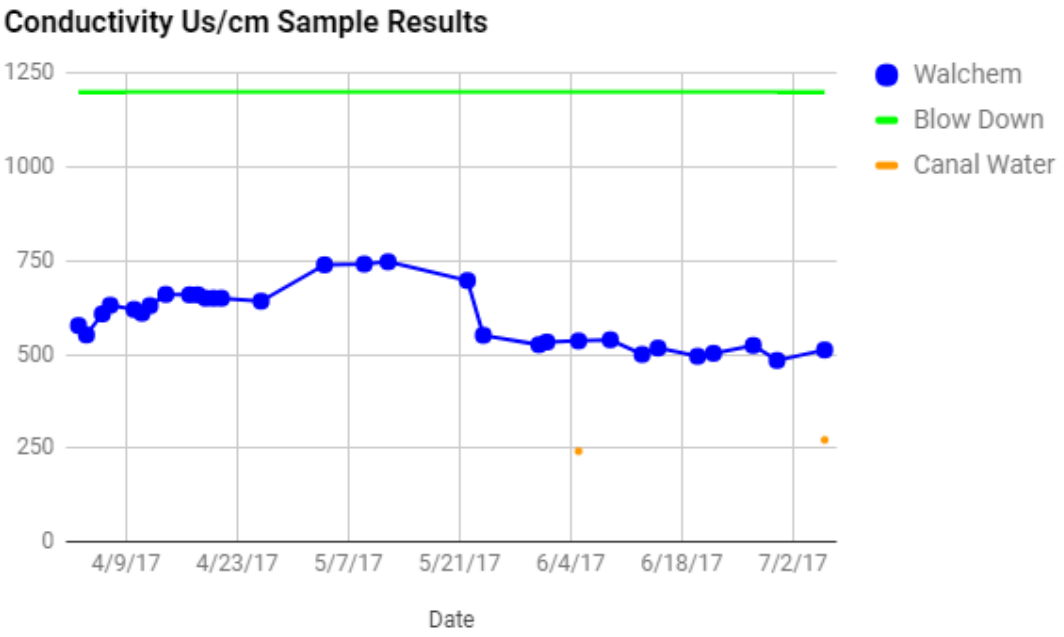
- Remove power to solenoid
- Remove solenoid valve
- Insert NPT pipe plugs
- Shut isolation valve(s)

Cost Comparison

Conductivity Sampling Results

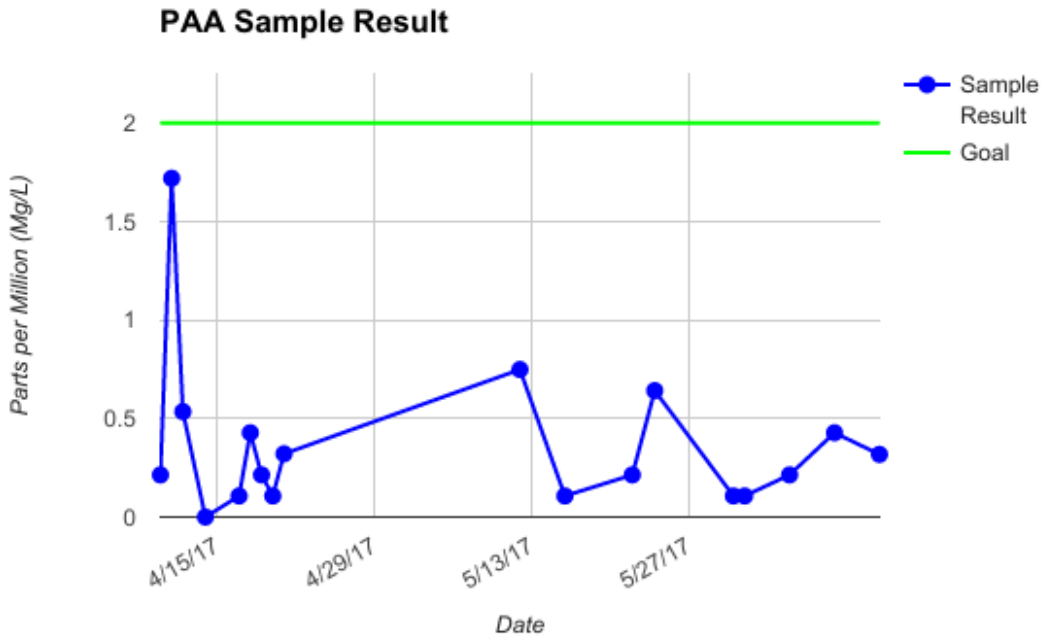
Target: 1200 µS/cm

Actual: 598 µS/cm



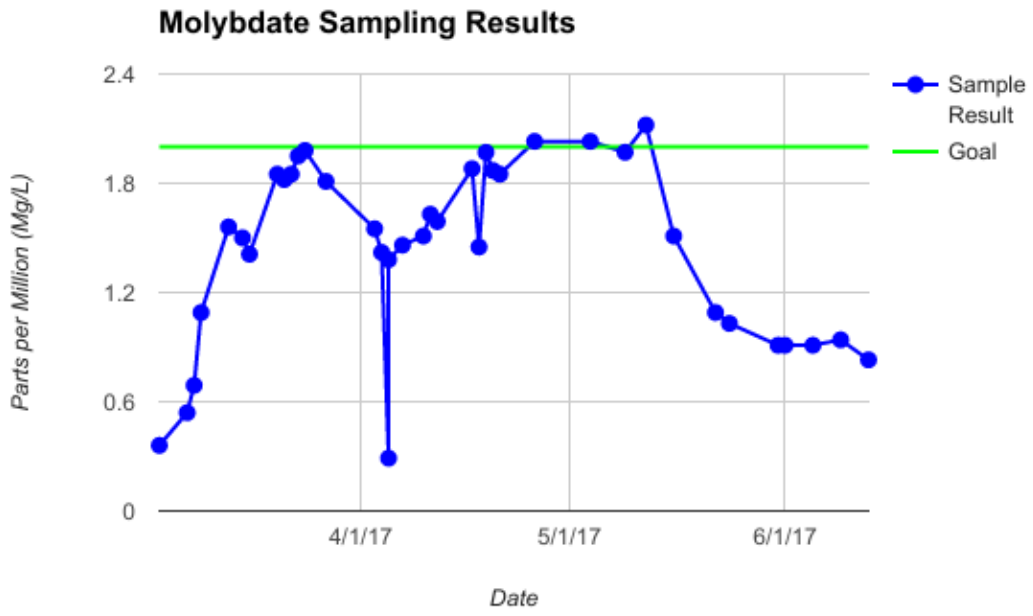
PAA Sampling Results

Target: 2.0 - 5.0 ppm
Actual: 0.37 ppm average



Molybdate Sampling Results

Target: 2 - 4 ppm
Actual: 1.45 ppm average

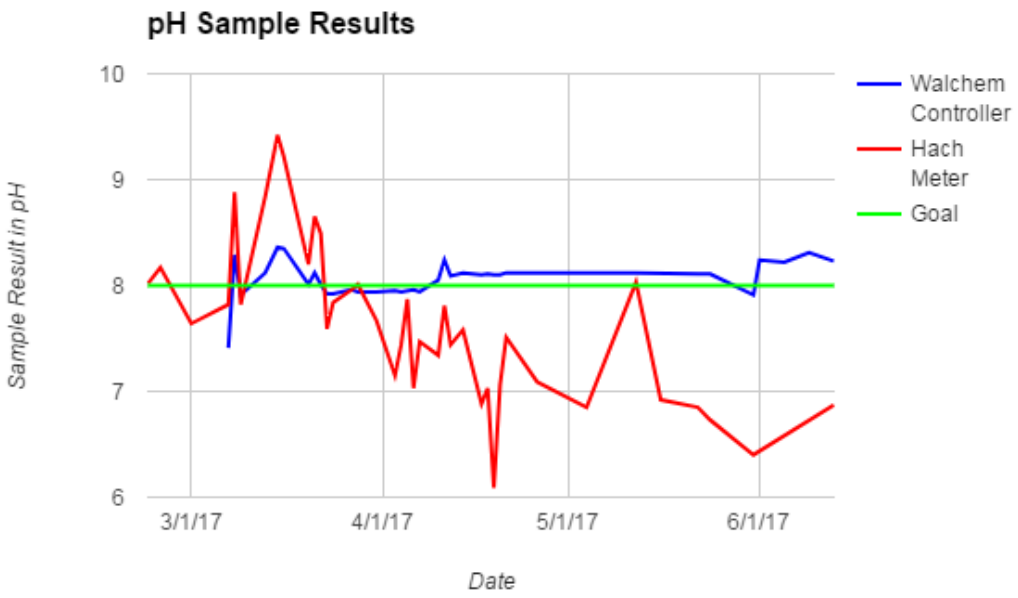


pH Sampling Results

Target: 8.0 - 8.5 pH

Actual: 8.10 pH* and 7.65** average

*Readings from Walchem Controller
**Readings from Hach Meter



Initial Theories

- Most Plausible: There is a leak somewhere in the loop, requiring more make-up and diluting the chemistry.
- Plausible: The injection rates are not adequate and need to be increased to meet demands
- Least Plausible: The equipment or chemicals are insufficient and cannot meet expectations
- Least Plausible: Evaporation and drift are accounting for all of the water losses
- Filter A&B filtering chemicals out??

System Tracking and Analysis

Cooling Tower Daily Operator Log

Process Cooling Tower System - D-Site Cooling Tower Operators						*Revised by K. Rule - 052417*
Month/Year:	**Date:**					
	Parameter	Monday	Tuesday	Wednesday	Thursday	Friday
Pump Readings						
#801	record hours					
Oil level	OK/NG					
#802	record hours					
Oil level	OK/NG					
#803	record hours					
Oil level	OK/NG					
#804	record hours					
Oil level	OK/NG					
#805	record hours					
Oil level	OK/NG					
#806	record hours					
Oil level	OK/NG					
Fan Readings						
Fan #1	record hours					
Fan #2	record hours					
VFD						
Fan #1	record hours					
Fan #2	record hours					
Base Load Pump M&O						
Water Pressure In/Out	record psi					
Differential	35 psi max					
Backwash	record gallons					
Blowdown (cumulative)	record hours					
Air Pressure In/Out	record psi					
Base Load Pump/D-site						
Water Pressure In/Out	record psi					
Differential	100 psi max					
Filter A (cum.)	record gallons					
Filter B (cum.)	record gallons					
Filter Total (cum.)	record gallons					
Potable water	record gallons					
Chemistry						
Conductivity	1000 uS max.					
pH	7.9 - 8.3					
WD-2010 tank level	>1/4					
WD-561 (NaOH) tank level	>1/8					
Aqucar DB5 tank level	>1/4					
Peracetic acid tank level	>1/8					
Operator Name/Initials						
Notes/comments	Enter in green logbook					

Water Use Tracking

No Backwash or Blowdown

2017 Date	Conductivity	pH	Backwash (gals)	Blowdown (Hrs)	Potable (gal)	Make-up H2O Filter A (gal)	Make-up H2O Filter B (gal)	Elevated tower (minutes) total min.	Elevated tower gallons
4/17/17	651	8.1	24877	383.0		334200	45900	60	45000
4/18/17	658	8.1	24877	383.0		351200	60700	20	15000
4/19/17	679	8.1	24877	383.0		359500	67900	18	13500
4/20/17	657	8.1	24877	383.0		367800	75100	17	12750
4/21/17	651	8.1	24877	383.0		384000	89300	5	3750
						92300	**89300**		**90000**
4/24/17	652	8.1	24877	383.0		408600	110700	20	15000
4/25/17	656	8.1	24877	383.0		424900	124900	17	12750
4/26/17	644	8.1	24877	383.0		424900	124900	0	0
4/27/17	642	8.1	24877	383.0		441400	139300	17	12750
4/28/17	650	8.1	24877	383.0		458000	153600	0	0
						74000	**64300**		**40500**
5/1/17	642	8.1	24877	383.0		509300	198200	60	45000
5/2/17	575	8.1	24877	383.0		525900	212700	30	22500
5/3/17			24877	383.0				17	12750
5/4/17	649	8.1	24877	383.0		559700	242100	17	12750
5/5/17	731	8.1	24877	383.0		568100	249400	30	22500
						110100	**95800**		**115500**
5/8/17	739	8.1	24877	383.0		600700	277800	110	82500
5/9/17	716	8.1	24877	383.0		608900	285000	20	15000
5/10/17	731	8.1	24877	383.0		613100	292100	0	0
5/11/17	737	8.1	24877	383.0		625100	299100	54	40500
5/12/17	744	8.1	24877	383.0		641300	313200	30	22500
					137000	**73200**	**63800**		**160500**
5/15/17	N/A	N/A	24877	383.0		697400	362200	80	60000
5/16/17	N/A	N/A	24877	383.0		722100	383800	40	30000
5/17/17	N/A	N/A	24877	383.0		746900	405300	40	30000
5/18/17	N/A	N/A	24877	383.0		780300	434700	120	90000
5/19/17	N/A	N/A	24877	383.0		816700	465900	45	33750
					328100	**175400**	**152700**		**243750**
5/22/17	689	8.1	24877	383.0		916500	552400	100	75000
5/23/17	562	8.1	24877	383.0		931300	565200	20	15000
5/24/17	569	8.1	24877	383.0		953900	584800	40	30000
5/25/17	549	8.1	24877	383.0		978100	605600	20	15000
5/26/17	555	8.0	24877	383.0		999000	624700	120	90000
					341100	**182300**	**158800**	no chart	**225000**
5/29/17	holiday							no chart	
5/30/17	531	7.9	24877	383.0		99200	85100	40	30000
5/31/17	523	7.9	24877	383.0		121600	104300	40	30000
6/1/17	506	7.8	24877	383.0		151200	129500	40	30000
6/2/17	533	8.1	24877	383.0		184700	157900	100	75000
						184700	**157900**		**165000**
6/5/17	528	8.1	24877	383.0		266800	226500	17	12750
6/6/17	552	8.1	24877	383.0		288100	247000	20	15000
6/7/17	545	8.1	24877	383.0		309500	267600	20	15000
6/8/17	545	8.2	24962	383.0		333000	290100	55	41250
6/9/17	545	8.2	24969	383.0		383300	299300	125	93750
						198600	**141400**		**177750**

Make-up 18,000 - 21,000 gallons per day YTD

Overall Water Use

7/1/2017

	Sump make-up through filters A&B	**Elevated Tower**	**Canal**
Instrument	GF Signet P51530-P0 Flow Sensors, Signet Accum-U-Flow meter**	Calculation using daily chart recorder.	Krohne Altoflux IFS 4000 F Electromagnetic Flowmeter
Calibration/Service Frequency	Serviced as needed	Serviced as needed	Annual calibration
Gallons YTD	3,824,800* Gallons YTD	3,991,500 Gallons YTD	4,377,500 Gallons YTD
Average Gallons Daily	18,213 Avg. Gallons Daily	21,931 Avg. Gallons Daily	24,182 Avg. Gallons Daily

**Does not include first 11 weeks due to meters not working*
***Replacing with new meter*

Water Use Analysis

	ΔT 1°	ΔT 2°	ΔT 5°	ΔT 10°
Evaporation	36.36%	50.00%	64.52%	71.43%
Bleed	9.09%	12.50%	16.13%	17.86%
Drift	54.55%	37.50%	19.35%	10.71%

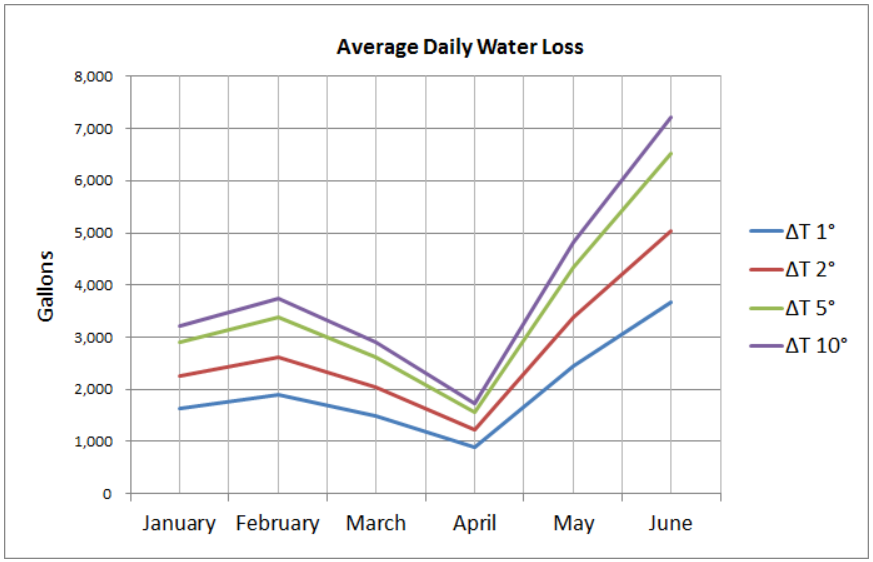
Formulas provided by ASHRAE and Water Dynamics:

- The Evaporation loss equals the (system flow rate) x (.01) x (ΔT)
- The Bleed-off loss equals the (evaporation loss)/(cycles of concentration -1)
  - PPPL maintains 5 cycles of concentration (evap + bd)/bd
- The Drift loss equals the the (system flow rate) x (0.0015)
- The Makeup GPM is the total of the three previous values

Water Use Analysis

	ΔT 1°	ΔT 2°	ΔT 5°	ΔT 10°
January	1,638	2,253	2,907	3,219
February	1,909	2,625	3,387	3,751
March	1,480	2,035	2,626	2,908
April	886	1,218	1,572	1,741
May	2,452	3,372	4,351	4,818
June	3,670	5,047	6,512	7,211
Total YTD	**362,827**	**498,938**	**643,829**	**712,882**

Approximate range

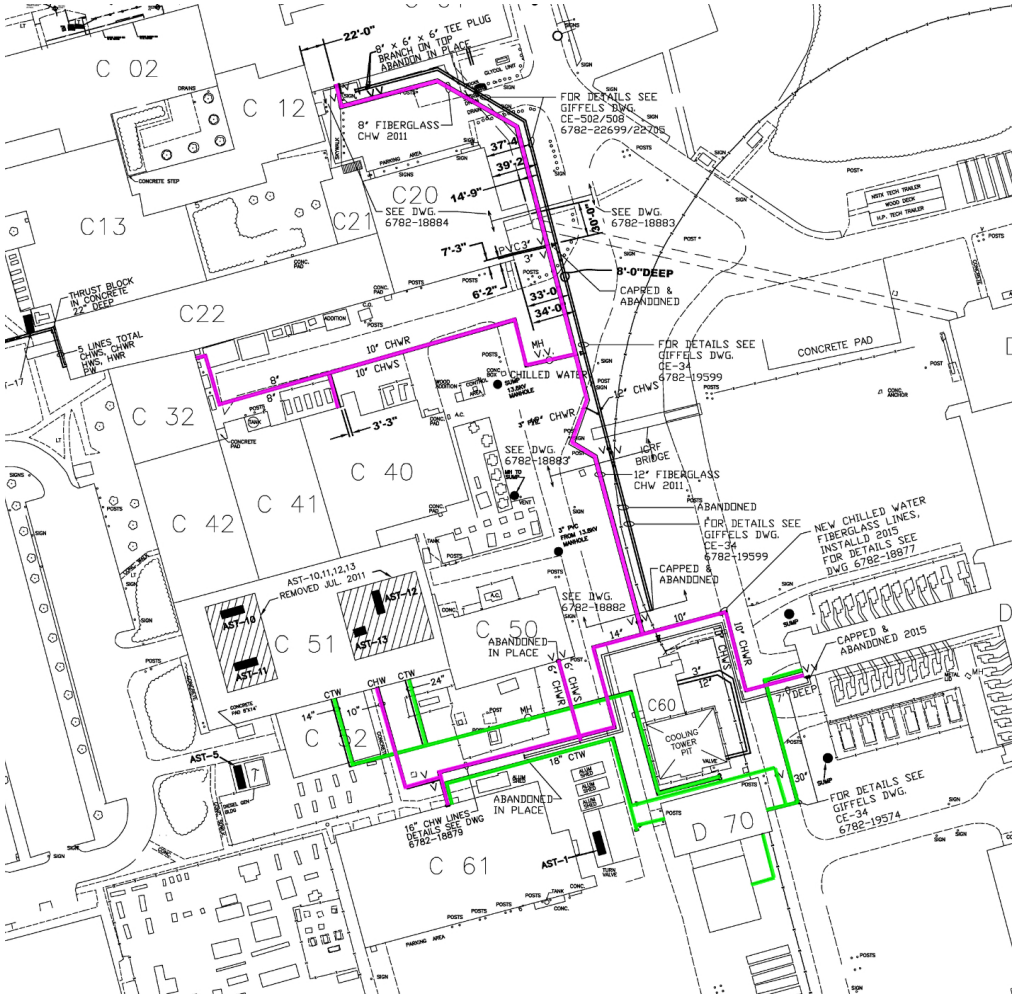


- There are between 1000 - 7000 gallons a day unaccounted for
- There are between 360,000 - 713,000 gallons YTD unaccounted for
- Without an absolute ΔT it is hard to determine actual amount

System Repairs

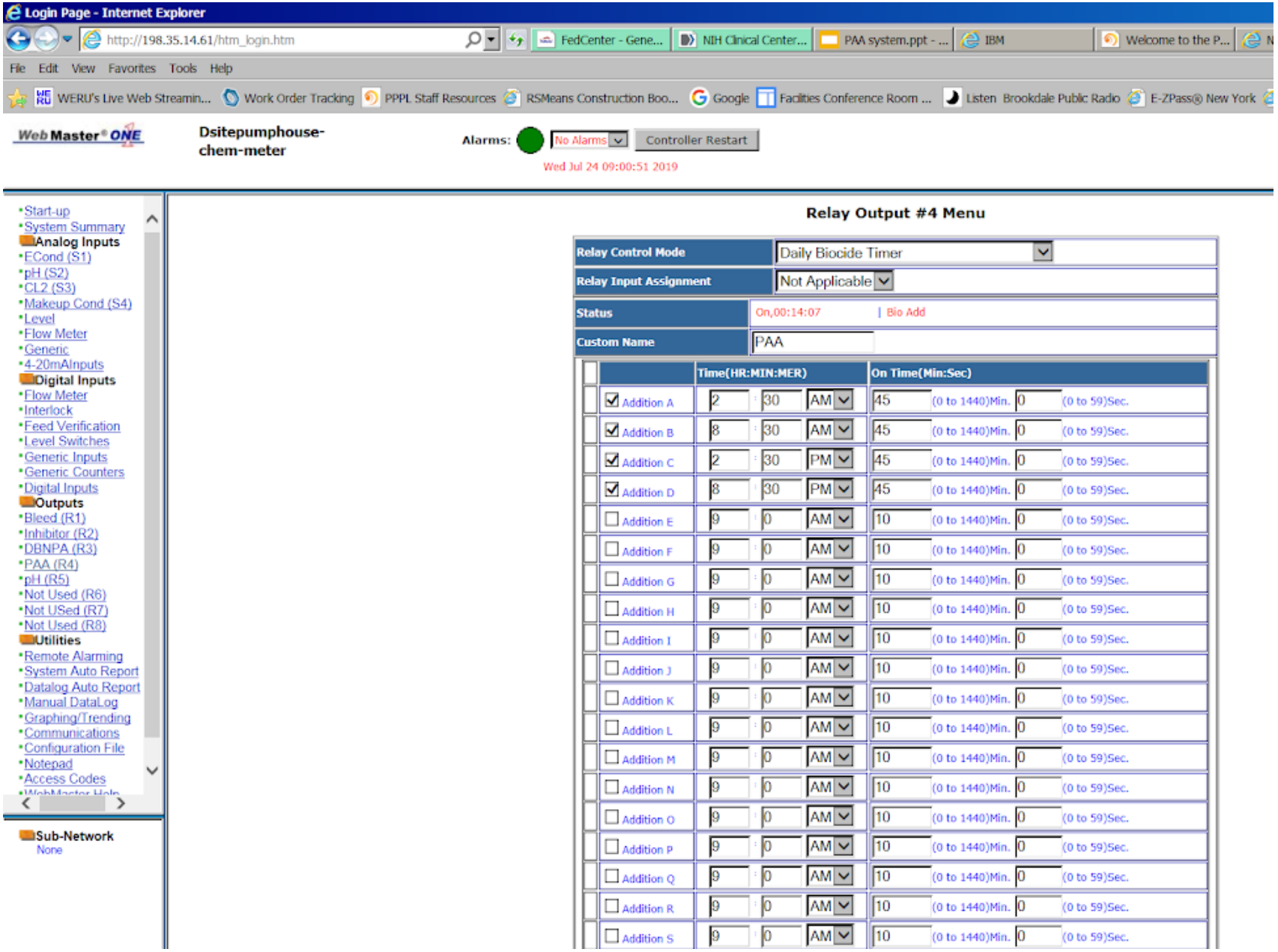
- Power-operated actuator blowdown valve
- Cooling Tower ‘Filter B’ backwash valve
- Canal check valve
- Strainer
- VFD fan control
- Tower leaks

Cooling Tower Water & Chilled Water Lines



Conclusions

- There are infrastructure issues that are causing the system loop to lose water
- It is difficult to achieve target chemical levels while the water is constantly being diluted with make-up water and/or losing water
- Large quantities of chemicals are being injected to overcome these issues, creating a financial strain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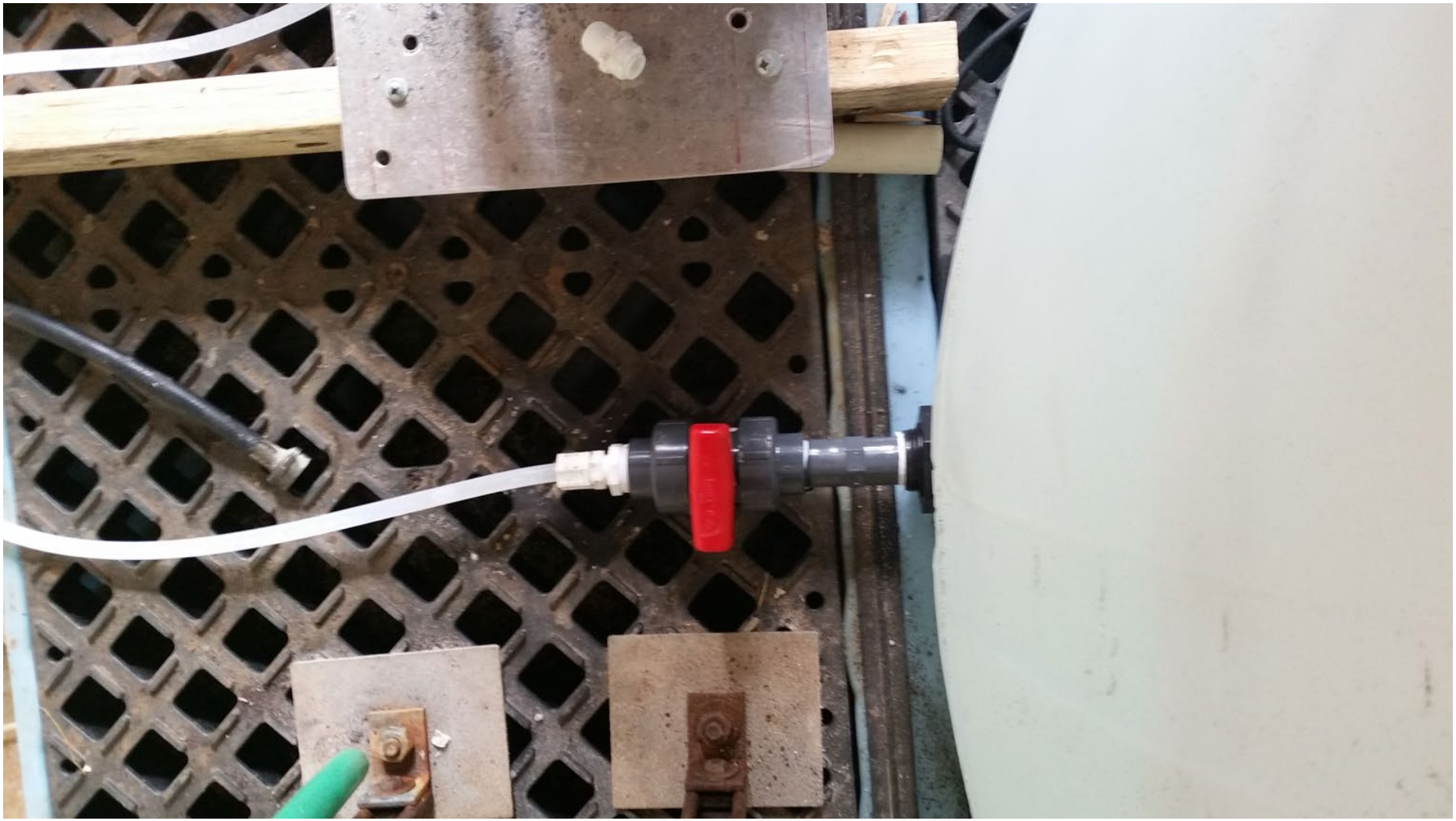
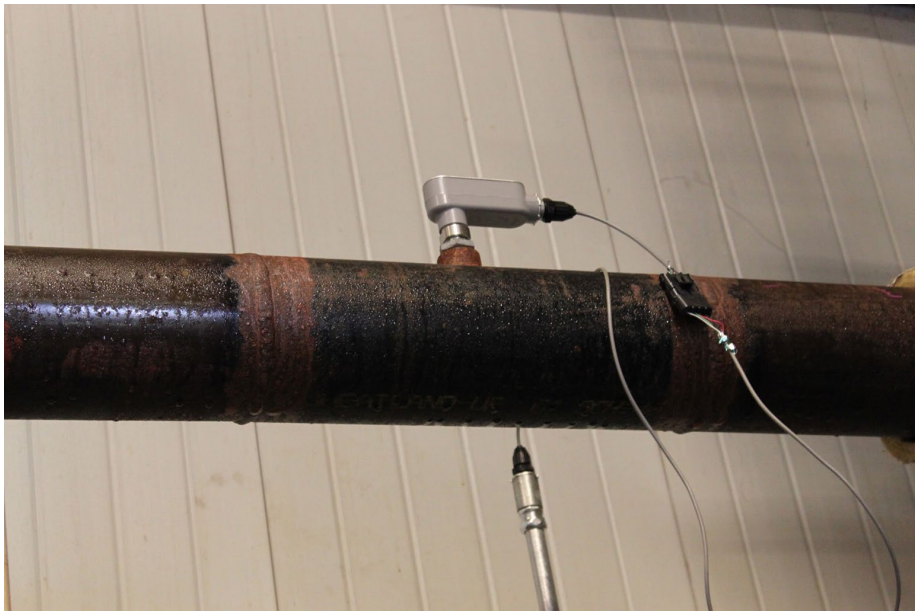
File Edit View Favorites Tools Help
Web Master ONE
Dsitepumphouse-chem-meter
Alarms:
No Alarms
Controller Restart
Wed Jul 24 09:00:51 2019
Start-up
System Summary
Analog Inputs
ECond (S1)
pH (S2)
CL2 (S3)
Makeup Cond (S4)
Level
Flow Meter
Generic
4-20mAInputs
Digital Inputs
Flow Meter
Interlock
Feed Verification
Level Switches
Generic Inputs
Generic Counters
Digital Inputs
Outputs
Bleed (R1)
Inhibitor (R2)
DBNPA (R3)
PAA (R4)
pH (R5)
Not Used (R6)
Not USed (R7)
Not Used (R8)
Utilities
Remote Alarming
System Auto Report
Datalog Auto Report
Manual DataLog
Graphing/Trending
Communications
Configuration File
Notepad
Access Codes
Sub-Network
None
Relay Output #4 Menu
Relay Control Mode
Daily Biocide Timer
Relay Input Assignment
Not Applicable
Status
On,00:14:07
| Bio Add
Custom Name
PAA
Time(HR:MIN:MER)
On Time(Min:Sec)
Addition A 2 30 AM 45 (0 to 1440)Min. 0 (0 to 59)Sec.
Addition B 8 30 AM 45 (0 to 1440)Min. 0 (0 to 59)Sec.
Addition C 2 30 PM 45 (0 to 1440)Min. 0 (0 to 59)Sec.
Addition D 8 30 PM 45 (0 to 1440)Min. 0 (0 to 59)Sec.
Addition E 9 0 AM 10 (0 to 1440)Min. 0 (0 to 59)Sec.
Addition F 9 0 AM 10 (0 to 1440)Min. 0 (0 to 59)Sec.
Addition G 9 0 AM 10 (0 to 1440)Min. 0 (0 to 59)Sec.
Addition H 9 0 AM 10 (0 to 1440)Min. 0 (0 to 59)Sec.
Addition I 9 0 AM 10 (0 to 1440)Min. 0 (0 to 59)Sec.
Addition J 9 0 AM 10 (0 to 1440)Min. 0 (0 to 59)Sec.
Addition K 9 0 AM 10 (0 to 1440)Min. 0 (0 to 59)Sec.
Addition L 9 0 AM 10 (0 to 1440)Min. 0 (0 to 59)Sec.
Addition M 9 0 AM 10 (0 to 1440)Min. 0 (0 to 59)Sec.
Addition N 9 0 AM 10 (0 to 1440)Min. 0 (0 to 59)Sec.
Addition O 9 0 AM 10 (0 to 1440)Min. 0 (0 to 59)Sec.
Addition P 9 0 AM 10 (0 to 1440)Min. 0 (0 to 59)Sec.
Addition Q 9 0 AM 10 (0 to 1440)Min. 0 (0 to 59)Sec.
Addition R 9 0 AM 10 (0 to 1440)Min. 0 (0 to 59)Sec.
Addition S 9 0 AM 10 (0 to 1440)Min. 0 (0 to 59)Sec.



Install Canal Water Conductivity Probe

BEFORE

AFTER



Use conductivity delta to determine blowdown cycles