TESTING OF PAA AND SODIUM HYPOCHLORITE FOR WET WEATHER DISINFECTION

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Brian Clark

Same Old, Same Old?

'60 '70 '80 '90 '00 '10 '20

Ohio

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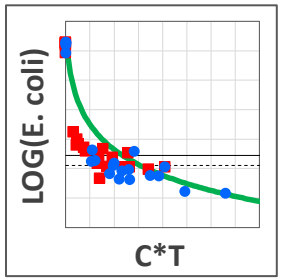
Acknowledgements

- Barry Zerkle, Superintendent, City of Sidney
- Brian Clark, Assistant Superintendent, City of Sidney
- Gregg Mitchell, Laboratory Chemist, City of Sidney
- Jamie Gellner, Hazen and Sawyer
- Tony Farina, Hazen and Sawyer

Presentation Overview

Project Background

Bench Scale Testing
of PAA and Hypo



Results and Discussion

Full Scale Implications

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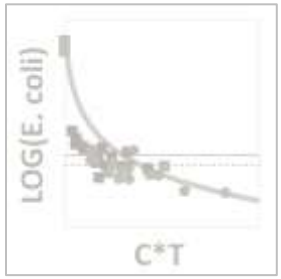


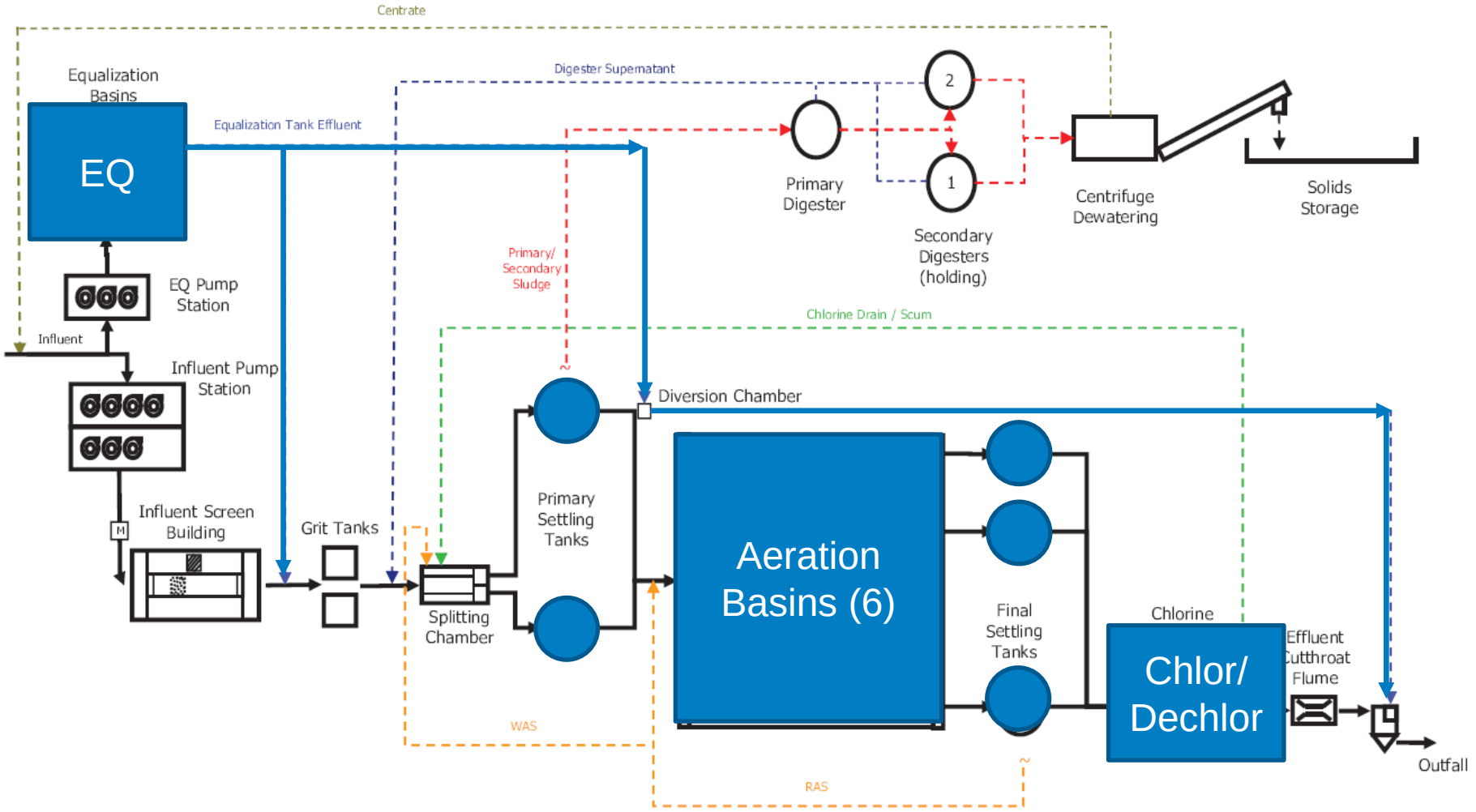
Results and Discussion

Full Scale Implications

Plant / Project Overview

- Permitted capacity: 7 mgd
  - Peak wet weather flows up to 36 mgd
- All flows must be disinfected prior to discharge
- Current secondary effluent disinfection method: chlorine gas
- UV selected for secondary effluent – alternate disinfection needed for wet weather
- E. coli limits
  - Weekly: 284 / 100 mL
  - Monthly: 126 / 100 mL
- TRC: 0.038 mg/L

City of Sidney WWTP Treatment Process



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Disinfection Alternatives Considered

- Sodium hypochlorite
  - Long track record. Similar to chlorine disinfection currently used for secondary effluent
- Peracetic acid (PAA)
  - Relatively new to municipal disinfection
  - Highly effective disinfectant
- On site hypo generation (OSG)
  - Low concentration of hypo produced → high storage volume
  - Intermittent use, long payback period

What is peracetic acid?

$$\underbrace{CH_3COOH}_{\text{Acetic Acid (15\% - 38\%)}} + \underbrace{H_2O_2}_{\text{Hydrogen Peroxide (9\% - 23\%)}} \longleftrightarrow \underbrace{CH_3COOOH}_{\text{Peracetic Acid (12\% – 15\%)}} + H_2O$$

- Used as a disinfectant and sanitizer in the food industry since 1950s.
- Commonly used in Europe for municipal WW disinfection
- Highly effective disinfectant. PAA doses can be 2 – 4 times less than Hypo doses on secondary effluent

PAA Manufacturers and Chemical Information

Manufacturer	Chemical	PAA	Hydrogen Peroxide	Acetic Acid	Solution Density
PeroxyChem	VigorOX WWTII	15%	9 – 11%	33 – 38%	9.42 lb/gal
Enviro Tech	Bio Side HS	15%	22%	15 – 16%	
Solvay	Proxitane WW-12	12%	18.5%	15%	9.2 lb/gal

- Freezing point: - 50 to - 60 ^{o}F.

Case Studies – Other Locations and Design Doses

Location	Application	Dose	Residual
Steubenville, OH	Secondary Effluent	1.5 mg/L	0.4 mg/L
Pittsburgh, PA (ALCOSAN)	Primary Effluent		5.5 – 6 mg/L
Detroit	CSO	10 mg/L	6 – 8 mg/L
Louisville, KY	Primary Effluent	10 mg/L	
	Secondary Effluent	1.5 - 2 mg/L	

PAA vs Hypochlorite

Chemical	Advantages	Disadvantages
PAA	• No formation of disinfection by-products (DBPs, not currently regulated at Sidney) • Potentially lower dosage requirement • Potentially less chemical required for neutralization • Less costly when neutralization not required • Lower volume storage requirement • Longer shelf life	• Higher chemical cost • Limited number of suppliers • SST tanks and piping required for bulk feed system (higher cost) • Slight increase in effluent BOD
Hypo	• Long track record of wastewater disinfection • Multiple manufacturers • Lower chemical cost	• Potential formation of DBPs • Degradation of stored chemical at higher concentrations • Neutralization with sodium bisulfite (SBS) required • Higher dose requirement

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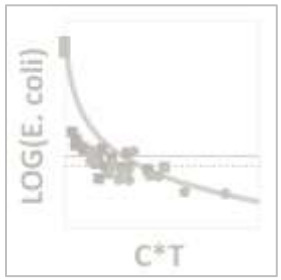

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Wet Weather Disinfection Dose Testing Plan

- Goal: determine dose-response curves at representative water quality of wet weather events
- Sampling period: July – September 2014 (dry weather)
- Sampling events
  - At least one event during week and one on weekend
- Sampling locations
  - Influent / Final Effluent
  - Manufactured blend
- Chemicals and manufacturers tested
  - Hypo - Univar
  - PAA – Peroxychem VigorOX (15%)

Key Parameters of Wastewater Disinfection

Dose (mg/L) = Total Demand (mg/L) + Residual (mg/L)

- Facility sizing
  - Pumps
  - Storage

- TSS
- Organic matter
- Particulates
- Colloidal material
- Organisms (E. coli, fecal coliform, etc)
- Etc….

- Contact time
  - Basin size and design flow
- E. coli kill
- Determined through jar testing and dose response curves

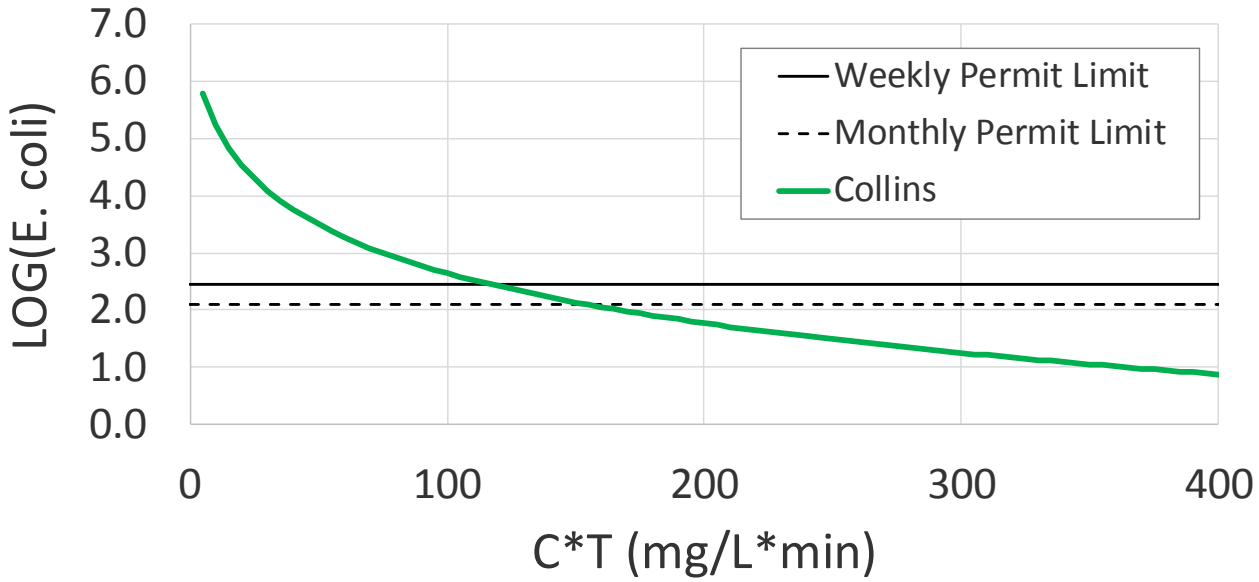
Testing Objectives: Determine Key Disinfection Parameters

Objectives

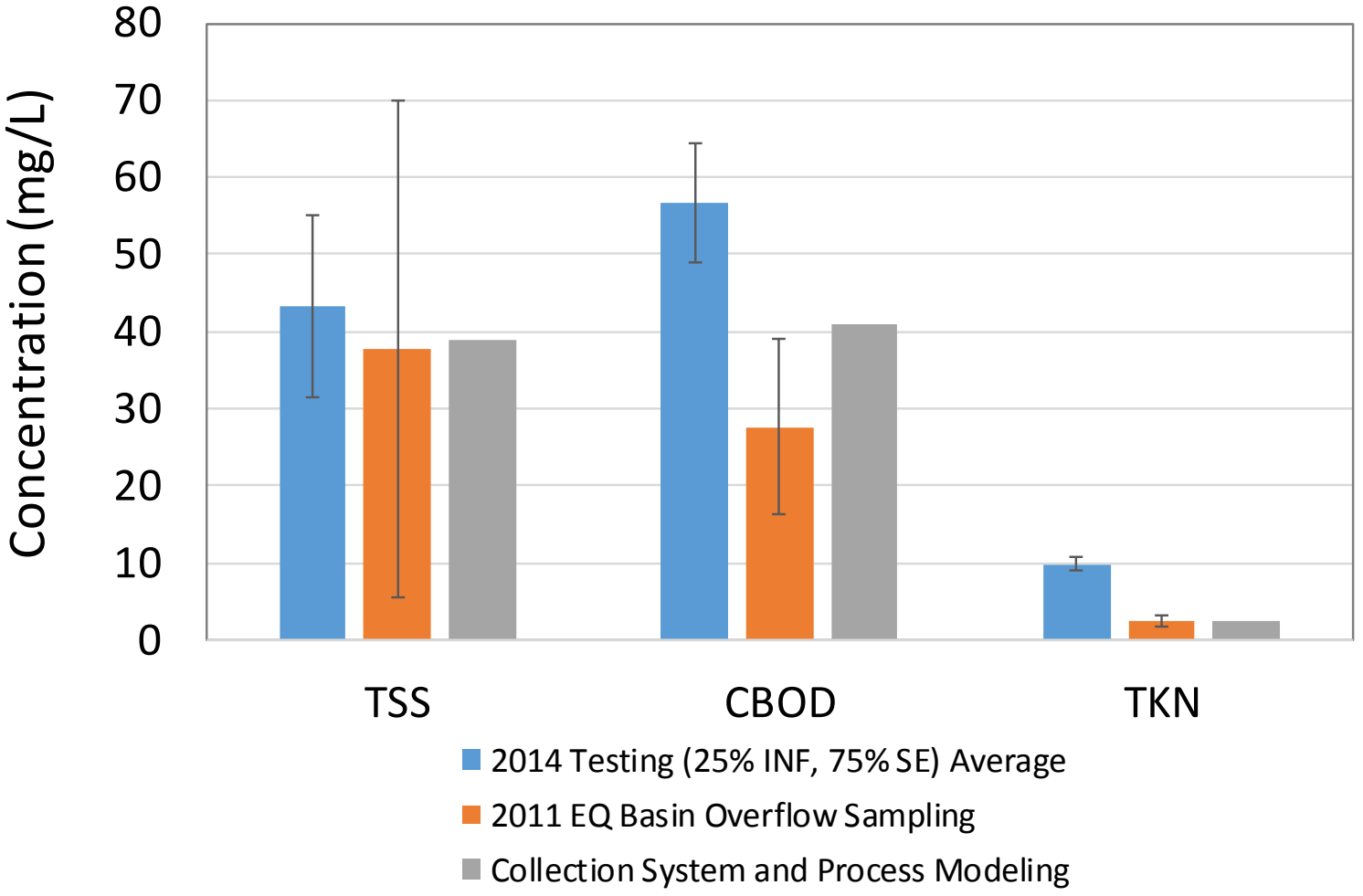
- Develop dose-response curves at representative water quality to determine target dose and contact time
- Compare performance of PAA and hypo to select one chemical for design

Critical Disinfection Parameters

- E.coli initial and final
- T: Contact time (minutes)
- C: Chemical residual (mg/L)
- C_o: Chemical dose (mg/L)



Wet Weather Flow Characterization

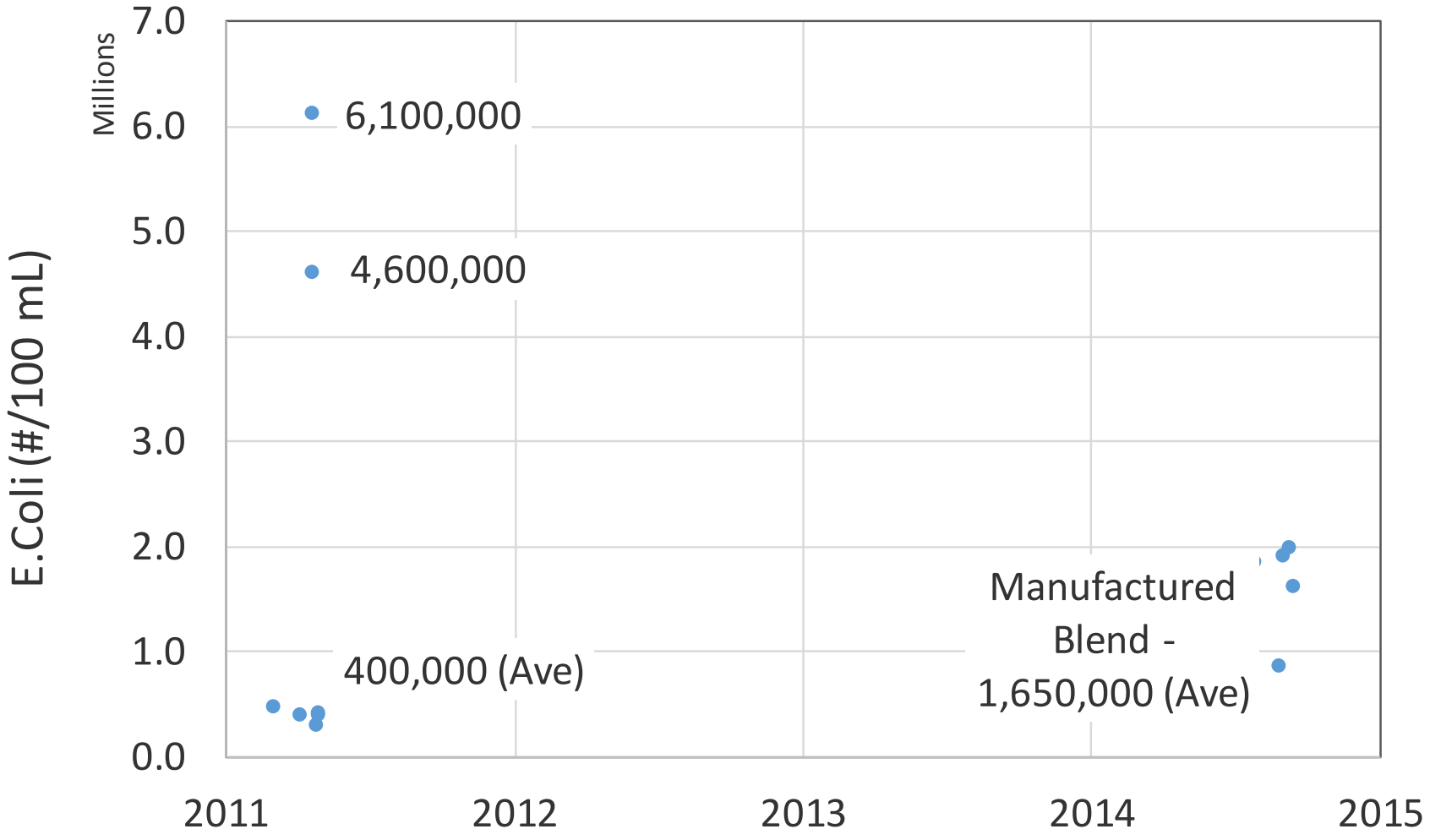


Wet Weather Disinfection Testing

- City staff performed benchtop testing
  - 7 testing events, each included PAA and hypo at multiple doses and contact times
  - Blend of 25% influent and 75% secondary effluent (based on achieving TSS and CBOD5 concentrations similar to anticipated wet weather concentrations)

● - PAA (11) ● - Hypo (12)		Total Contact Time		
		20	30	60
Dose	5	●		
	7		● ● ●	● ●
	10	● ● ●	● ● ● ●	● ●
	15	● ●		
	20	● ●		

E. Coli Concentration in Wet Weather Flows



Dose-Response Testing Samples

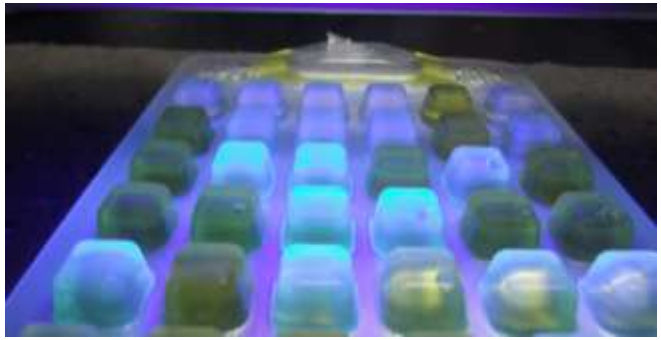
- Analysis
  - TSS, CBOD, TKN, alkalinity, pH, fecal coliform, E. coli, temp
  - Total residual chlorine/PAA
- Contact time periods
  - 5, 10, 15, 20, 30, 60 min
- Hypo, PAA doses
  - 5, 7, 10, 15, 20 mg/L (also 0 mg/L control)

Sampling procedures

- Simulated wet weather samples dosed with PAA / hypo and stirred initially to simulate rapid mixing
- Samples were not continuously mixed during remainder of test to simulate a typical contact tank

Sampling Procedures (cont'd)

- Samples were collected and analyzed for E.coli and disinfectant residual
- PAA and hypo residual: Total Chlorine method (8167).
  - PAA determined by applying PAA factor (1.07 * equivalent CL_2 dose)
- E.coli sample incubation: Model 251 incubator bath
  - Incubation temperature: 35 deg C
  - Duration: 18 – 22 hours
- E. coli sample measurement:
  - IDEXX Colilert-18



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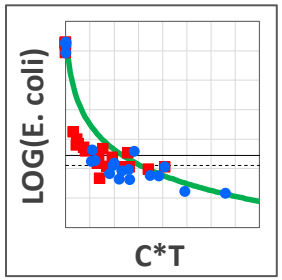

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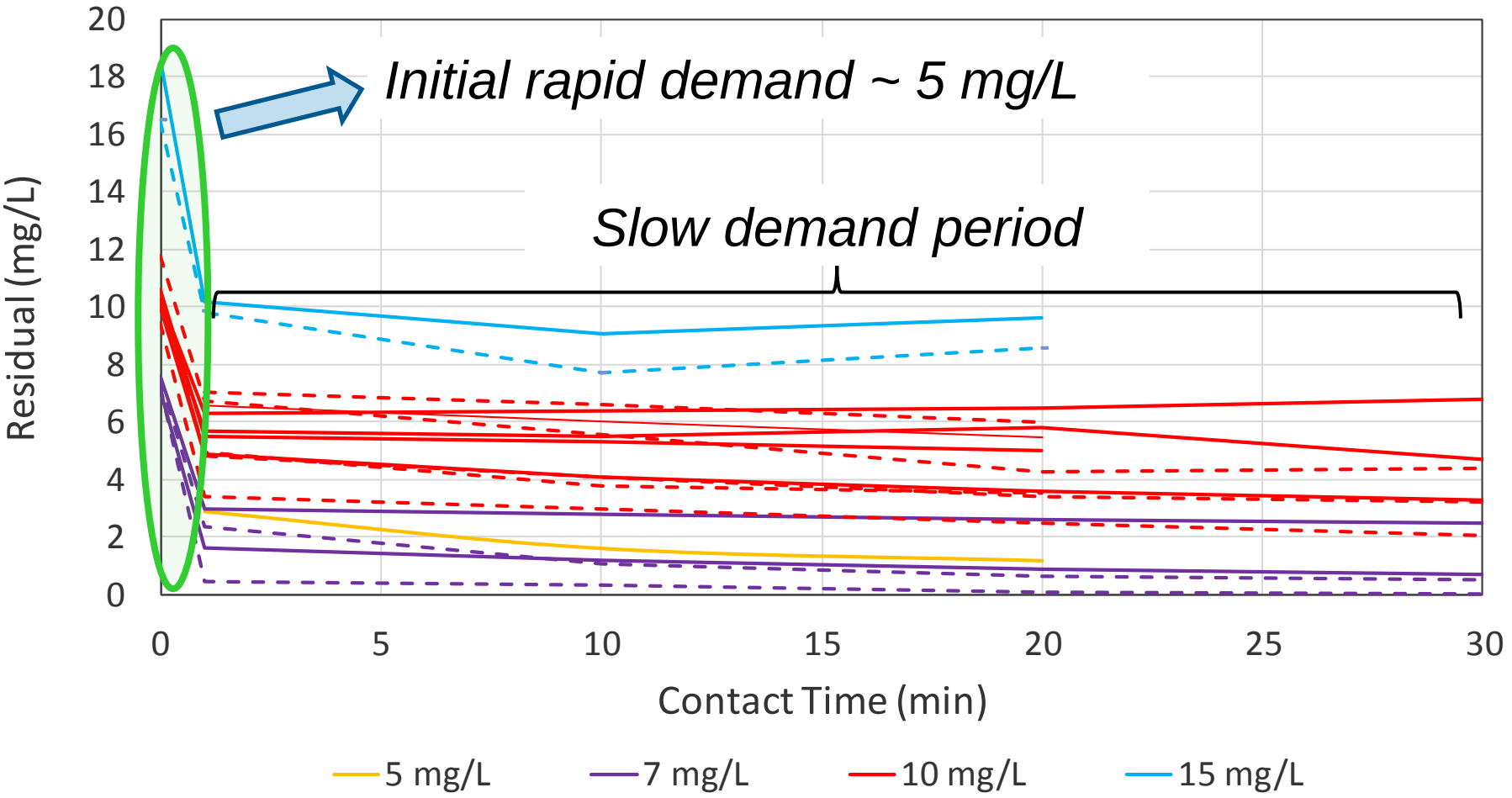
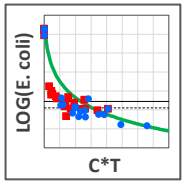
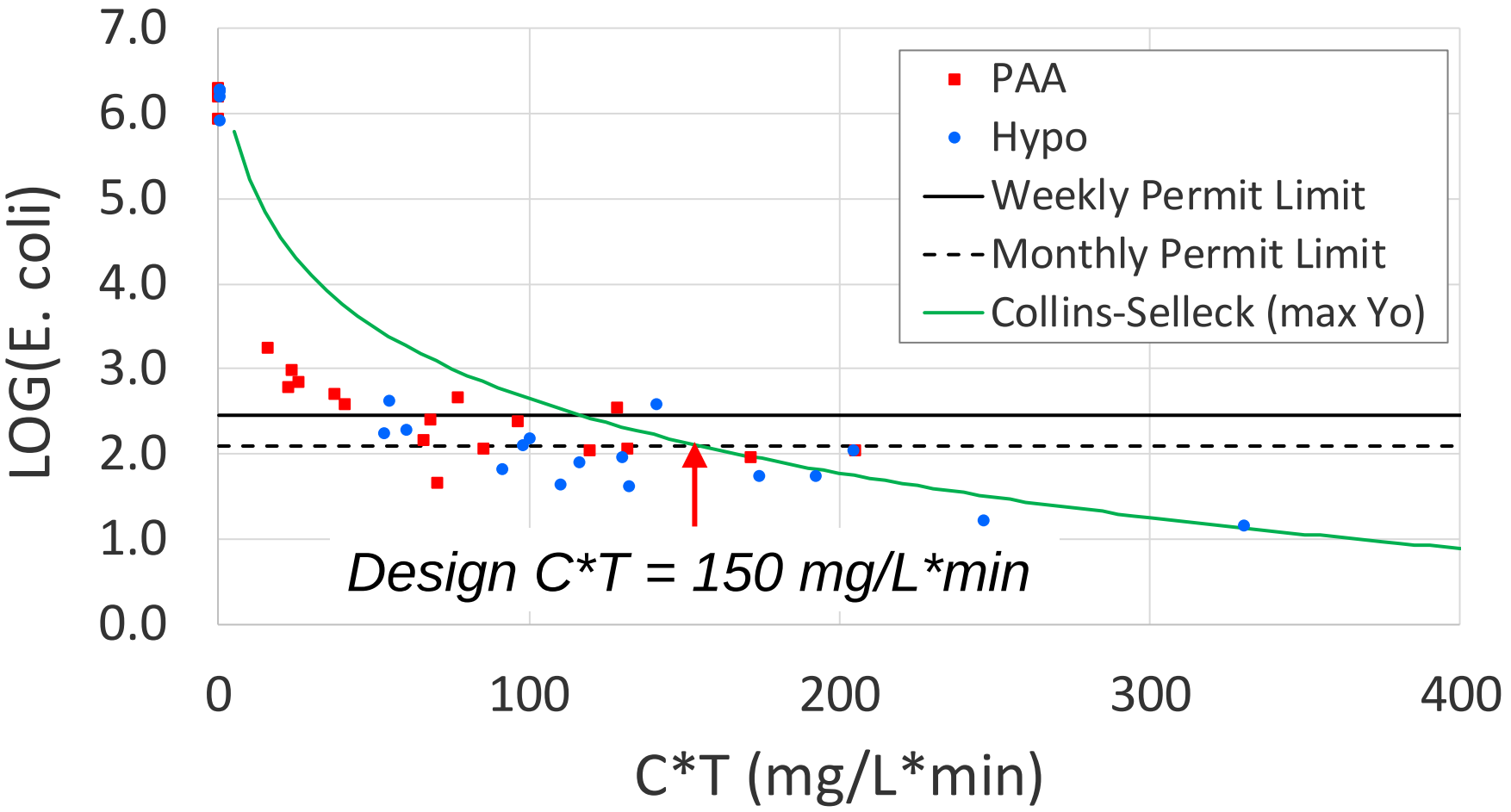
Test Results – Measured Residual

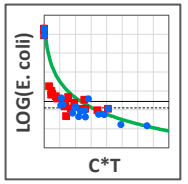


Determination of Design C*T





Selection of Design Parameters



- Jar Testing

C*T = 150 mg/L*min

Design Parameters

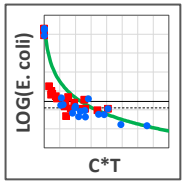
- Dose
- Residual
- Chem. Demand
- Contact Time

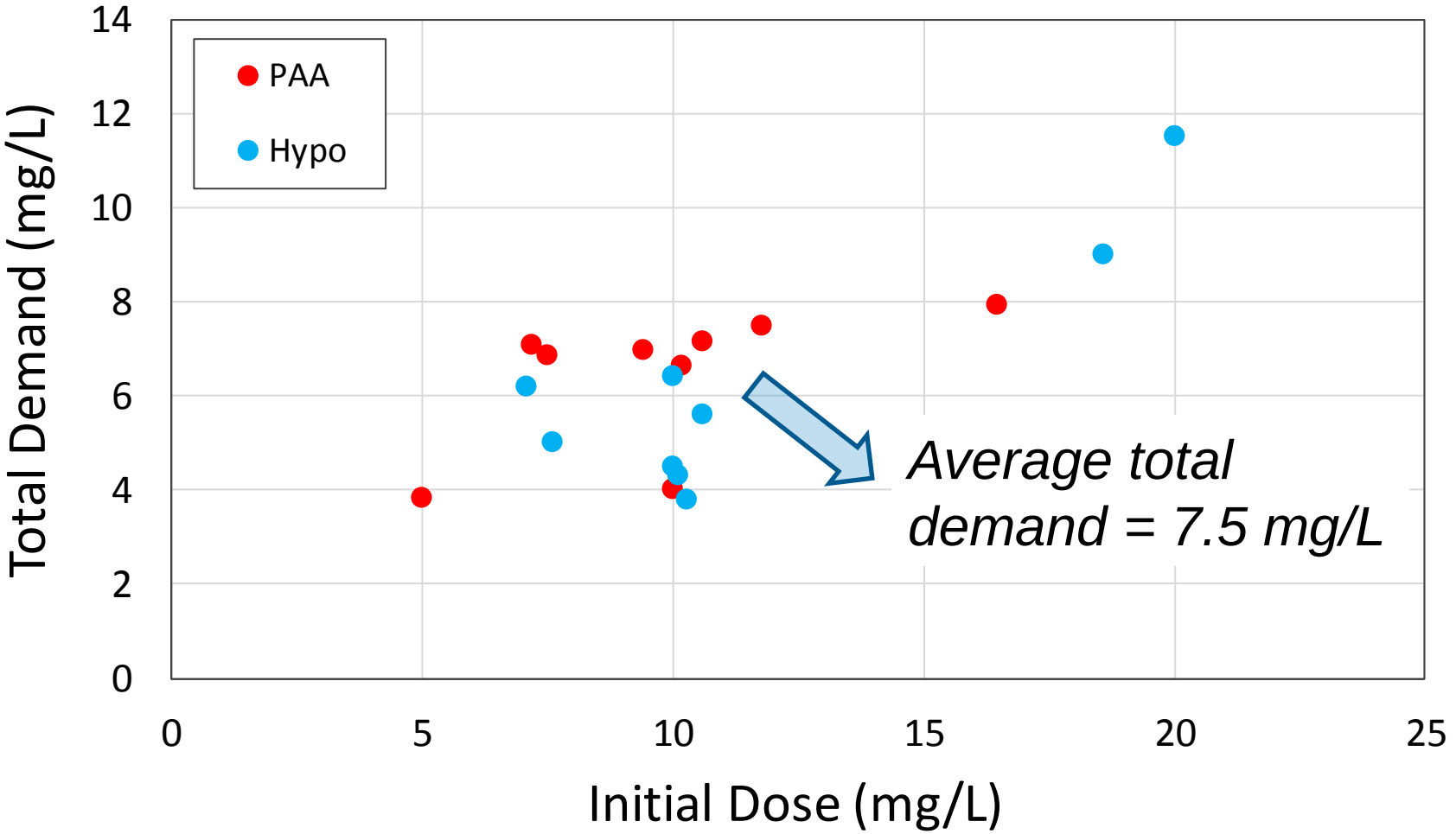
- Contact Tank
- Pumps
- Chemical Storage

System Sizing

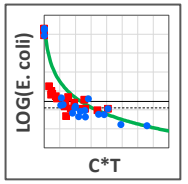
- *C = 20 minutes selected to optimize balance of basin size, disinfection dose, and chemical storage required.*

Estimation of Chemical Demand at T = 20 minutes





Design Dose

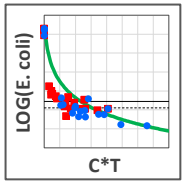


Total Demand (mg/L) + Residual (mg/L) = Dose (mg/L)

7.5 mg/L at C = 20 minutes	7.5 mg/L based on design C*T = 150 mg/L*min	15 mg/L

- *Design dose was the same for PAA and hypo based on jar testing results*

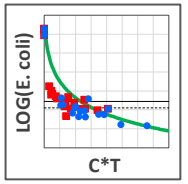
Neutralization



- Current NPDES Total Residual Chlorine Limit: 0.038 mg/L
- Expected residual limit if PAA selected
- Neutralization with sodium bisulfite (SBS) assumed to be required for both chemicals

SBS Dose = 1.5(Hypo/PAA) residual*

Disinfection Design Criteria – Dose / Contact Time



Parameter	PAA	Hypo
Peak Flow (MGD)	22.5	22.5
Peak Volume per Event (MG)	18	18
Target C*T (mg/L*min)	150	150
Contact Time (min)	20	20
Contact Basin Volume (Gal)	315,000	315,000
Target Residual (mg/L)	7.5	7.5
Estimated Demand (mg/L)	7.5	7.5
Design Dose (mg/L)	15	15
SBS Required?	Yes	Yes
SBS Dose (mg/L)	12	12

1. Peak flow based on maximum influent pumping capacity of 36 MGD and secondary treatment maximum hydraulic capacity of 13.5 MGD.
2. Estimated demand observed during testing for similar feed dose and contact time. Actual demand will vary depending on feed dose and other variables.

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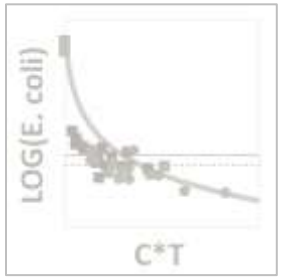


Results and Discussion

Full Scale Implications

PAA vs Hypo

	PAA	Hypo
Strength Available	12% or 15%	5% - 12.5%
Anticipated feed dose (mg/L)	15	15
Shelf life (per manufacturer)	6-12 months	3-6 months (5%)
Neutralization required?	Yes	Yes
Availability	Limited number of suppliers (2, possibly more)	Widely available
Disinfection byproducts	Does not form	Can form trace amounts
Impact on other parameters	Increases BOD, decreases pH	Increases pH
Storage options	Totes or SST tank (totes replaced after a few months)	Totes or Plastic Tank
Piping materials of construction	SST	PVC, PE

Chemical Costs – PAA vs Hypo

	PAA	Hypo
Cost per gallon	$7.41 (12%)	$1.12 (8%)
Cost per pound of active chemical ($/lb)	$6.67	$1.67
Cost for one storm event	$15,200 (12%)	$3,160 (8%)
Average volume per year (gal)	4,700	6,500
Average cost per year[1]	$35,700	$7,300
Average cost of SBS per year[1]	$2,600	$2,600

1) Assumes no chemical is wasted and no degradation occurs. SBS dose based on target disinfectant concentration of 7.5 mg/L at end of contact zone; cost is based on $1.89/gallon, and 25% strength.

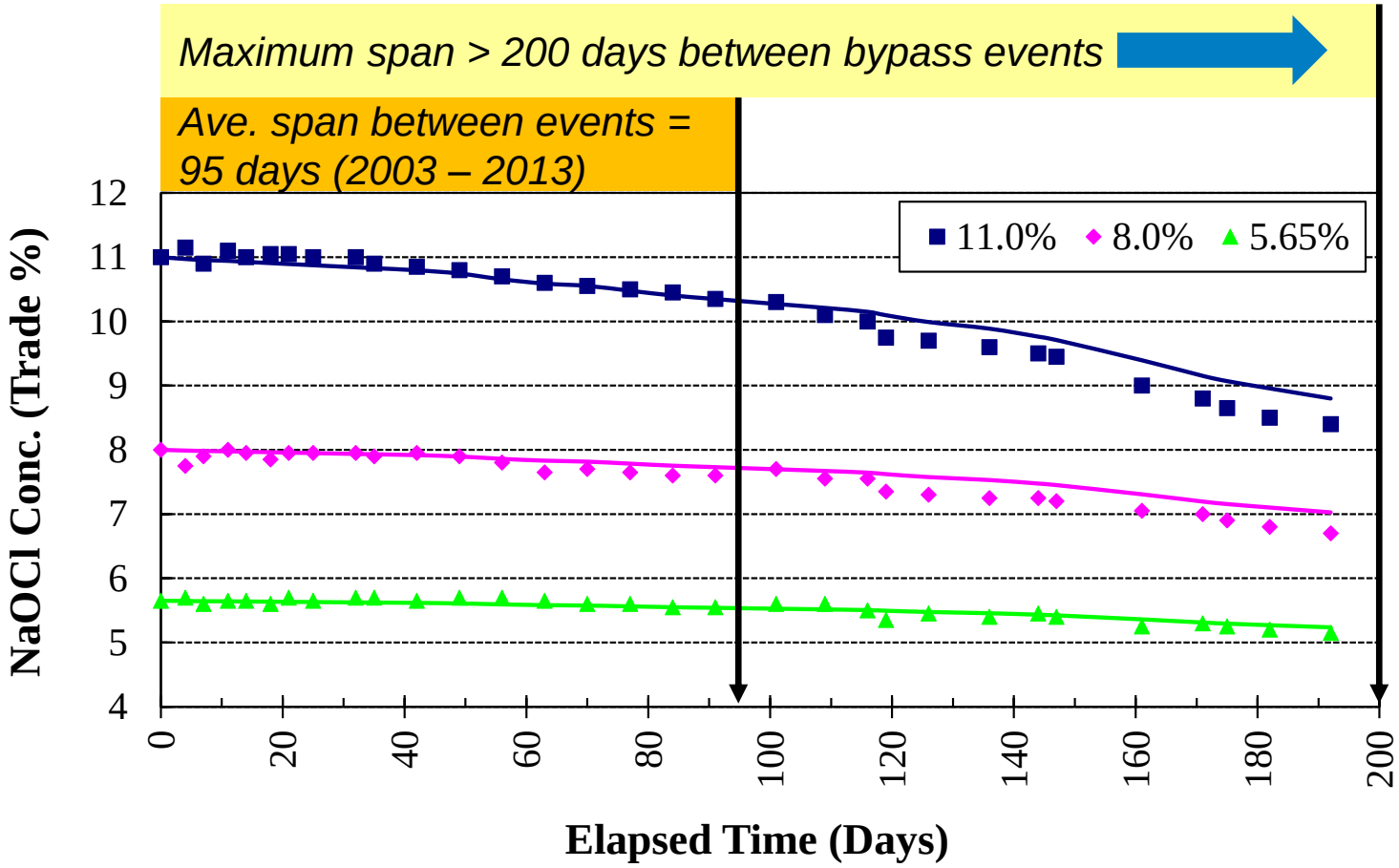
Disinfection Design Criteria – Chemical Volume

Parameter	PAA	Hypo		
Peak Flow (MGD)	22.5	22.5		
Peak Volume per Event (MG)[1]	18	18		
Chemical Strength (%)	12%	12.5%	8%	5%
Chemical Strength (lb/gal)	1.1 lb PAA/gal	1.04 lb Cl_2/gal	0.67 lb Cl_2/gal	0.42 lb Cl_2/gal
Chemical Volume per Event (gal)[2]	2,051	2,400	3,600	5,800
SBS Volume per Event (gal)[3]	700	700	700	700

1) Peak wet weather flow based on peak influent pumping of 36 mgd and maximum secondary treatment capacity of 13.5 mgd.
2) Actual demand will vary based on feed dose and other constituents.
3) 25% SBS supplied by Univar

Hypo Degradation

- Hypo degraded from 12% to 8% during testing (~6 weeks)
- Similar results observed during a study in Detroit



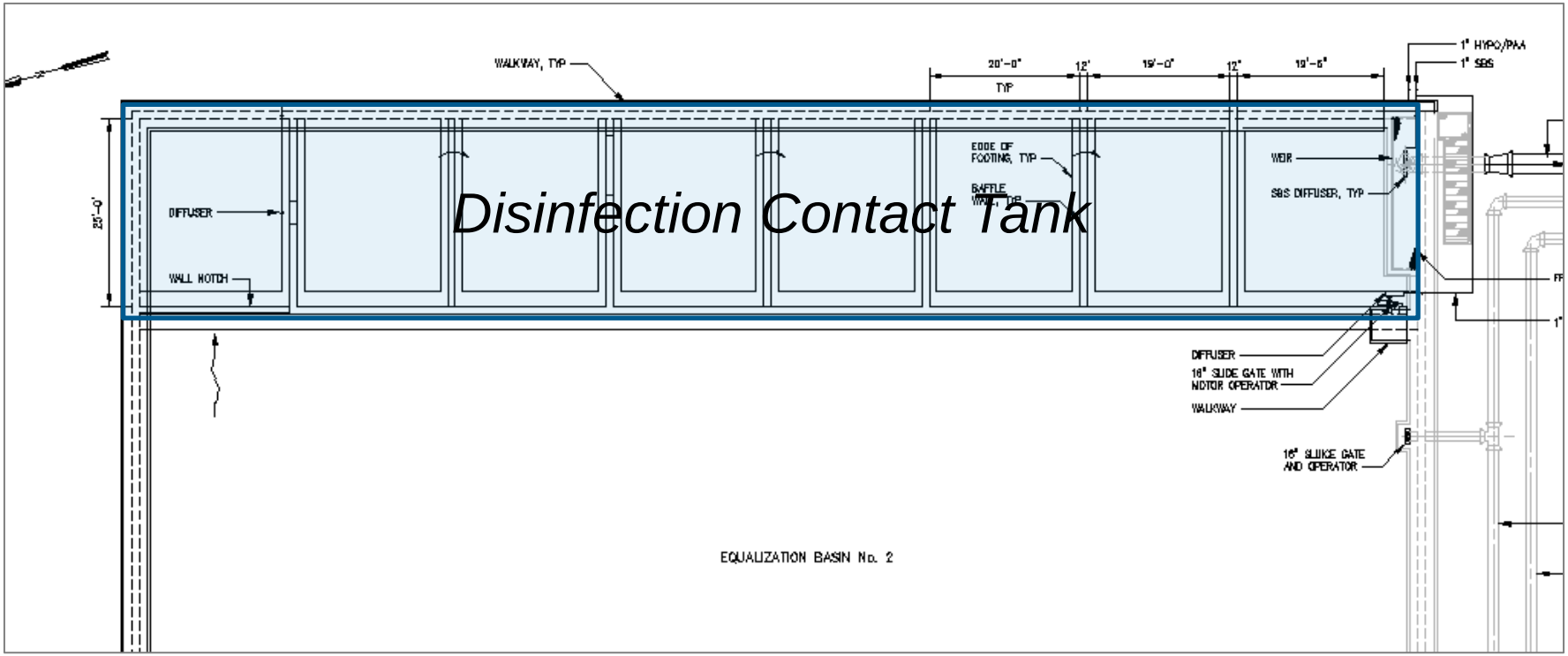
Chemical Selected for Final Design

- 5% Hypo selected based on preliminary cost evaluation
  - High annual cost for PAA vs. Hypo
  - Neutralization required for both chemicals
  - Higher cost materials of construction

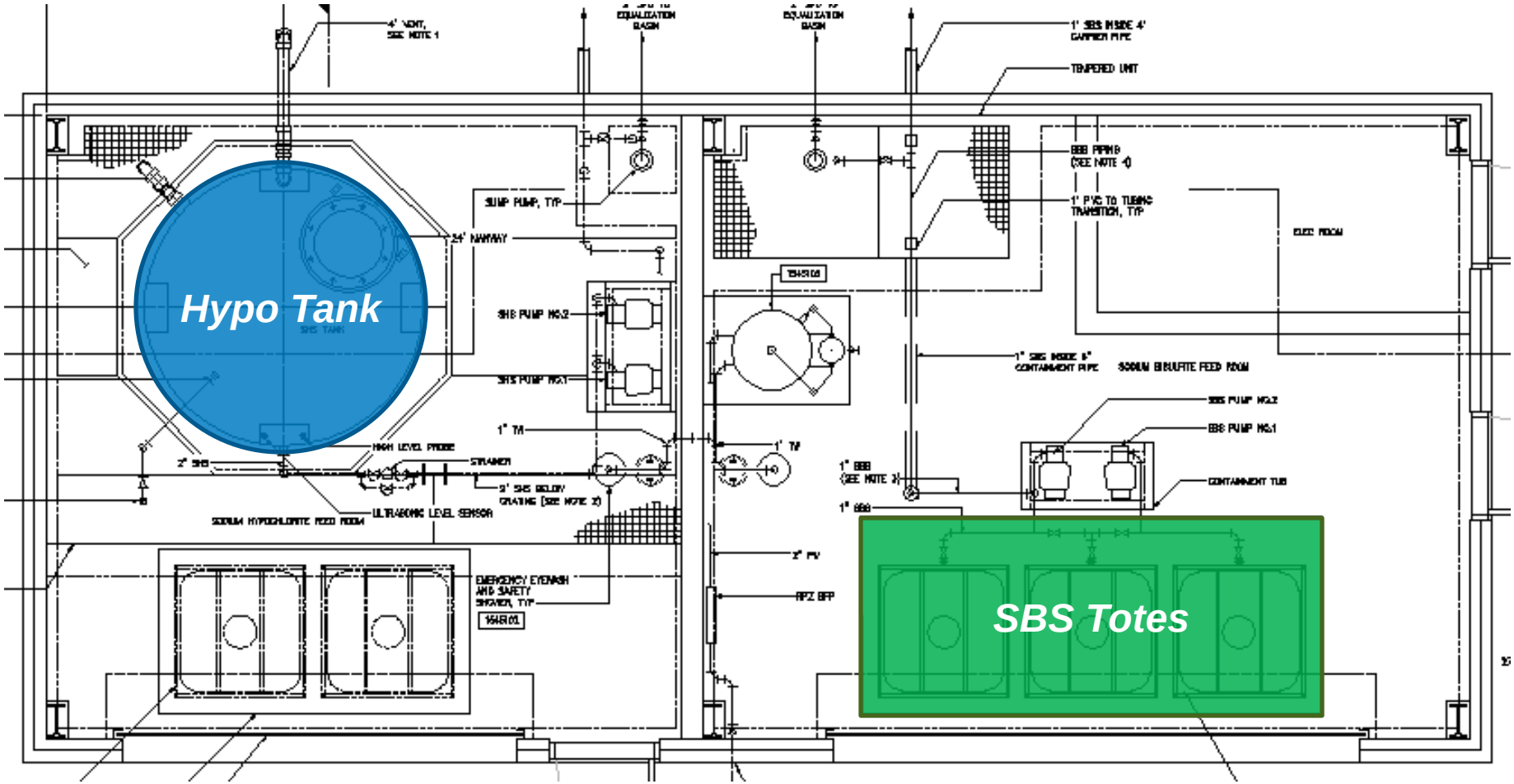
Wet Weather Disinfection Facilities

- Contact Zone
  - Volume: 312,500 gal @ 20 min
  - Inside or adjacent to EQ Basins
- Chemical Feed Building
  - Hypo storage (tank) and feed pumps
  - SBS storage (totes) and feed pumps
  - Concrete foundation, pre-engineered metal building
  - Chemical piping: tube inside PVC carrier pipe, slope to allow draining

Contact Tank



Chemical feed facility layout



Summary

- Both PAA and hypo were found to be effective disinfectants for wet weather flows.
- Similar dosages were required for both PAA and hypo to achieve equivalent E.coli kills for wet weather flows.
  - Based on anticipated doses and residuals, both PAA and hypo would require neutralization
  - Hypo selected for full scale implementation based on costs
- Initial demand and residual for both was high – likely due to wet weather primary effluent quality

Questions?

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