OaSys iCT™

Advanced dosage control for
chemical disinfection applications

2025 Case Studies – Model-based Optimization of Disinfection Chemistries Region of Peel & Baton Rouge

NWWC 2025
Victoria, BC
November 4, 2025

USP technologies™
Solutions for a clean environment

Disinfection Process Control – Can we get better?

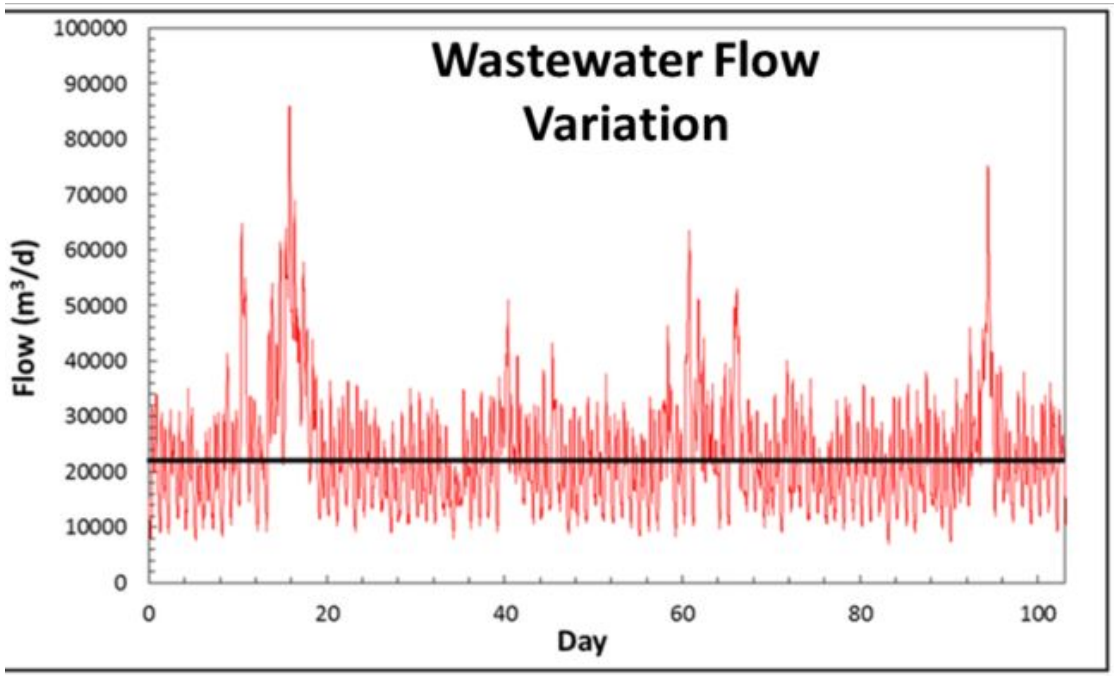
- WRRFs typically overdose disinfectant by a factor of two
- If chemical disinfection is used, several issues arise:
  1. Excessive disinfectant cost and supply disruption
  2. Excessive quenching cost and supply disruption
  3. Risk of DBPs formation (especially with excess chlorination)
  4. Inconsistent performance
  5. Inadequate public health protection (during CSOs, plant upsets, etc.)
- Improving disinfection + saving money: Is this possible?

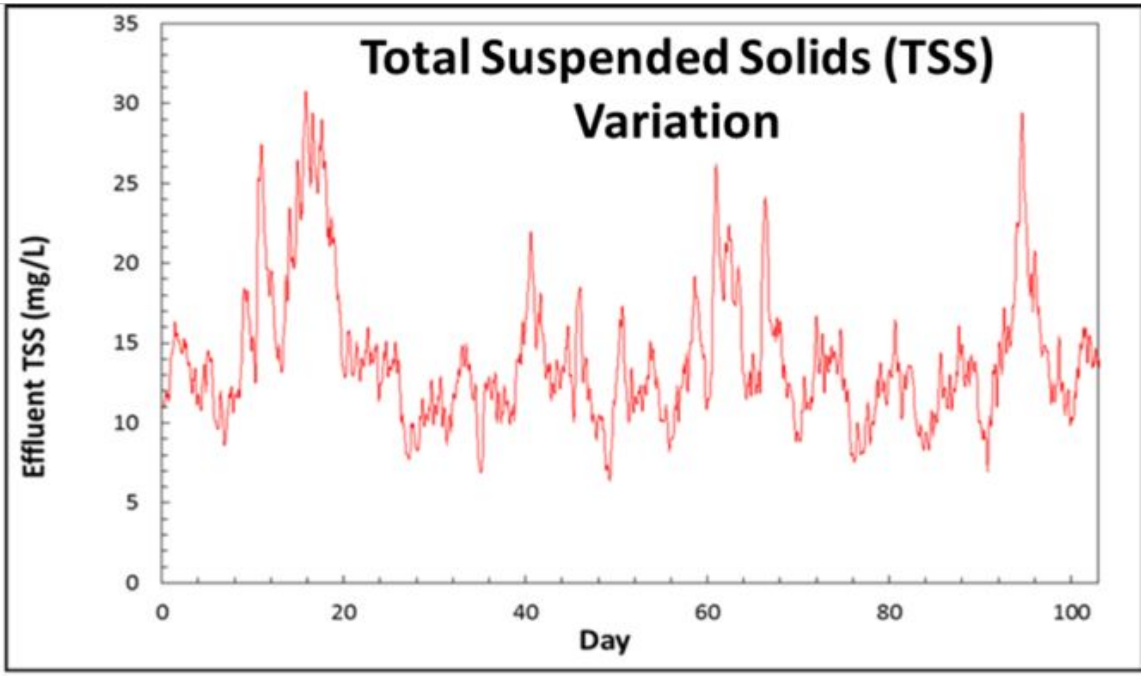
What is OaSys iCT™ Role?

iCT™ is a novel control approach that optimizes disinfection performance by calculating the optimal chemical dosage that accounts for sources of treatment variability in real time.

Recommended for WWTP with:
•Highly variable flow or water quality
•High disinfection and/or quenching costs
•Limited contact basin sizing
•Tightening disinfection permit limits

Considerations for Chemical Disinfection





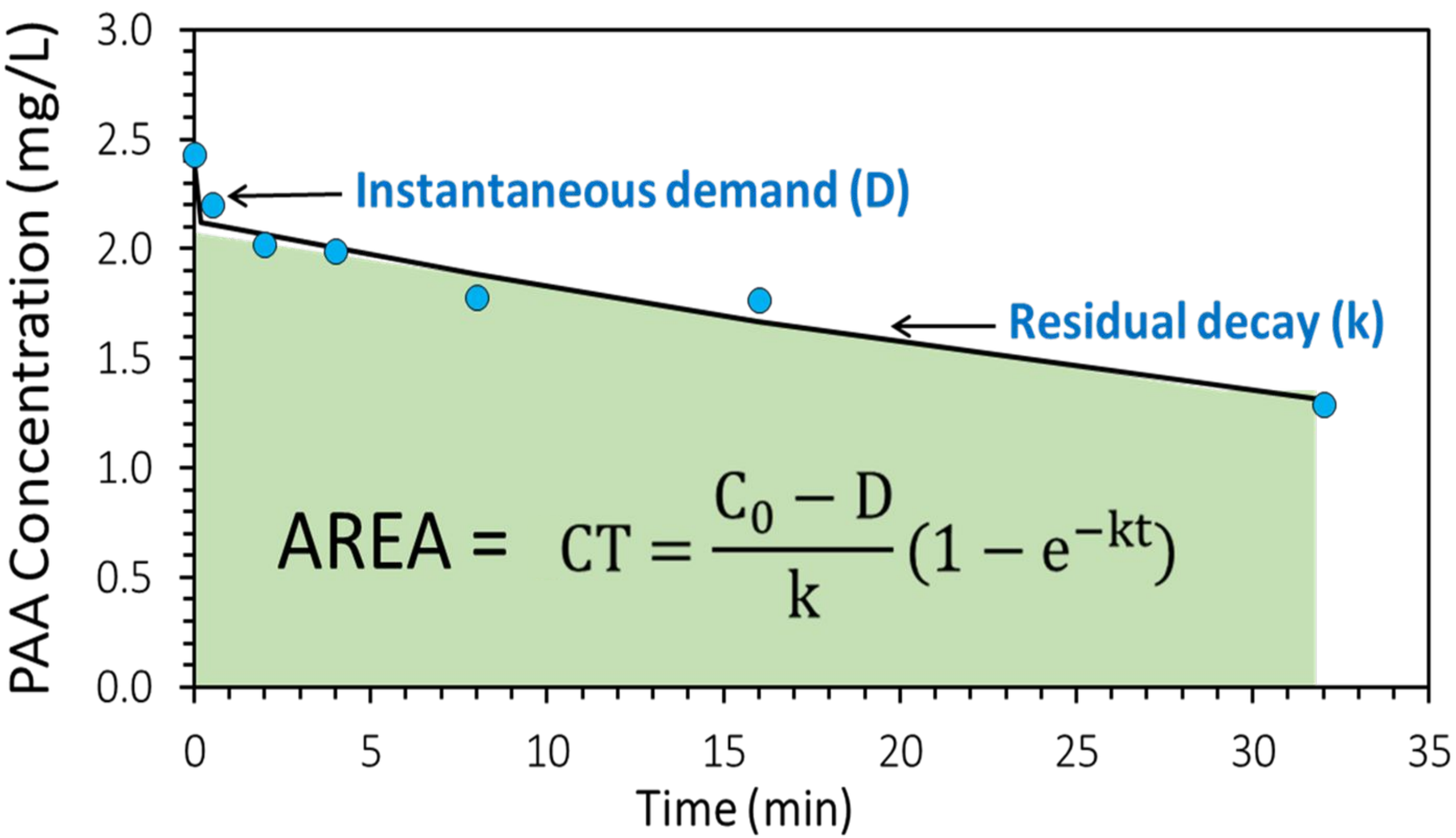
- The primary challenge for chemical disinfection: VARIABILITY
- Flow variability: daily/diurnal hydraulics, rainfall events
- Water quality variability: TSS, BOD, nutrients (e.g. NH_3), upsets, etc.

A Deeper Look: The Integral of CT

Core principle of CT integral: relationship between concentration and time

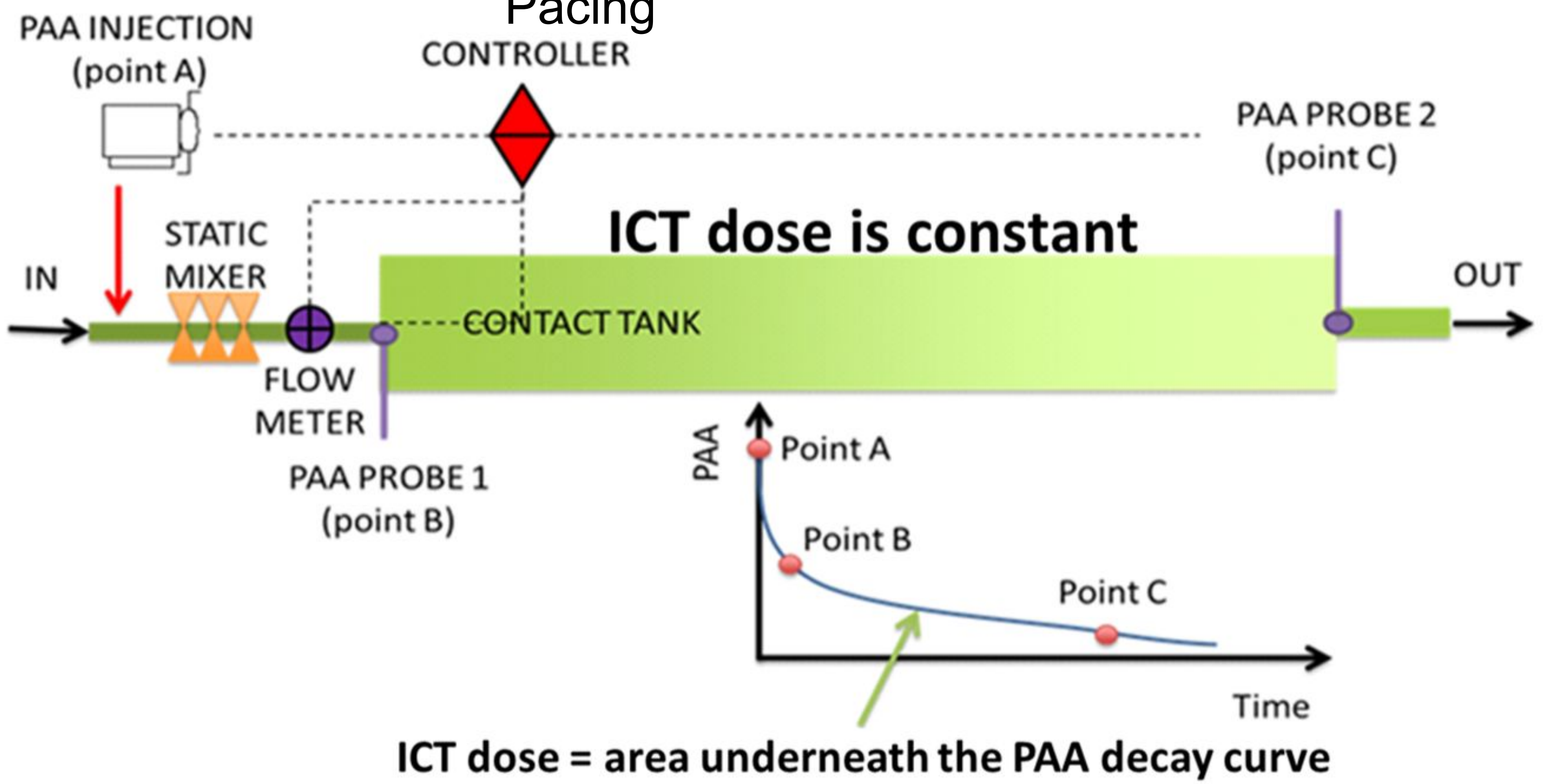
It's a measure of the exposure of microorganisms to the disinfectant

Oxidizing disinfectants have an initial instantaneous demand (D), followed by a slow residual decay (k)

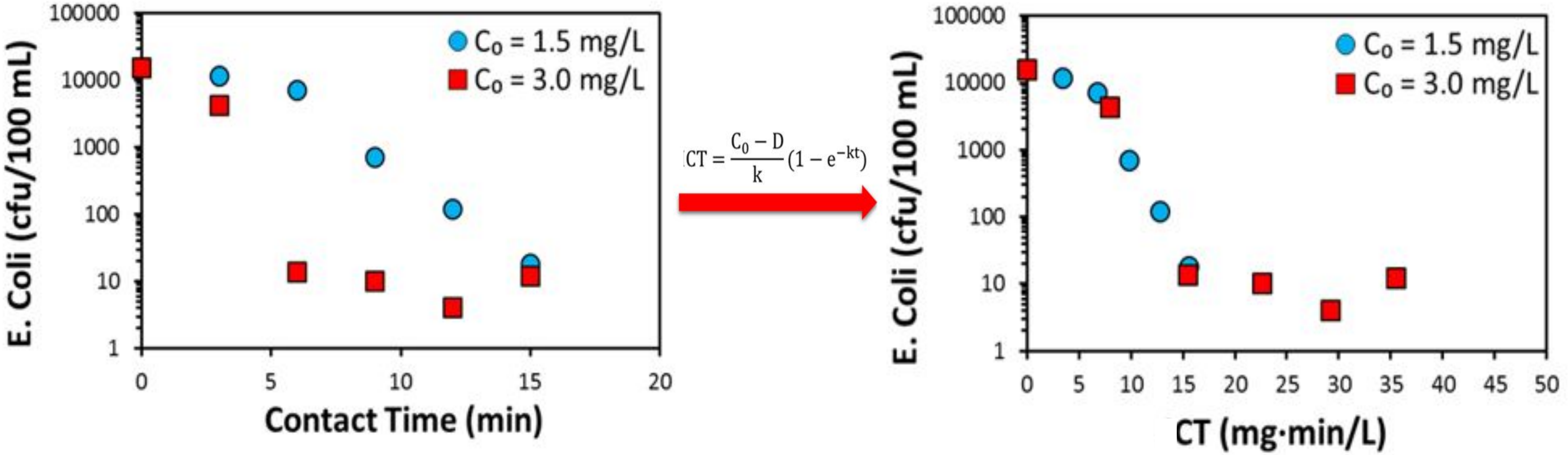


The OaSys iCT™ Approach

OaSys iCT™ Dose Pacing

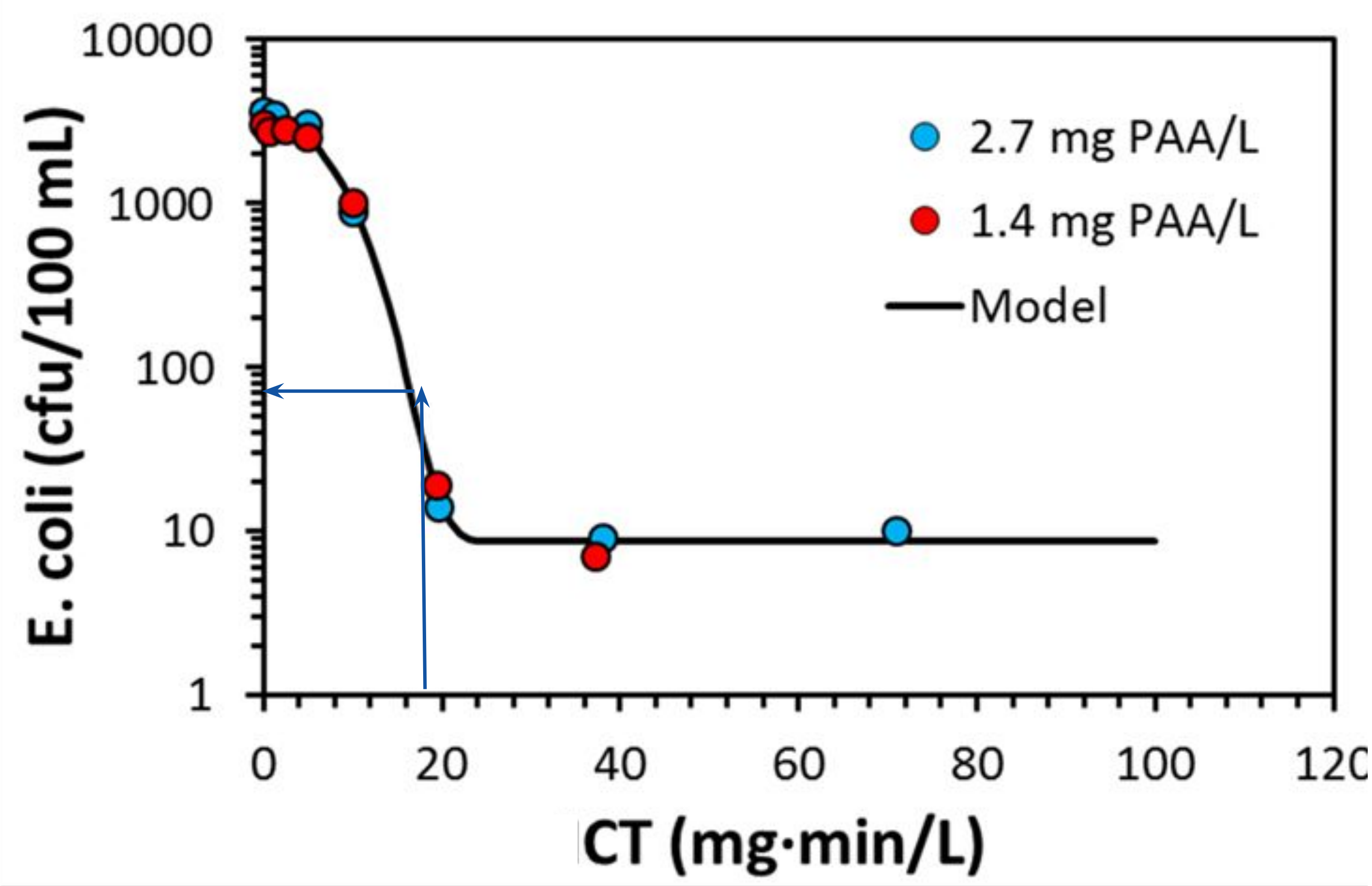


A Deeper Look: The Integral of CT

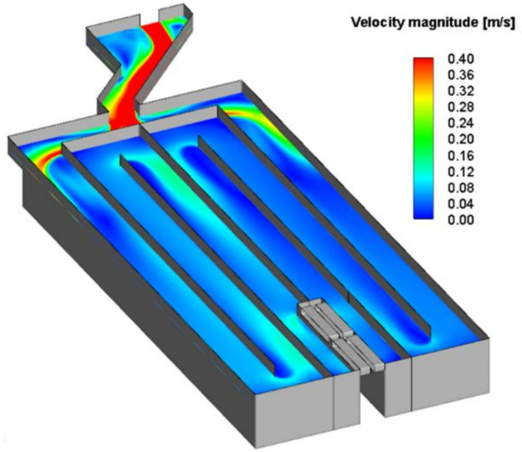


Microbial Kinetics – OaSys iCT™ allows you to control CT dose

A Deeper Look: The Integral of CT

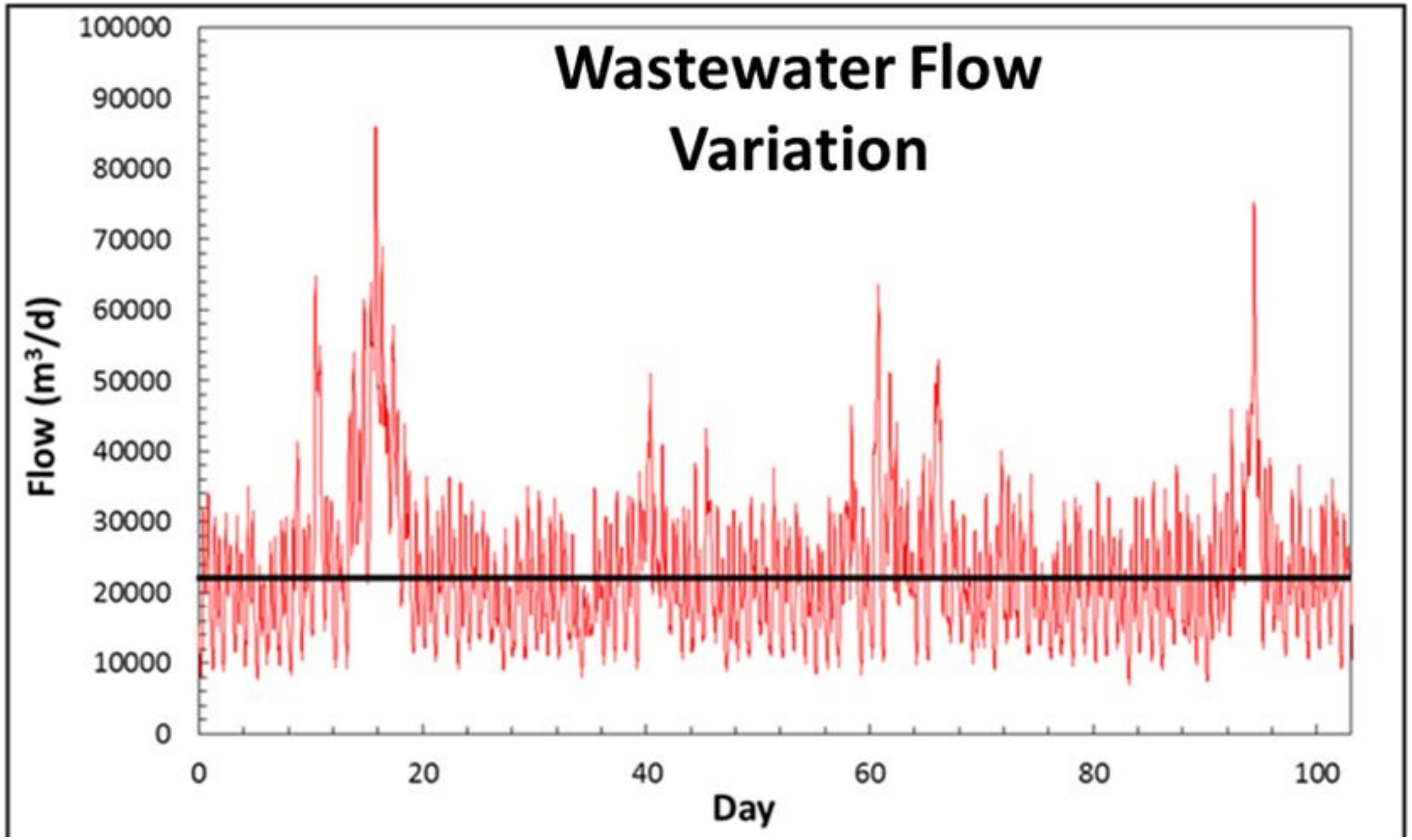


iCT™ incorporates reactor hydraulics and chemical demand and decay into the disinfection model



…and we can use this curve to select our iCT™ setpoint

Flow Pacing: The Variability Problem

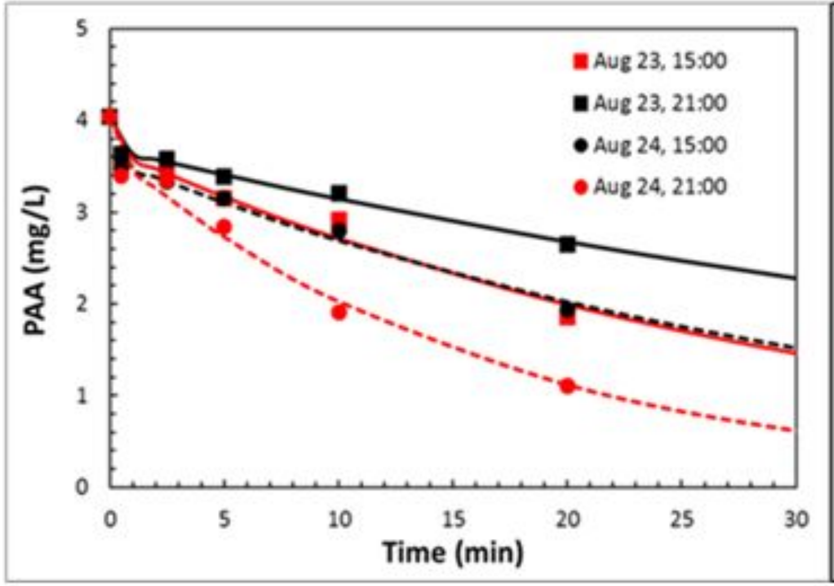


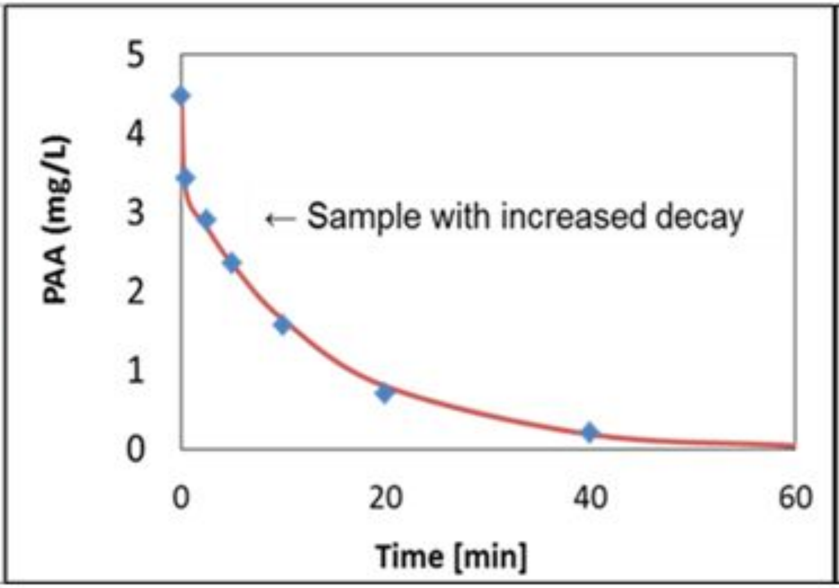
Flow variability = HRT variability

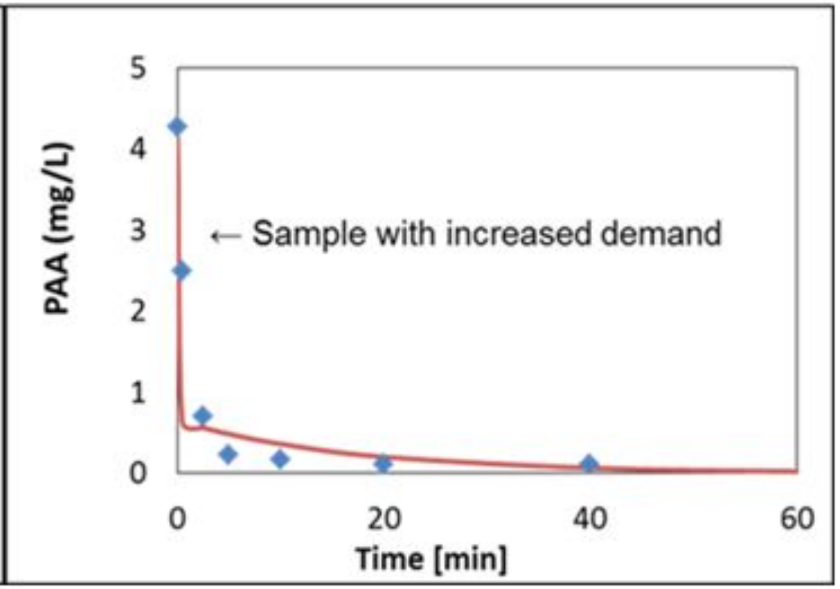
flow-pacing only keeps the concentration fixed

The result is intentional over-dosing

Flow Pacing: Demand/Decay Problems







$$C = (C_0 - D)e^{-kt}$$

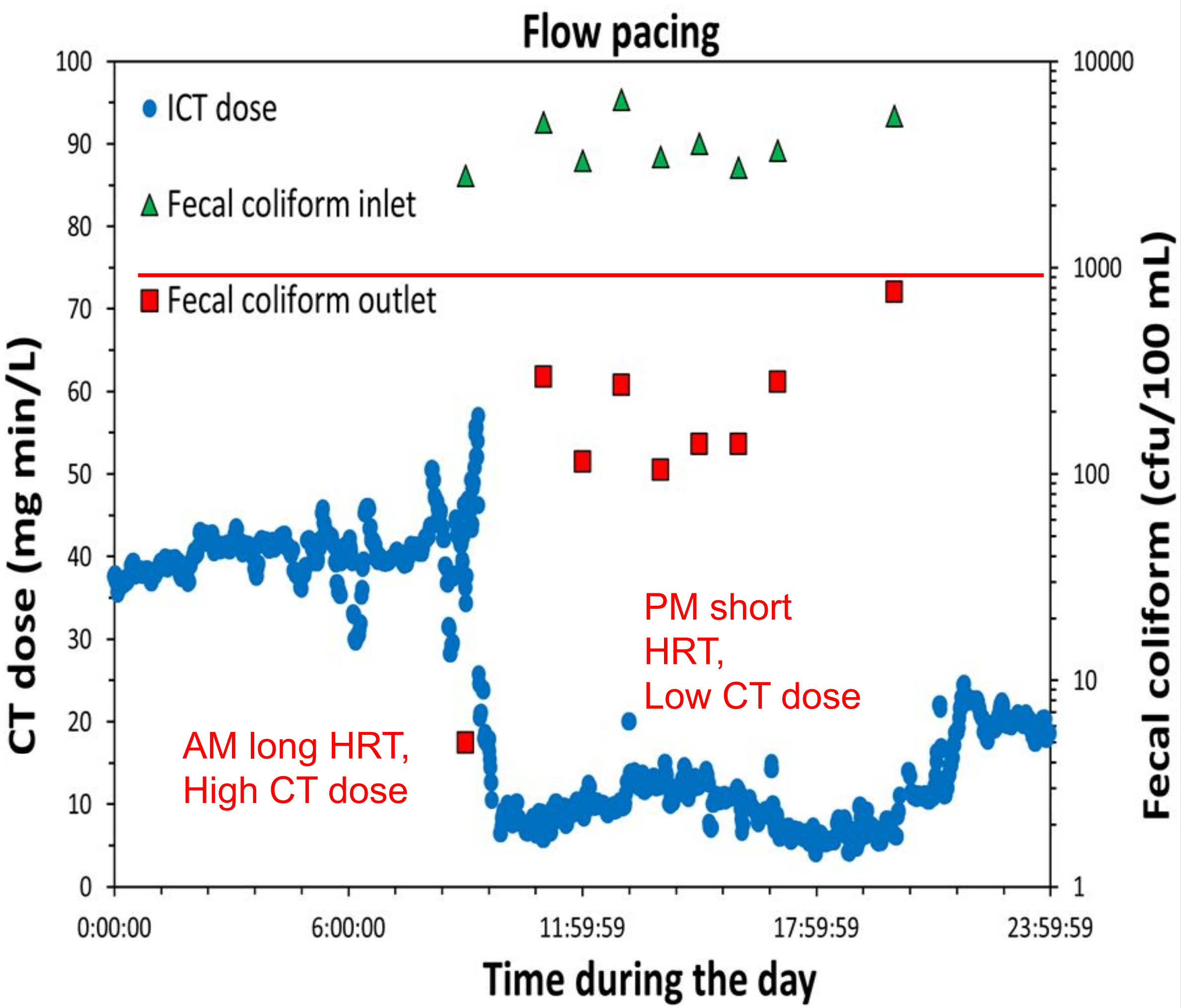
where,
C is the concentration of PAA at time t; mg/L
C_0 is initial concentration of PAA; mg/L
D is the instantaneous demand of PAA; mg/L
k is the decay rate constant of PAA; min^{-1}
t is the contact time; min^{-1}

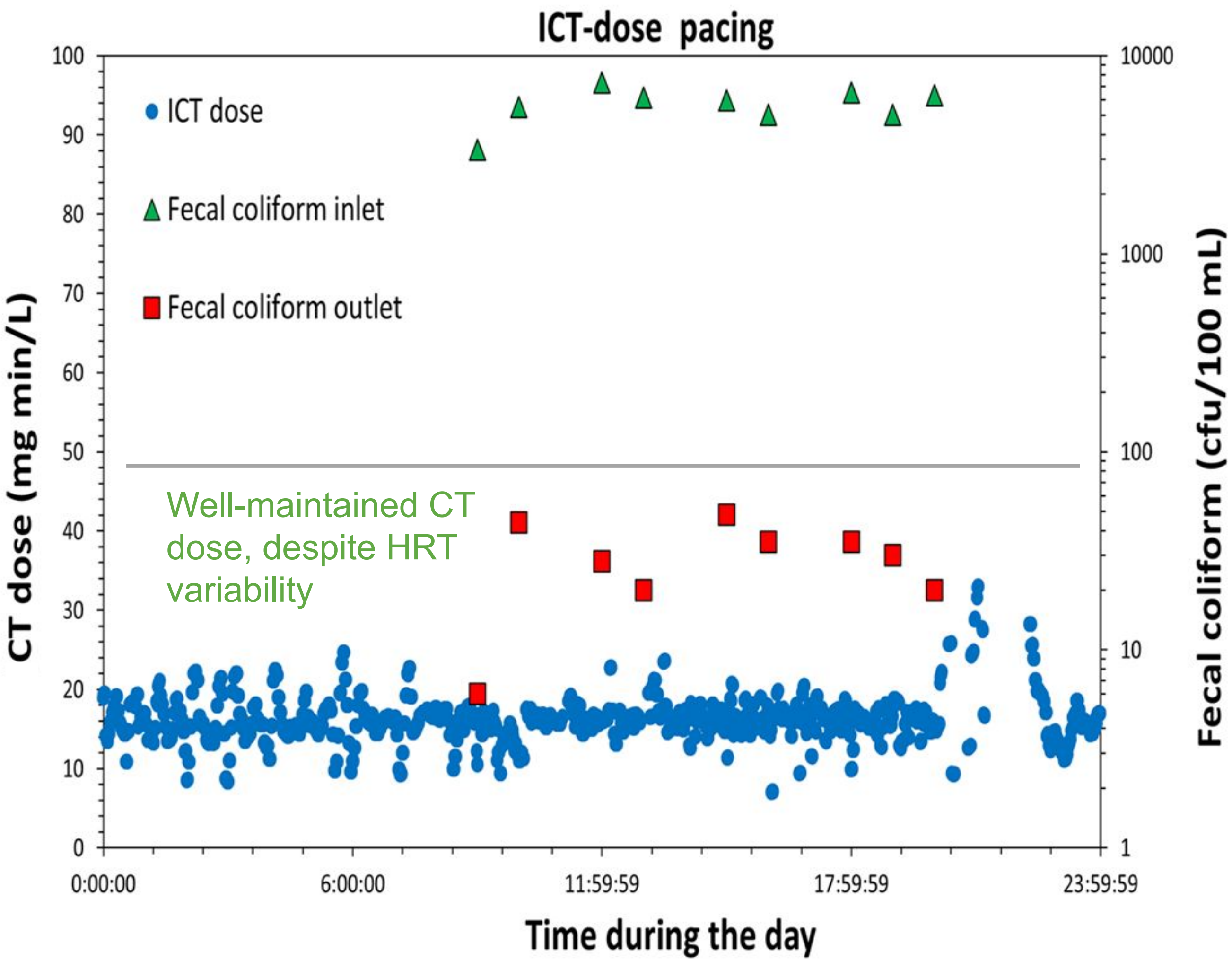
Wastewater quality changes…

Disinfectant decomposition is affected by:

- Organics
- Trace Metals
- Temperature
- pH

Flow Pacing vs OaSys iCT™

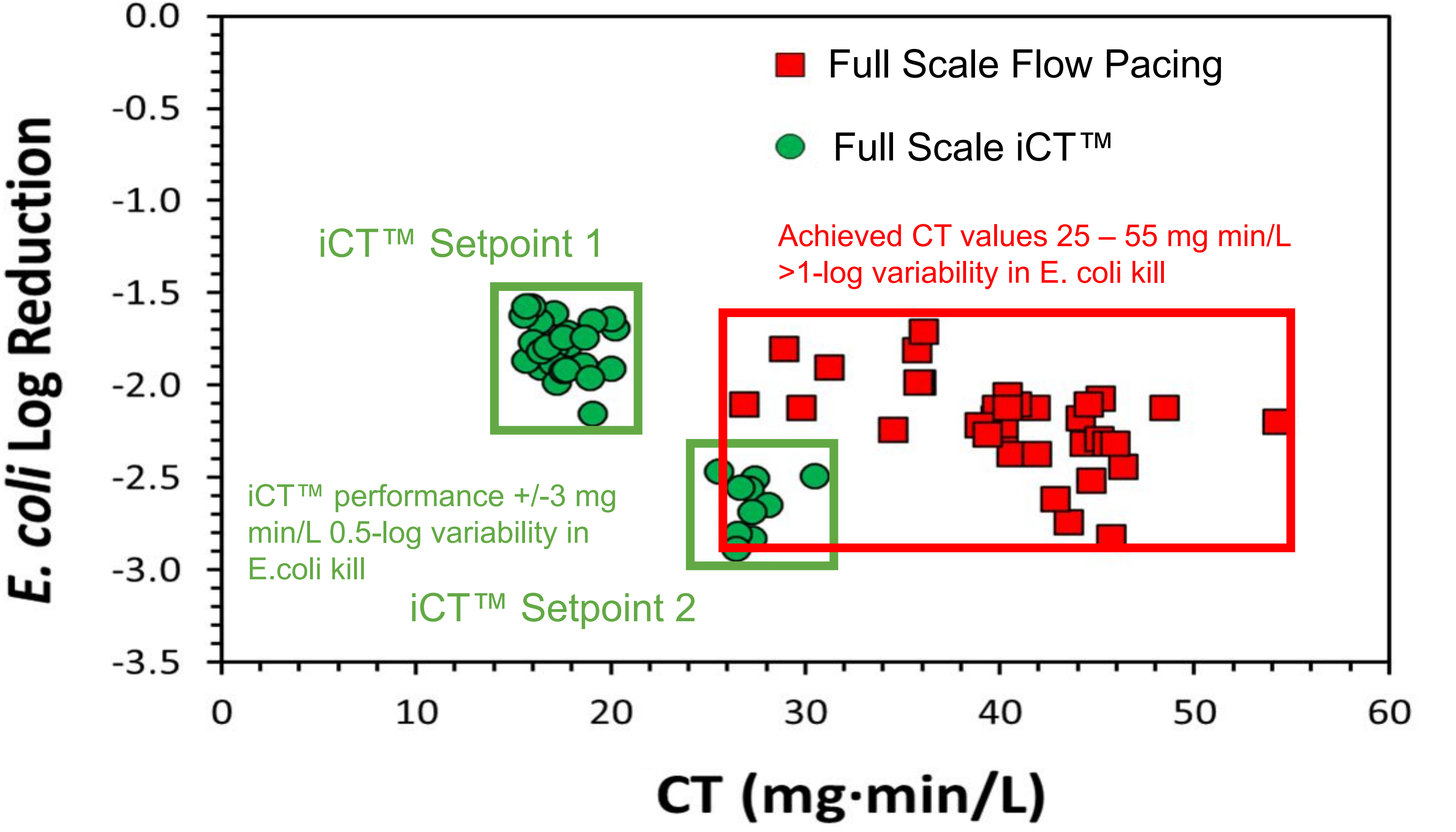




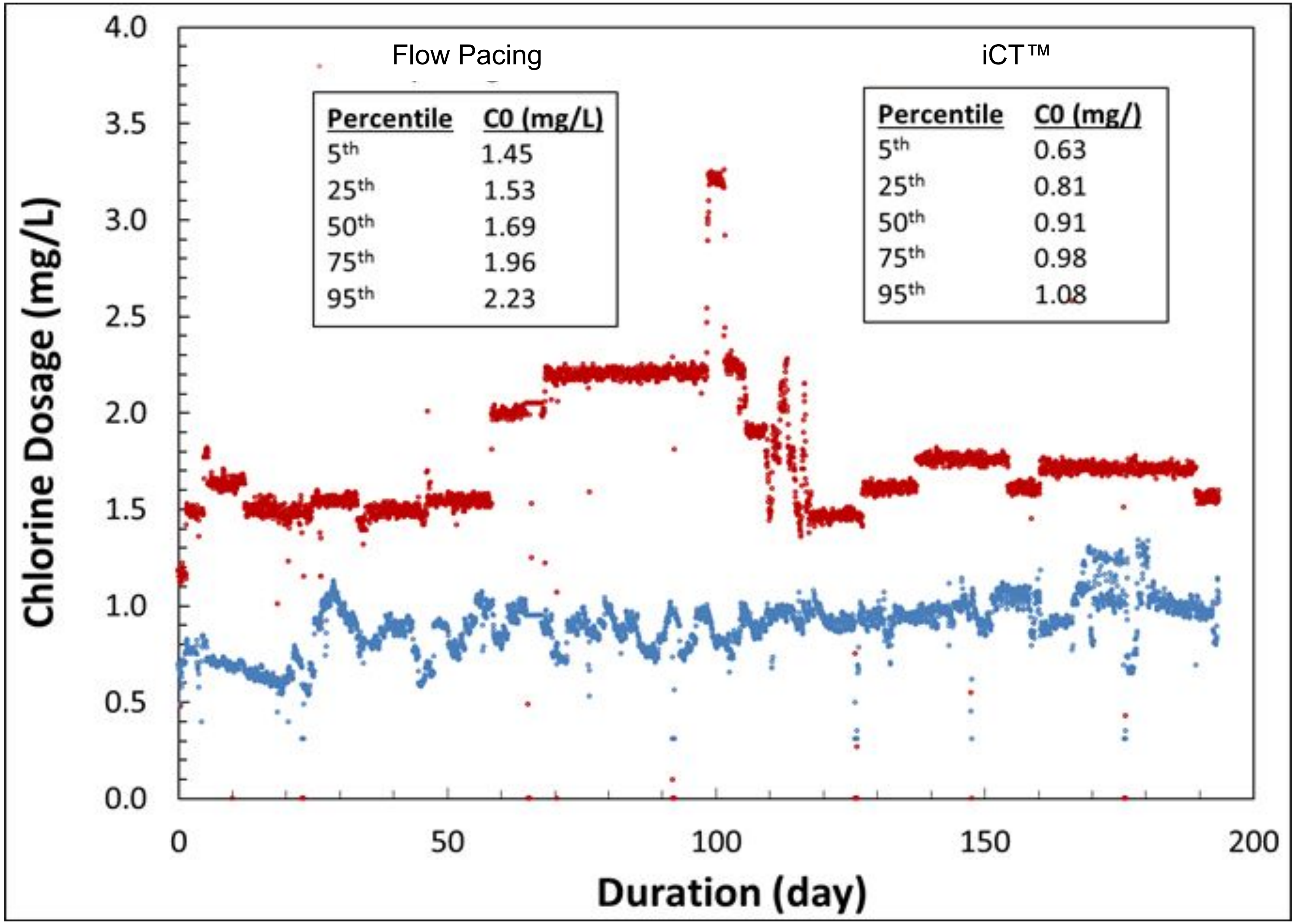
2-log variability in coliform at outfall is not optimal
Maintains coliform below 1000 cfu/100 mL

<0.5-log variability in outfall coliform
Maintains coliform below 100 cfu/100 mL

Performance Variability



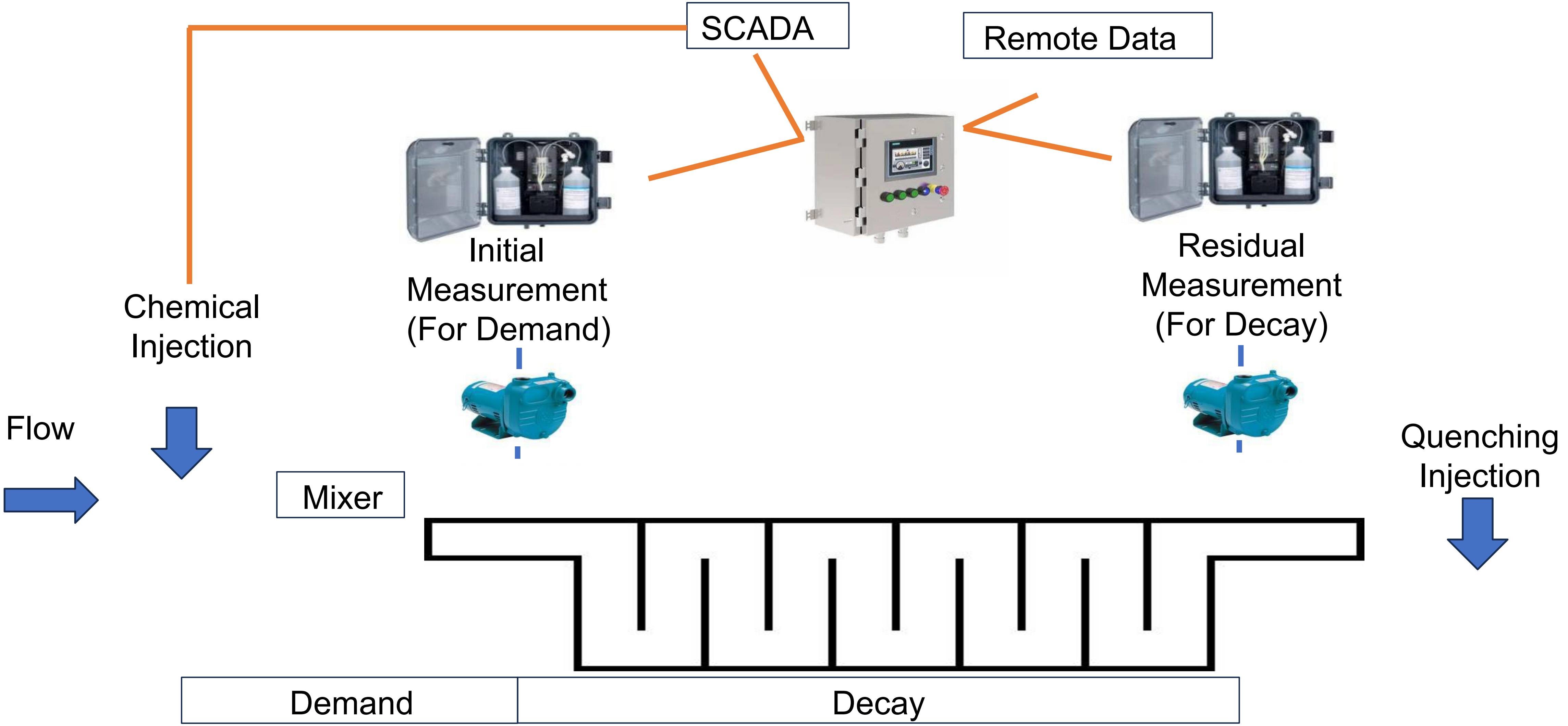
Demonstrated Savings



<u>AND…</u>

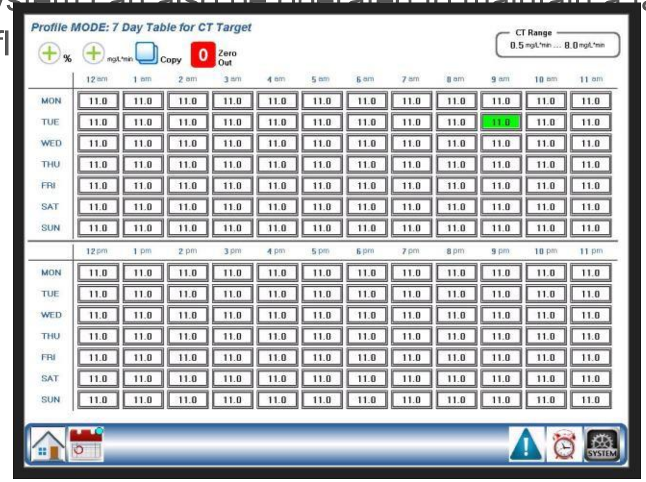
- iCT™ dose required 50% less hypochlorite
- Lower and more stable residual chlorine in effluent
- Expected reduction in demand for quenching chemical

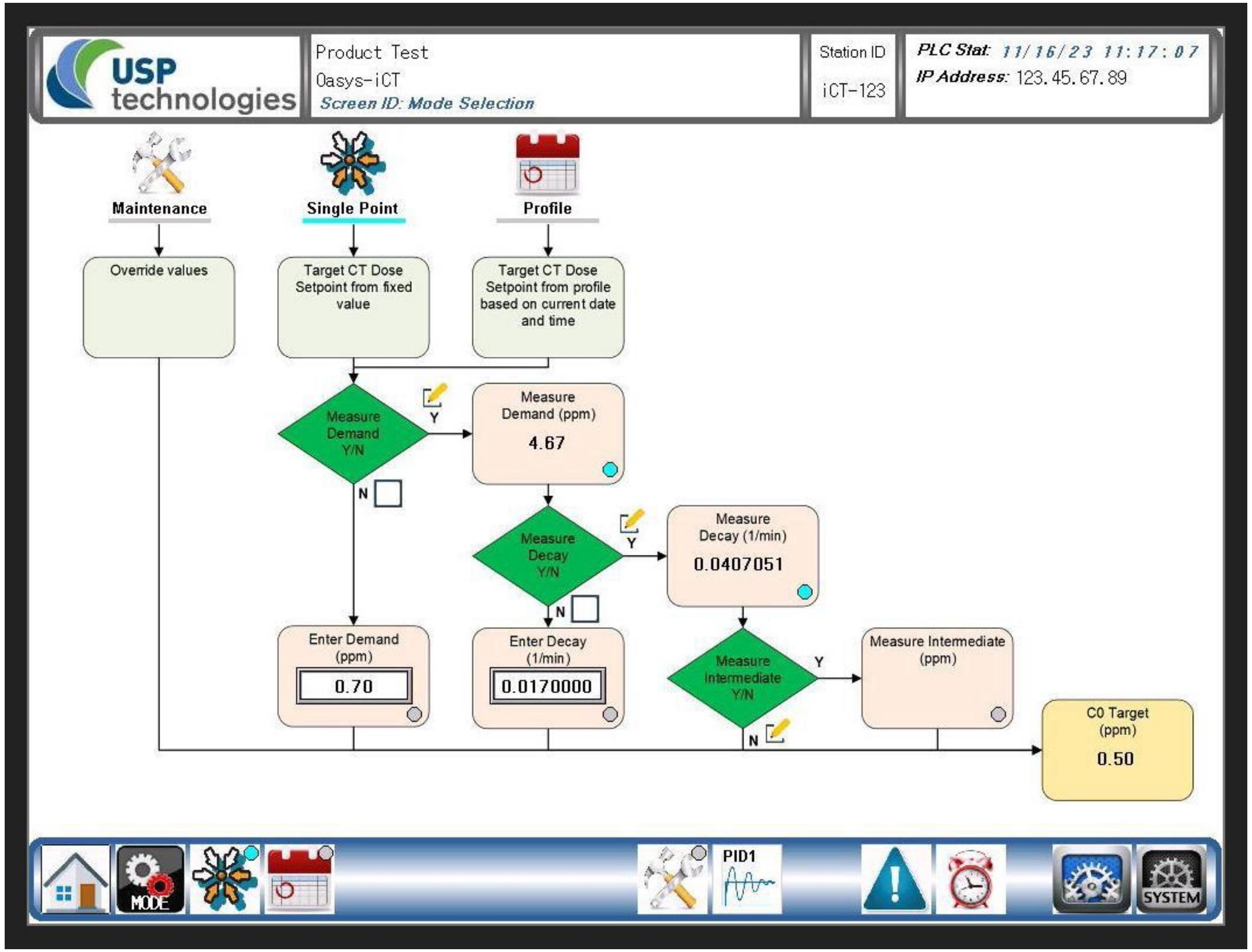
What is it?


SCADA
Remote Data
Initial Measurement (For Demand)
Residual Measurement (For Decay)
Chemical Injection
Flow
Mixer
Quenching Injection
Demand
Decay

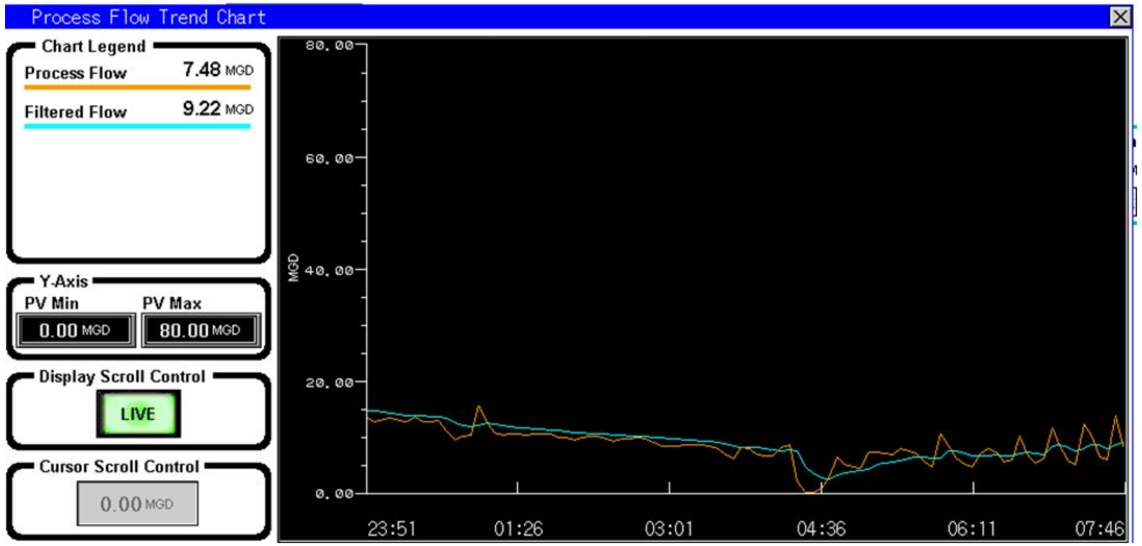
Operating Modes

- Demand based on Initial concentration measurement vs. Injected concentration.
- Decay based on Residual concentration relative to Initial concentration vs. HRT.
- iCT dynamically calculates the ideal Injected concentration to meet CT dose targets based on Demand and Decay.
- Demand and Decay can be measured or entered to provide flexibility and redundancy.
- System can be controlled based on a Single Point CT dose target or based on a configurable daily and hourly Profile.
- System can also be operated to maintain a target effl

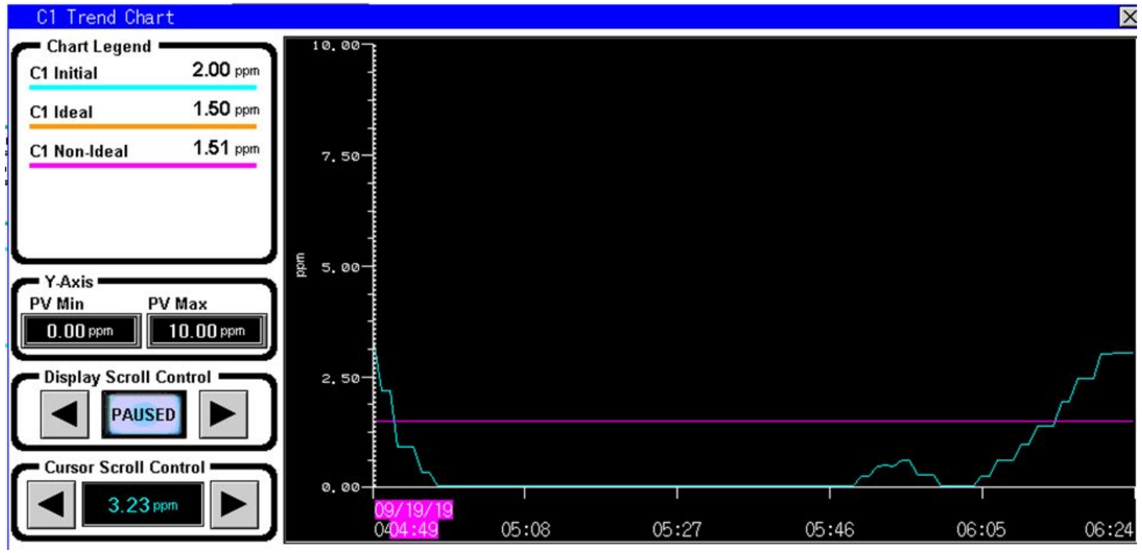




OaSys iCT™ - Troubleshooting

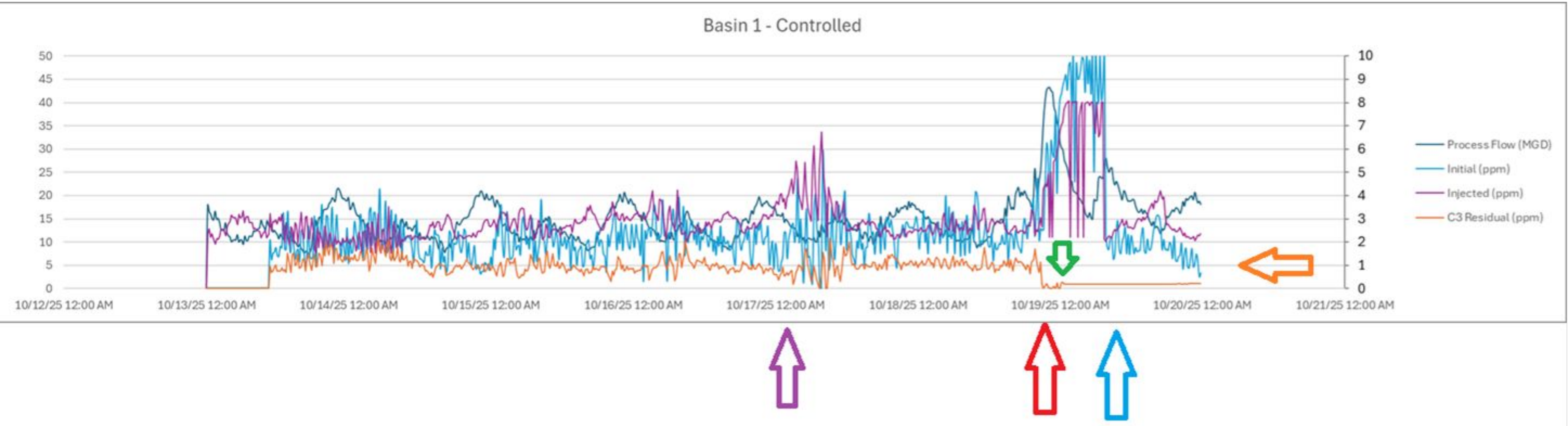


- Available process flow signal measured at contact basin effluent – limitation to control
- No accurate available upstream signal
  - Rapid increases in flow could lead to undertreatment
  - Rapid decreases in flow could lead to overtreatment
  - Results in C_3 residual noise
- Signal occasionally drops to 0 MGD at low flow
- Signal noise required filtering/smoothing to be useful for control



- Facility experiences rapid changes in background chlorine demand
- These result from water quality changes in process upstream
- Graph at left shows increase in background demand that occurred following low flow event of above graph
- C_1 residual drops to 0 mg/L for an hour following low flow event
- Flat dosing strategy results in not enough chemical to meet background demand

OaSys iCT™ - C_3 Control Scenario



- Goal was to maintain C_3 residual to 1 mg/L, achieved average of 1.02 mg/L for control period
- High demand event on 10/17 – C_0 jumps to ~5mg/L while flow remains consistent. C_3 residual relatively well maintained around 1 mg/L
- High flow event from about 15MGD to 45MGD. The system ramped up as can be seen by the increase in injected (purple line) and initial (light blue line).
- C_3 residual analyzer faulted causing the system to increase the dose. System did not fault to 0 mg/L which would have triggered a failsafe dose.
- Sunday morning the team put the system back into manual dose as they should since there was a fault with the system.
- Operating period demonstrates the system is as tuned as possible using with flow measured from the end of the contact basin, managed with filtering and flow tuning to reduce swings

OaSys iCT Echo™

Why do we need the Echo system?

What is the benefit?

- Reactor size: 32 L
- Operation Mode
  - ✔ Flow-Pace (fixed concentration)
  - ✔ iCT-Pace (Analyzer feed the data to dose controller to calculate iCT including demand and decay to obtain dose for the next cycle)

- Real Wastewater is used for testing
- 24/7 operation is available enables collection of diurnal data

Why do we need OaSys Echo?

Limitation of Full-Scale Trial

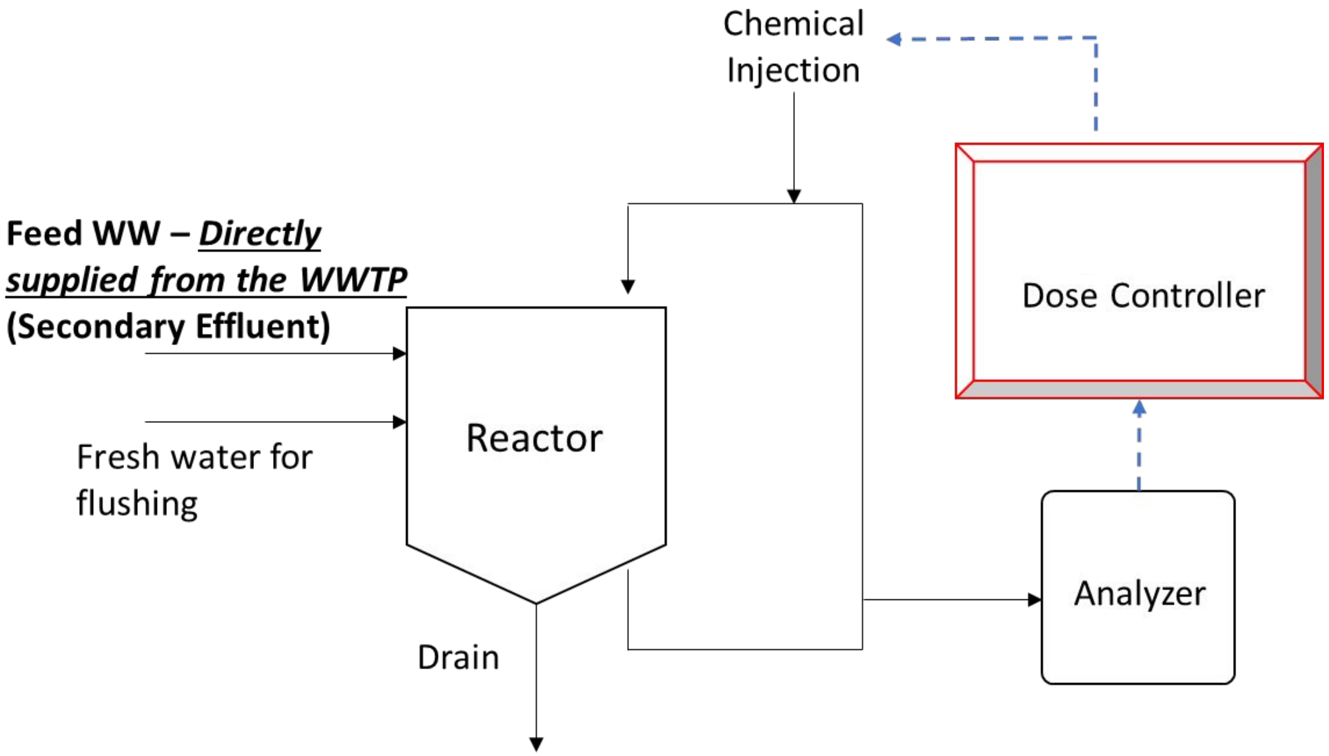
- High capital/maintenance and operation costs. Requires measurement on all individual contact basins.
- Requires ability to measure demand and final effluent residual in process (which may not be accessible)
- Testing of alternative disinfectants requires regulatory authorization if done at full-scale
- Risk of pathogen or DBP violation in case of non-performance

Benefit of Slip-Stream System Trial

- Lower capital/operational cost/complexity compared with full-scale trial and can be easily converted to full-scale operation
- Ability to simulate process where direct measurement is not available.
- Simulate and model the use of alternative disinfectants without requiring regulatory approval
- Can model the effluent residual based on detention time to outfall
- No risk of violation. Test volume is negligible compared to plant effluent and can be discharged to the plant drain
- Self-cleaning cycles can be included to prevent biofouling and ensure performance

Experimental Setup at Region of Peel Clarkson WWTP

- **OaSys iCT Echo™ System**



- Secondary WW supplied into the system
- System run as sequential batch mode (Batch length: 50 mins)
- Residual disinfectant is measured by online analyzer saved in the controller
- Demand, decay and CT calculated by using the residual disinfectant data
- Operation Mode
  - Fix Dose Mode
    Set the dose in controller
  - CT Mode (optimized dosage)
    Dosage was determined based on demand and decay from previous batch

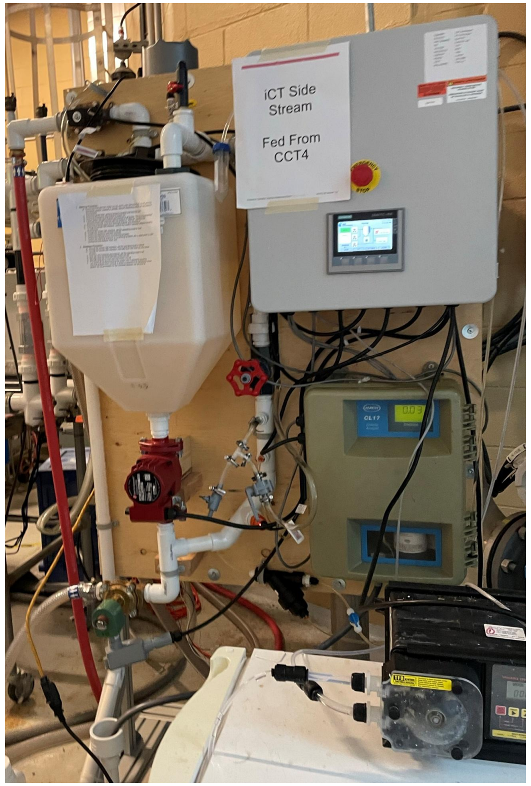
Test condition and Data Collection

- ❑ Test Conditions for Demand and Decay and Pathogen Inactivation

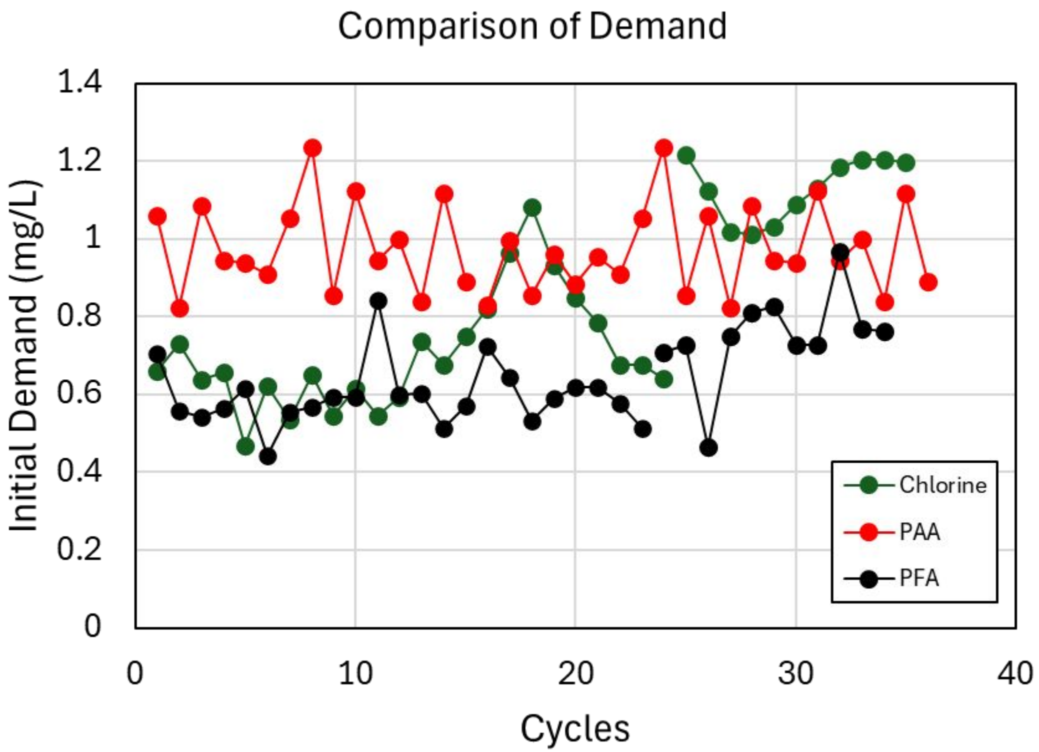
	NaClO	PFA	PAA
Fix Conc	3 ppm, 4ppm, 5 ppm	2 ppm, 3 ppm	2 ppm, 3 ppm
iCT (mg*min/L)	25	8.7	60

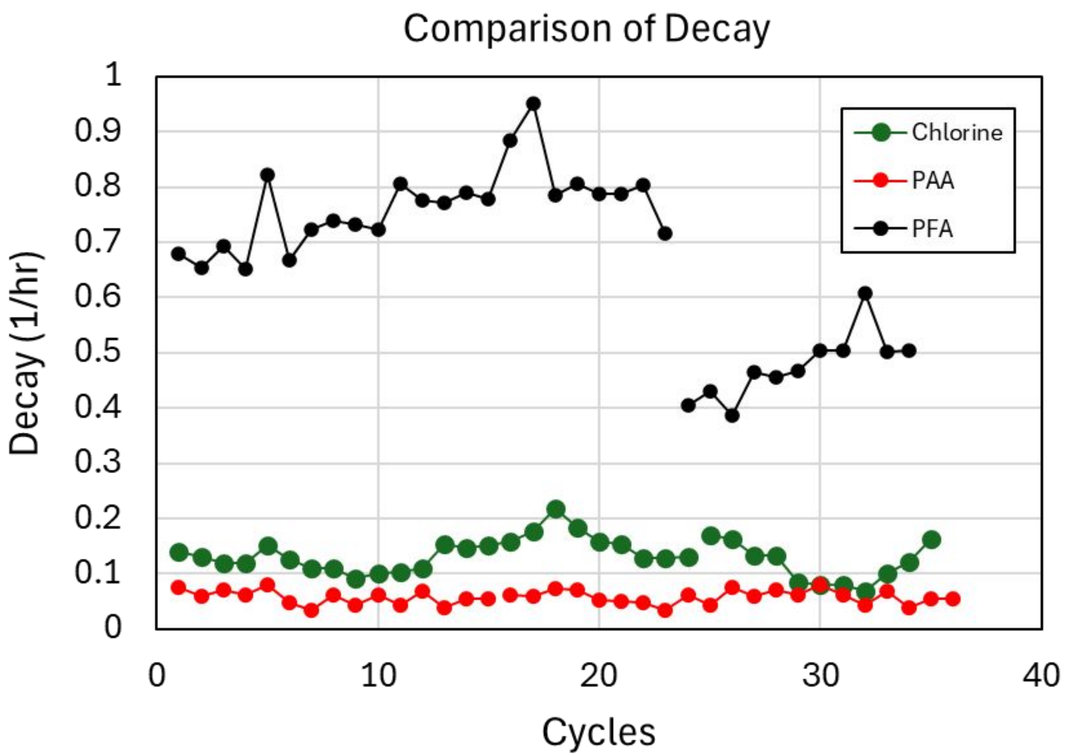
- ❑ Data Collection

  - Test duration: 50 mins
  - Residual Chlorine: Measured and stored in controller (every 2.5 mins)
  - Pathogen Sampling: 0, 5,10, 20, 30, 40 mins
    (Pathogen sampling was performed occasionally)
  - Water quality was measured 6 times in a day



Kinetic Comparison at 3 ppm

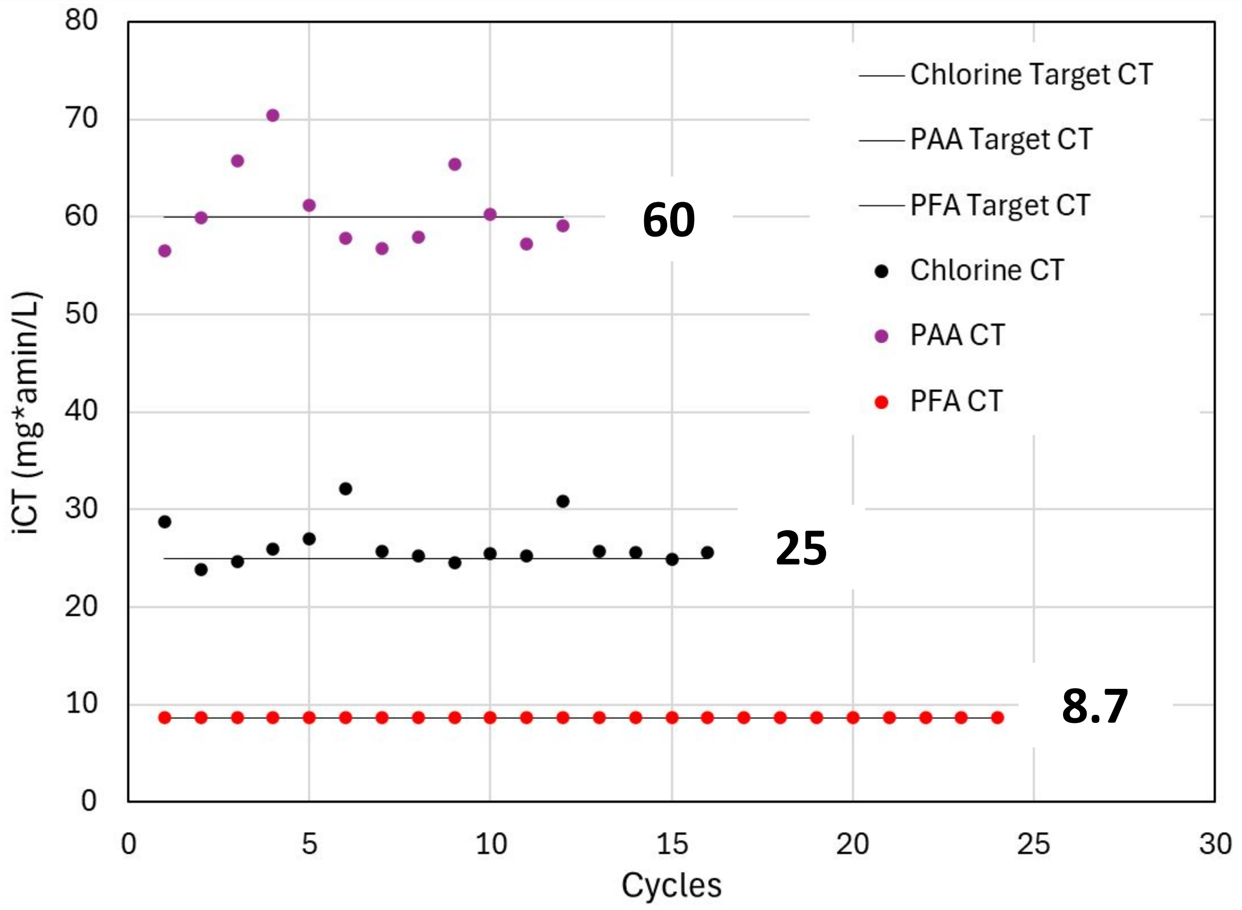




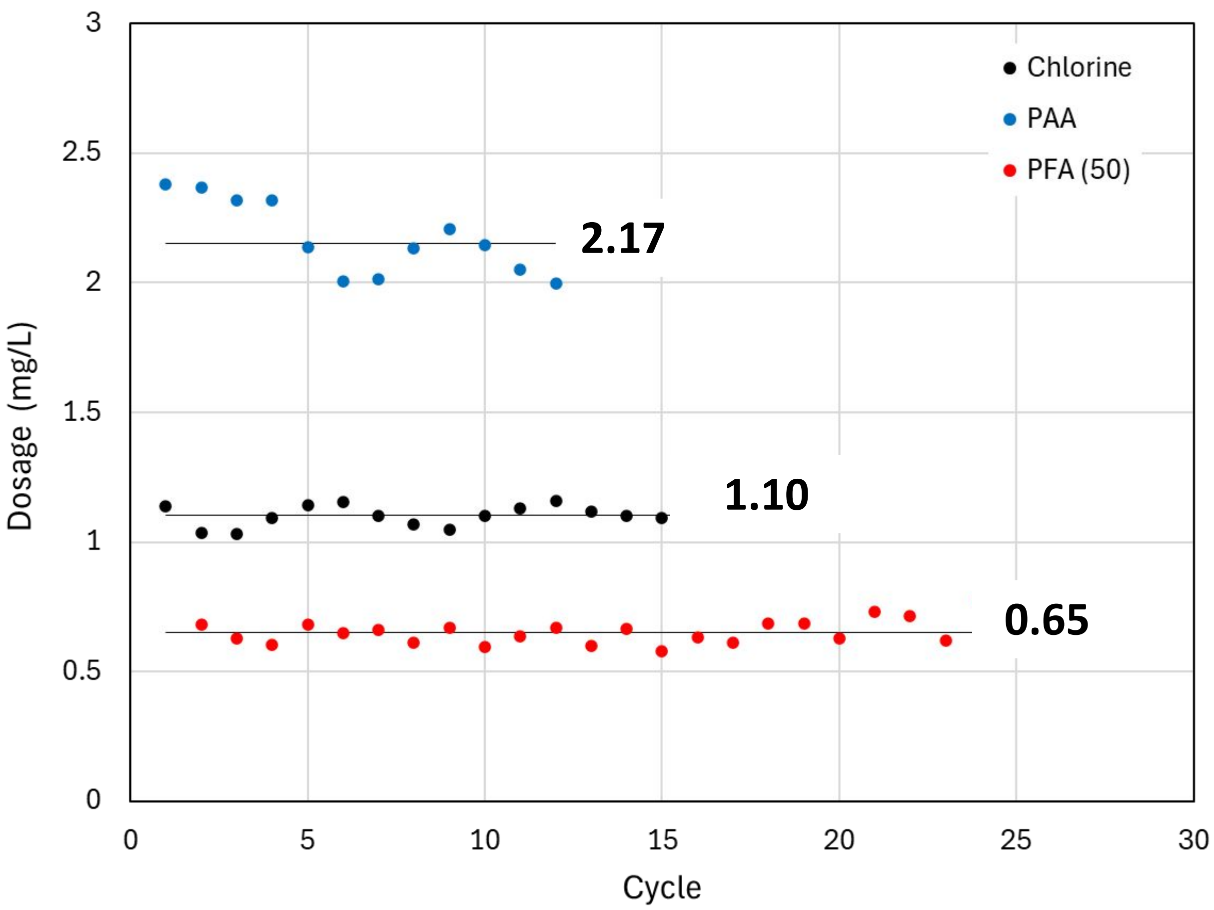
	Demand (mg/L)			Decay (1/hr)		
	NaClO	PAA	PFA	NaClO	PAA	PFA
Avg	0.85	0.98	0.64	0.131	0.058	0.660
Max	1.22	1.24	0.97	0.219	0.080	0.952
Min	0.47	0.82	0.44	0.068	0.034	0.351

Comparison in CT operation mode

iCT Operation



Dosage



Cost Comparison in CT operation mode

- ❑ Cost (per kilogram) USD

Sodium Hypochlorite (12%)	Sodium Bisulfite (38%)	PAA (15%)
0.44	0.33	1.42

- ❑ PFA Cost USD – 1 ppm

CAPEX	1 MGD	10 MGD	50 MGD
220,000	24,793/yr	204,273/yr	928,514/yr

- ❑ Cost estimate based on average dosage from CT operation

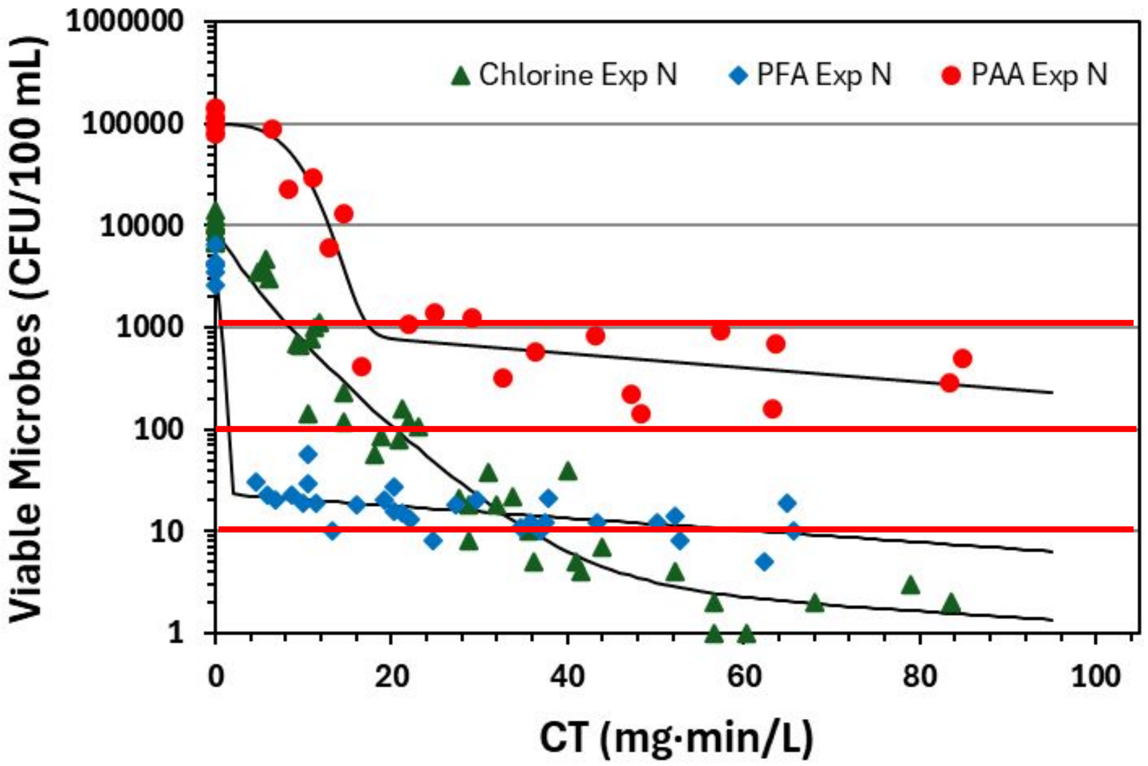
  - ✔ Days of disinfection in 2024: 131 days (from May 23rd to Sept 30th, 2024)
  - ✔ Average Daily Flowrate: 220,556 m^3/day (58 MGD) (during disinfection season in 2024)
  - ✔ Volume of contact pipe: 15,550 m^3

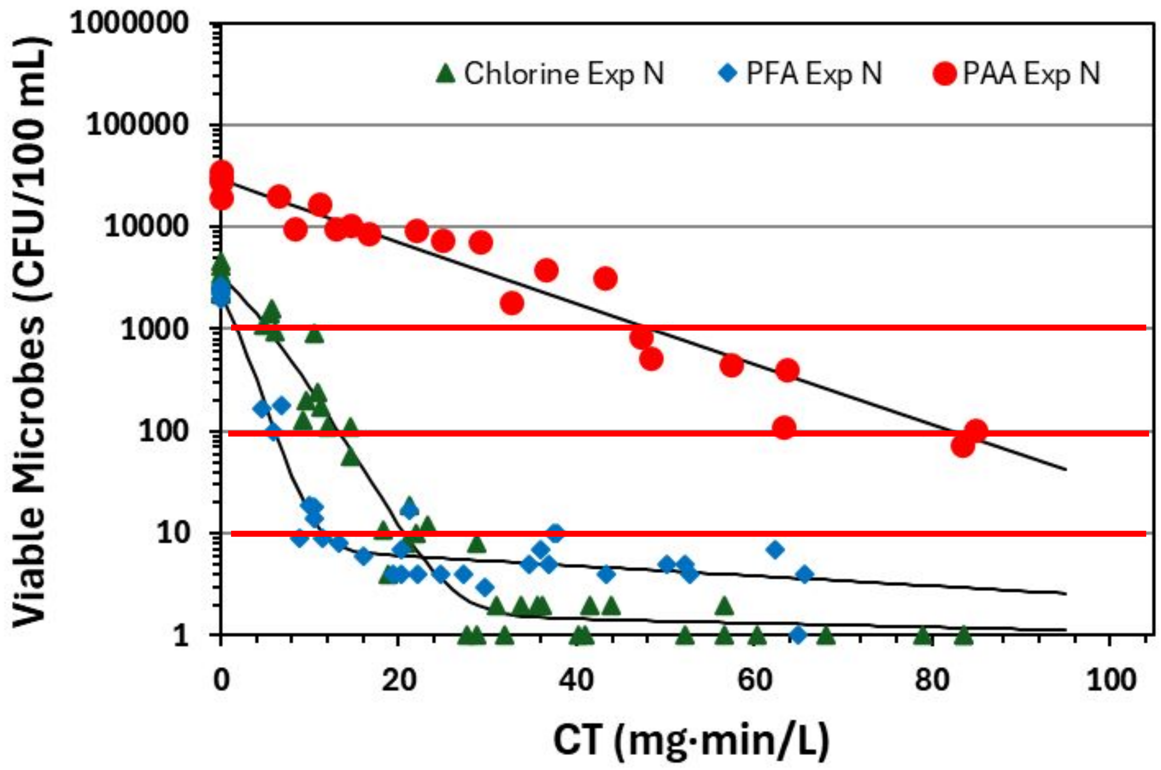
USD	Sodium Hypochlorite	Sodium Bisulfite	PFA	PAA
Dosage (mg/L)	1.10	1.10	0.65	2.15
Chemical consumption (kg/day)	2,022	638	1,434	3,161
Cost / year	116,534.5	27,600.3	251,268.6*	588,065.9
	144,134.8			

*Exclude CAPEX

Comparison based on Disinfection Target

Fecal Coliform **Enterococci**



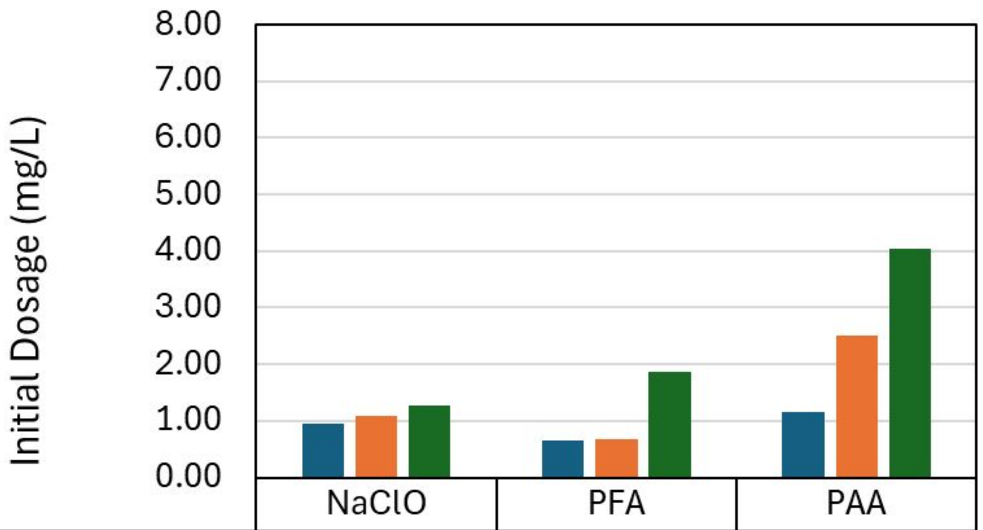


Target pathogen counts	Fecal Coliform		
	Chlorine	PFA	PAA
1000 cfu/100mL	8.55	0.85	17.5
100 cfu/100mL	20.5	1.4	146
10 cfu/100mL	35.5	62	290

Target pathogen counts	Enterococci		
	Chlorine	PFA	PAA
1000 cfu/100mL	5.32	1.82	48.4
100 cfu/100mL	13.3	6.11	82.2
10 cfu/100mL	20.6	11.5	116

Comparison based on Disinfection Target

Fecal Coliform

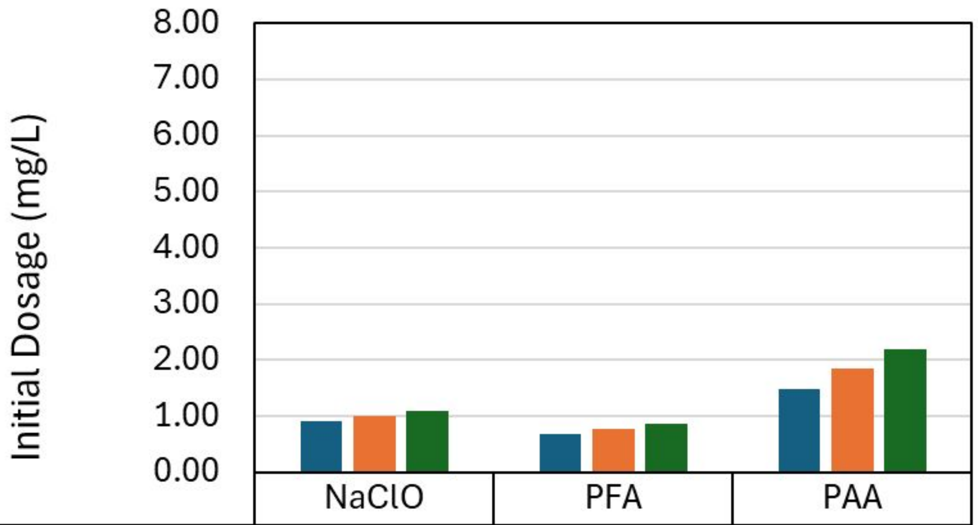


	NaClO	PFA	PAA
1000 cfu/100ml	0.95	0.66	1.16
100 cfu/100ml	1.09	0.67	2.51
10 cfu/100ml	1.27	1.87	4.03

✔ Chemical cost (1,000 USD) – Seasonal

	NaClO*	PFA	PAA
1000 cfu/100ml	105	254	317
100 cfu/100ml	127	258	688
10 cfu/100ml	155	722	1,103

Enterococci



	NaClO	PFA	PAA
1000 cfu/100ml	0.91	0.67	1.49
100 cfu/100ml	1.00	0.76	1.84
10 cfu/100ml	1.09	0.87	2.20

✔ Chemical cost (1,000 US) – Seasonal

	NaClO*	PFA	PAA
1000 cfu/100ml	100	259	508
100 cfu/100ml	114	294	630
10 cfu/100ml	128	335	751

*NaClO cost is including sodium bisulfite cost. It was estimated based on the calculated disinfectant residual concentration.

Thank You!

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