HRSD
Cleaning wastewater every day for a better Bay.

Part A: Dissolved Oxygen (DO) Trends at SWIFT RC

Upgrades to control of SWIFT Water DO (independent of TOC)

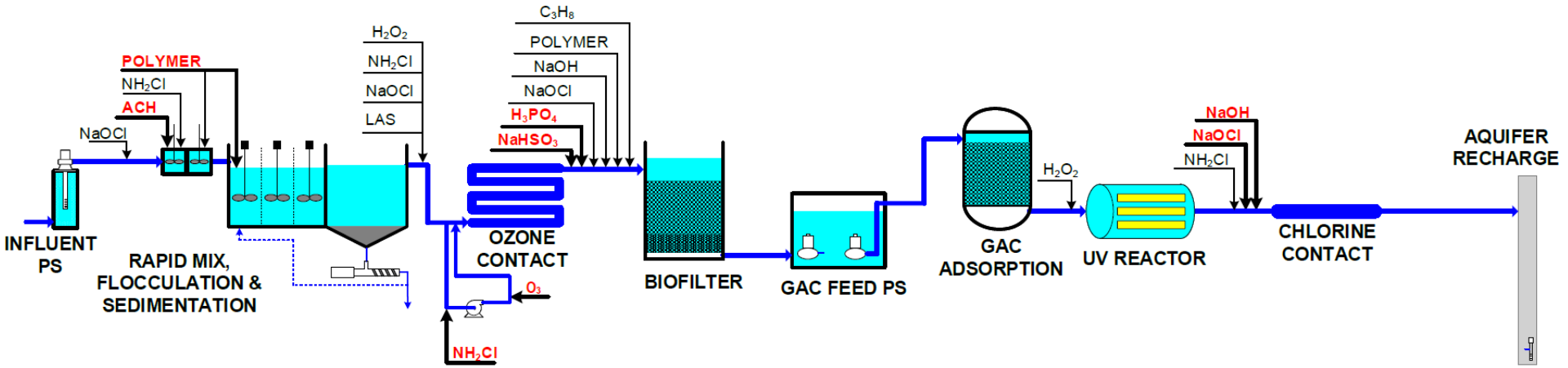
Part B: James River SWIFT Process Concepts

SWIFT Research Center Developments Applied to the James River SWIFT Design

swift
Sustainable
Water Initiative
for Tomorrow

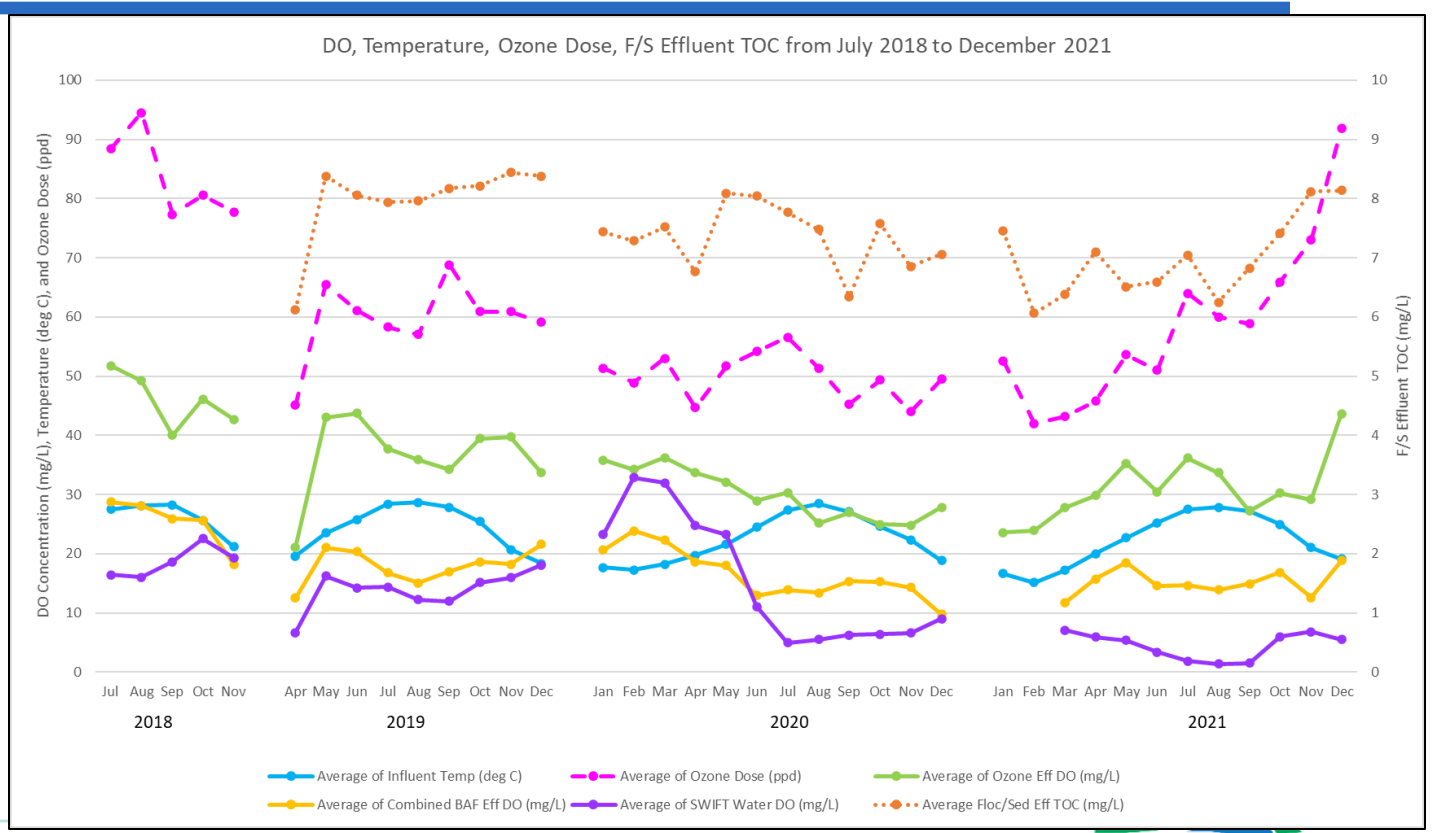
80
years of sustainability
HRSD

SWIFT Research Center (Current active chemicals)

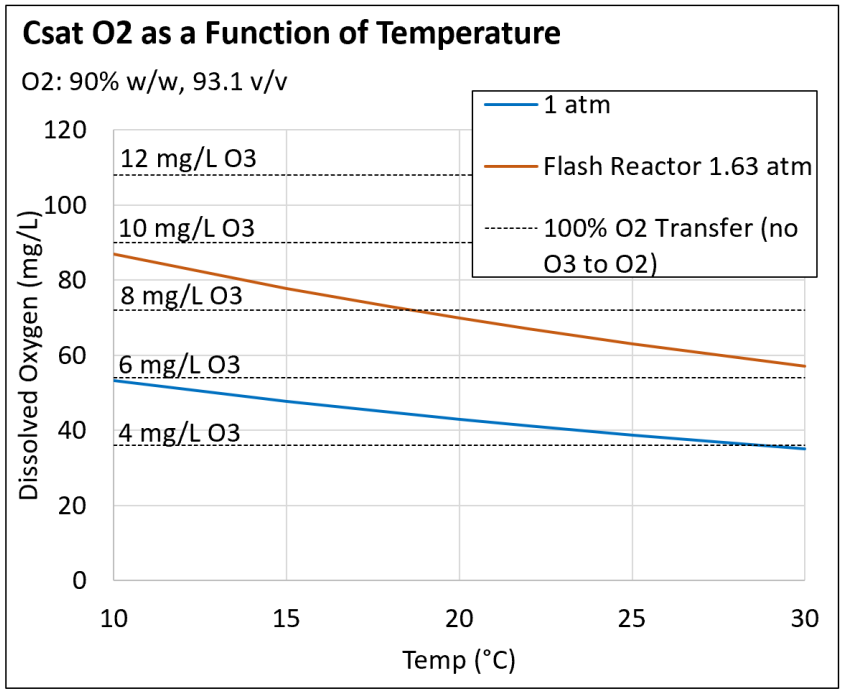


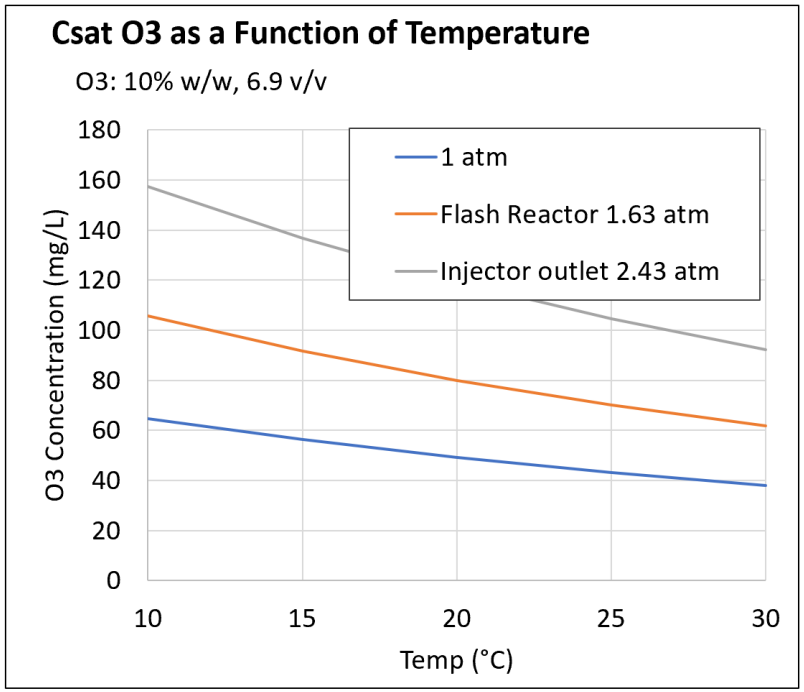
Ozone Dose and DO

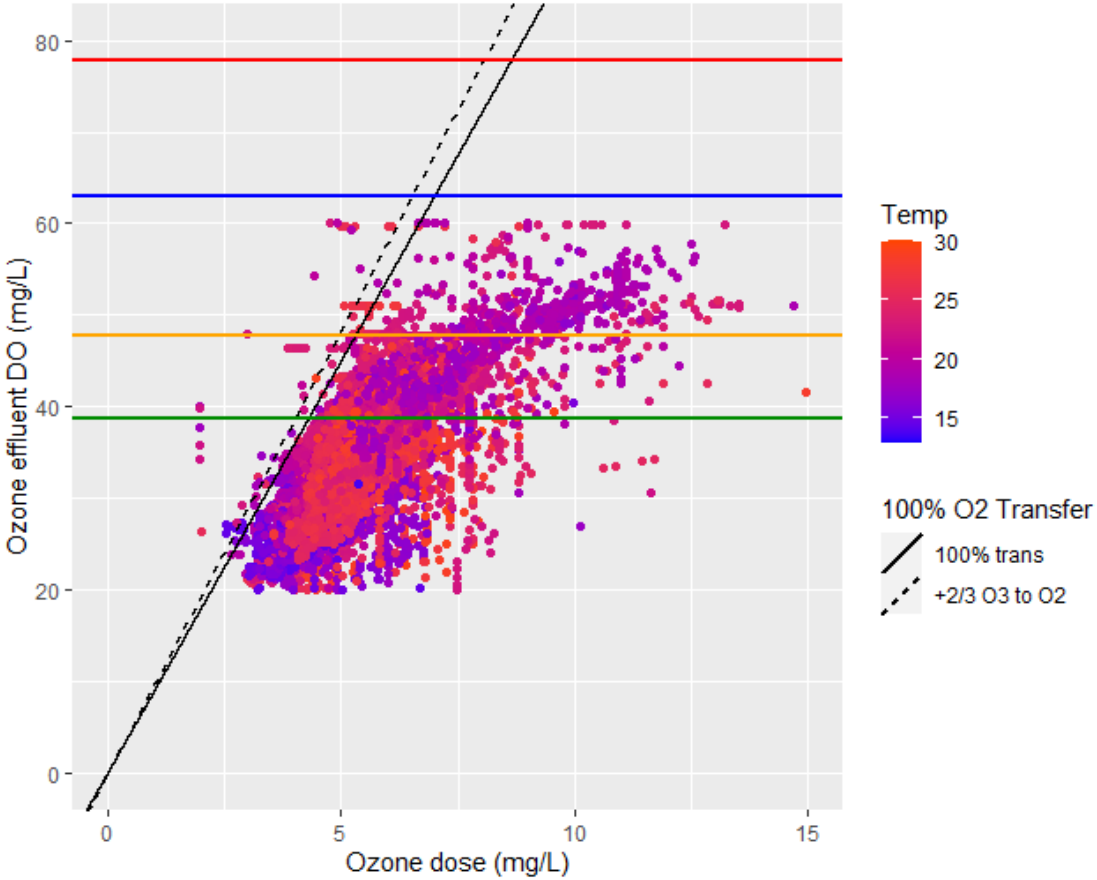
- O3 dose and F/S TOC trend well together
- O3 dose and O3 effluent DO generally trend well together
- O3 dose has averaged 40-55 ppd for 2020 but increased in 2021
- SWIFT Water DO consistently 5-10 mg/L, but low in summer 2021



10% w/w Ozone =6.9% v/v. N_2 volume negligible → 93.1% O2



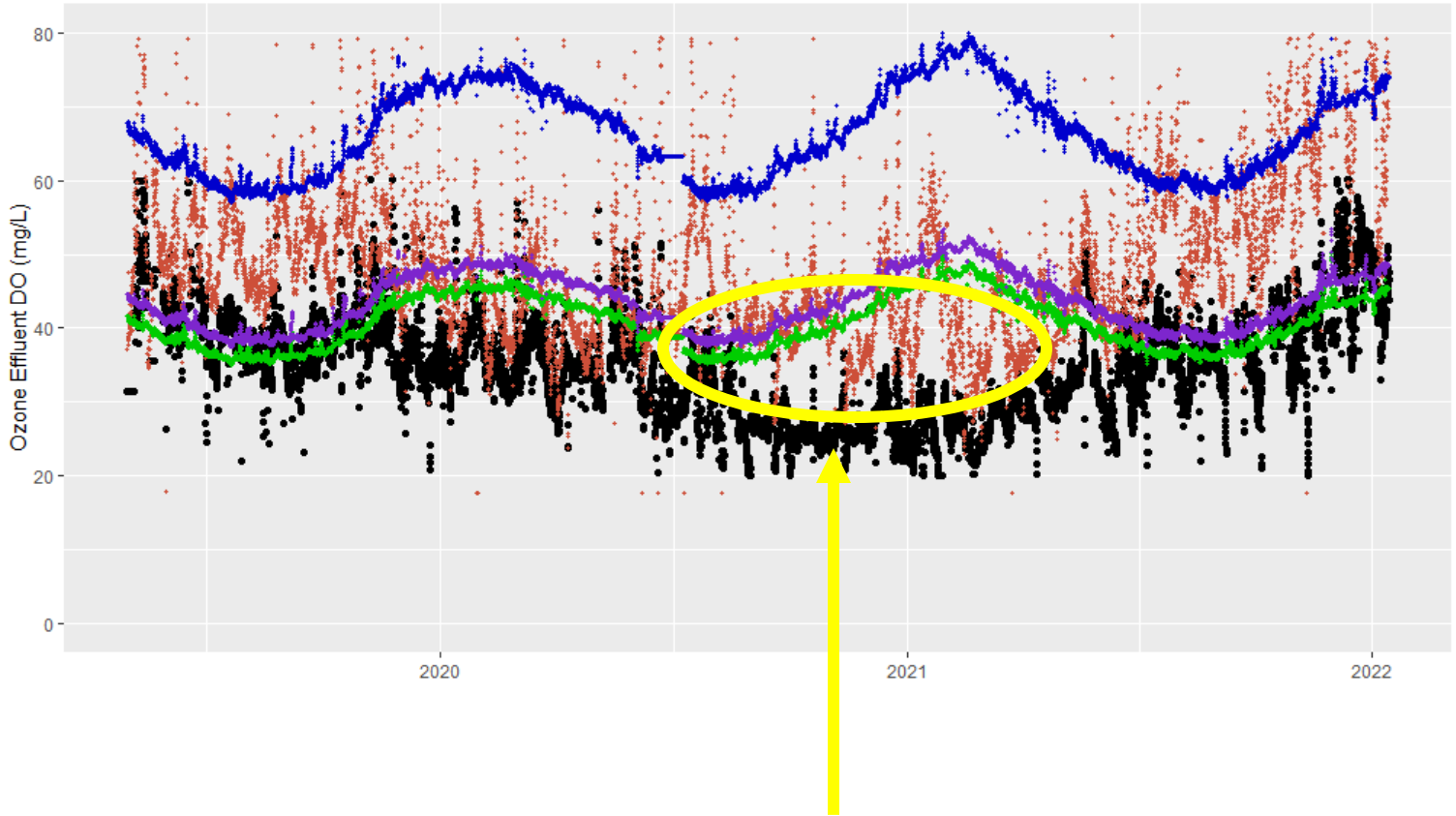




Csat O2: 93.1 %v/v, 90 %w/w

- 1.63 atm, 15° C
- 1.63 atm, 25° C
- 1 atm, 15° C
- 1 atm, 25° C

Values <20 mg/L removed



Csat O2- 1.63 atm (flash mixer)

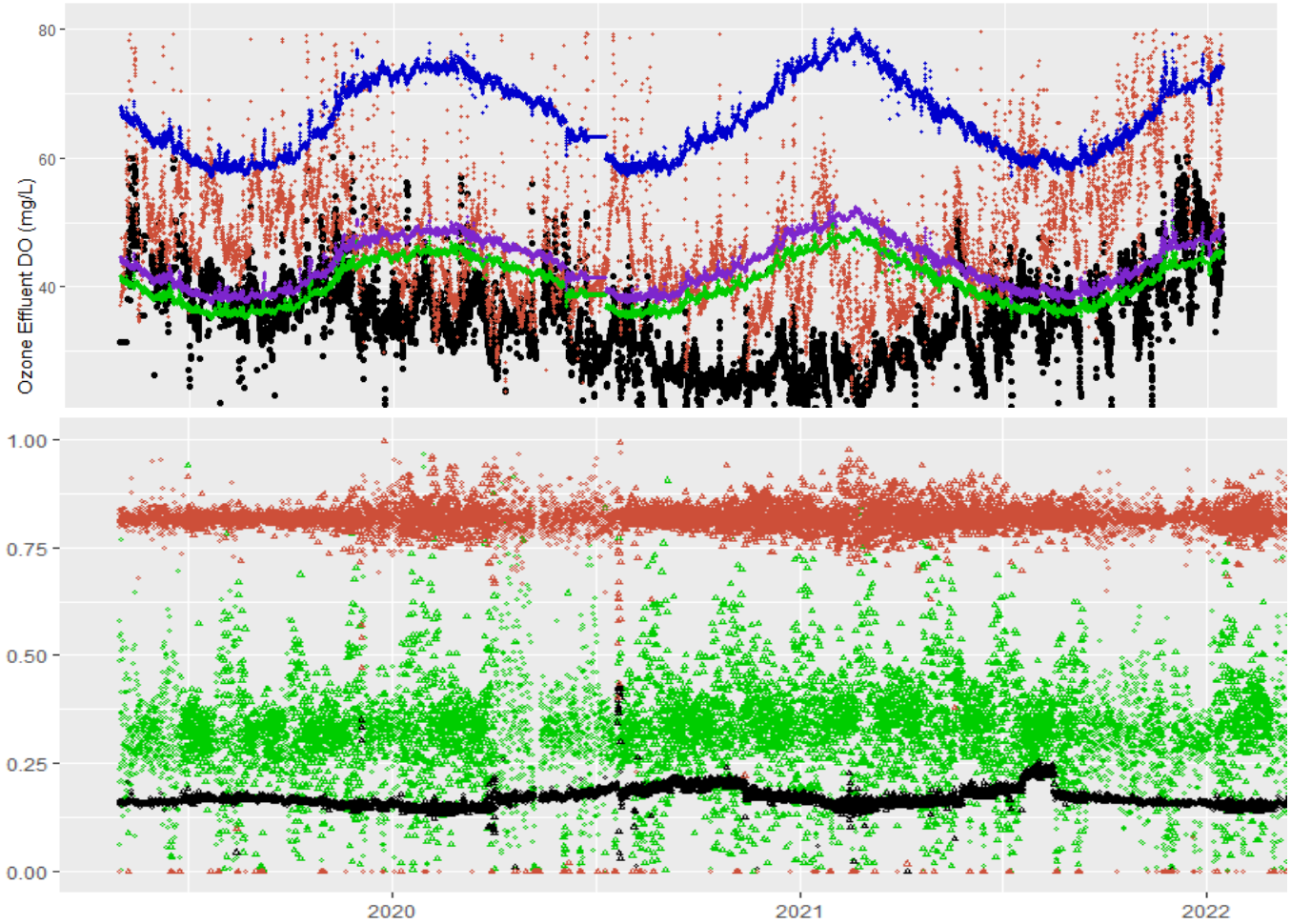
Csat O2- 1 atm

Csat O2- 1.07 atm (contactor entrance)

Measured DO- *values <20 mg/L removed*

100% Transfer of O2 (9x O3 dose, no O3 to O2)

Are we dosing the ozone that we think we are?



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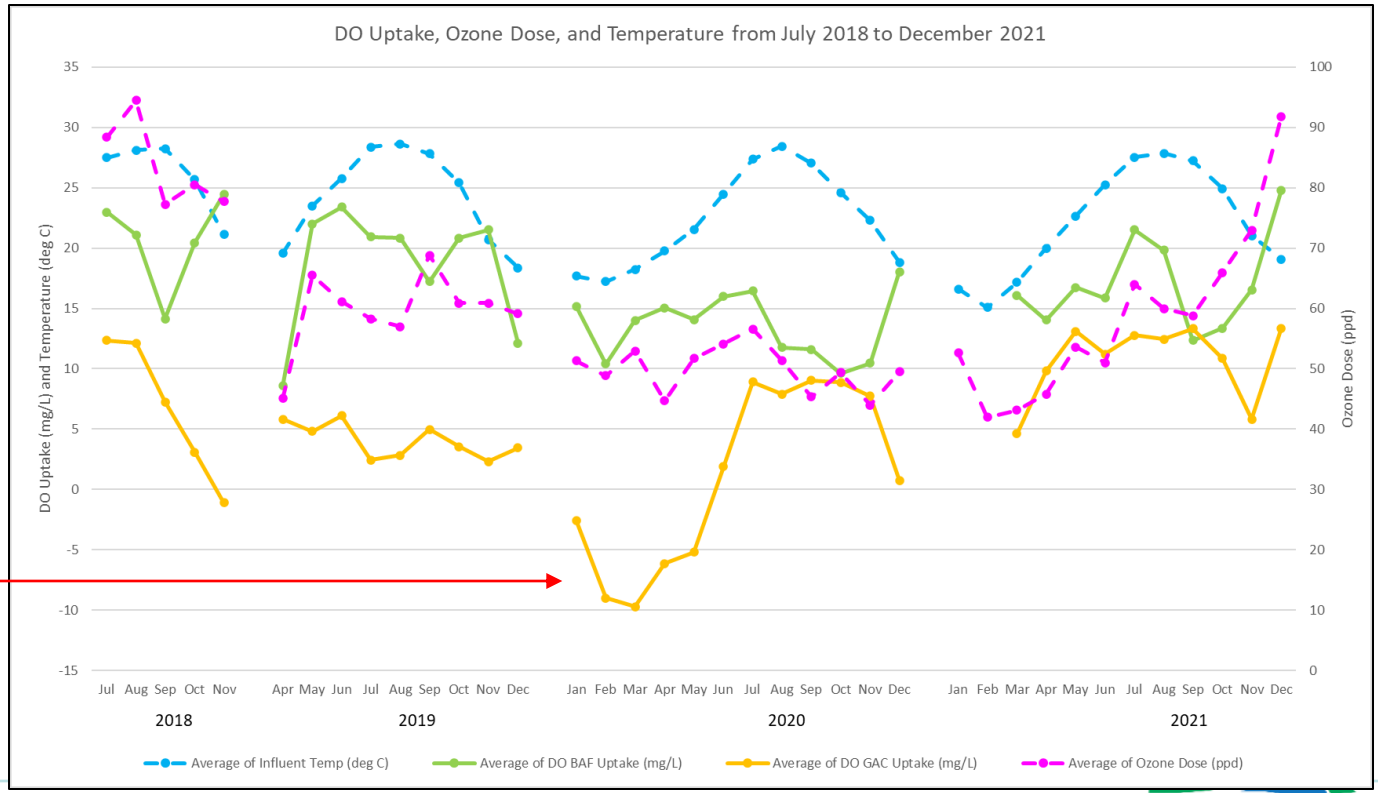
Gas Flow*Conc/O3 ppd

Lox tank level change (in/hr) /O3 ppd

Generator efficiency kW/O3 ppd

DO Uptake Comparison

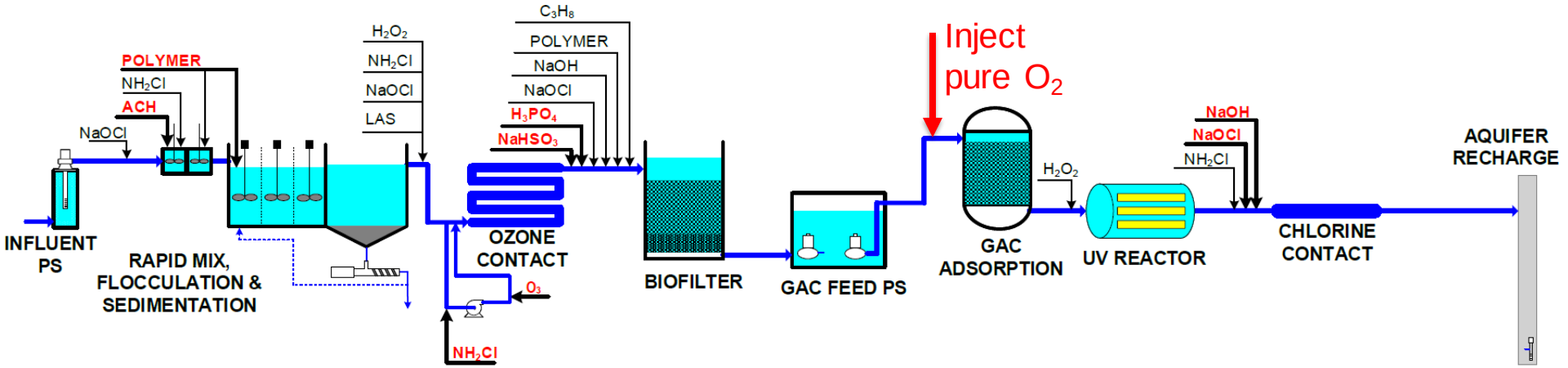
- DO uptake across BAF has consistently been 10-20 mg/L through 2020 and 2021
- Since recalibration, GAC uptake has consistently been 3-13 mg/L
- SWIFT DO probe recalibration



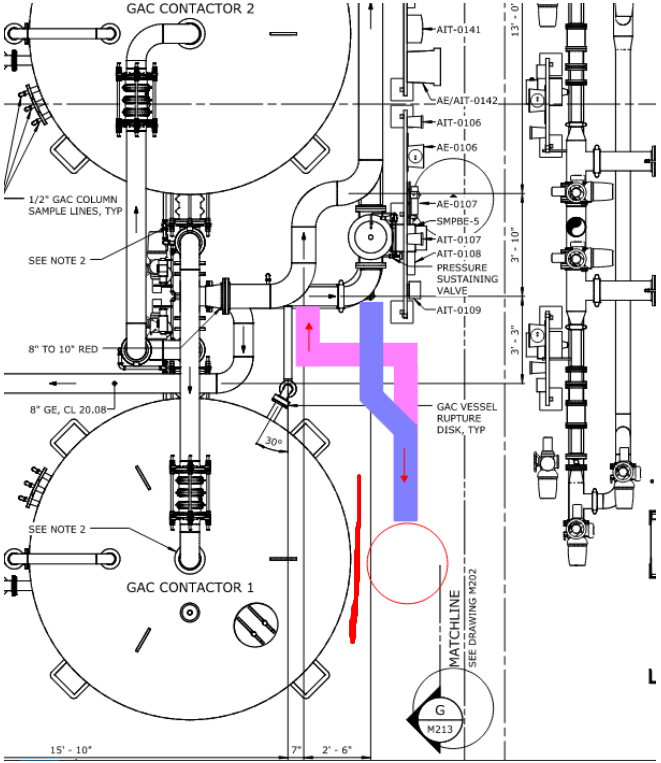
Factors Causing Low SWIFT Water DO

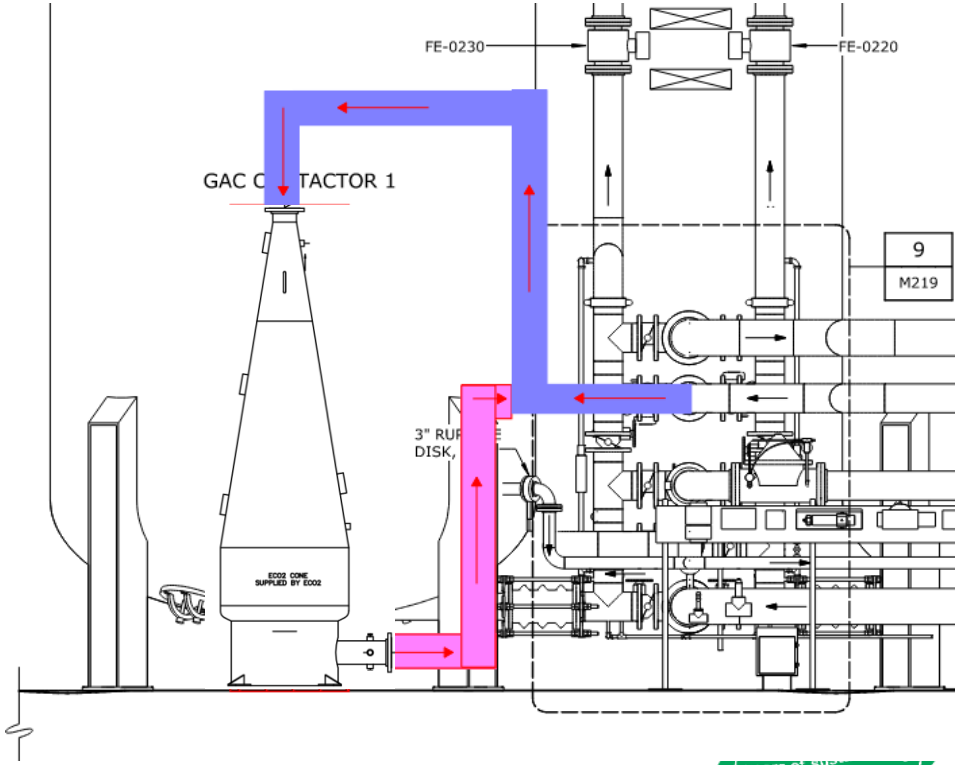
- Low O3 Demand – Less O_2 gas flow introduced to water
- High Temperature – Lower O_2 solubility, more loss from GAC feed pump station wetwell, more biological uptake in BAF and GAC
- Low Flow – more loss from GAC feed pump station wet well, more biological uptake in BAF and GAC
- High BVs on GAC – More biological uptake of O_2
- End of 2020, inexplicably low ozone effluent DO

SWIFT Research Center (Current active chemicals)



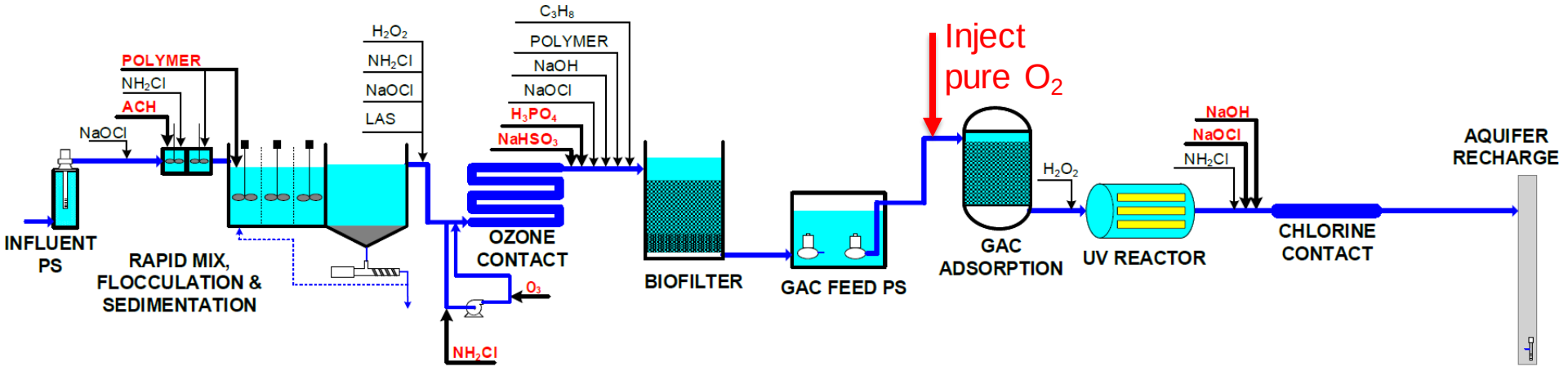
Speece Cone Design – Installed Adjacent to GAC Contactor 1



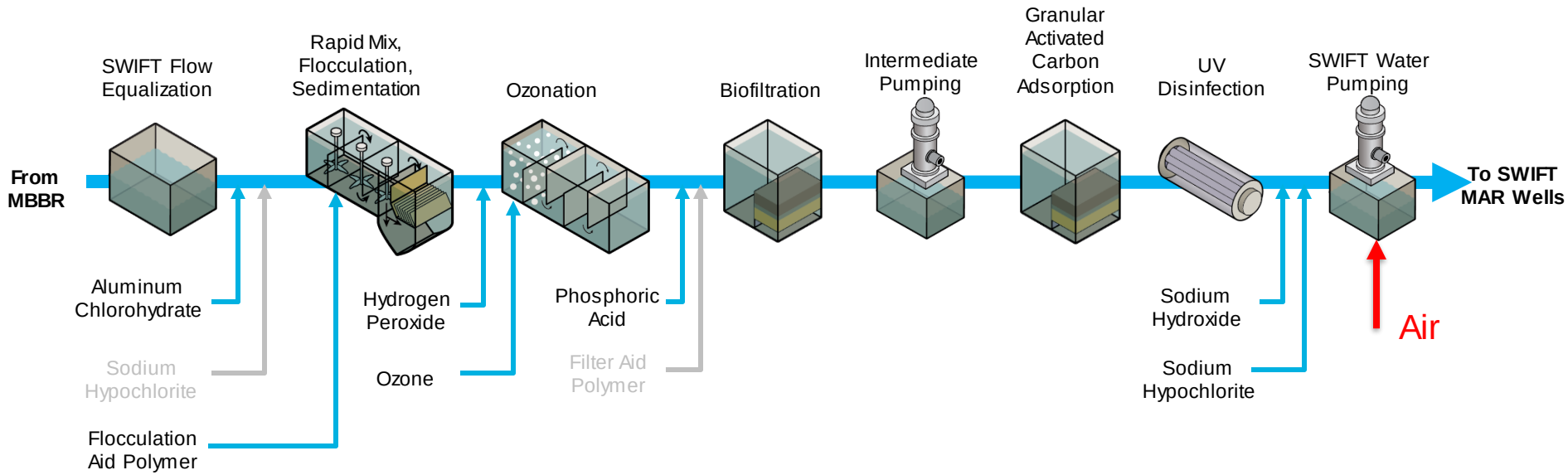


Speece Cone Example

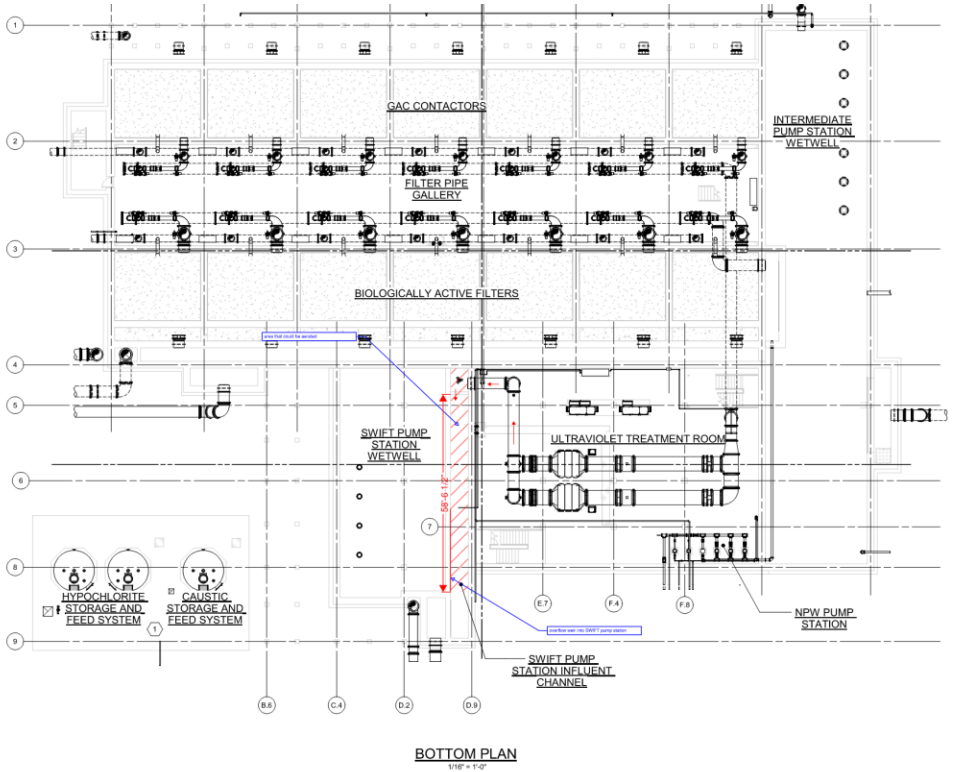
SWIFT Research Center (Current active chemicals)

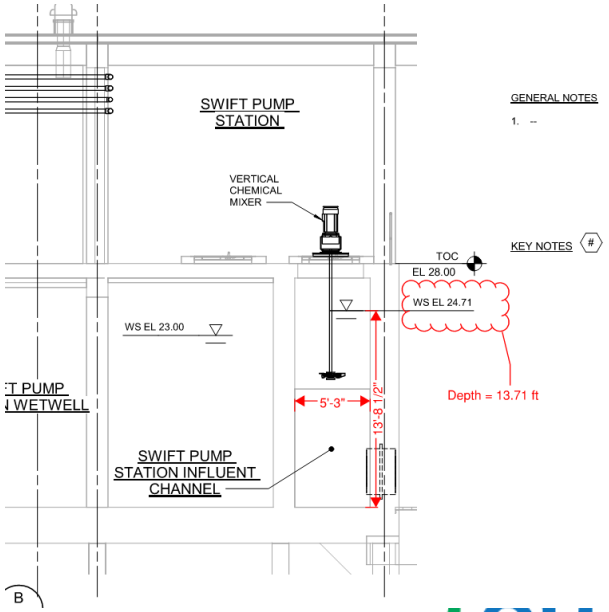


James River SWIFT Process Flow Diagram



Potential Diffuser Location – SWIFT PS Wetwell Influent Channel





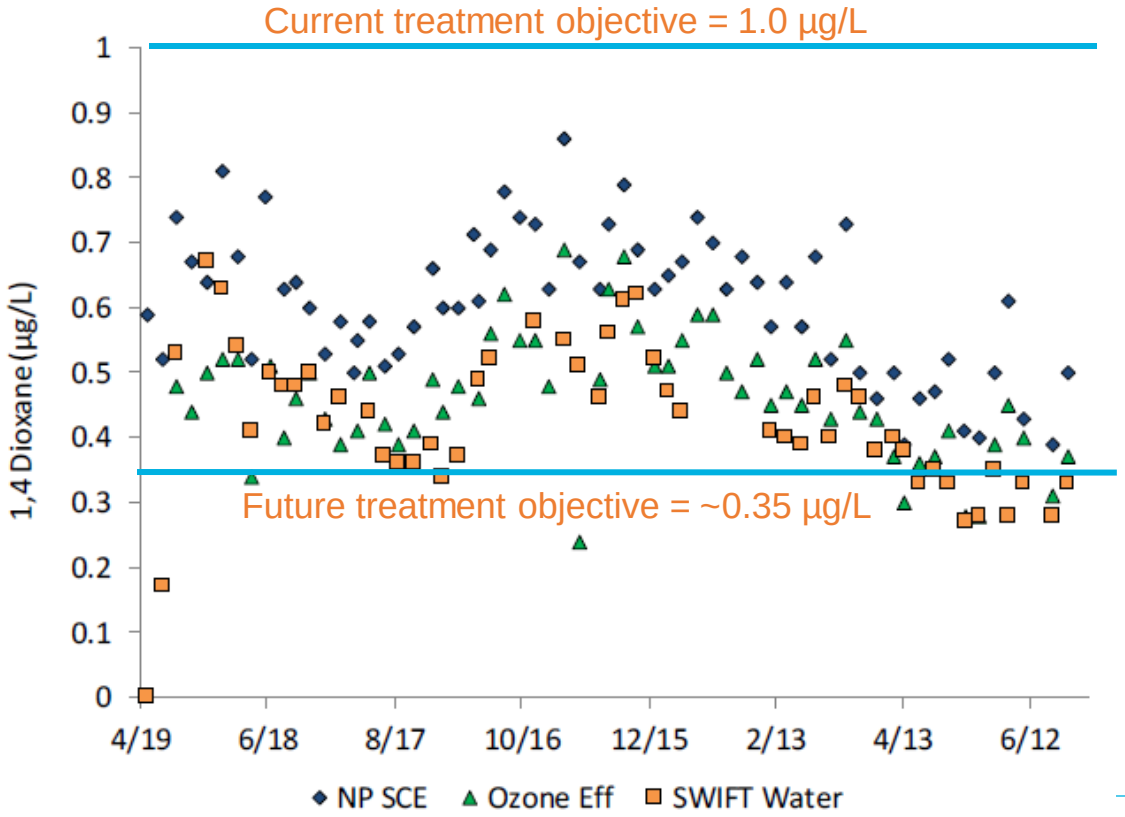
Part B: James River SWIFT Process Concepts

SWIFT Research Center Developments Applied to the James River SWIFT Design

- Improved control of 1,4-dioxane at Bethel Landfill
- Ozone with hydrogen peroxide and multi-point fine bubble dissolution
- Propane for enhanced 1,4-dioxane removal in biofilters?
- Free chlorine only for recharge well protection
- Ozone/BAF for wastewater disinfection

80 years of sustainability HRSD

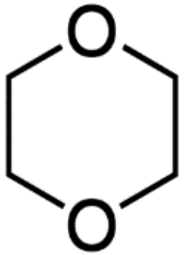
SWIFT Research Center 1,4-Dioxane



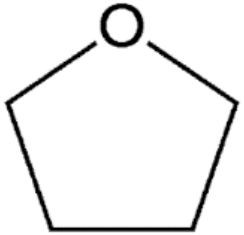
HRSD 1,4-dioxane (µg/L) Secondary Effluent

	ABTP	BHTP	**JRTP**	VIPTP	WBTP	YRTP
Min	0.48	0.55	**0.74**	0.49	0.52	0.34
Max	0.68	0.74	**1.6**	2.2	0.71	0.66
Average	0.56	0.64	**1.12**	0.93	0.61	0.48

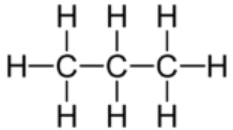
Biofilter Pilot – Co-metabolic removal of 1,4-dioxane using tetrahydrofuran or propane



1,4-Dioxane



Tetrahydrofuran (THF)



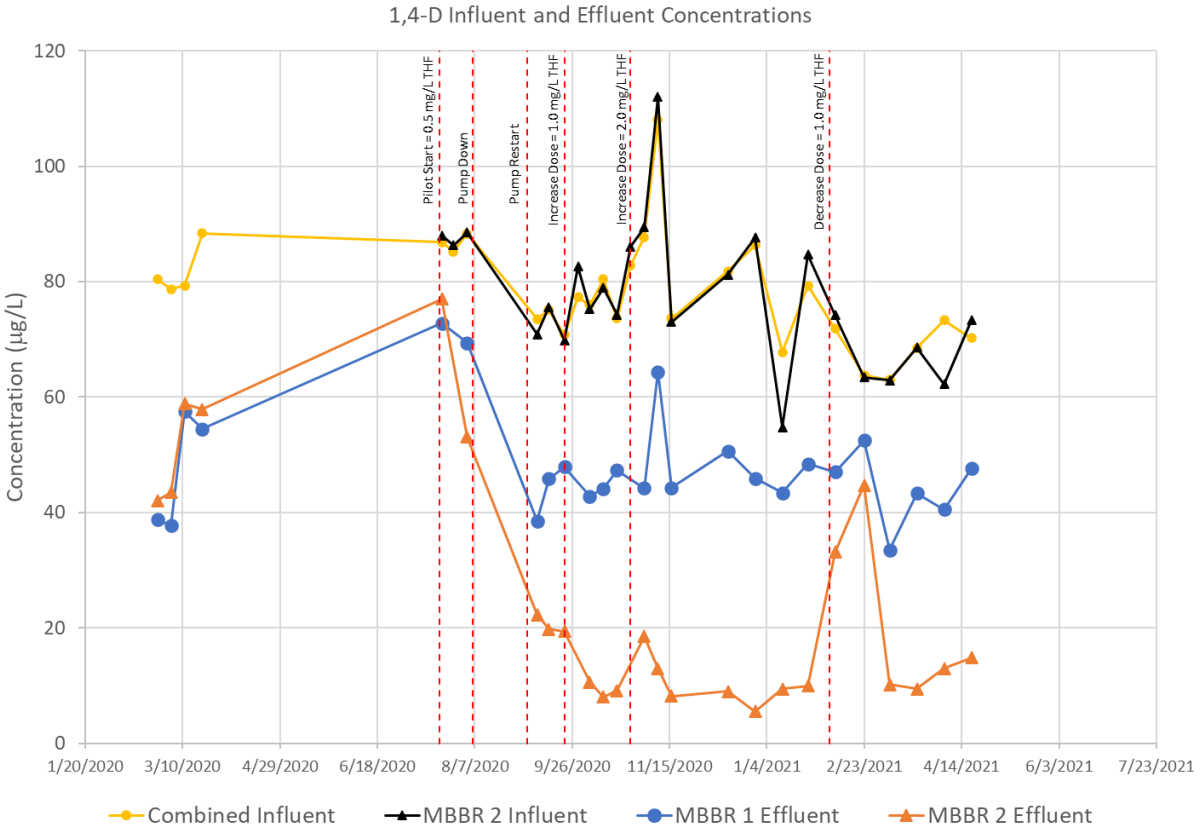
Propane

(Cordone et al., 2016; Zenker et al., 2004)

(Deng et al., 2018; Li et al., 2020; Mahendra et al., 2007)

Waste Management – Bethel Landfill Leachate Pretreatment System

THF Addition to MBBR2 Improved 1,4-Dioxane Removal



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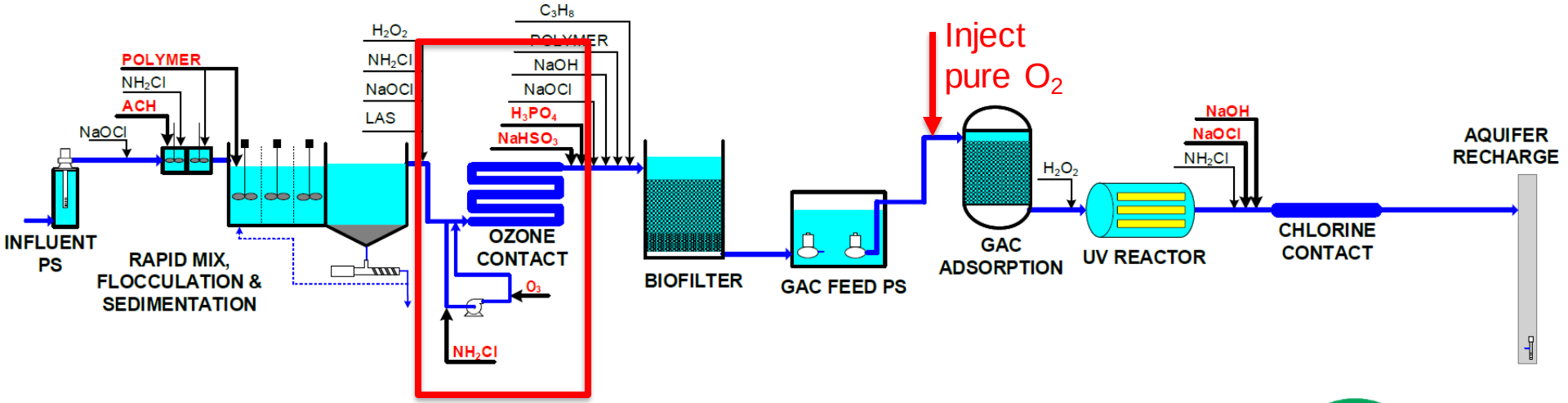


Ozonation at JR SWIFT

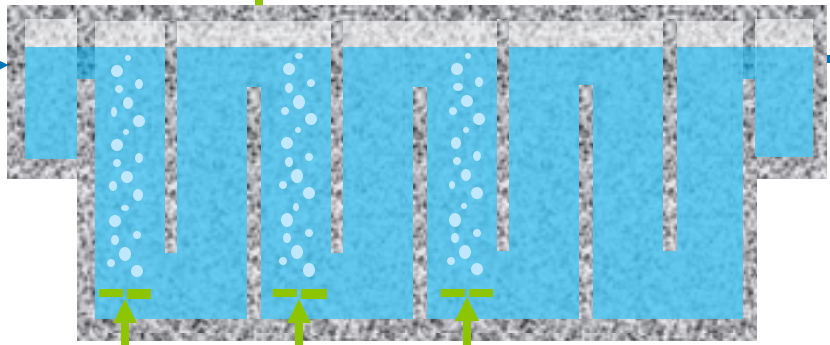
Liquid Oxygen Storage and Vaporizers

Ozone Destruct

Oxygen Gas

Hydrogen Peroxide

From Sedimentation Basins



To Biofilters

Gaseous Oxygen

Ozone Gas

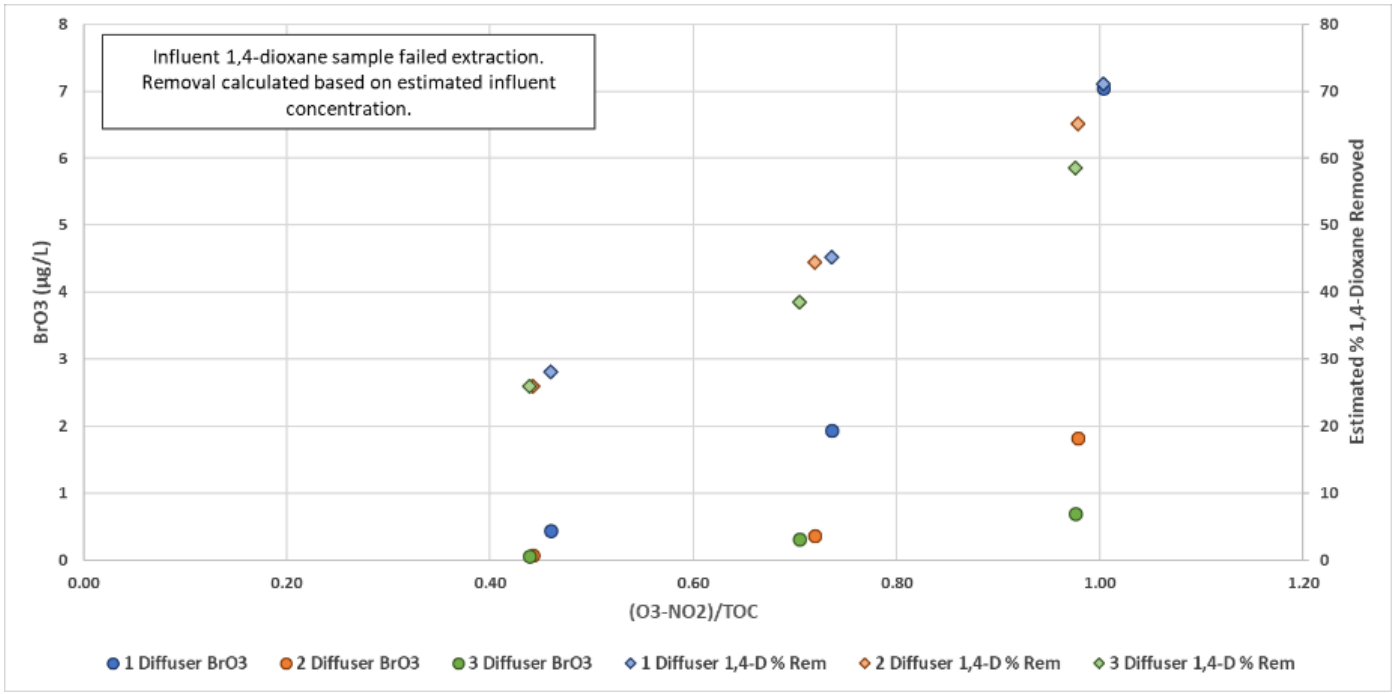
Nitrogen Boost

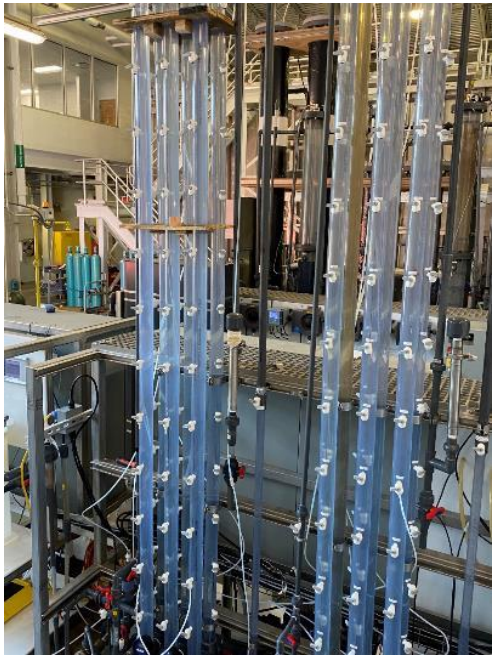
Ozone Generators

M M M

Ozone Contactor

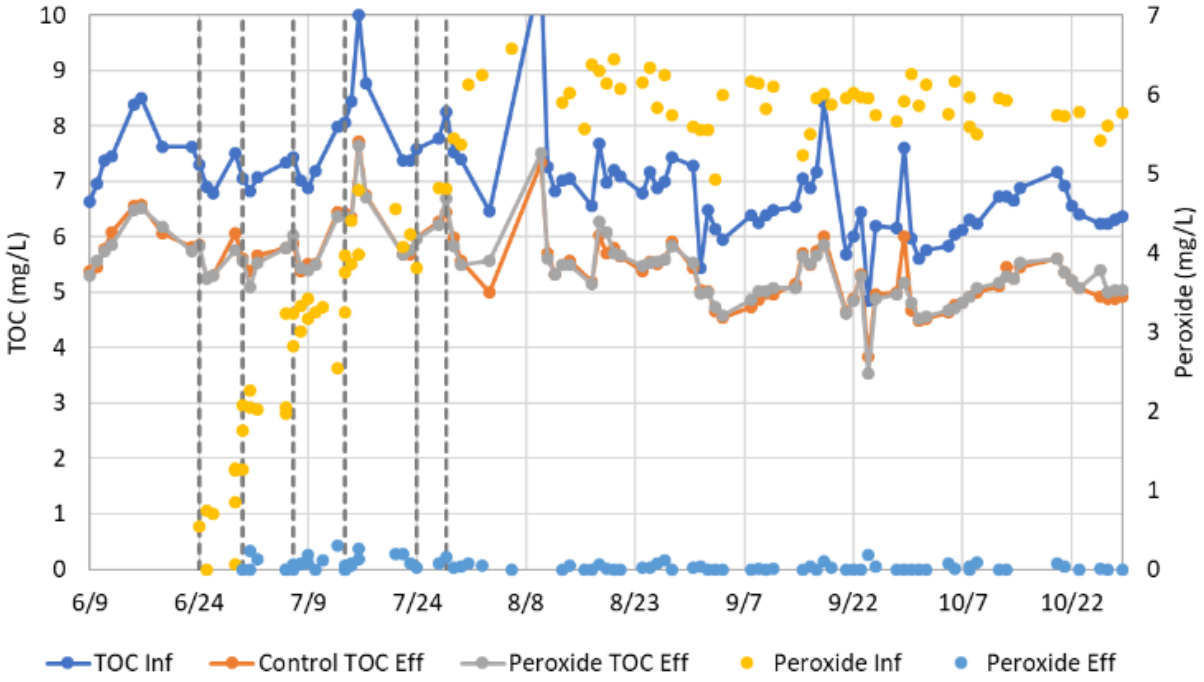
O_3/H_2O_2 Multi-diffuser Fine Bubble – Pilot Testing



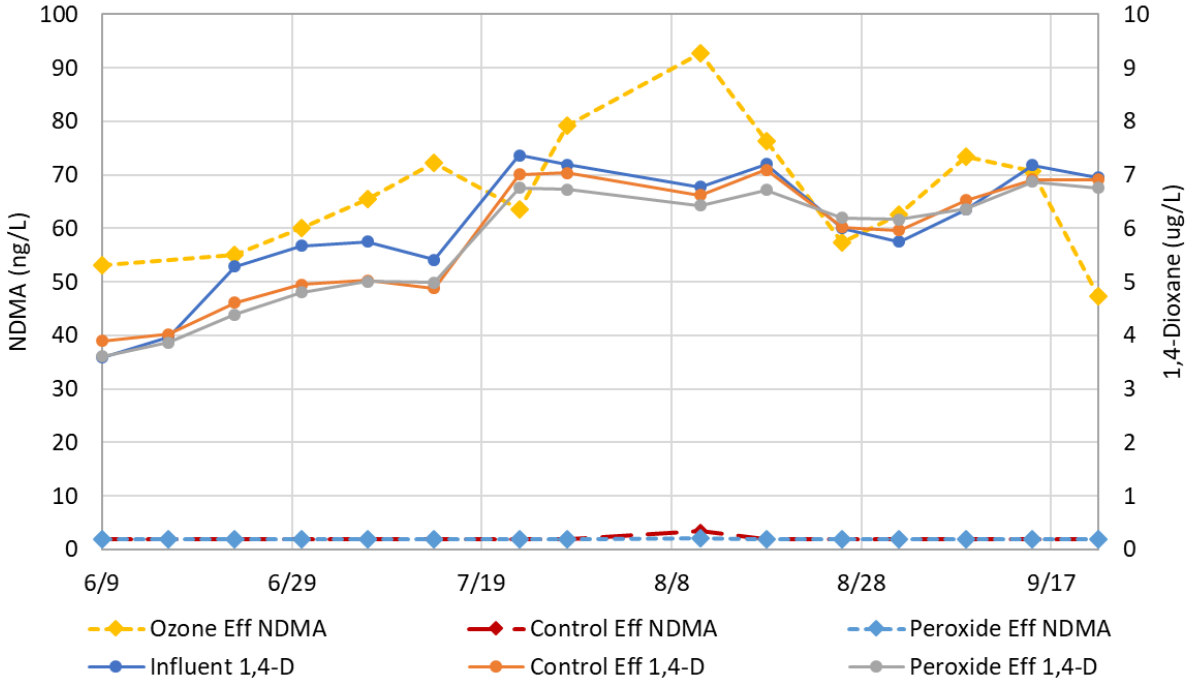


YR DNE Br= 0.398 mg/L

Hydrogen peroxide has no impact on BAF TOC removal



Hydrogen peroxide has no impact on BAF NDMA removal



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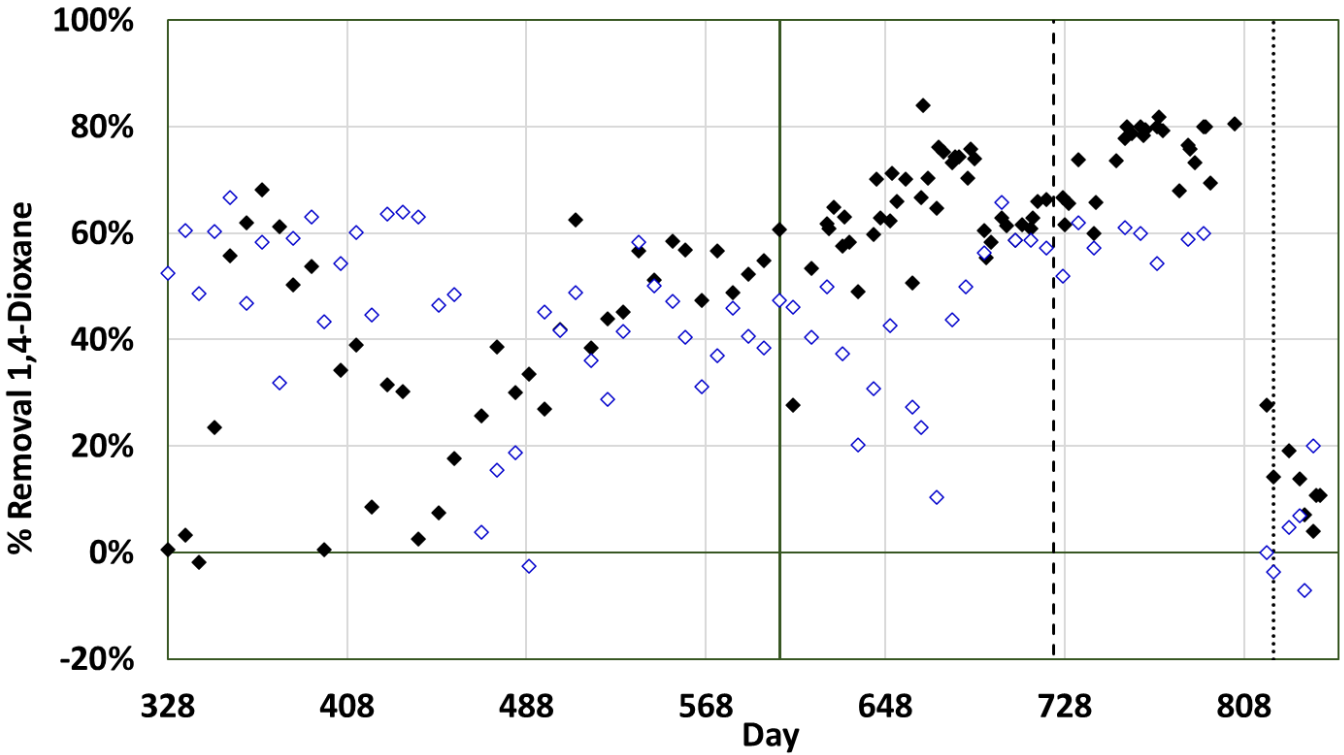
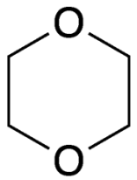
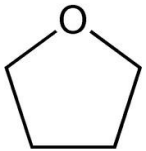
Pilot Propane Feed System

THF and propane have induced similar 1,4-dioxane removal





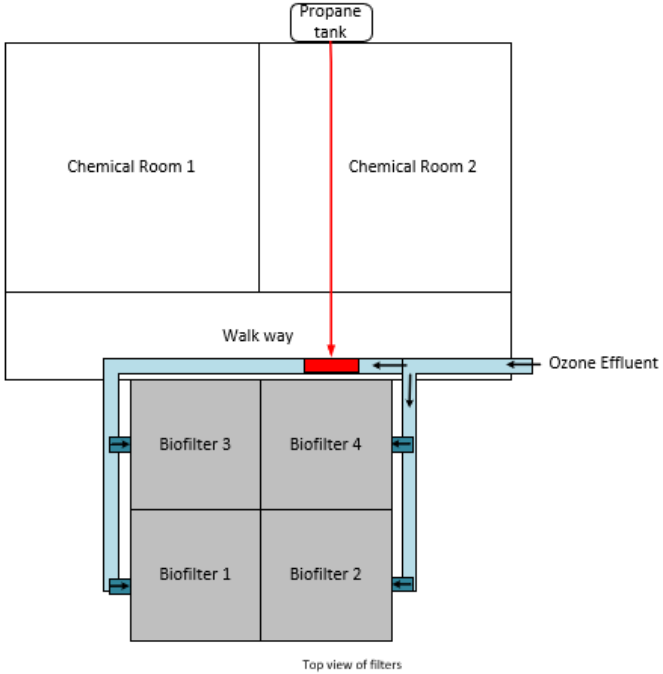
1,4-dioxane



tetrahydrofuran (THF)

propane

Full-scale Testing of Propane Feed



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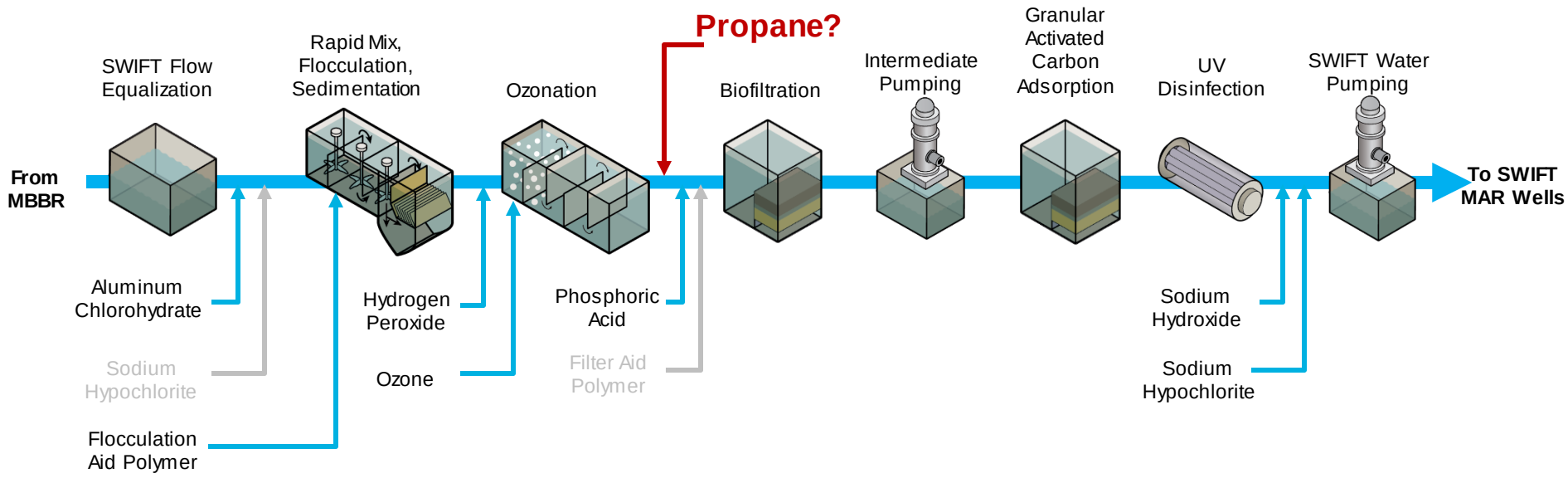

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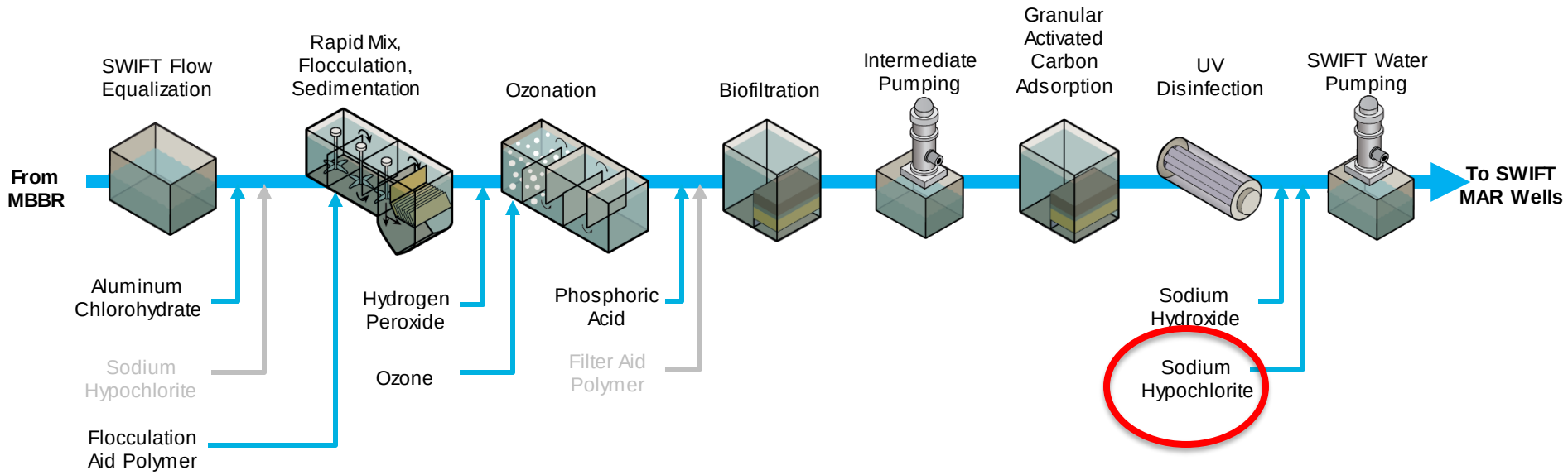

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80 years of sustainability HRSD

Ozone + BAF for Wastewater Disinfection?

- as expected, indicator bacteria are very well inactivated by ozone

	O3:TOC mass/mass	Fecal coliform (MPN/100ml)	Enterococci (MPN/100ml)	Total coliform (MPN/100ml)	*E. coli* (MPN/100ml)
NP secondary clarifier effluent	N/A	200	1450	10800	98000
Flocculation zone 3	N/A	15500	399	24200	>24200
Sedimentation effluent	N/A	135	<1	201	>2420
Ozone effluent, 1:1 H_2O_2:O_3 mass/mass 1 diffuser	0.2	120	<1	201	>2420
	0.5	2	<1	10	172
	0.8	<1	<1	4	68
Ozone effluent, 1:1 H_2O_2:O_3 mass/mass 3 diffusers	0.2	86	<1	129	1990
	0.5	2	1	2	34
	0.8	1	<1	3	71
Ozone effluent, No chemical addition 3 diffusers	0.2	52	<1	126	1550
	0.5	1	<1	1	64
	0.8	2	<1	2	37
BAF effluent 1 diffuser + H_2O_2	0.5	1	<1	2	11
BAF effluent 3 diffusers + H_2O_2	0.5	<1	<1	4	13
BAF effluent 3 diffusers no chem	0.5	<1	<1	<1	11

James River VPDES Permit Limits for FIB:

- Fecal Coliform = 200 MPN/100 mL
- Enterococci = 35 MPN/100 mL

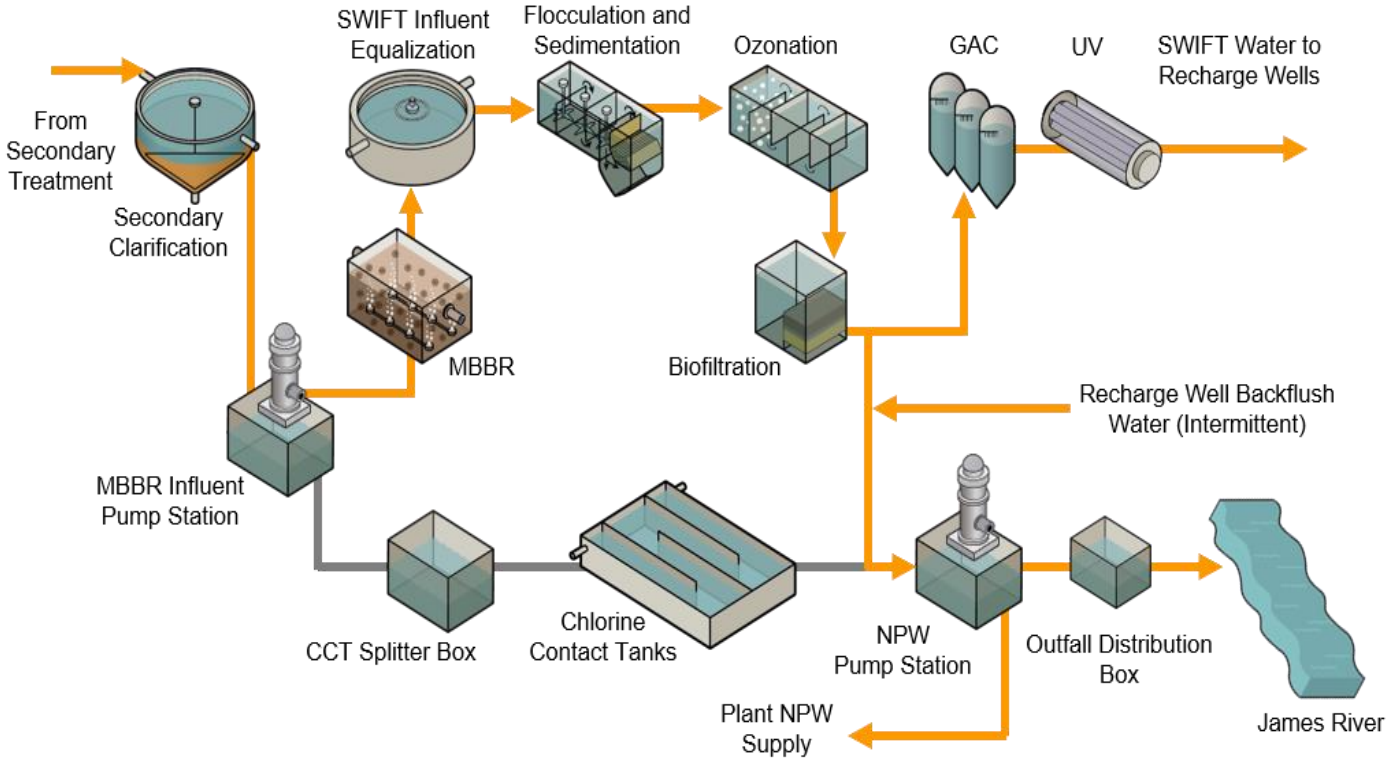
(monthly average, geometric mean)

Ozone + BAF for Wastewater Disinfection?
- viral indicators are also inactivated very efficiently

	O3:TOC mass/mass	Norovirus GI (gc/100ml)	Norovirus GII (gc/100ml)	PMMoV (gc/100ml)
NP raw wastewater		8.0E2	1.73E5	9.41E6
NP secondary clarifier effluent		<16.4	3.55E2	2.21E5
NP final effluent		<16.4	<40.4	2.59E5
Settled water		<1.64	<4.04	1.62E3
Ozone 3 mg/L NH_2Cl as Cl_2	0.75	<1.64	<4.04	9.28E2
Ozone no chemical addition	0.75	<1.64	<4.04	1.15E3
Ozone 1:1 H_2O_2 mass/mass	0.75	<1.64	<4.04	7.60E1
BAF effluent		<1.64E-2	<4.04E-2	1.13E-1

	CrAssphage (gc/100ml)	Male specific coliphage (PFU/100ml)	Somatic coliphage (PFU/100ml)
NP raw wastewater	5.13E7	3.68E4	4.73E4
NP secondary clarifier effluent	2.91E4	9.8	7.46E2
NP final effluent	4.45E4	6	10
Settled water	29.7	<0.01	2.89
Ozone 3 mg/L NH_2Cl as Cl_2	10.7	<0.01	<0.01
Ozone no chemical addition	87.7	<0.01	<0.01
Ozone 1:1 H_2O_2 mass/mass	3.07	<0.01	0.02
BAF effluent	<6.52E-2	<1E-3	1E-3

James River - Dry Weather Flow (<16 MGD)



James River - Wet Weather Flow (>16-21 MGD)