OWEA 2015 Annual Conference, Sandusky, OH, Wednesday, June 24, 11:00-11:45 AM

While We Are At, Nutrients Too, in Clark County

Bill Meinert, PE, Vice President - O'Brien & Gere
Bill.Meinert@obg.com





#obgPresents

Agenda

- *Clark County, OH, Southwest Regional Wastewater Treatment Plant*
- Design Development
  - Requirement – Expansion, Upgrade
  - Goal – Nutrient Removal
- Retrofit Details
  - Nutrient Removal
- Initial Performance
- Questions

Project Basis / Overview – Regulatory Drivers

- **Regulatory Activity**
  - Mad River TMDL
  - OEPA's Nutrient Reduction Strategy (Pending)
  - Gulf of Mexico Hypoxia Program (Pending?)

- **New NPDES Permit (March 2015)**
  - Capacity Expansion: 2.0 MGD → 4.0 MGD Rating (Future Need)
  - Monthly NH_3-N Limit Decrease: 2.5 mg/L → 1.7 mg/L
    - **Additional Future Limits ?**
      - Assess Nutrient Removal Options

NPDES Permit Requirements – 4.0 MGD

Parameter	Requirement / Limit		Frequency
Flow	Report (MGD)		Daily
Dissolved Oxygen	Minimum 5.7 mg/L		Daily
BOD_5	mg/L	lbs/day	Weekly
	12	401	
	8.0	267	Monthly
TSS	18	602	Weekly
	12	401	Monthly
Ammonia-N (NH_3-N)	3.2	107	Weekly
	1.7	57	Monthly
E.Coli	284 #/100 mL		Summer Weekly
	126 #/100mL		Summer Monthly
Phosphorus (as P)	Report		Monthly
TKN (as N)	Report		Quarterly
Nitrite Plus Nitrate (NO_x-N)	Report		Monthly

Influent, Effluent Parameters – Design v. Actual (Startup)

Stream	Parameter	Unit	New Data	Old Data for Comparison		
			July 2014-Sept 2014*	March 2013-May 2014	Jan 2010-April 2012**	Peaking Factor Analysis
Influent	pH	SU		7.90	7.95	
	TSS	mg/L	**391**	315	280	298
	$CBOD_5$	mg/L	**234**	162	133	128
Effluent	Flow	MGD	1.3	1.5	1.6	4.0
	Water Temp	˚C	20.3	14.3	15.2	
	DO	mg/L	8.5	9.1	9.0	
	Max pH	SU	8.2	8.0	8.0	
	Min pH	SU	7.5	7.9	7.9	
	TSS	mg/L	**4.0**	3.0	1.8	
	NH_3	mg/L	**0.57**	0.26	0.22	
	$CBOD_5$	mg/L	2.9	2.1	3.0	
	NOx	mg/L	12.9	15.4	10.9	
	TP	mg/L	**3.3**	2.6	2.7	
	TKN	mg/L		1.2	1.3	
Overflow Occurrence		No.	0	0	0	

**Review of monthly averages only*

***These influent values were used in the Basis of Design Mass Balance and Modeling Evaluations*

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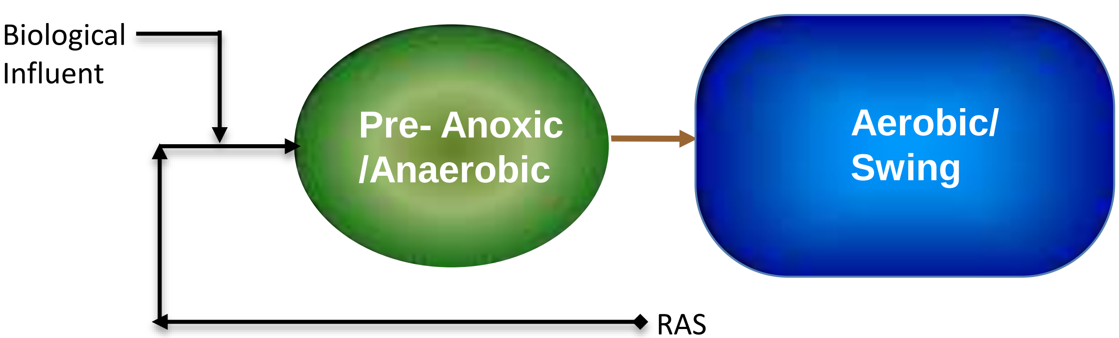
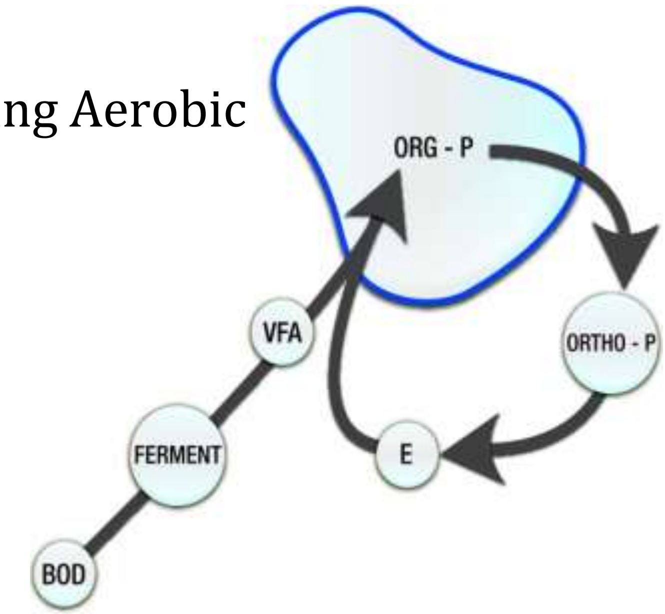
Phosphorus Removal by Biological Means

- **Fundamentals of Bio-P:**
  - Requires Anaerobic-Aerobic sequencing
  - **DO & NOx must be used up for Anaerobic conditions**
    - *NOx in RAS/ Denitrified in Pre-Anoxic Zone*
  - Need Readily biodegradable COD and VFAs during Anaerobic
  - Need Sufficient Aeration during Aerobic
- Poly-phosphate released in Anaerobic, stored during Aerobic
  - Stored Phosphorus is removed with the WAS



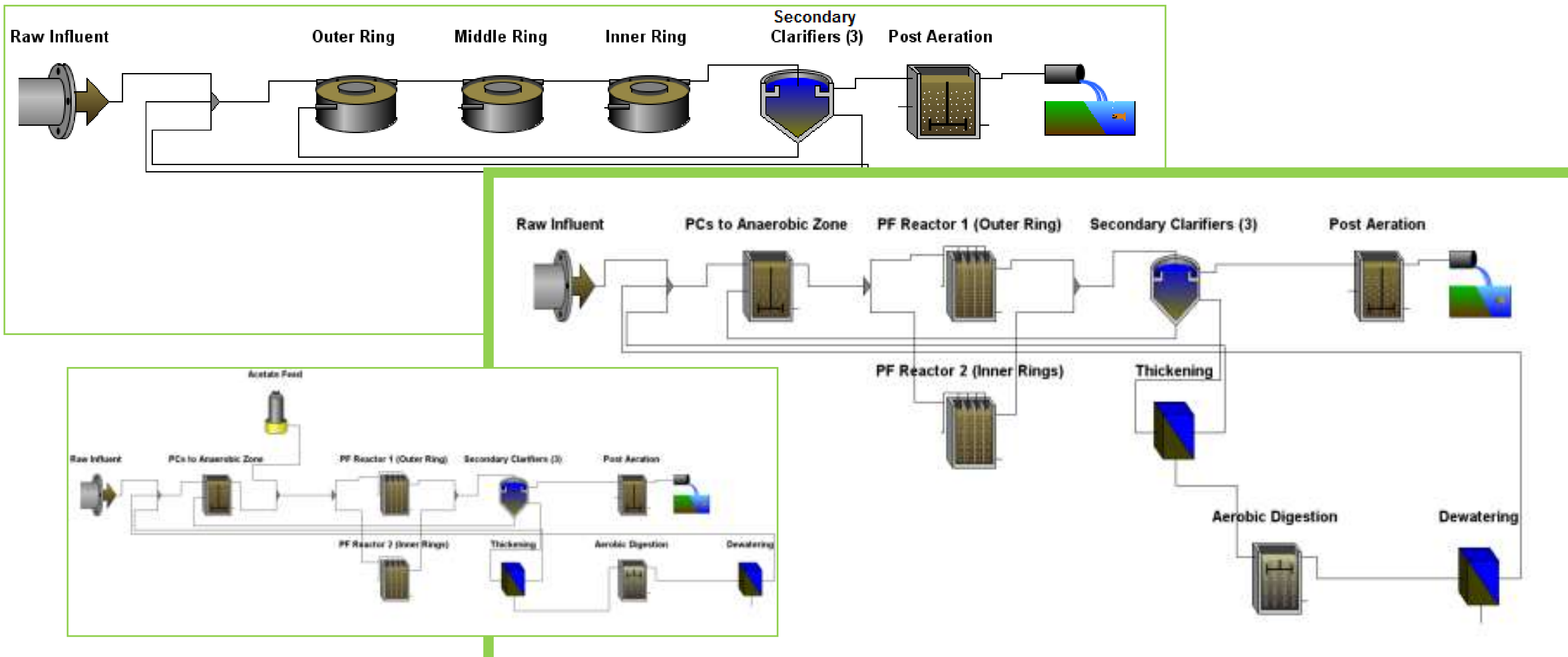


Importance of Influent Ratios

- BOD/N
  - >4.0 generally suggests sufficient BOD for effluent TN < 10 mg/L
- TKN/NH_3-N
  - Greater values indicate higher organic content
  - Potential for higher effluent dissolved organic nitrogen (EDON)
- BOD/P
  - > 30 indicates potential for effective Bio-P
  - < 20 indicates minimal removal with Bio-P
- rbCOD/P
  - Most rbCOD gets converted to acetate for EBPR
  - 1 mg P removal for 6–10 mg/L rbCOD

Process Modeling

- Calibrated existing plant for existing limits
- Modeling to evaluate conditions for Bio-P, BNR
  - <1 mg/L TP, 10 mg/L TN



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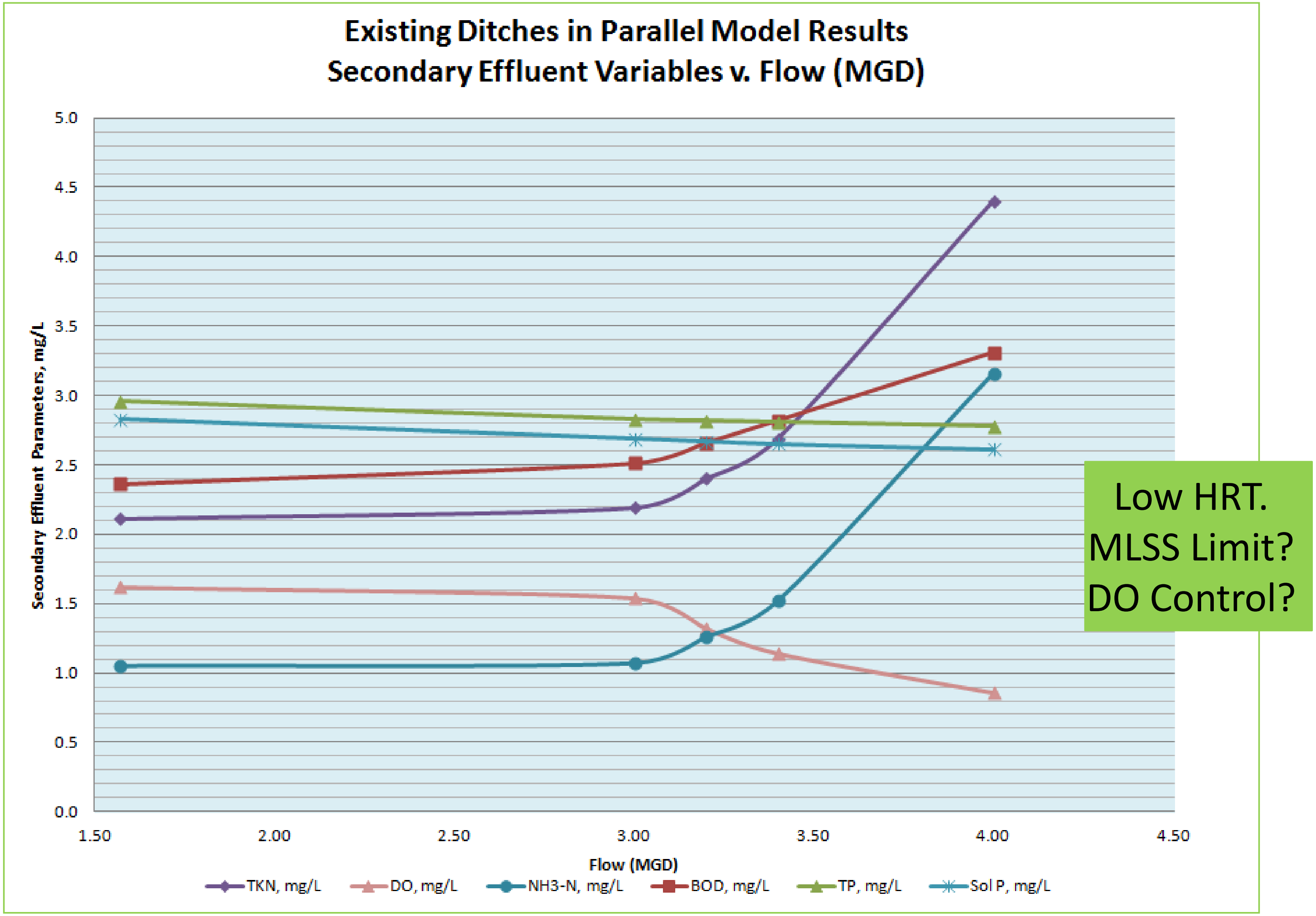
Process Modeling – Oxidation Ditch Mode



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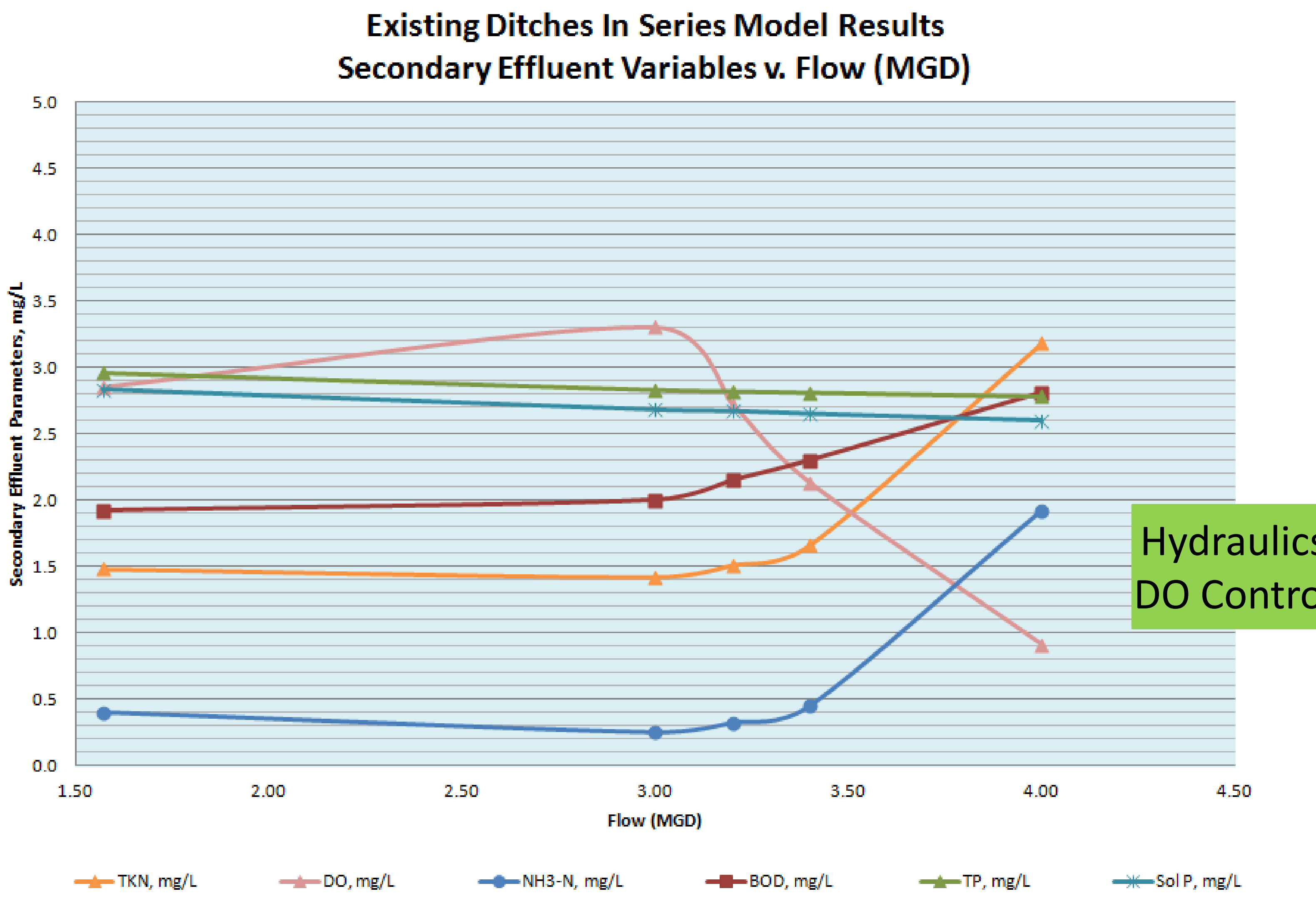
Process Modeling – Oxidation Ditch Mode



Hydraulics?
DO Control?

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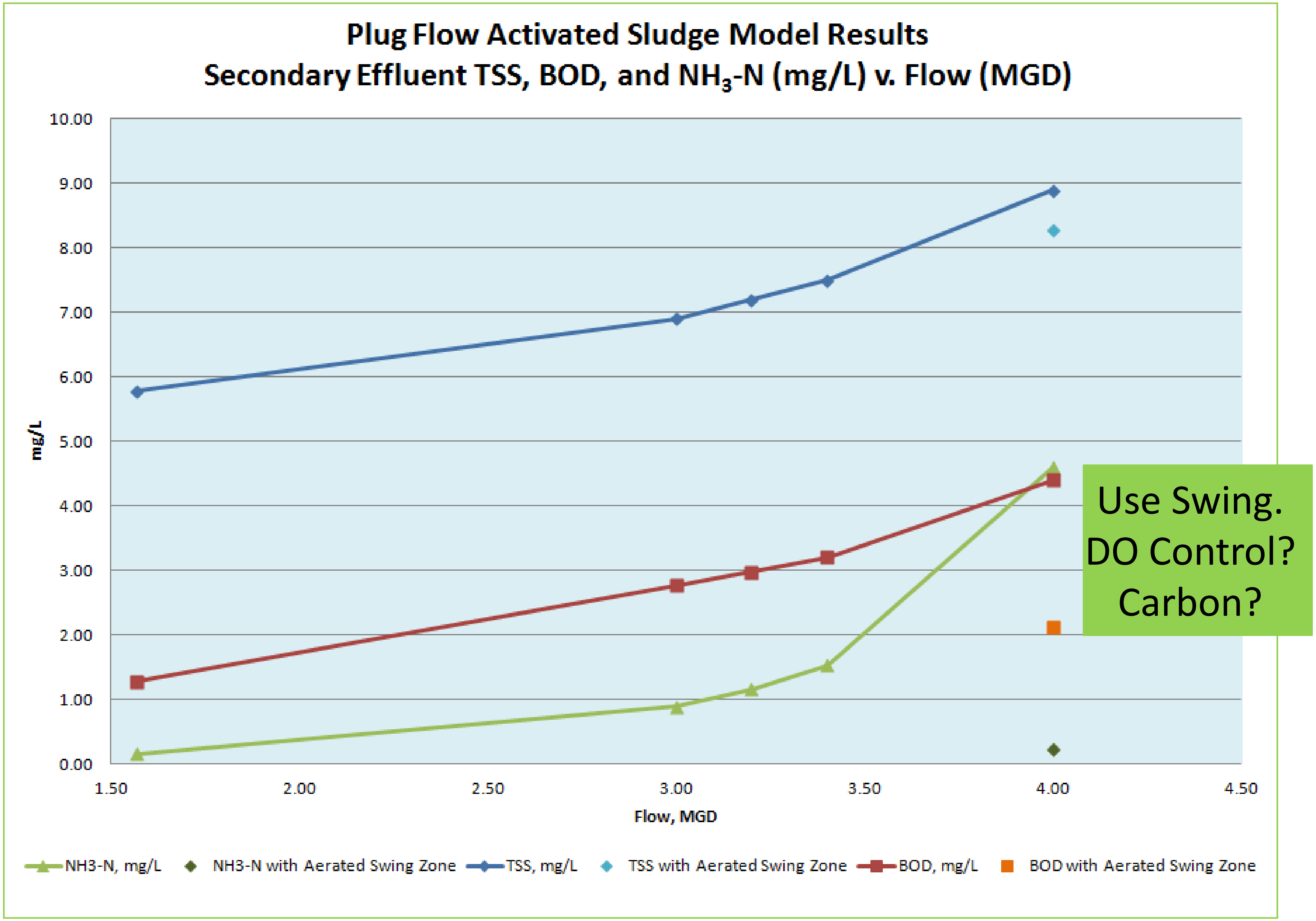
Process Modeling – Plug Flow Mode



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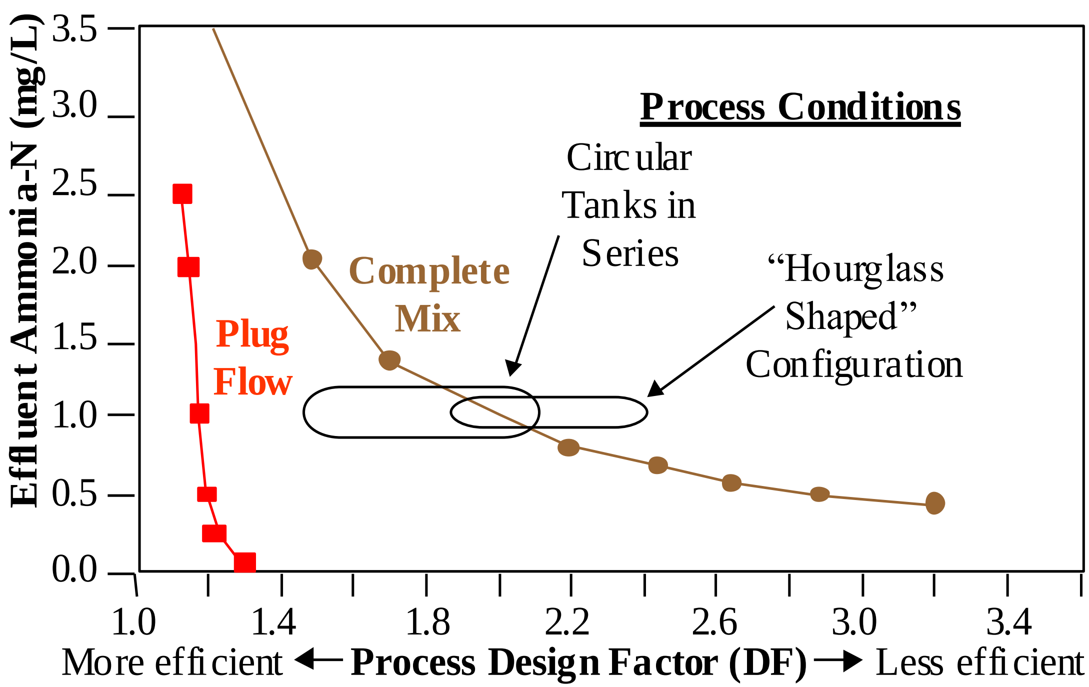
Oxidation Ditch vs. Plug Flow Operation

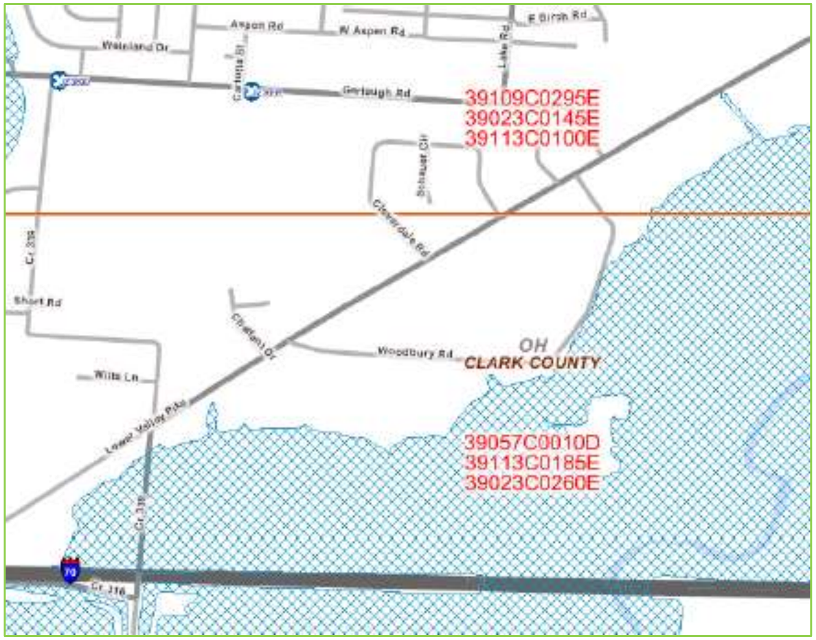
- Aerobic suspended growth process
  - Oxidation ditch *(to 3.2 MGD?)* vs.
  - Plug-flow configuration *(to 4 MGD, BNR)*



Effect of design factor on steady state effluent ammonia levels in complete mix and plug flow suspended growth reactors.

Oxidation Ditch vs. Plug Flow Operation

- Other Benefits
  - Improved Process Control
    - Dedicated Zones
    - Independent Mixing & Aeration
  - BNR
    - > Nitrification, TN & Bio-P
  - Lower Capital Cost
  - Lower O&M Cost
  - *Floodplain*



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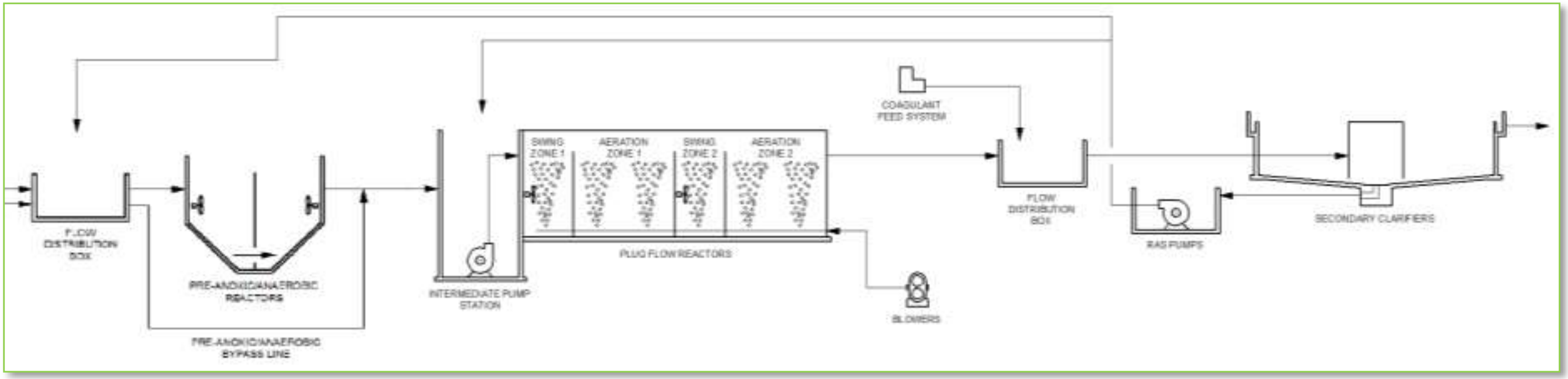
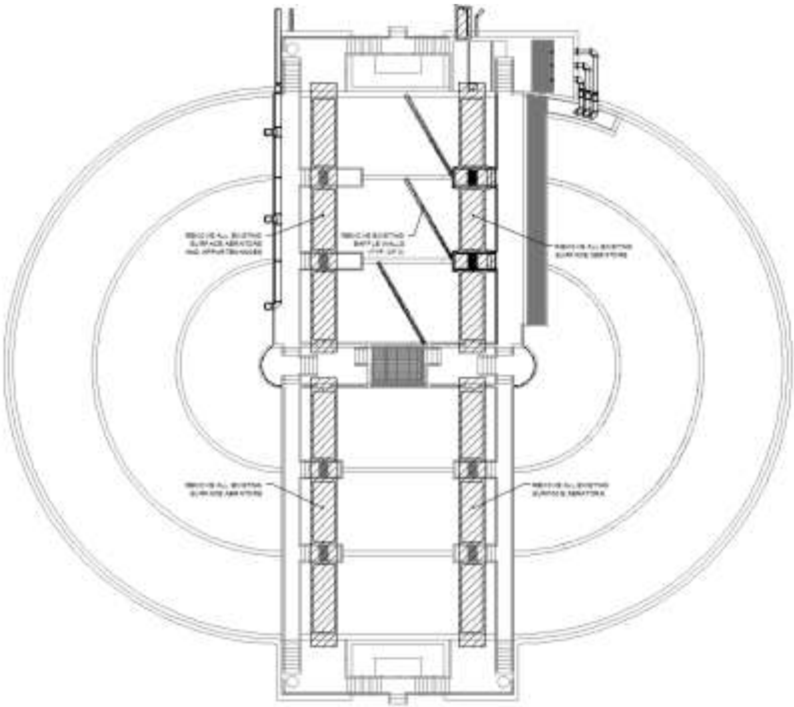
Other Benefits of Biological Nutrient Removal

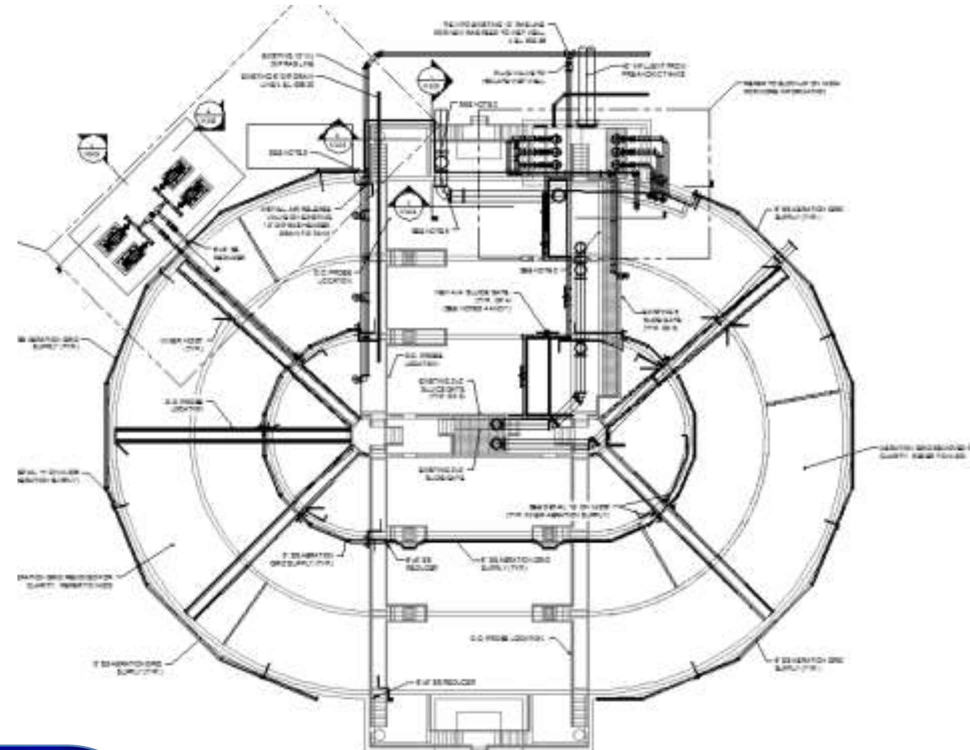
- Anoxic Treatment Reduces BOD w/o Oxygen
  - Reduce Overall Required Oxygen
- Anoxic/Anaerobic Conditions can enhance settleability
  - Select organisms, control filaments
- Bio-P can enhance alpha factor (oxygen uptake)
- Chem-P can increase inactive biomass

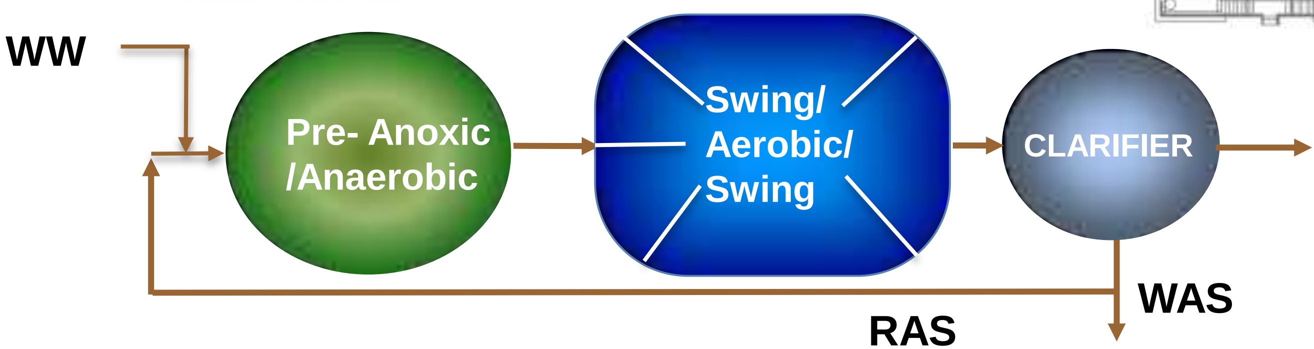


Oxidation Ditch BNR Conversion

- Converting oxidation ditches to plug flow reactors







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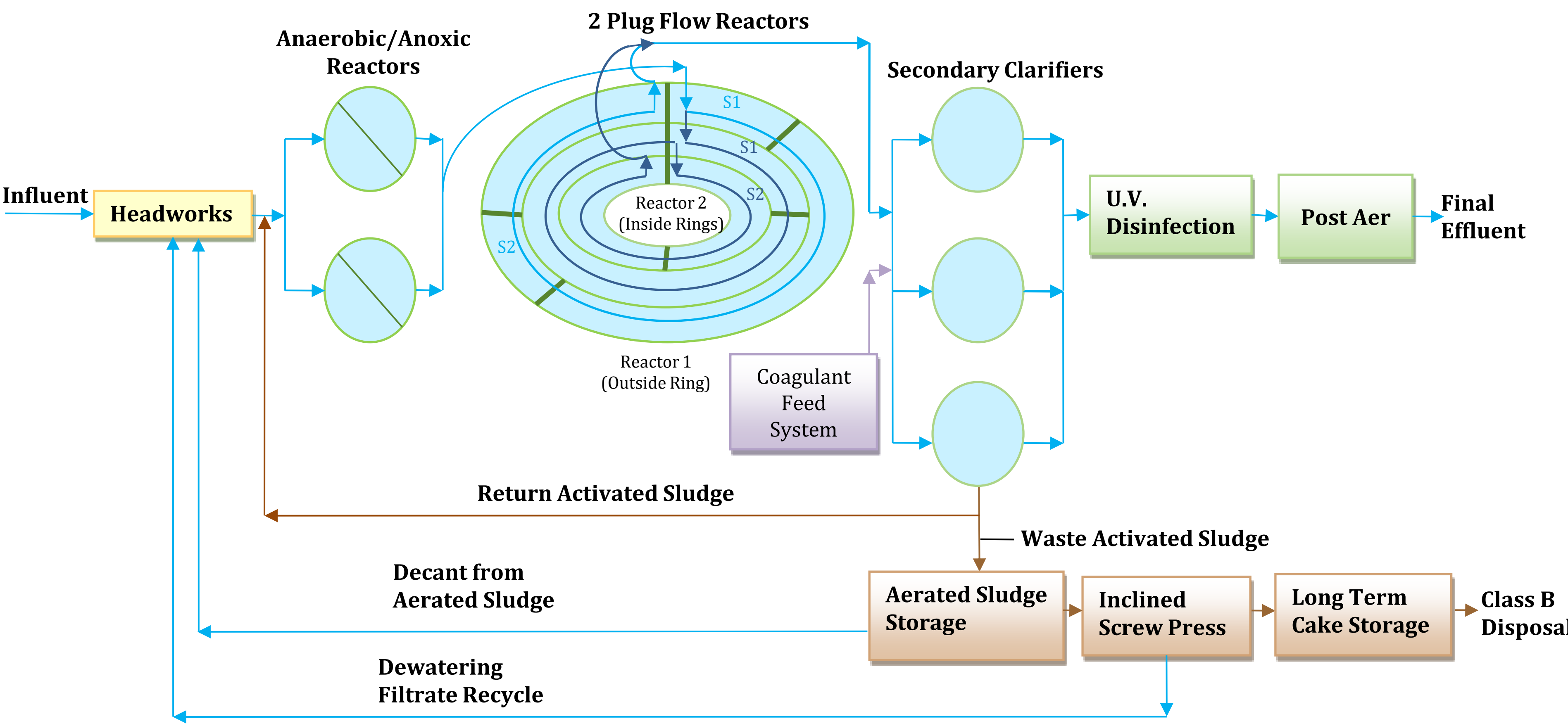
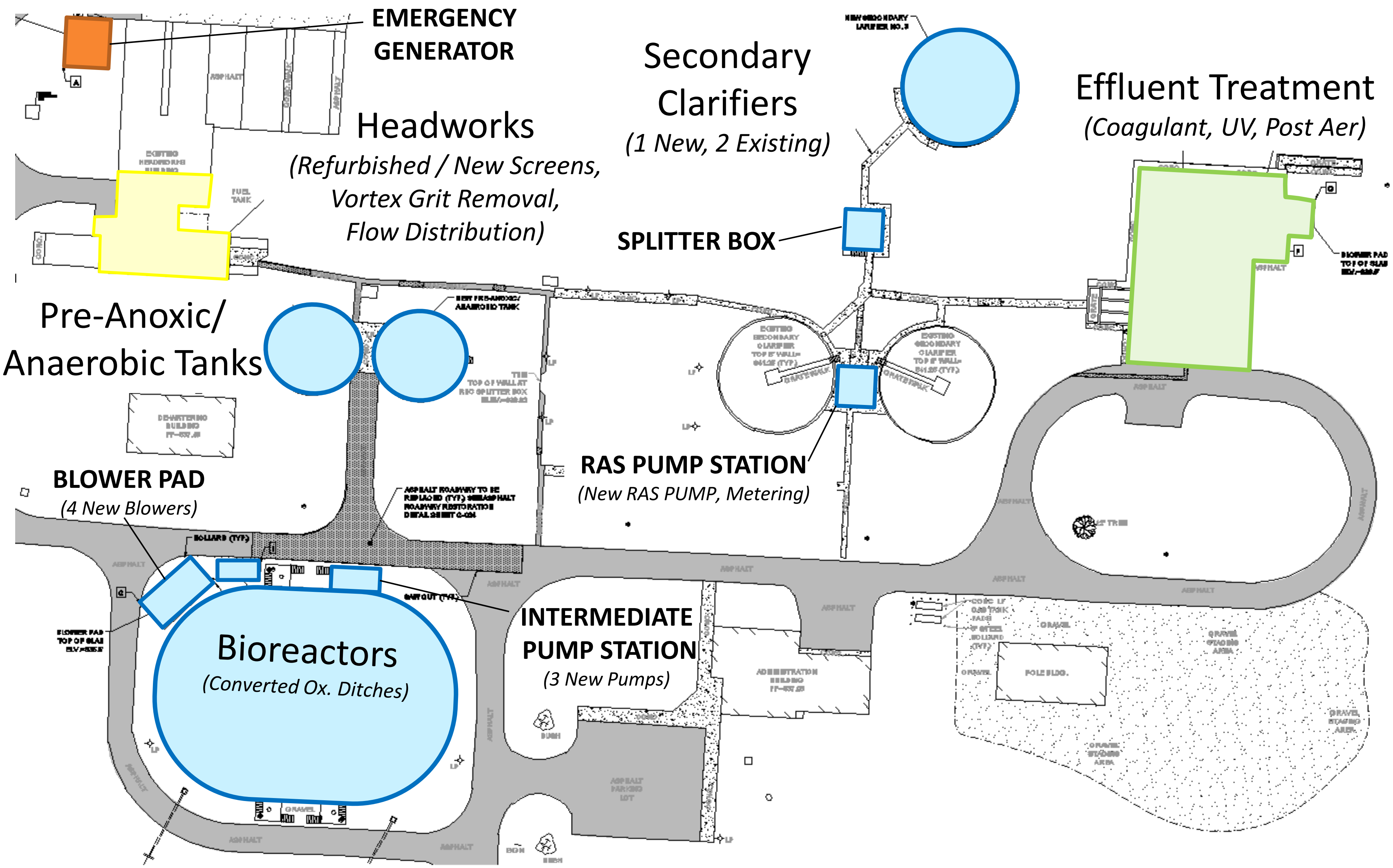
Overview – Process Flow Diagram



Project Basis / Overview – 4.0 Expansion Site Plan



Capacity Expansion from 2 to 4 MGD (10 MGD Peak)

Influent Screw Pumps (Ex. To Remain)

- Existing Screw Pumps to Remain (7.3 MGD Capacity)
  - Update when Peak Flow reaches 80% of firm pumping capacity

Influent Screening (Refurbish/New)

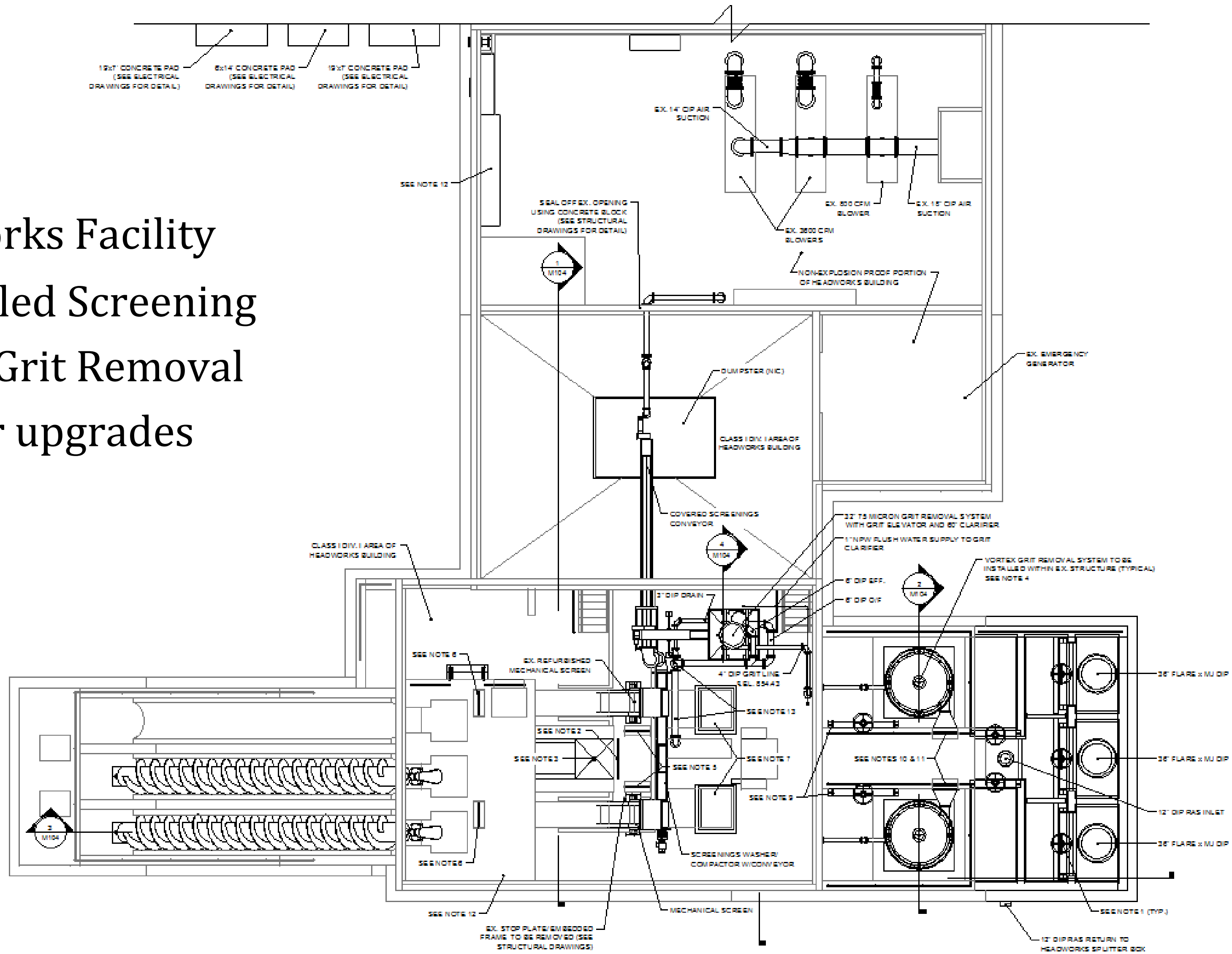
- Existing Mechanical Screen (5 MGD) to Remain
  - Add Second Mechanical Screen (5 MGD)
  - Replace Bar Rack (New 10 MGD, for Redundancy)
- New Shaftless Screw Screenings Conveyor

Grit Removal (New)

- New Vortex Grit Concentrators (With Stacked Tray Design)

Retrofitted Headworks Layout – Plan

- Headworks Facility
  - Doubled Screening
  - New Grit Removal
  - Other upgrades



Biological Treatment Zone Volumes

Zone	Train 1 Vol (MG)	Train 2 Vol (MG)	Total Vol (MG)	Primary Process Purpose
Pre- Anoxic /Anaerobic	0.11	0.11	0.22	RAS Denitrification/ Phosphorus Release
Swing	0.13	0.15	0.28	(Depends on Operation)
Aerobic	0.26	0.31	0.57	Nitrification/ P Uptake
Swing	0.15	0.18	0.33	(Depends on Operation)
Aerobic	0.09	0.10	0.19	Nitrification/ P Uptake
Total	0.74	0.85	1.59	BOD/Nutrient Removal

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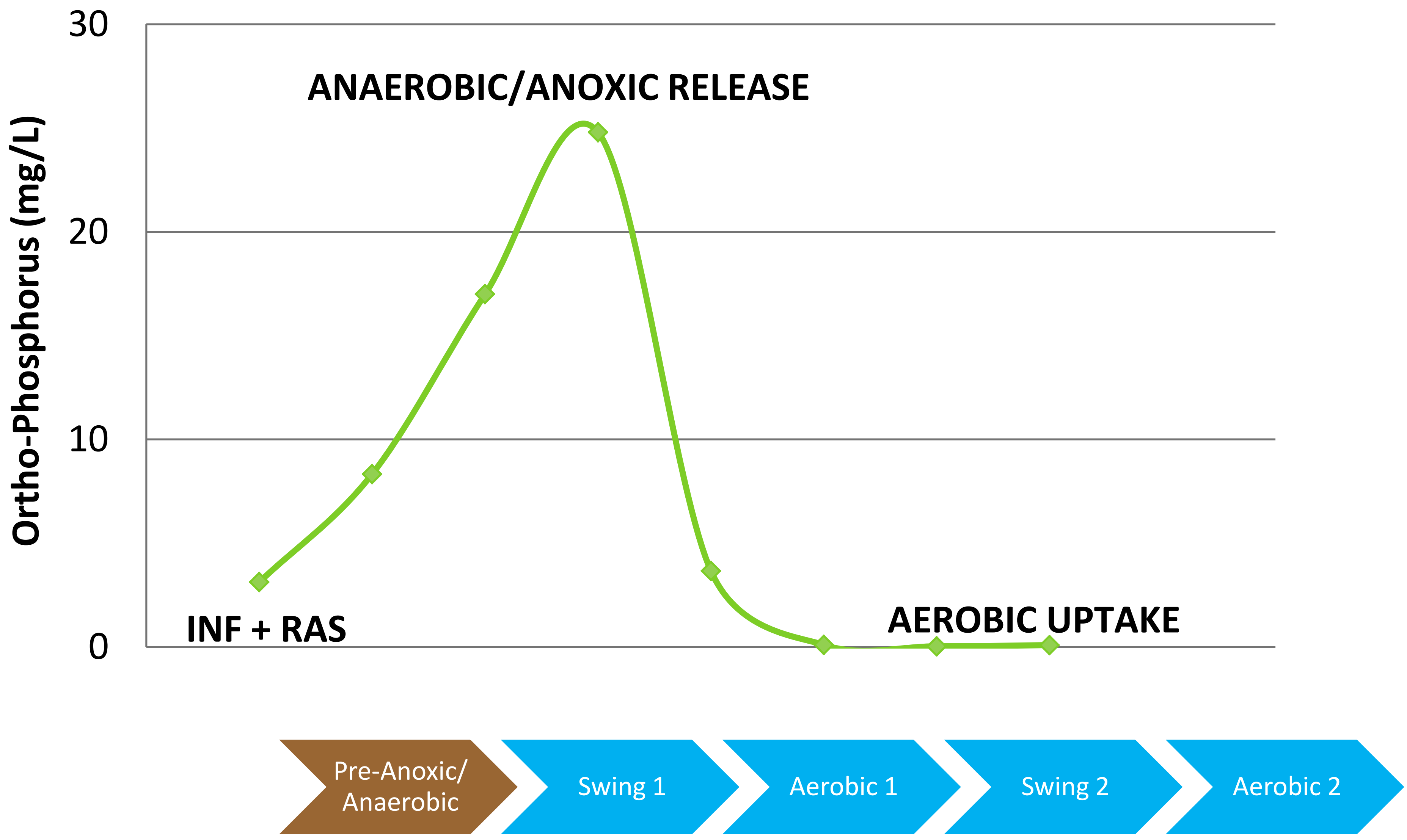
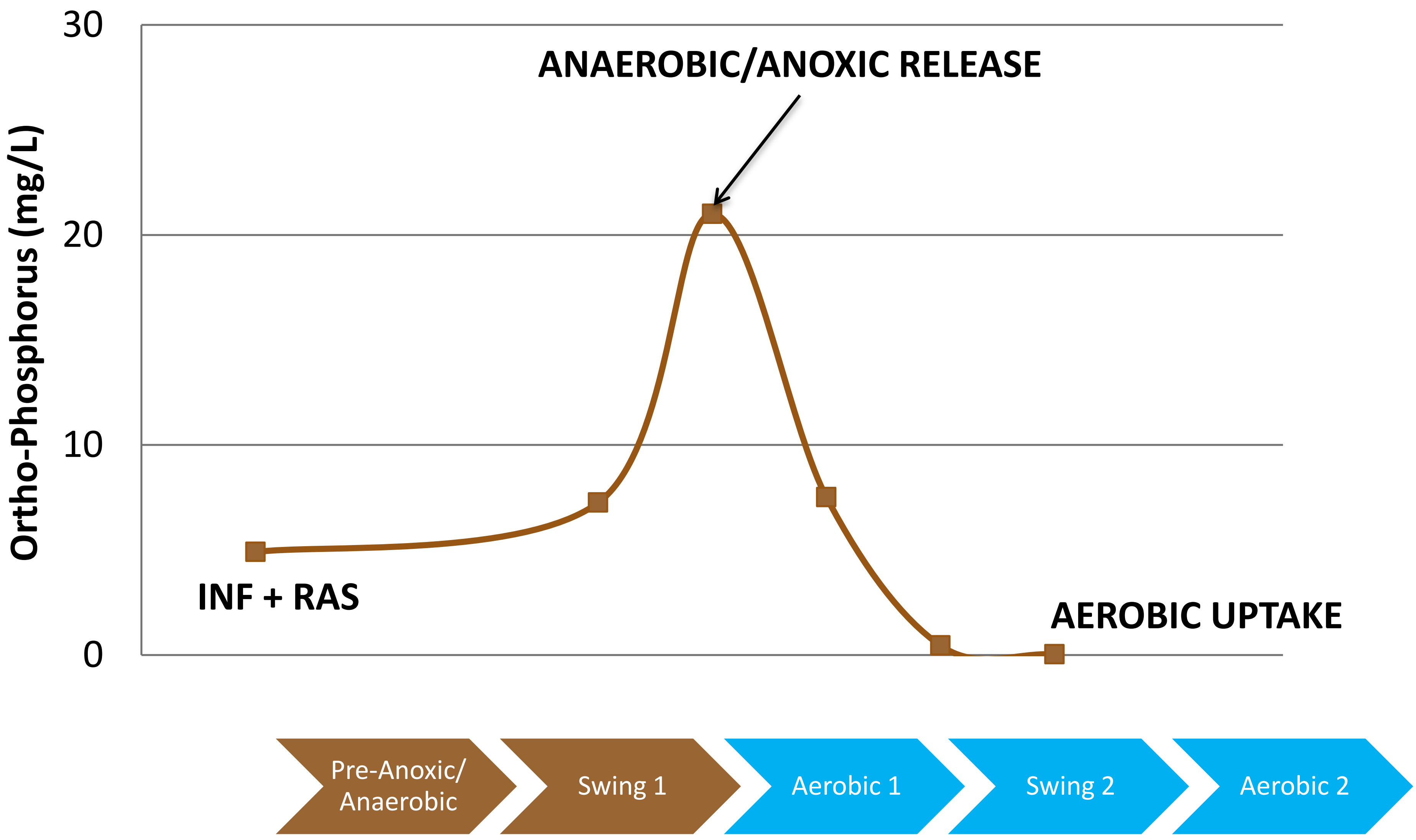
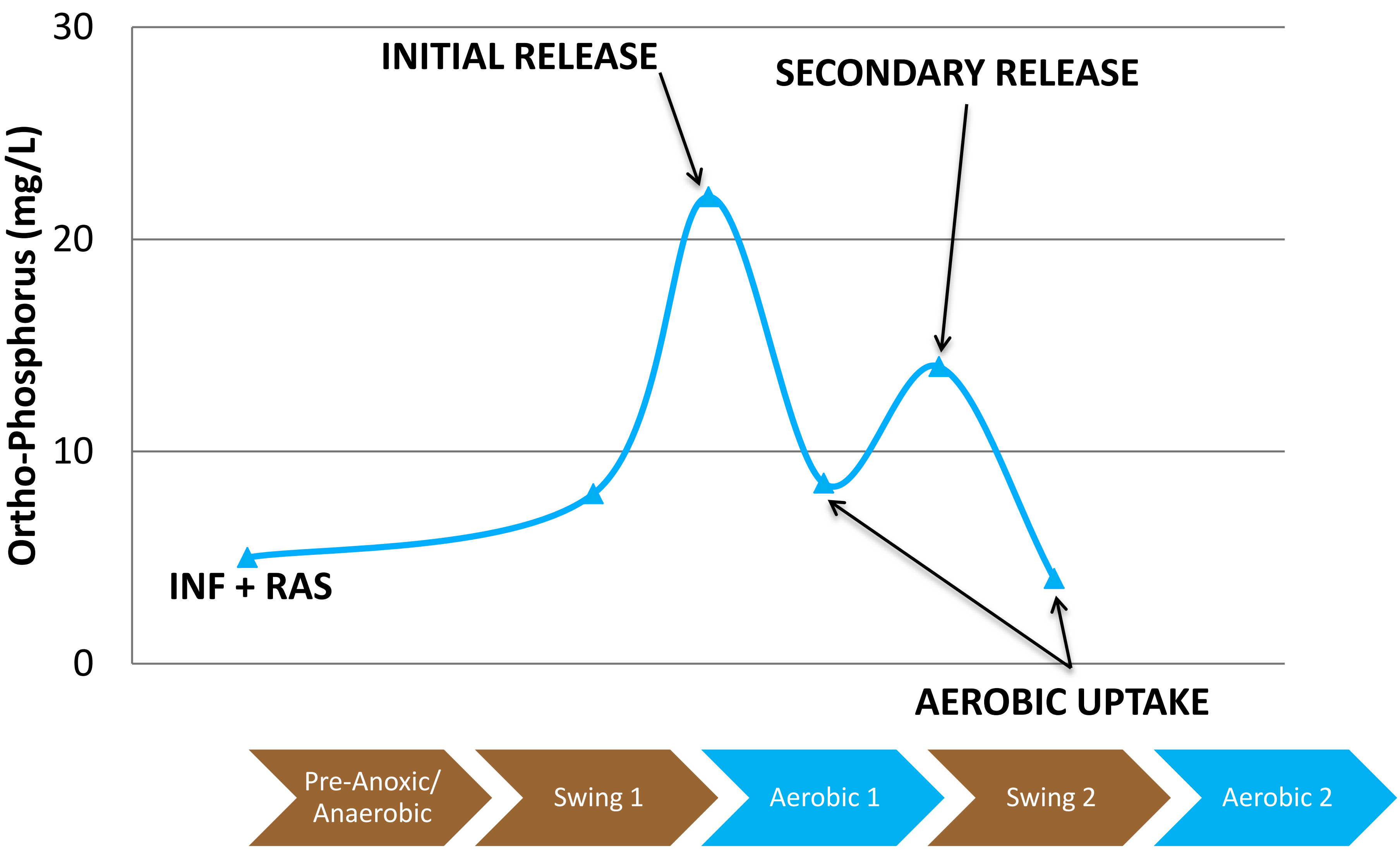
Ortho-Phosphorus Profile – Aerobic Swing Zones – 1.57 MGD



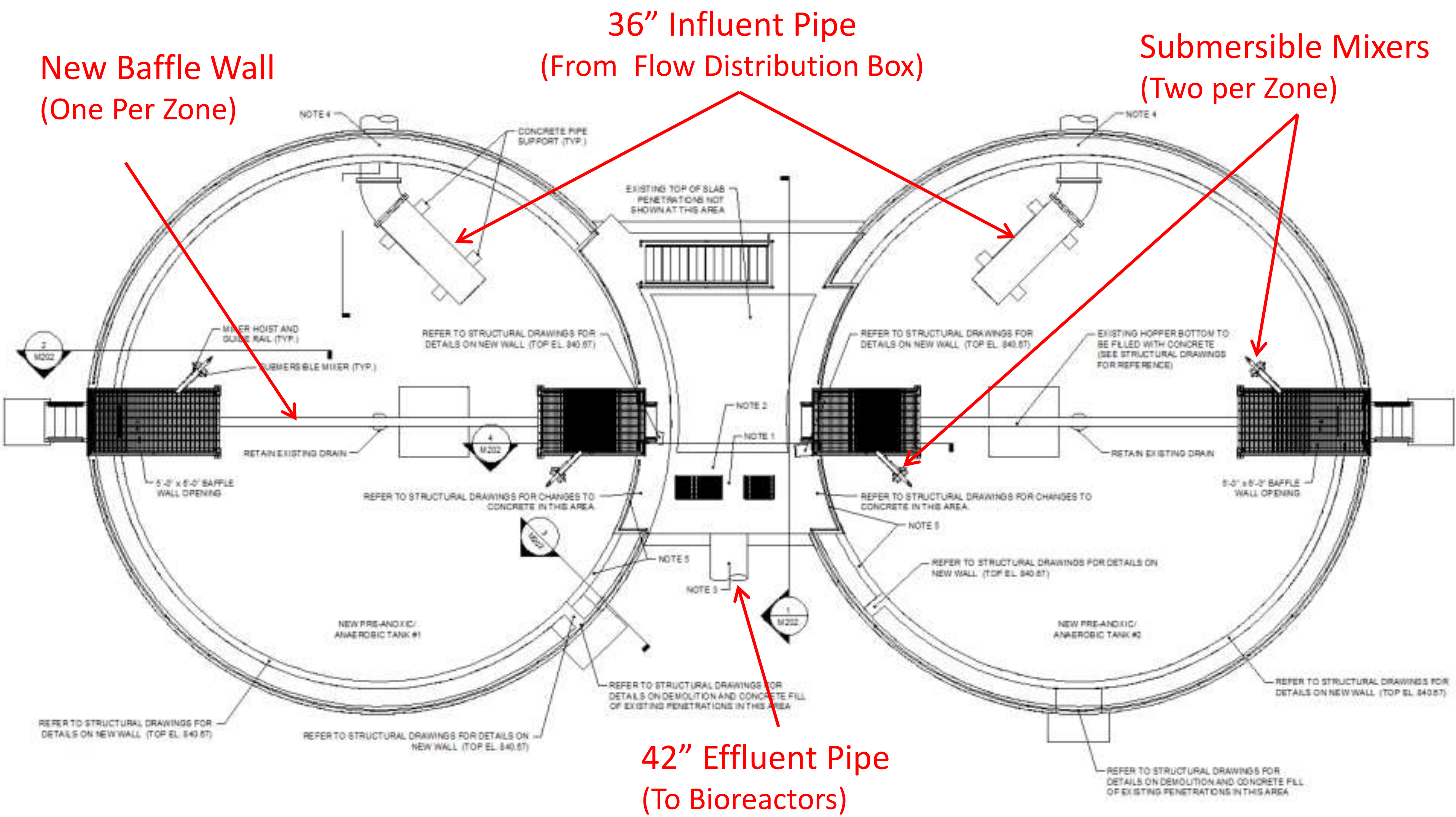
Ortho-Phosphorus Profile – Anaerobic Swing 1 – 3 MGD



Ortho-Phosphorus Profile – Secondary Release



Converted-PC Equalization to Pre-Anoxic/Anaerobic Reactors



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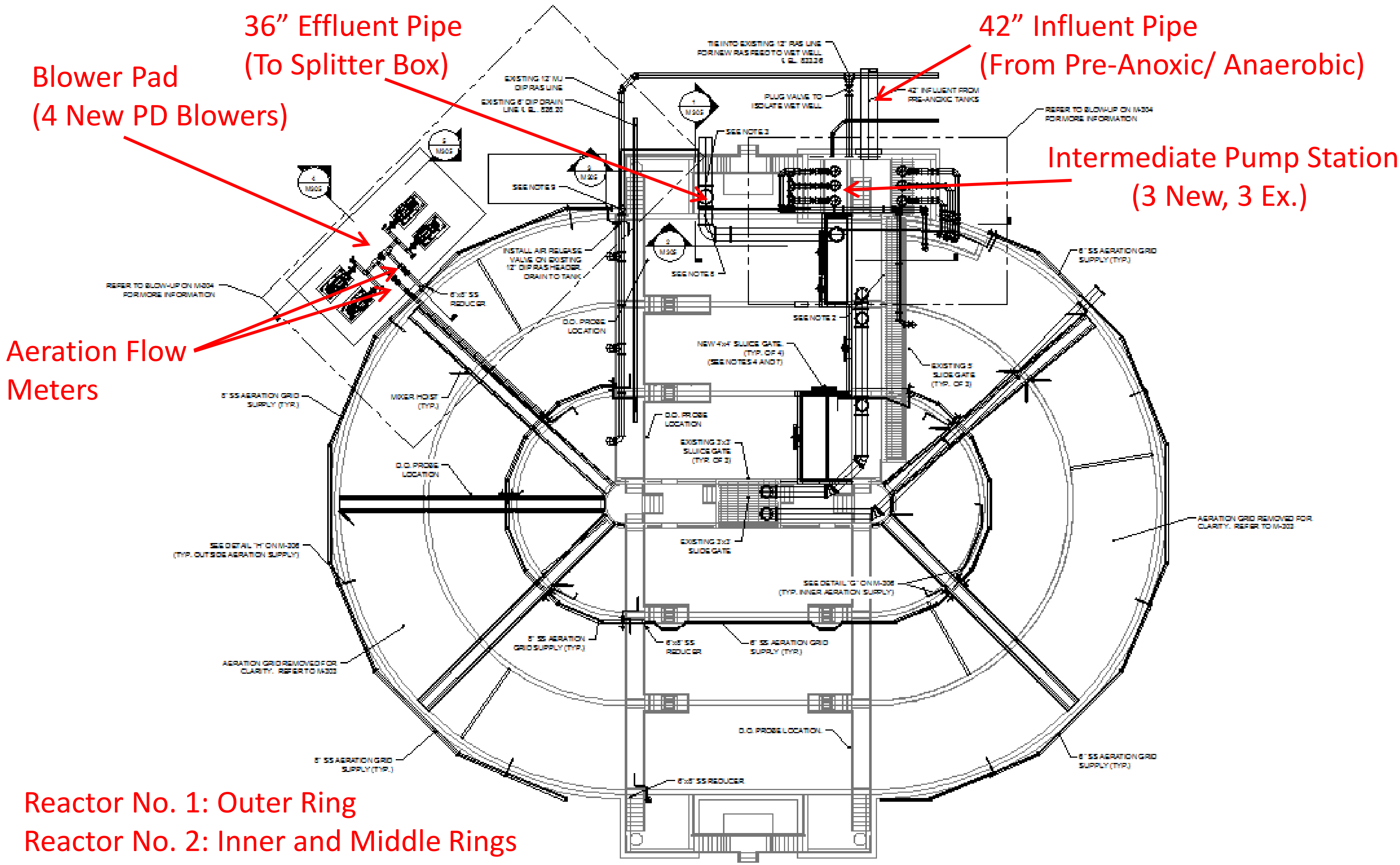
Converted Bioreactors (Upper Level)



Converted Bioreactors (Lower Level)

36" Effluent Pipe
(To Splitter Box)

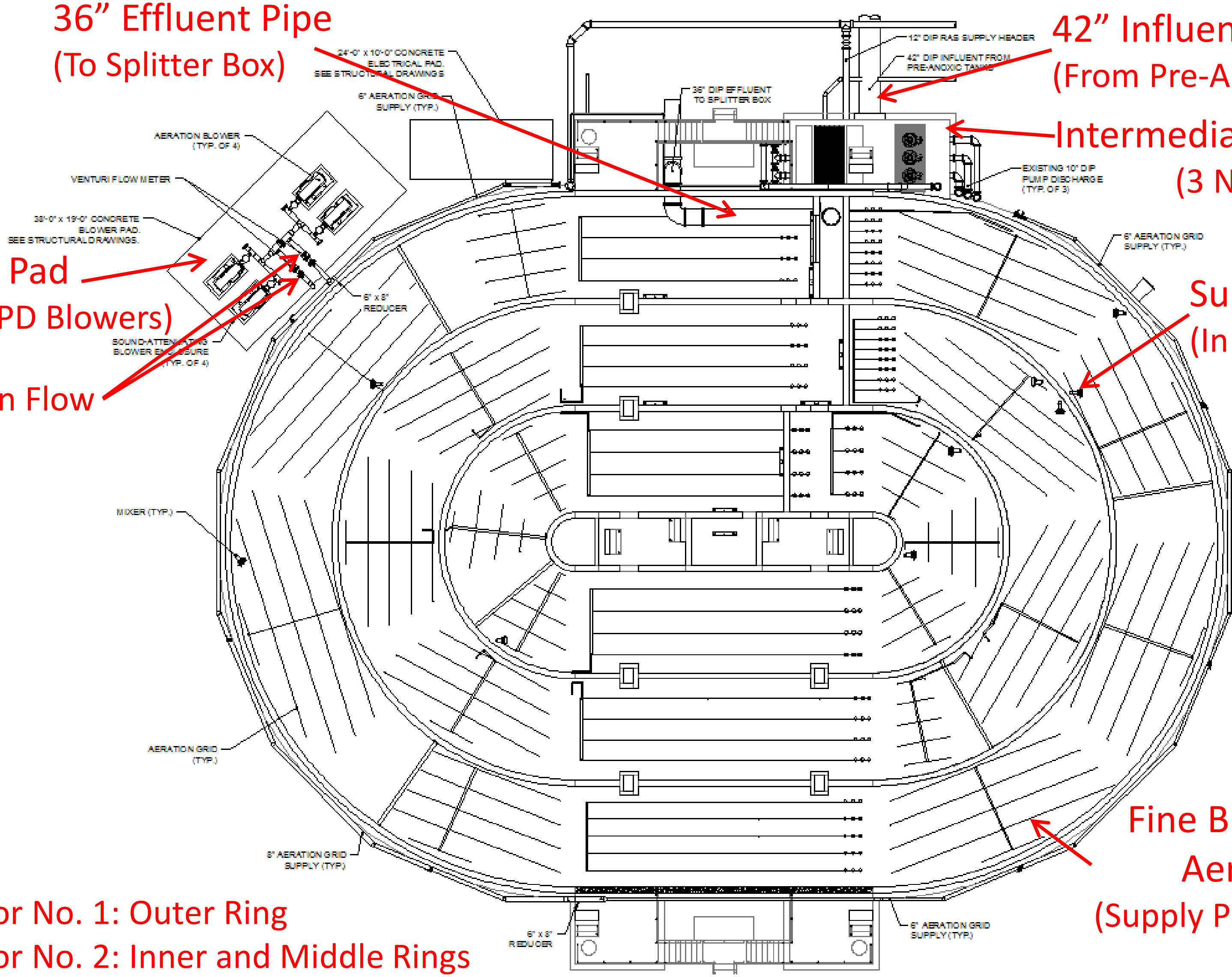
42" Influent Pipe
(From Pre-Anoxic/ Anaerobic)

Intermediate Pump Station
(3 New. 3 Ex.)

Blower Pad
(4 New PD Blowers)

Submersible Mixers
(In Swing Zones)

Aeration Flow
Meters



Fine Bubble Diffuser
Aeration Grids
(Supply Piping Around Tank)

Reactor No. 1: Outer Ring
Reactor No. 2: Inner and Middle Rings

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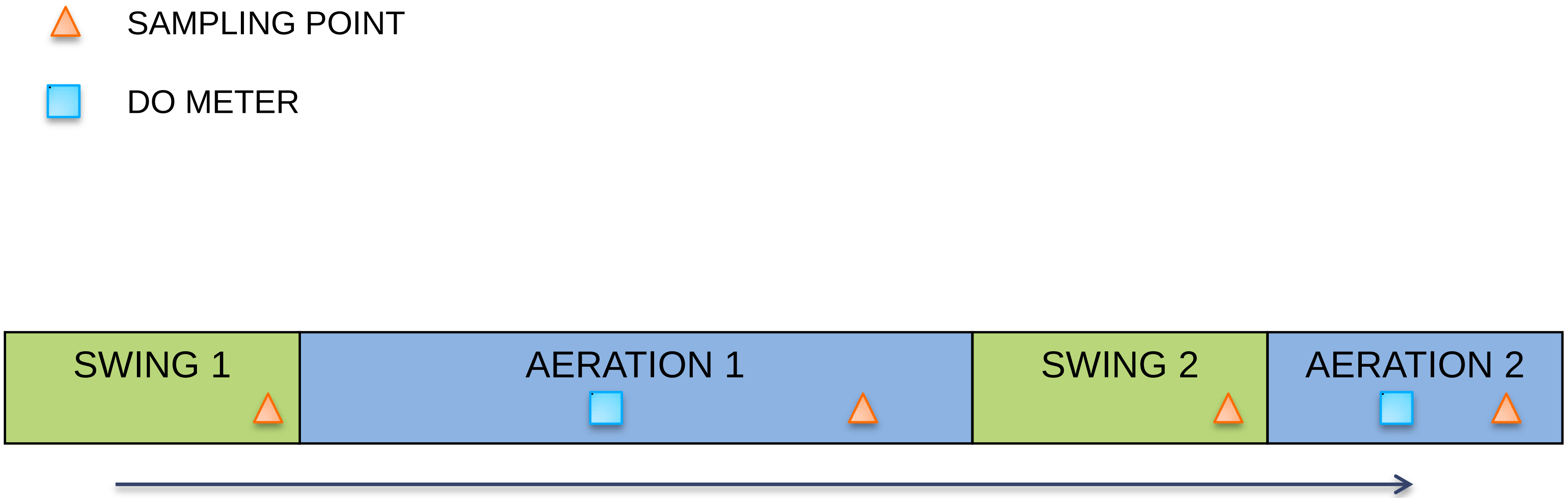
Biological – Equipment Installation Photos

Bioreactor Process Control



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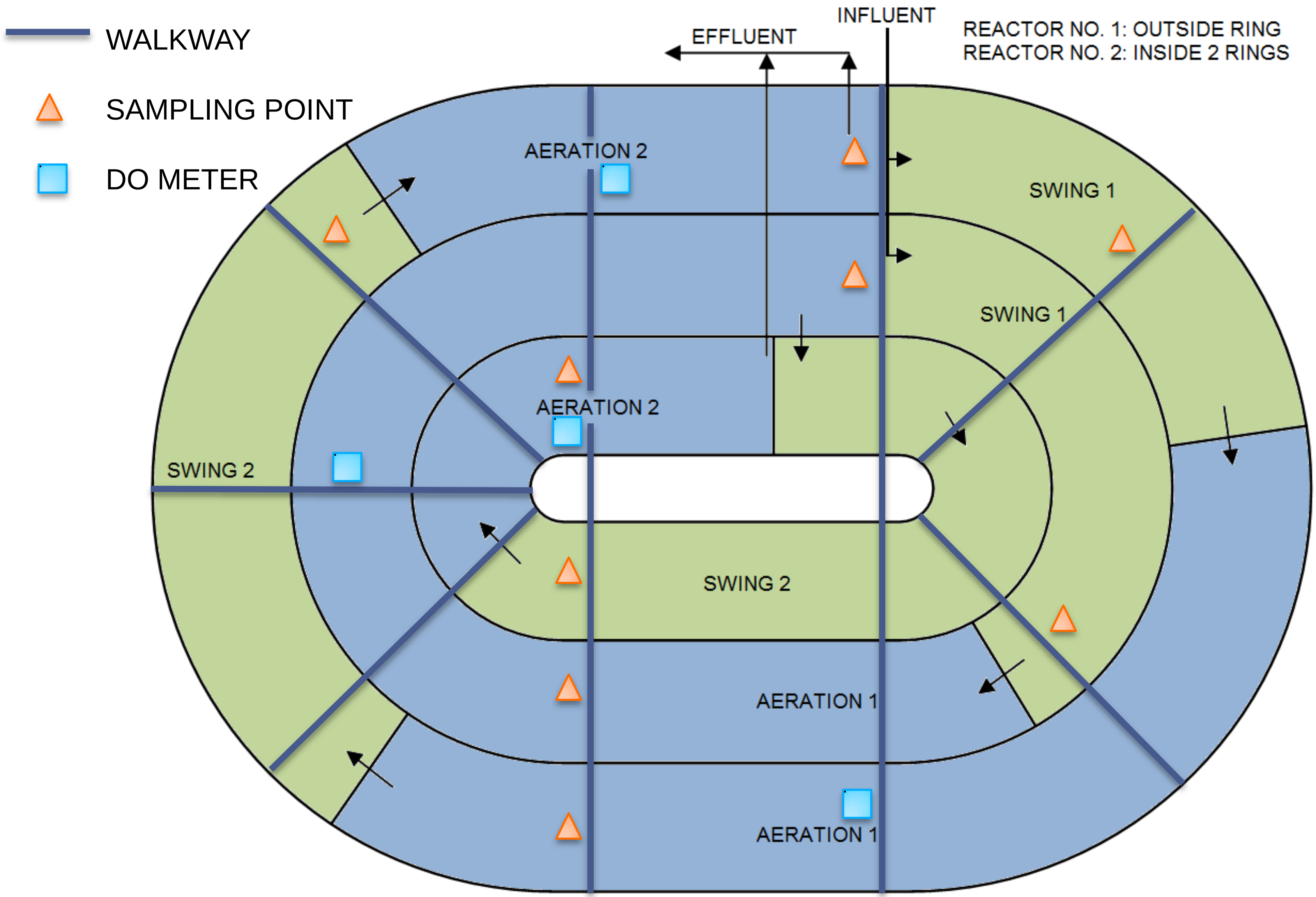
Bioreactor Process Flow & Control



Effluent Treatment – Expansion Design

Capacity Expansion from 2 to 4 MGD (10 MGD Peak)

Coagulant Storage and Feed

- Provisional, for intermittent use to ensure permit compliance

UV Disinfection

- Replacing Chlorine System, Increase Capacity to 10 MGD
  - Safety Concerns (Chlorine Storage)

Post – Aeration

- Convert old Chlorine Contact Tank to New Post- Air Tank
  - New Blowers, increase rating to 10 MGD

Tertiary Filters –Decommissioned in Place

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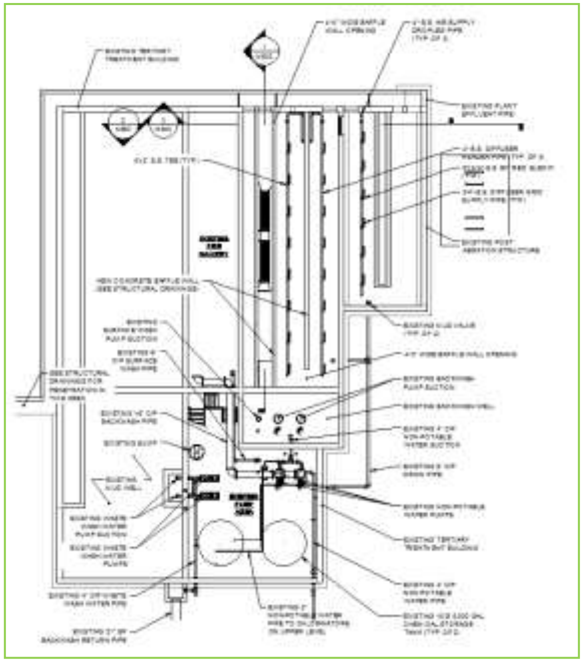
Coagulant Feed – Improves / Backs Up P Removal

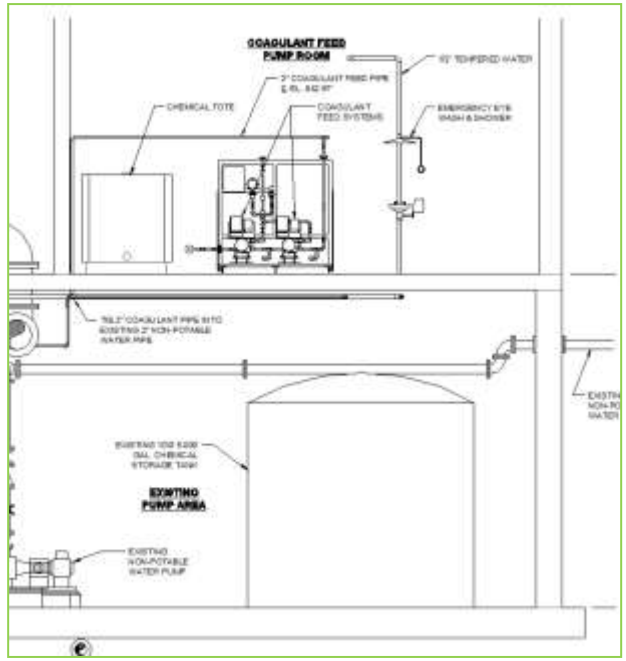
- **Upgraded to Biological Phosphorus Removal**
  - Low temperatures or inadequate influent ratios may inhibit BioP
  - Swing Zones in aeration mode may inhibit BioP
- **Coagulant added to enhance/back up Bio-P**
- **Can also enhance settling, reduce effluent TSS**

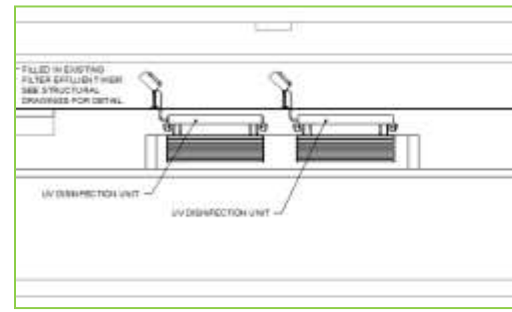
- **Alternatives**: Alum, Ferric Chloride, PACl, Sodium Aluminate, etc.
  - Installed: 35% Ferric Solution
- **Control:**
  - PCS automatically starts pumps when a pre-set effluent TSS is measured
    - By TSS Effluent Monitor
  - Feed rate is manually adjusted

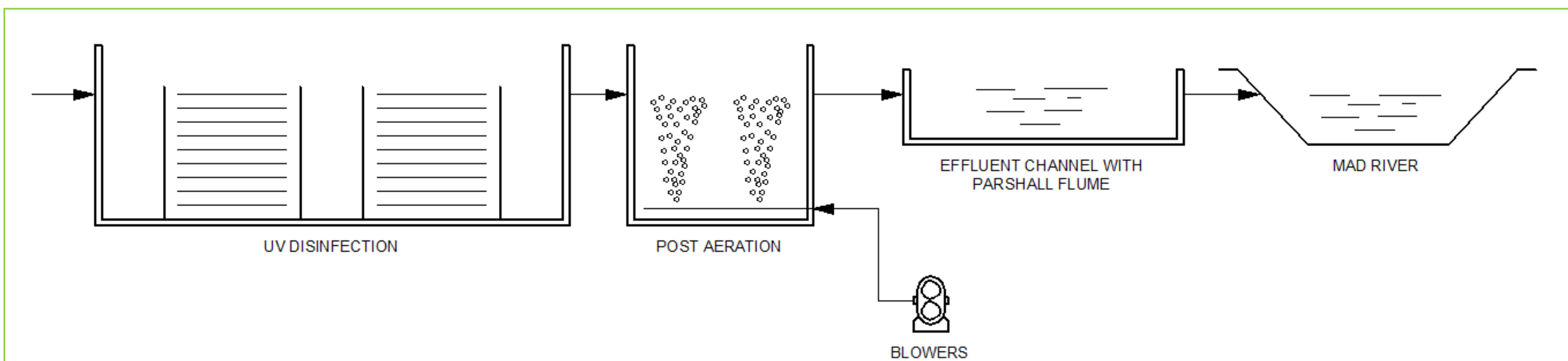
EFFLUENT TREATMENT

Coagulant Addition, UV, Post-Aeration









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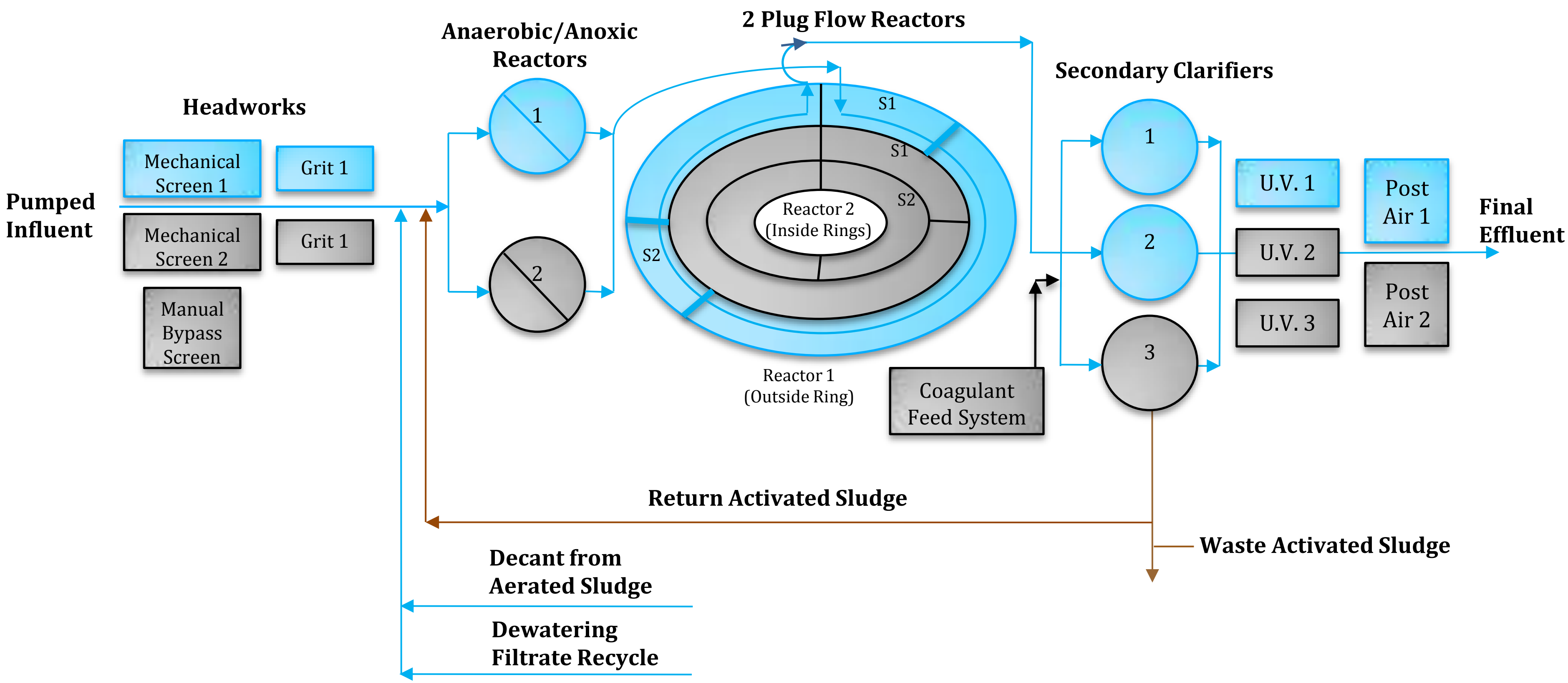
Coagulant Addition – Equipment Installation Photo

UV Disinfection – Equipment Installation Photo

Liquid Treatment - Average Flows (1.5 MGD)

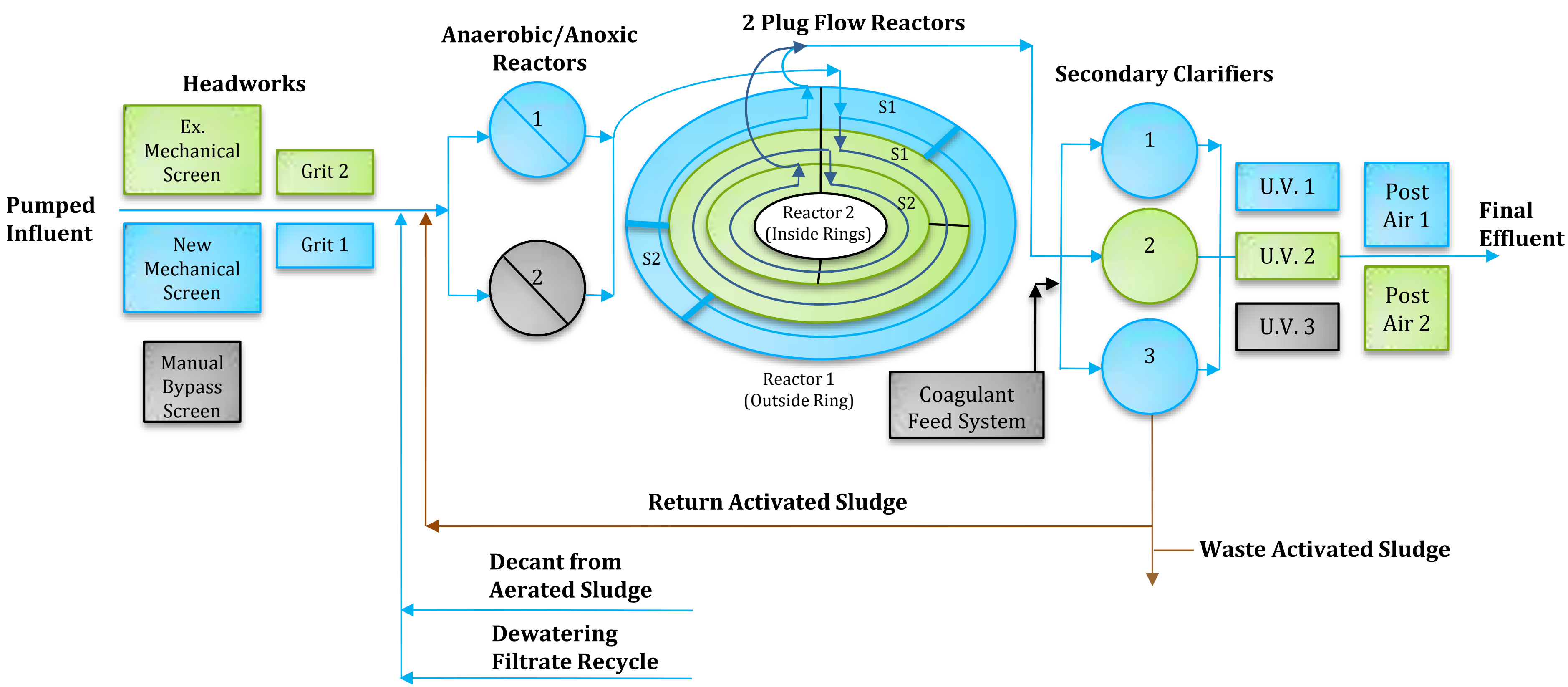
Average Flows: 1.5 MGD



Liquid Treatment – Sustained Storm (4 MGD, 3-5 Days)

Average Flows: 1.5 MGD

Sustained Storm: 4 MGD



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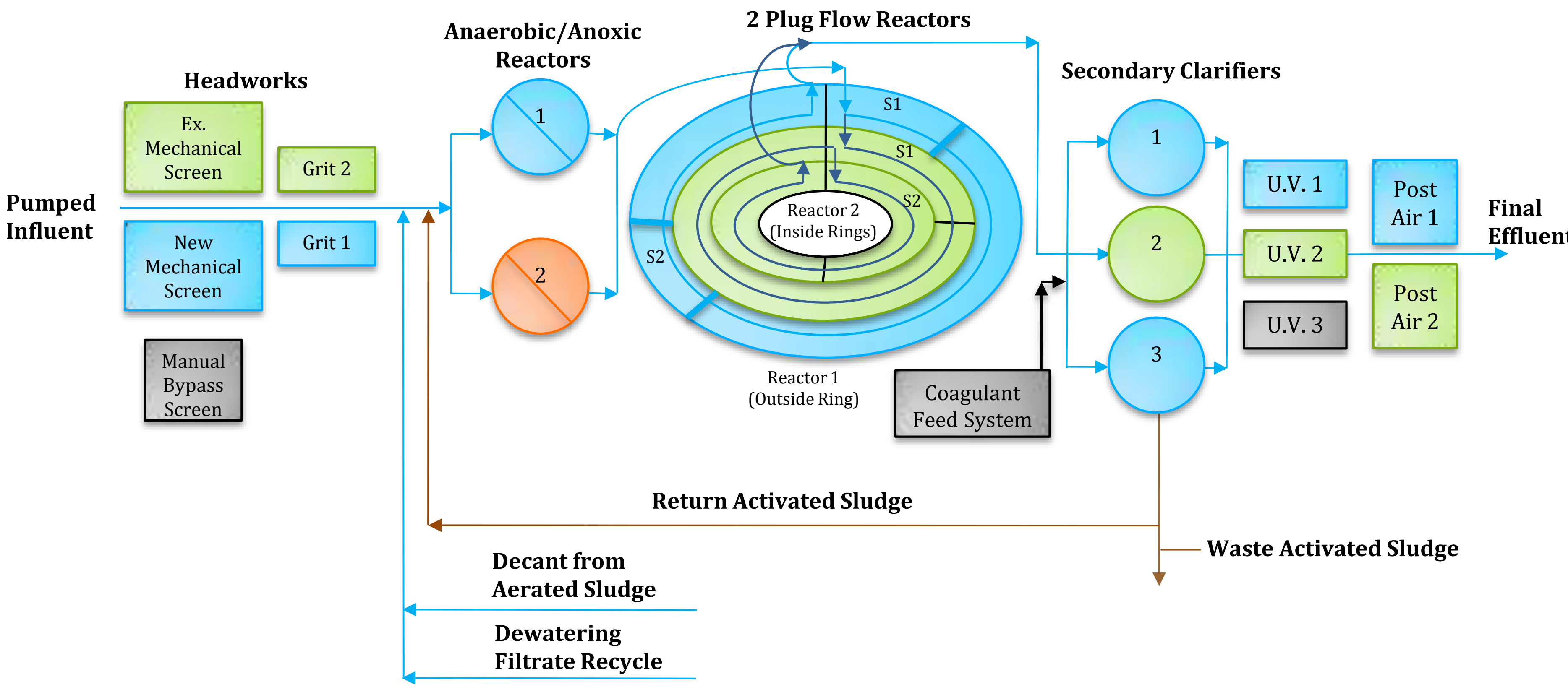
Liquid Treatment – Sustained Storm, Maintain Treatment

Average Flows: 1.5 MGD

Sustained Storm: 4 MGD

Storm, NR Issues: 5 MGD



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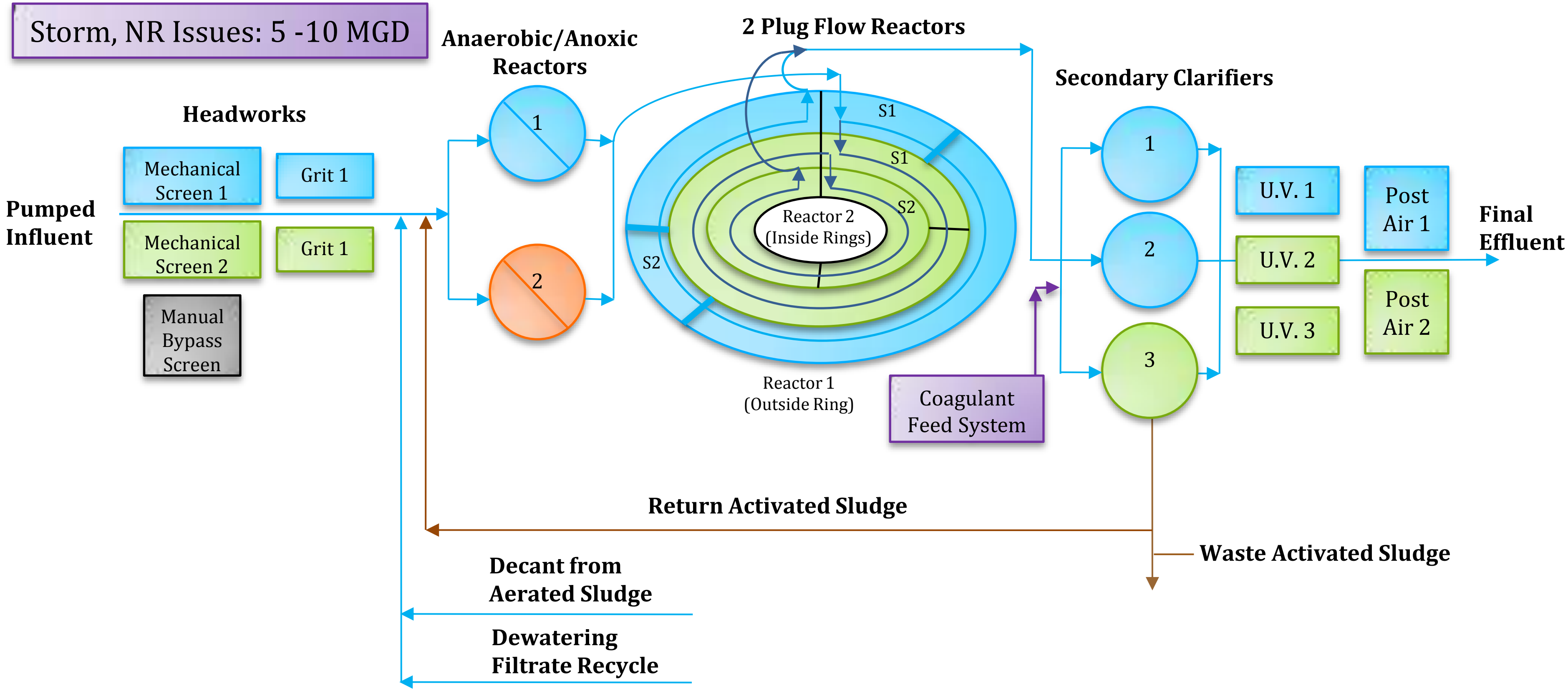
Future Treatment? – Growth to Capacity, Or Lower Limits

- Average Flows: 1.5 MGD
- Sustained Storm: 4 MGD
- Storm, NR Issues: 5 MGD
- Storm, NR Issues: 5 -10 MGD



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Training Sessions and Tools (Example - RAS/WAS Calculator)

- Enter Info Into Beige Cells
- Suggests WAS flows to achieve desired MLSS
- RAS rate to maintain

RAS rate	
Clarifier Diameter, ft	60.00
No. of SCs in use	3.00
Total Clarifier Influent, MGD	**2.18**
Tot. SC area in use, ft^2	8,482.30
Surface loading rate @ desired MLSS, (lb/day)/SF	7.10
Surface loading rate @ actual MLSS, (lb/day)/SF	**6.51**
SVI, mL/g	100.00
RAS rate, based on SVI, % of inf	50.35
RAS rate, based on SVI, MGD	0.73
SC Influent Solids, lbs/day	40,479.91
RAS solids, lbs/day	37,200.74
RAS, MGD	0.38
BR influent TSS, mg/L	280.00
Desired BR MLSS, mg/L	4,050.40
Underflow SS, mg/L	11,779.86
Effluent TSS, mg/L	8.71
BR influent flow, MGD	1.45
SC Effluent Flow	1.42
WAS flow, MGD	0.03
Minimum RAS Flow at **Target** MLSS, MGD*	**0.70700**
Minimum recommended RAS Flow, calculated based on **current MLSS***	**0.53**

ENTER VALUES INTO CELLS THAT ARE HIGHLIGHTED

WAS Rate		
Pre Anoxic Tank Volume, MG	0.11	each
Train 1 (outer ring) Tank Volume, MG	0.63	each
Train 2 (inner ring) Tank Volume, MG	0.74	each
No. of Pre-Anoxic/Anaerobic Tanks online	1.00	of 2 total
Is Plug Flow Bioreactor Train 1 online?	1.00	1 for yes, 0 for no
Is Plug Flow Bioreactor Train 2 online?	0.00	1 for yes, 0 for no
Pre-Anoxic working vol, MG	0.11	
Bioreactor working vol, MG	0.63	
Tot. Online Tank Volume, MG	0.74	
Influent Flow, MGD	1.45	Enter current average flow in MGD, 4 MGD is basis of design flow
Actual current MLSS, mg/L	3,349.00	Enter value based on most recent lab or online instrument analysis
Desired MLSS, mg/L	4,050.40	Design modeling average was **4,050.4** mg/L
MLSS to be removed, lbs	-4,328.76	Negative indicates target MLSS is higher than current MLSS
Extra MLSS to be pumped in addition to WAS, MG	-0.04	
RAS/WAS TSS, mg/L	11,779.86	Enter value based on most recent lab or online instrument analysis
Solids Inventory in Reactors, lbs	20,668.69	
Desired Solids Inventory	24,997.45	
WAS to maintain Solids Inventory, lbs/day	3,279.17	Based on removing Influent TSS conc. to effluent target conc.
Calculated SRT at current solids inventory, days	6.30	Average in design modeling was **5.93** days
Calculated SRT at target solids inventory, days	7.62	Average in design modeling was **5.93** days
Desired WAS rate, MGD	0.03	Based on maintaining solids inventory
Desired average WAS rate, GPM	23.18	Based on maintaining solids inventory
SC Effluent Target TSS, mg/L	8.71	Design modeling average was **8.7**
Hours spent wasting sludge, hrs/day	16.00	
WAS flow rate while wasting, GPM	34.77	Flow needed just to maintain solids inventory at current level
If a change is being made to the MLSS enter the number of days to be spent changing it.	9.00	
WAS flow to correct MLSS, GPM	**29.67**	for **16.0** hours a day for **9.0** days.
	then return to	**34.77** GPM for
		16.0 hours a day

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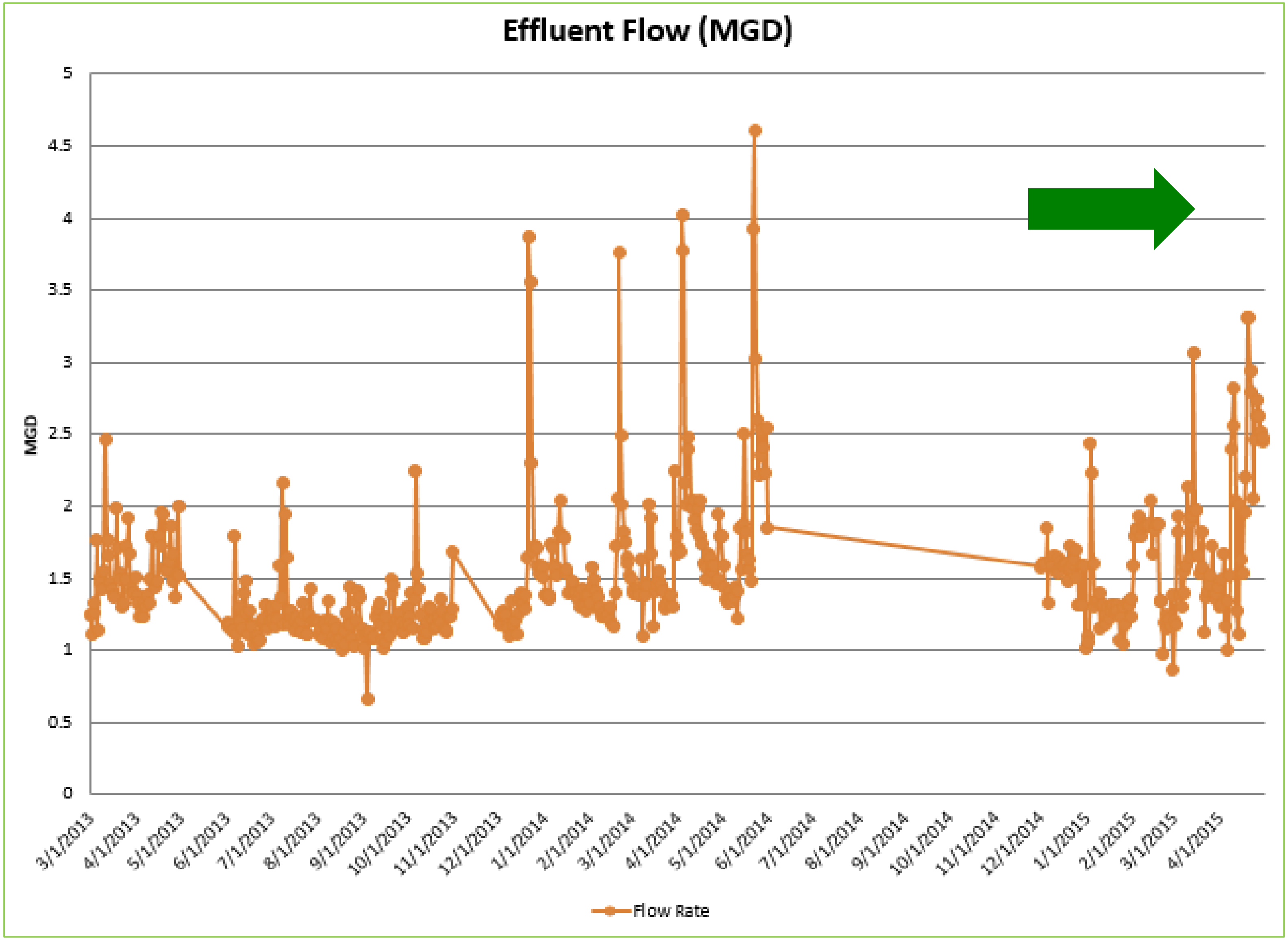
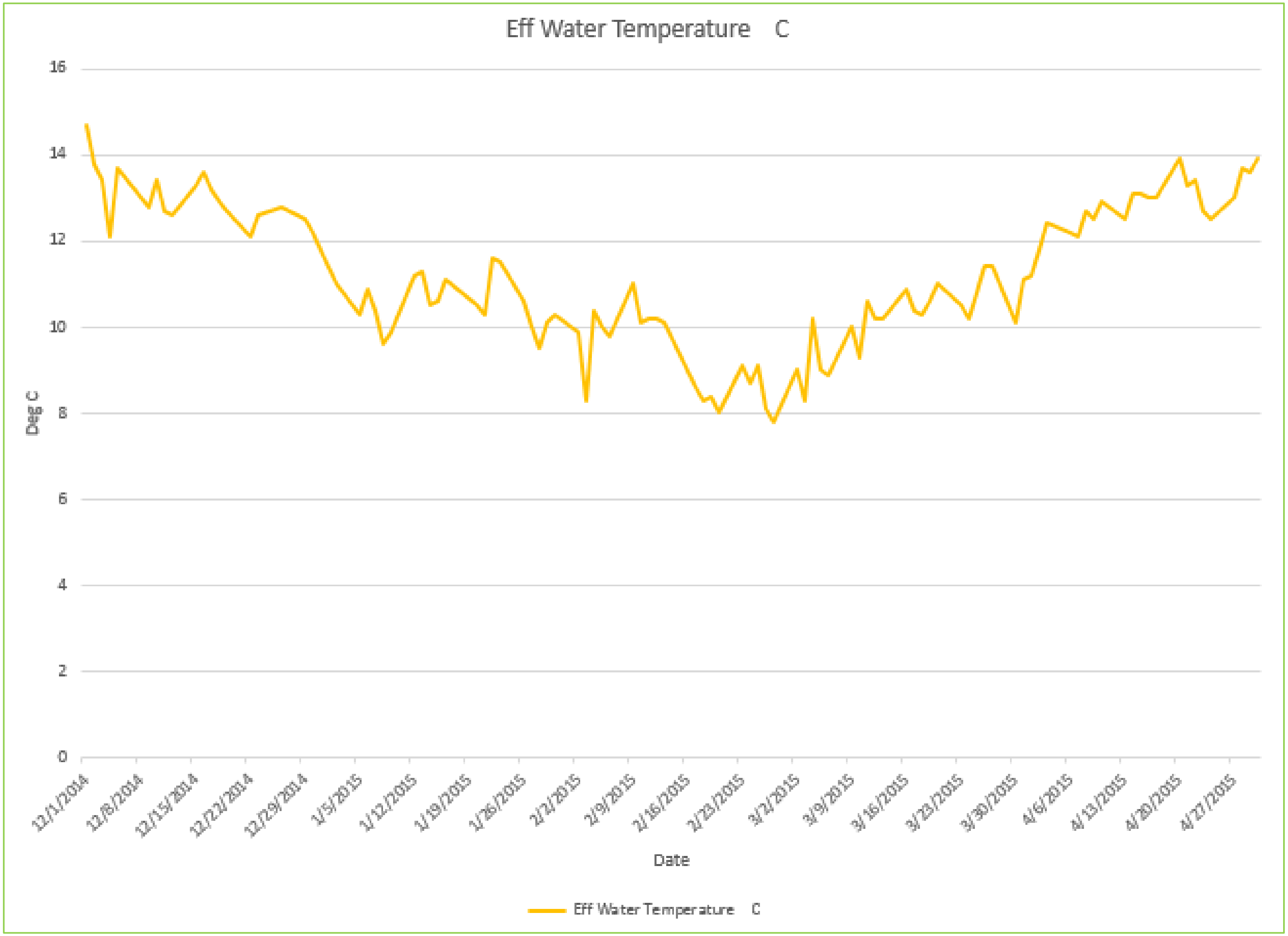
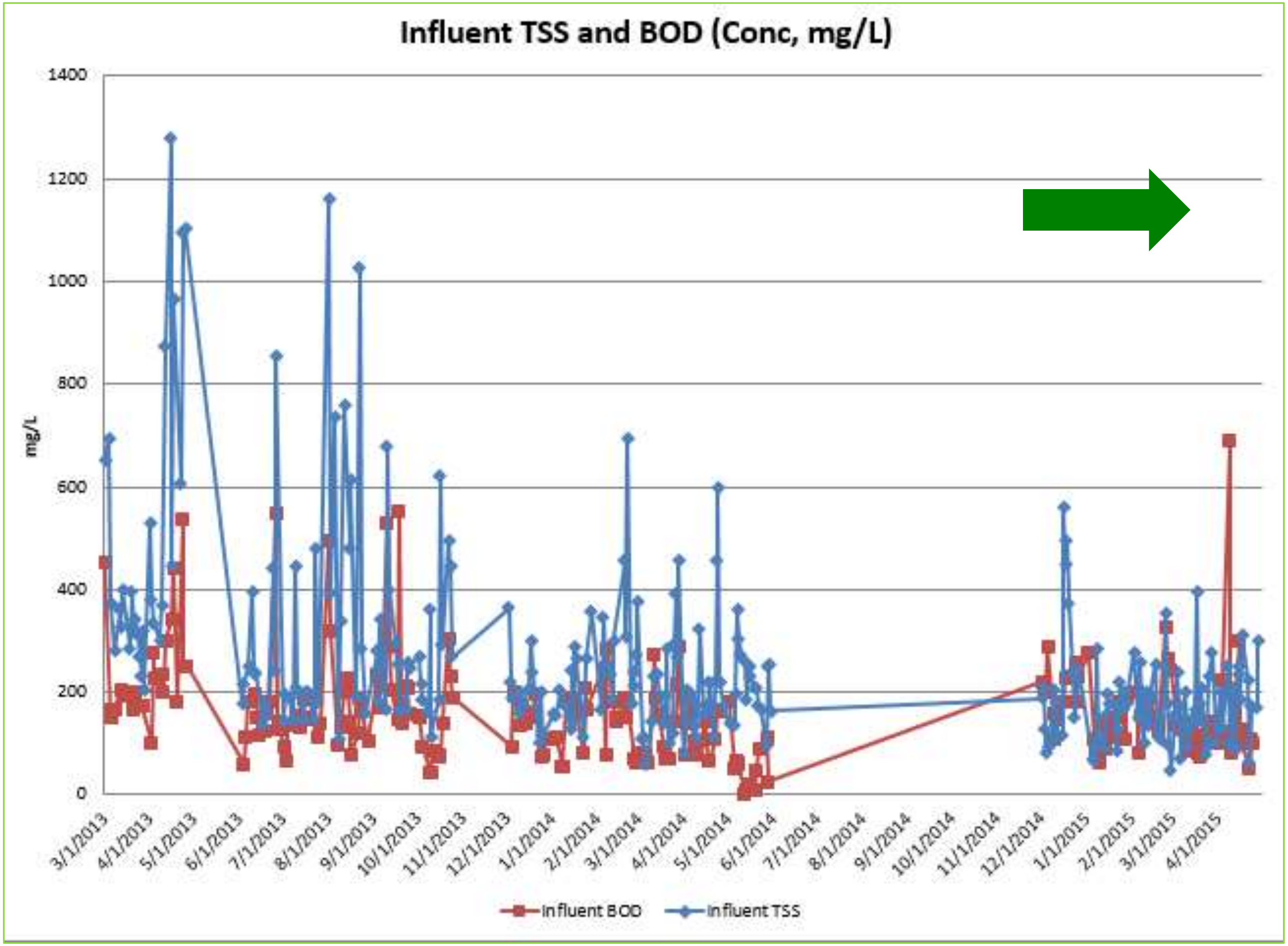
Initial Operation – Performance



Initial Operation – Performance



Initial Operation – Performance



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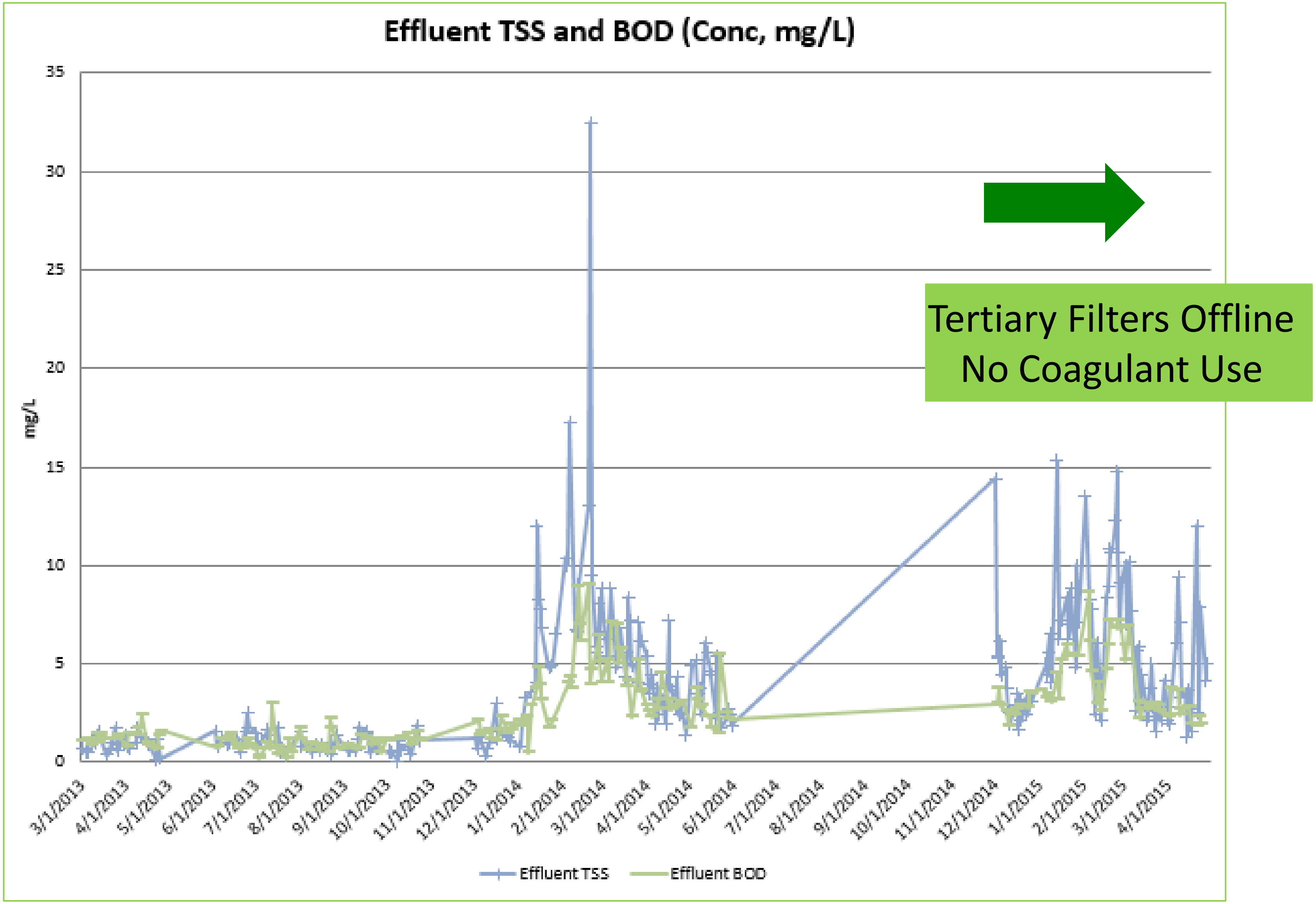

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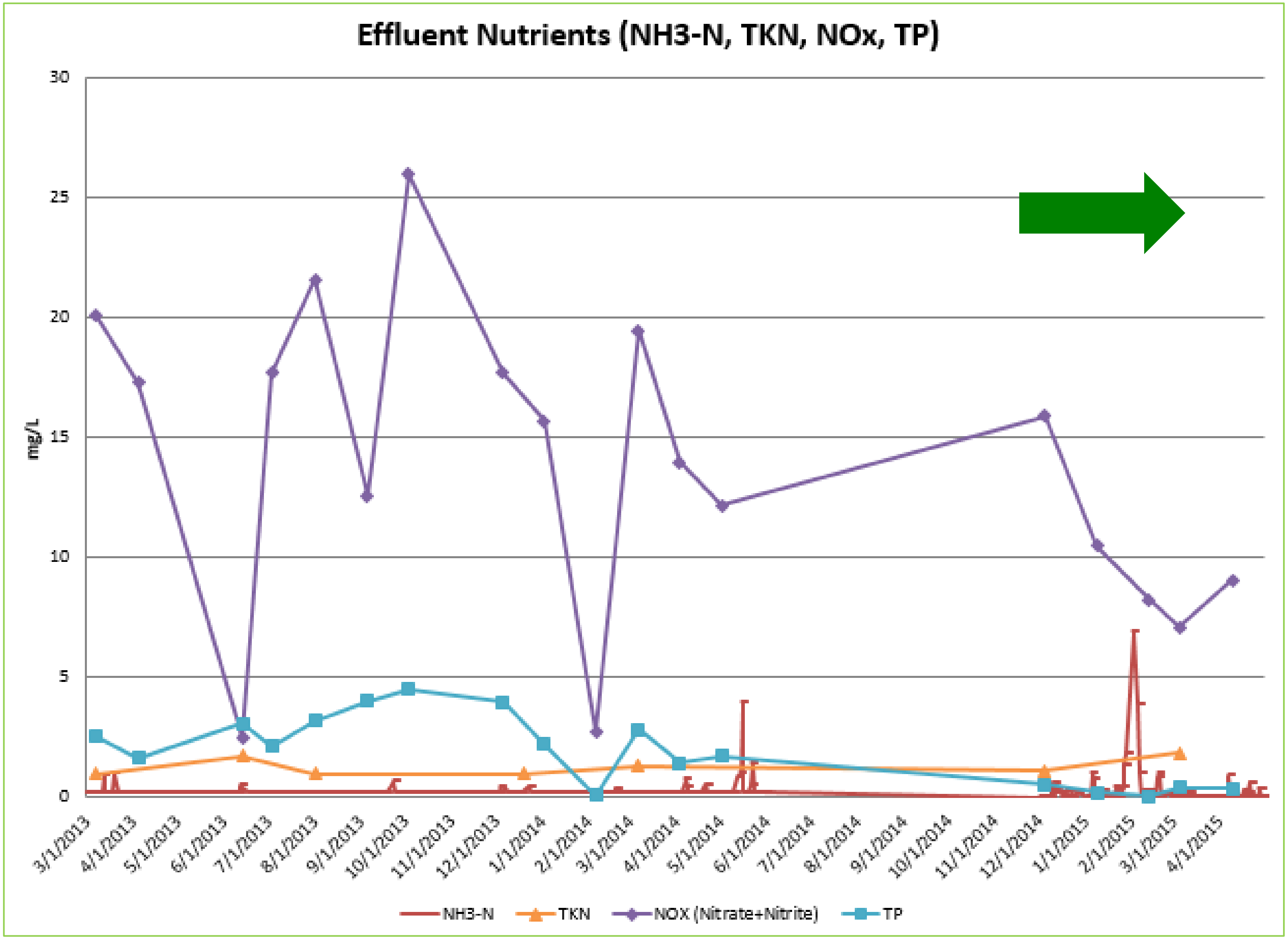
Initial Operation – Performance



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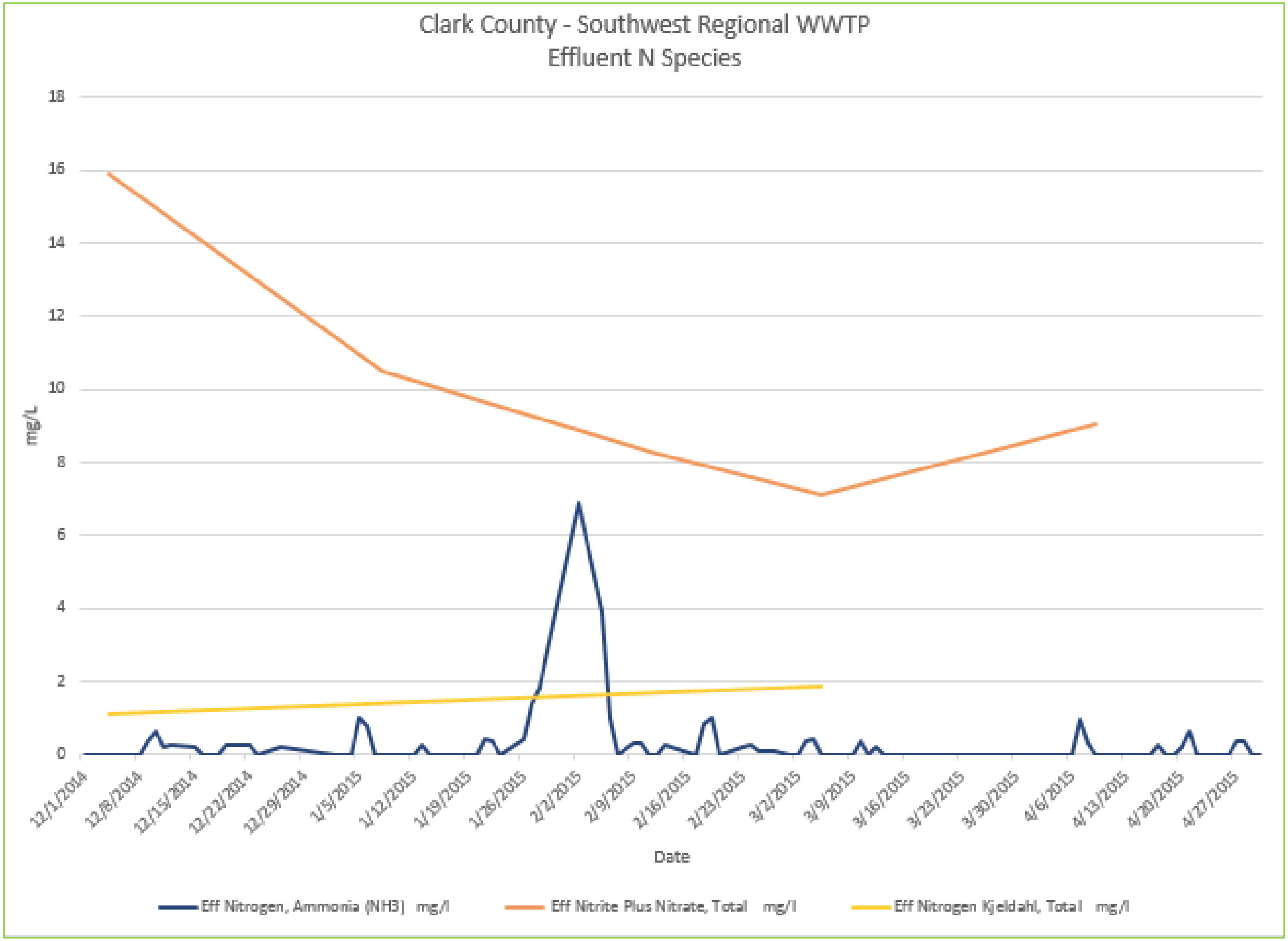
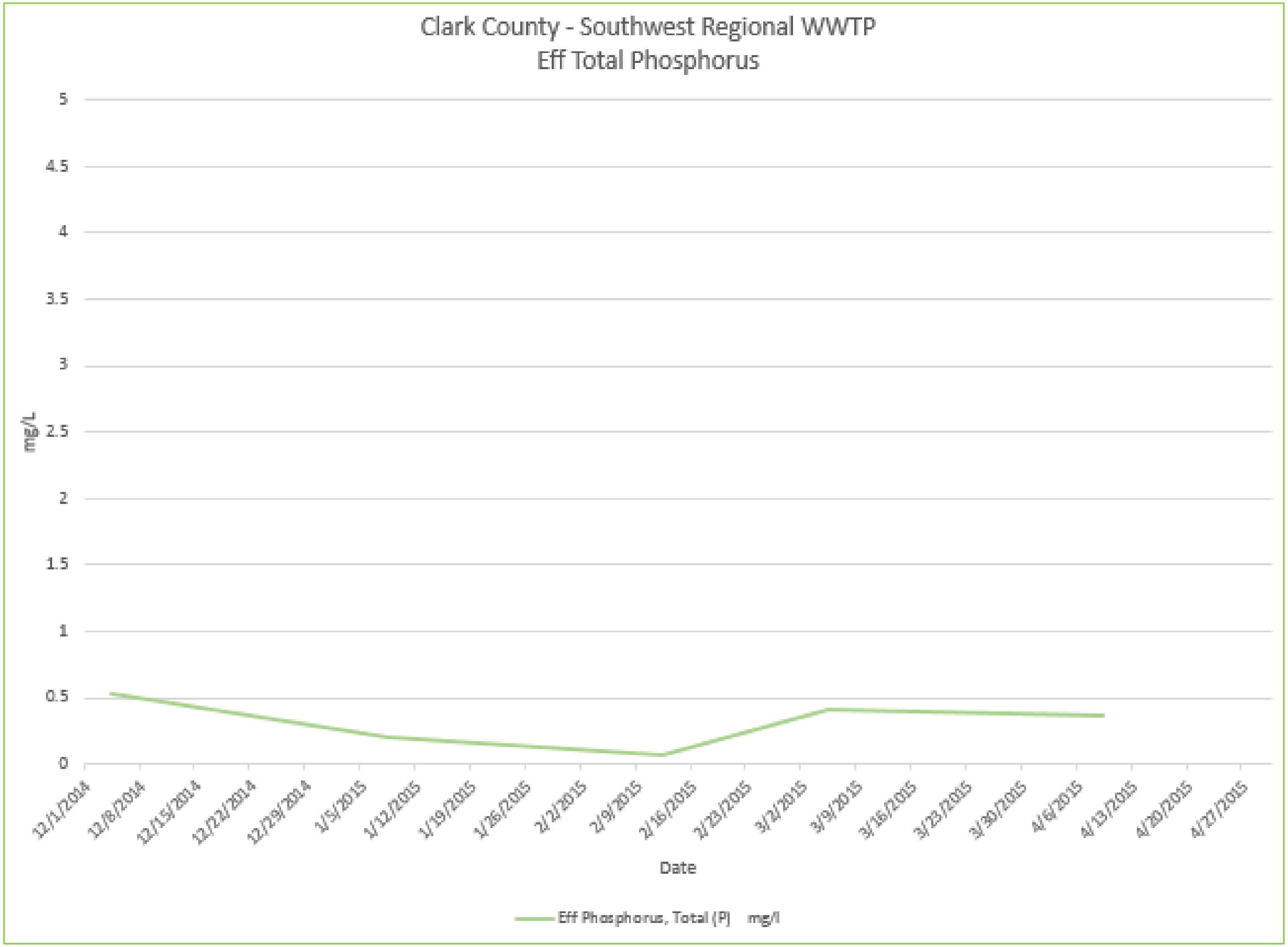
Initial Operation – Performance



Initial Operation – Performance



Expansion, Upgrade, and ready for Nutrients

- Nutrient Removal is more cost effective when influent BOD is managed
  - Deliver the sBOD to where it is best utilized
- DO control easier and better in Plug Flow mode
- When matched in proper ratios to N and P, BNR is very effective

- *BOD is "Free Carbon", little or no aeration needed with Nutrient Removal*

- Recycle loads from solids treatment can influence performance

- Cost-Effective Expansion & Upgrade
  - $7.1M Project Cost
    - Optimize existing infrastructure, $2-3/GPD capital cost
    - BNR (TN 10, TN 1) *($100-500k of $7.1M?)*

QUESTIONS?

Bill Meinert, O'Brien & Gere

(443) 474-7332, Bill.Meinert@obg.com

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Thank you!

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