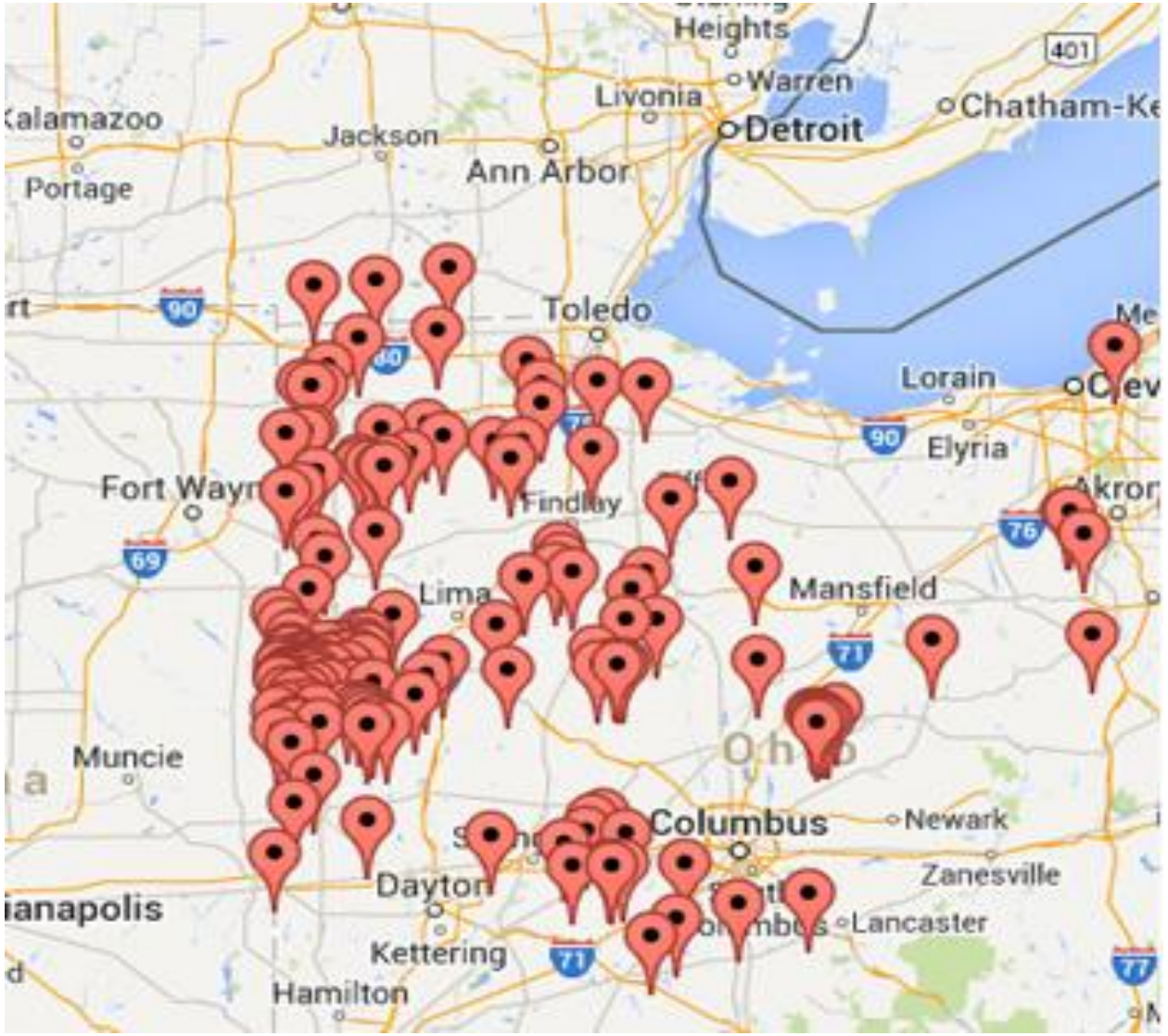
Demonstration of an Innovative Phosphorus Recovery Technology with Widespread Application to the Great Lakes Region

May 22, 2019

Outline

- *Scope of challenge*
- *Technology Overview*
- *Demonstrated applications*
  - *Municipal*
  - *Agricultural*
- *Co-product value*
- *Summary*

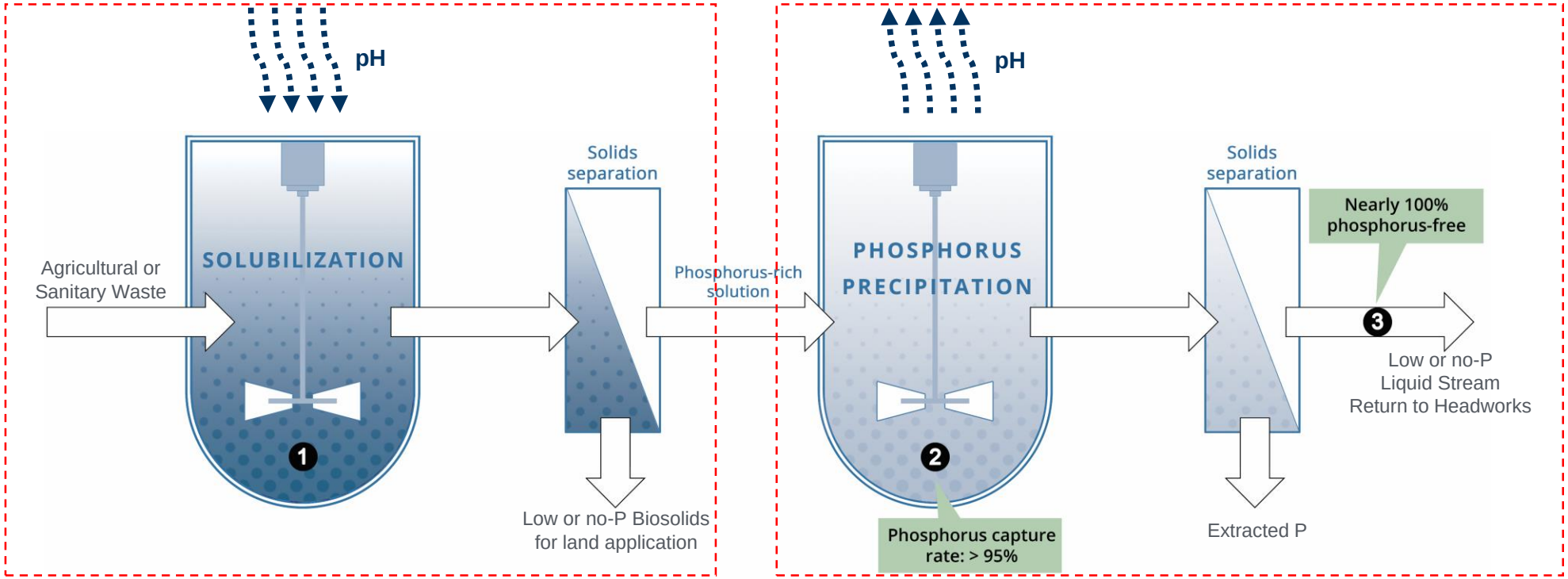
Scope of Challenge



APPLIED ENVIRONMENTAL SOLUTIONS

https://civileats.com

Quick Wash Process



Two step process –allowing for tuning of a solution to a given application

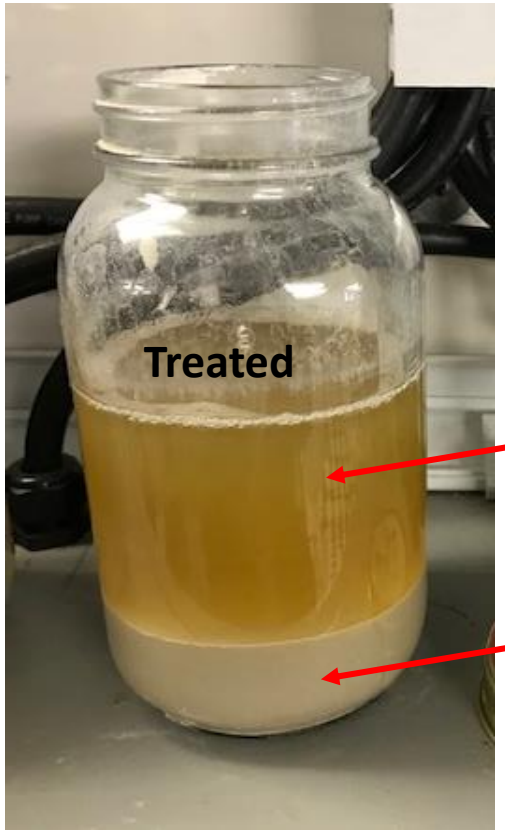
- Step 1 (Solubilization): Transforms particulate phosphorus into a soluble form (can vary from 70% - 97% depending on stream characteristics)
- Step 2 (Precipitation): Precipitates out soluble phosphorus in the form of amorphous calcium phosphate (95%+ capture)

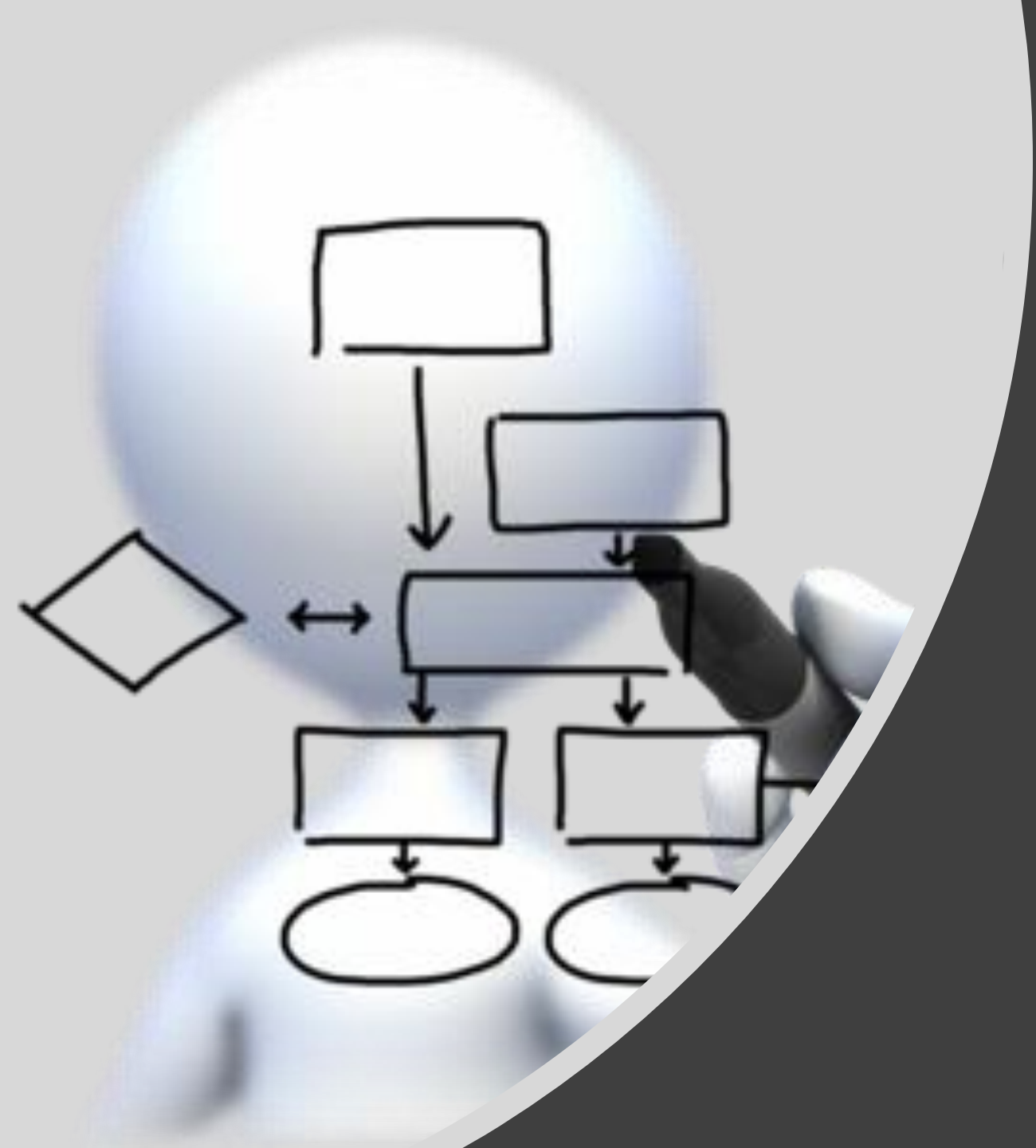
APPLIED ENVIRONMENTAL SOLUTIONS

Quick Wash

- US Patent 8,673,046
- Phosphorus recovered as amorphous calcium phosphate

LIFT©





Applications
- Municipal

OWDA Demonstration Program – Perrysburg, OH

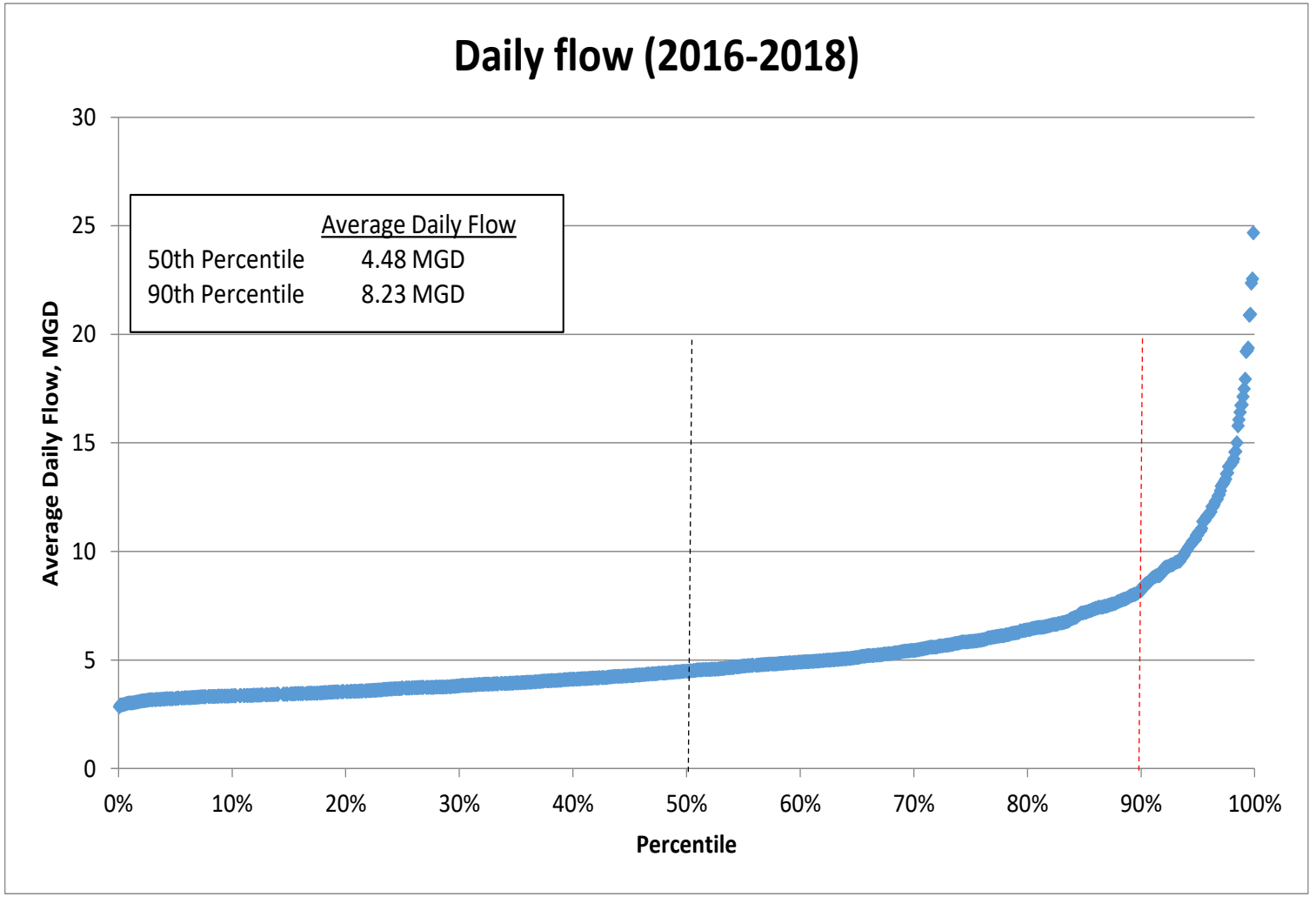
APPLIED ENVIRONMENTAL SOLUTIONS

June 2018 – December 2018

Program Objectives

1.	Demonstrate the ability to significantly reduce side stream P loads
2.	Initial assessment of calcium phosphate quality produced
3.	Develop economics

Historic Flow Distribution



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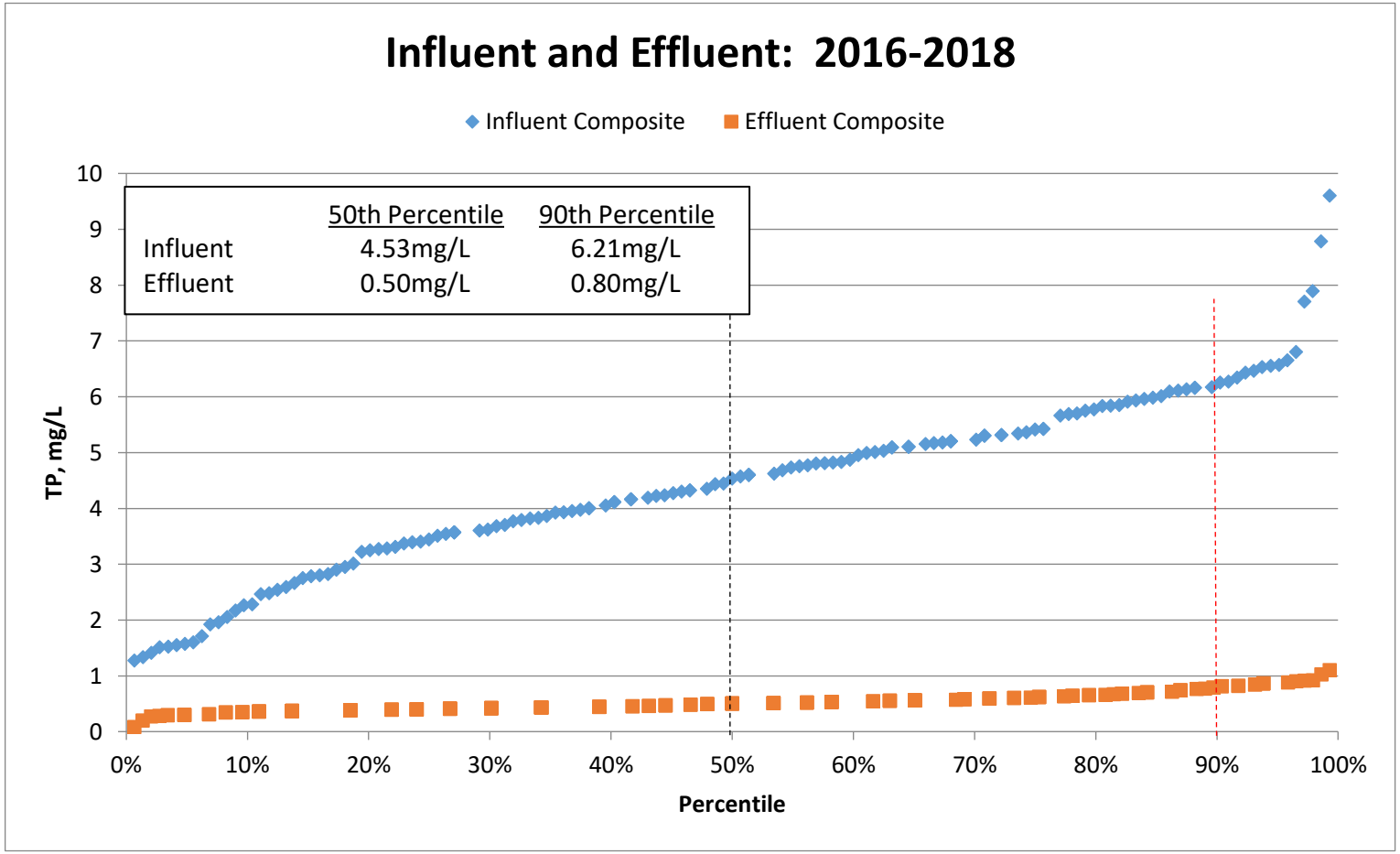
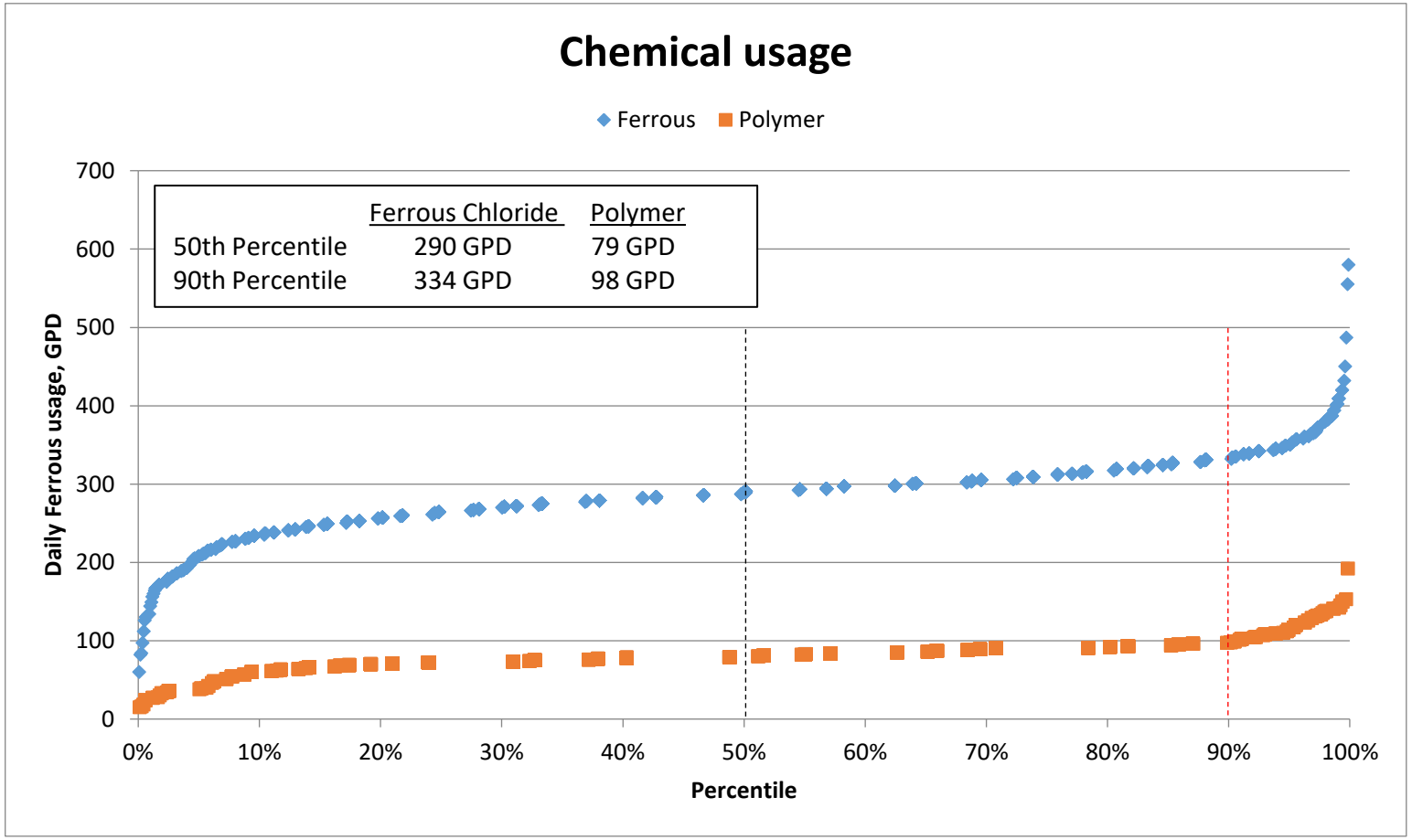
Historic Phosphorus Performance



Source	Concentration, mg/L	Flow, GPD	Phosphorus, lb/day
BFP Filtrate	12.15	29,977	3.04
Digester Supernate	117.6	15,333	15.07
Total Recycle	28.18	34,484	8.12

Historic Chemical usage



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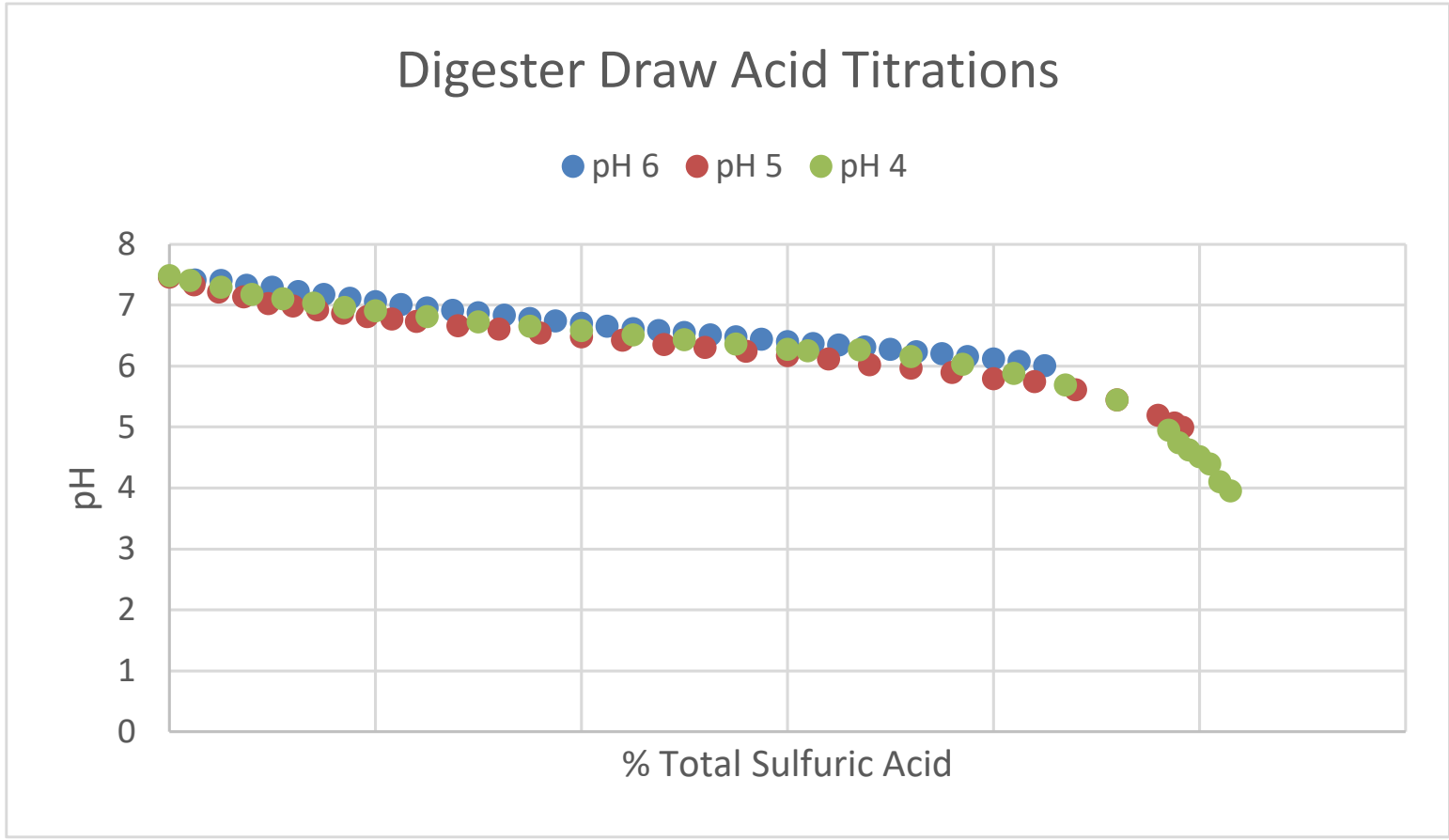
Typical Solubilization Titrations



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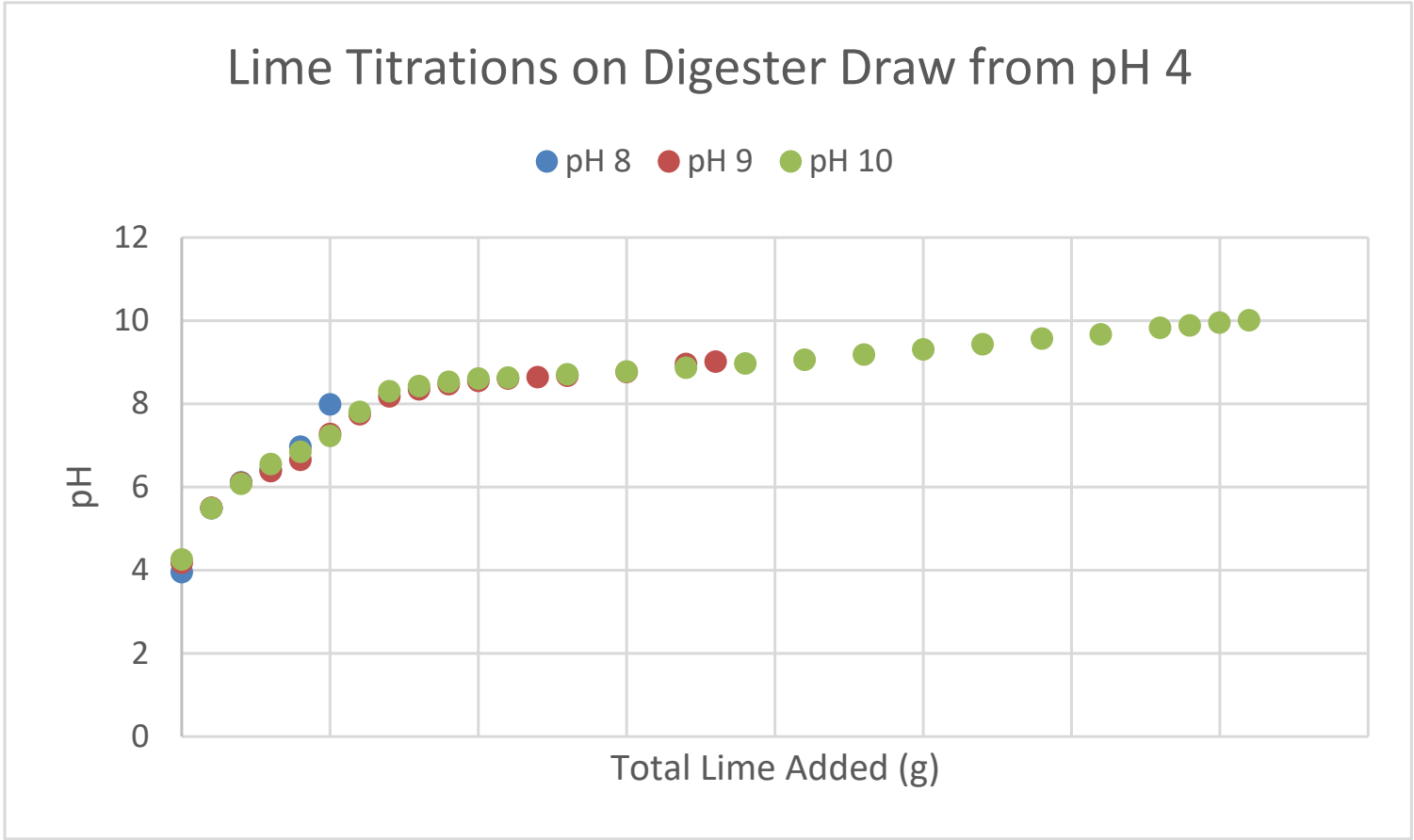
Representative Titration curve on precipitation



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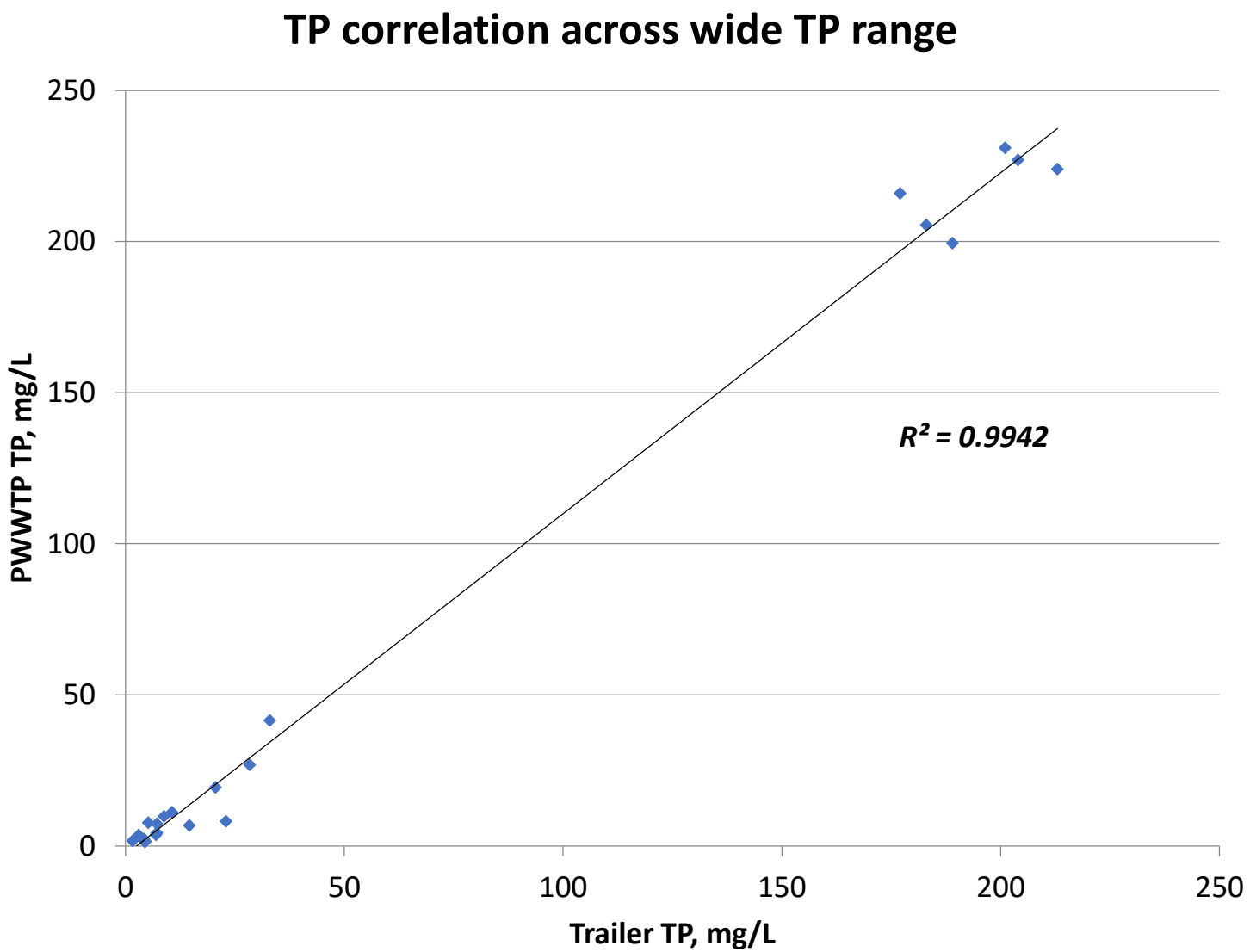
TP testing correlation with WWTP Lab



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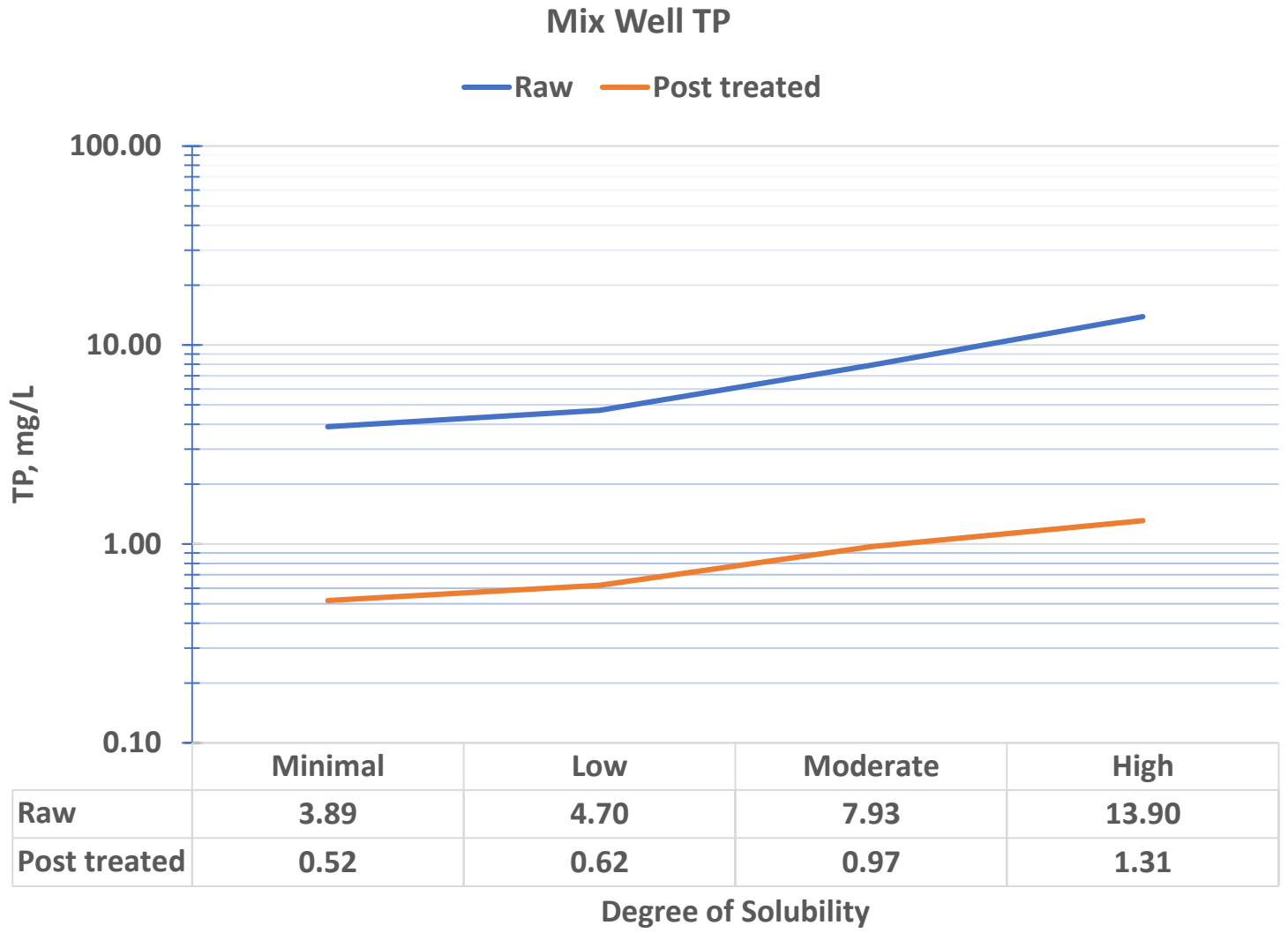
Mix Well Feed Results



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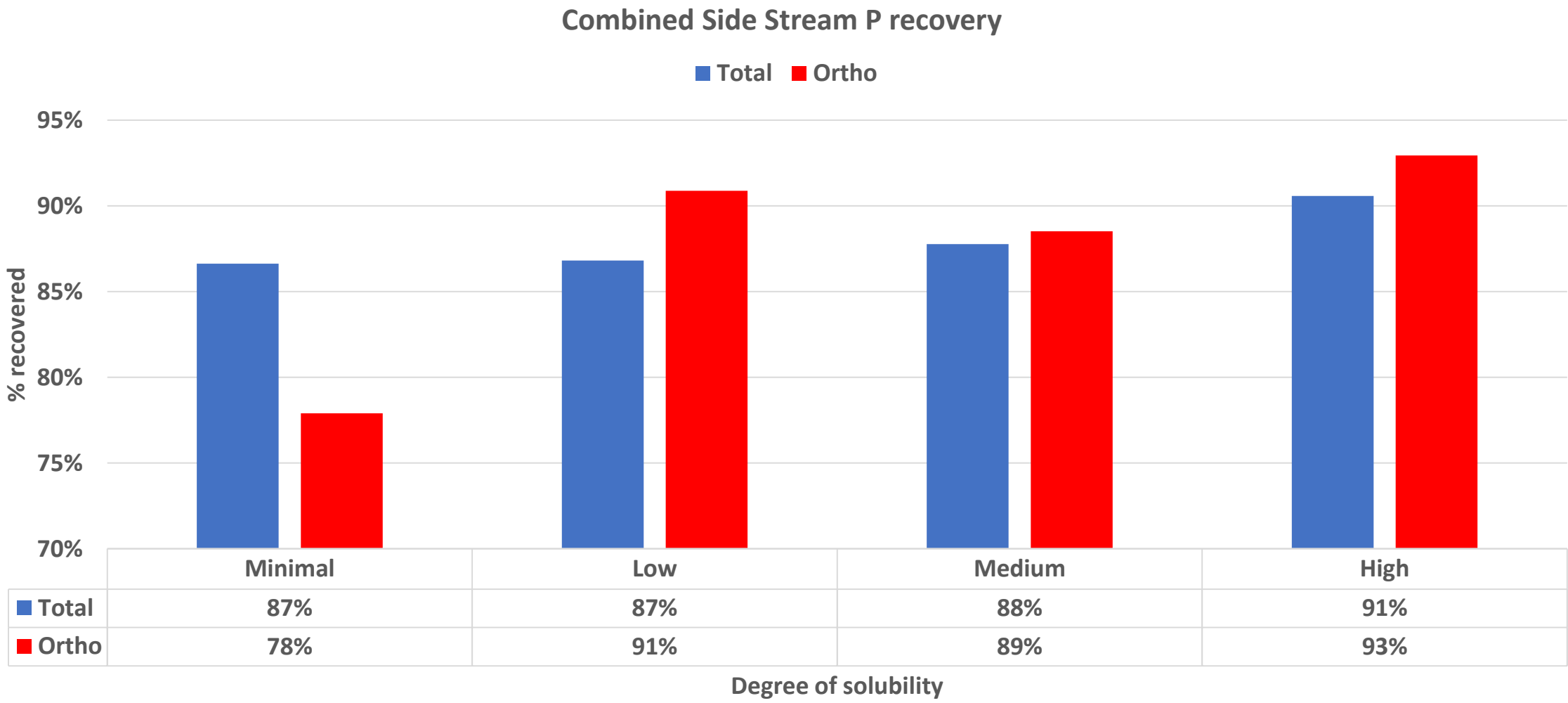
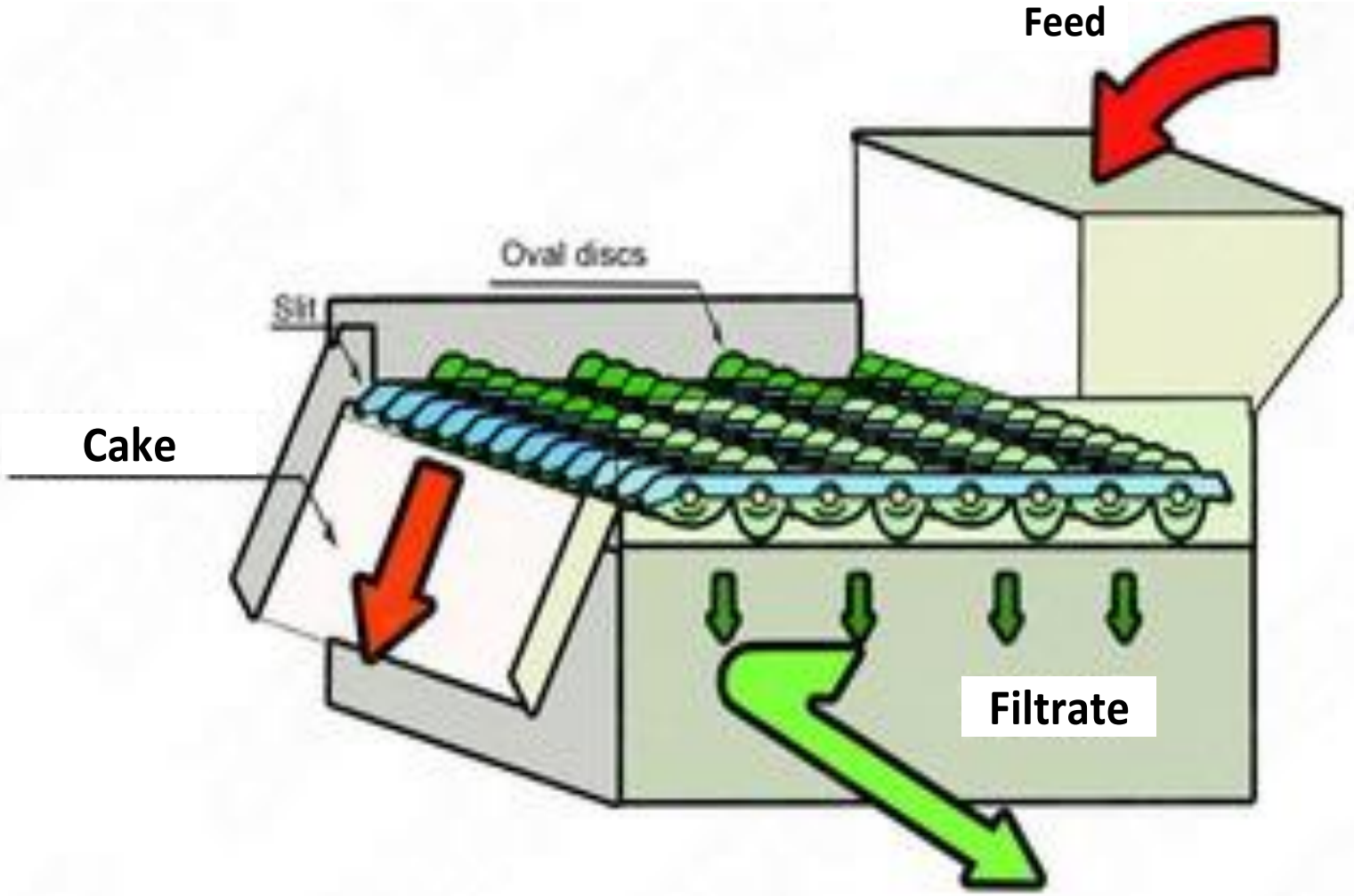
Side Stream P recovery



	Minimal	Low	Medium	High
Total	87%	87%	88%	91%
Ortho	78%	91%	89%	93%

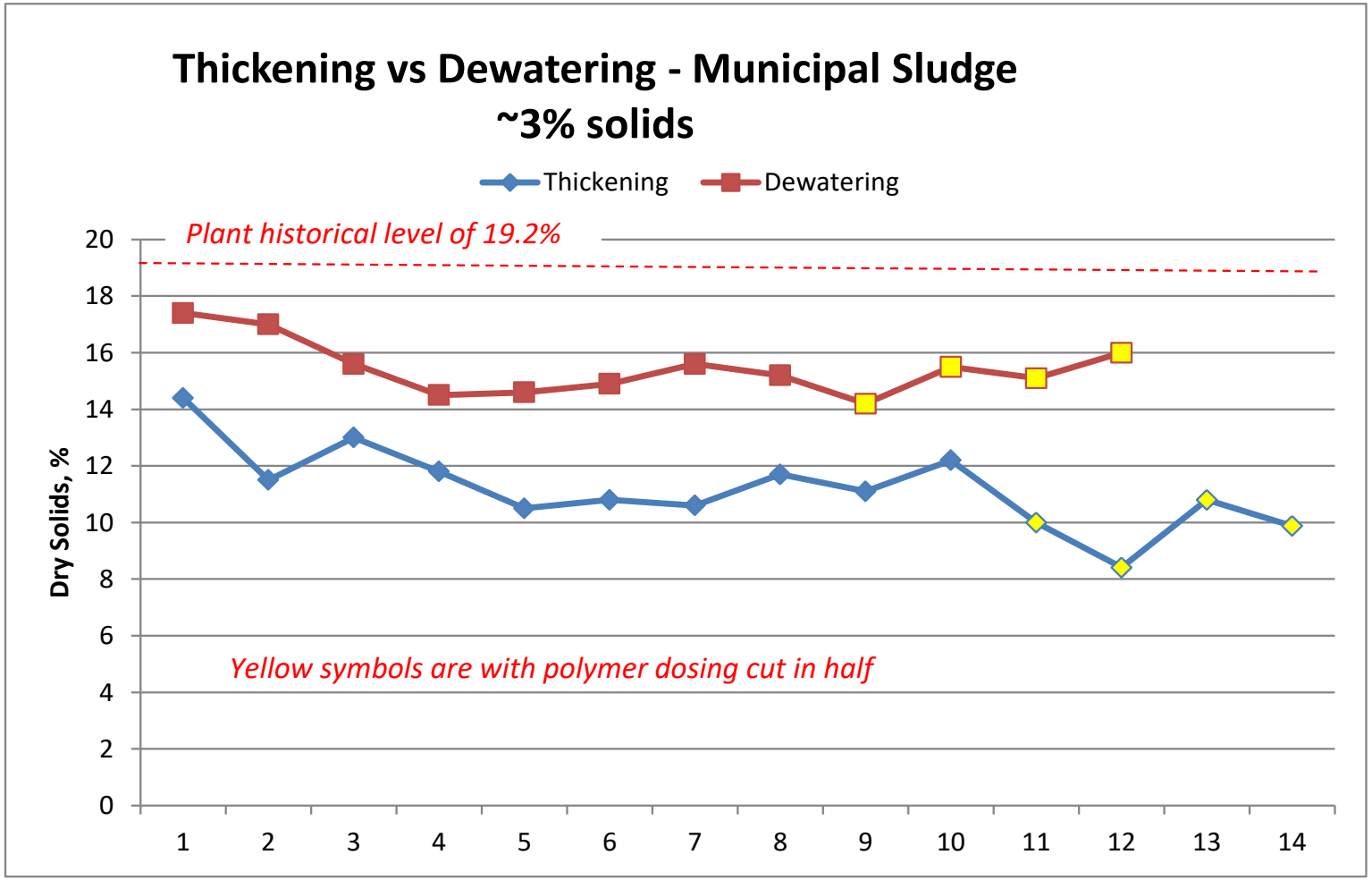
APPLIED ENVIRONMENTAL SOLUTIONS

KDS Rotating Disc Separator



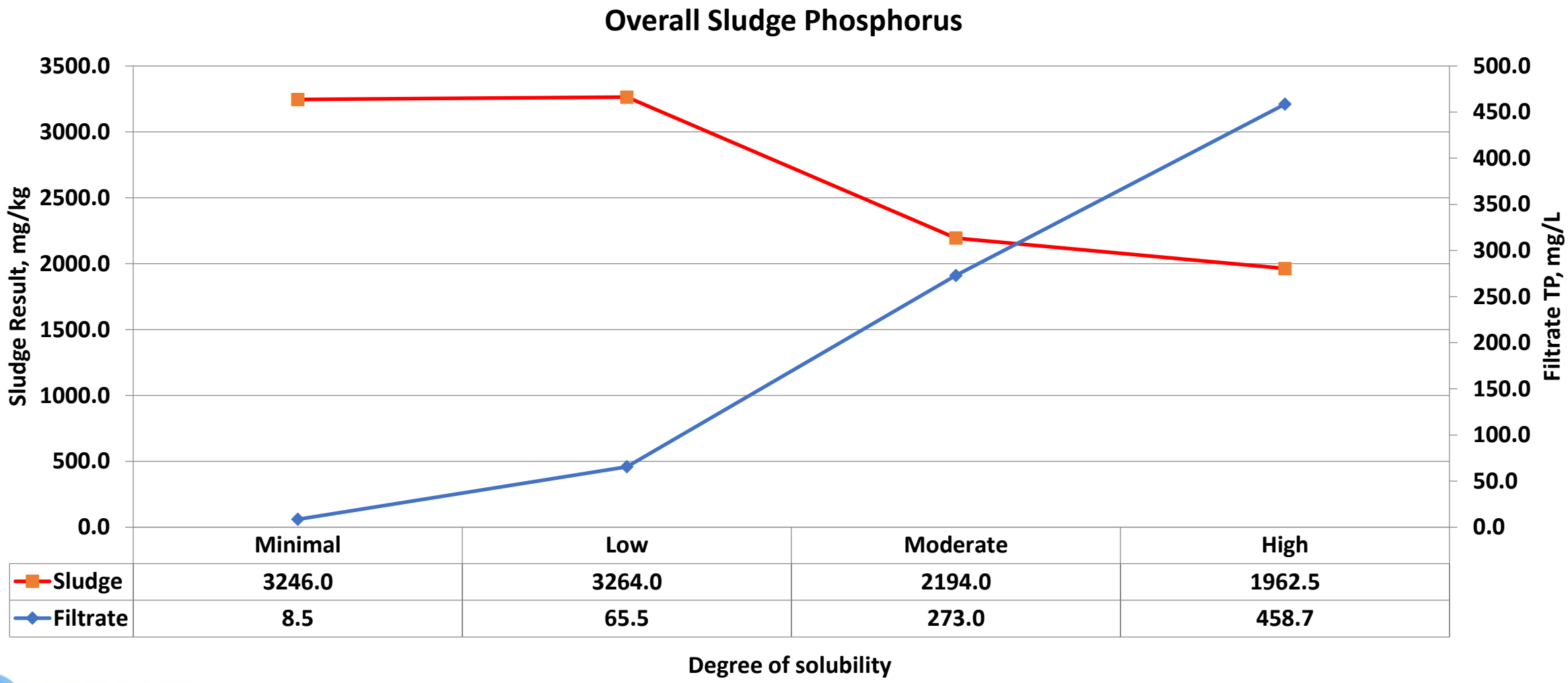
APPLIED ENVIRONMENTAL SOLUTIONS

Dewatering Performance



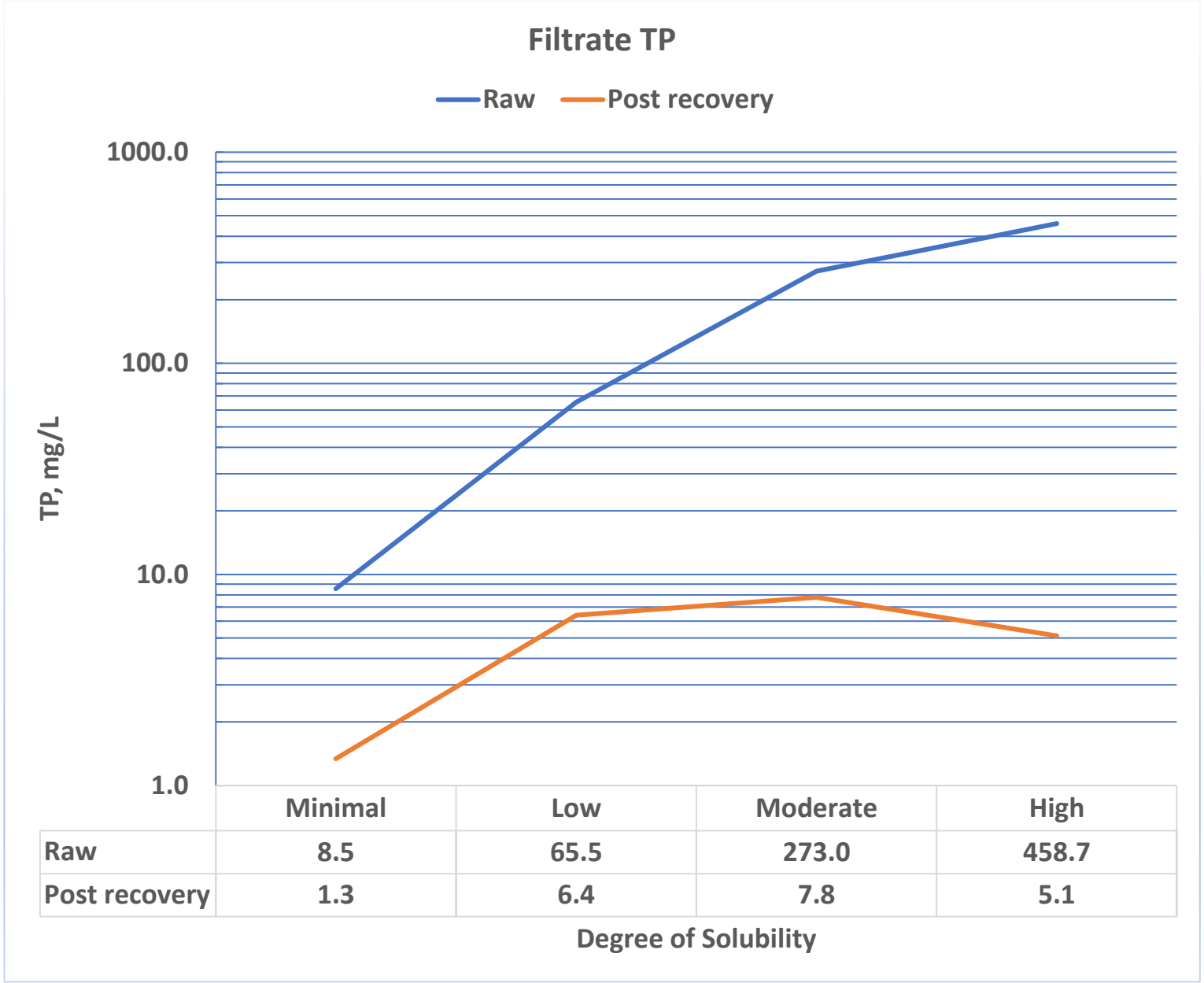
APPLIED ENVIRONMENTAL SOLUTIONS

Sludge P recovery



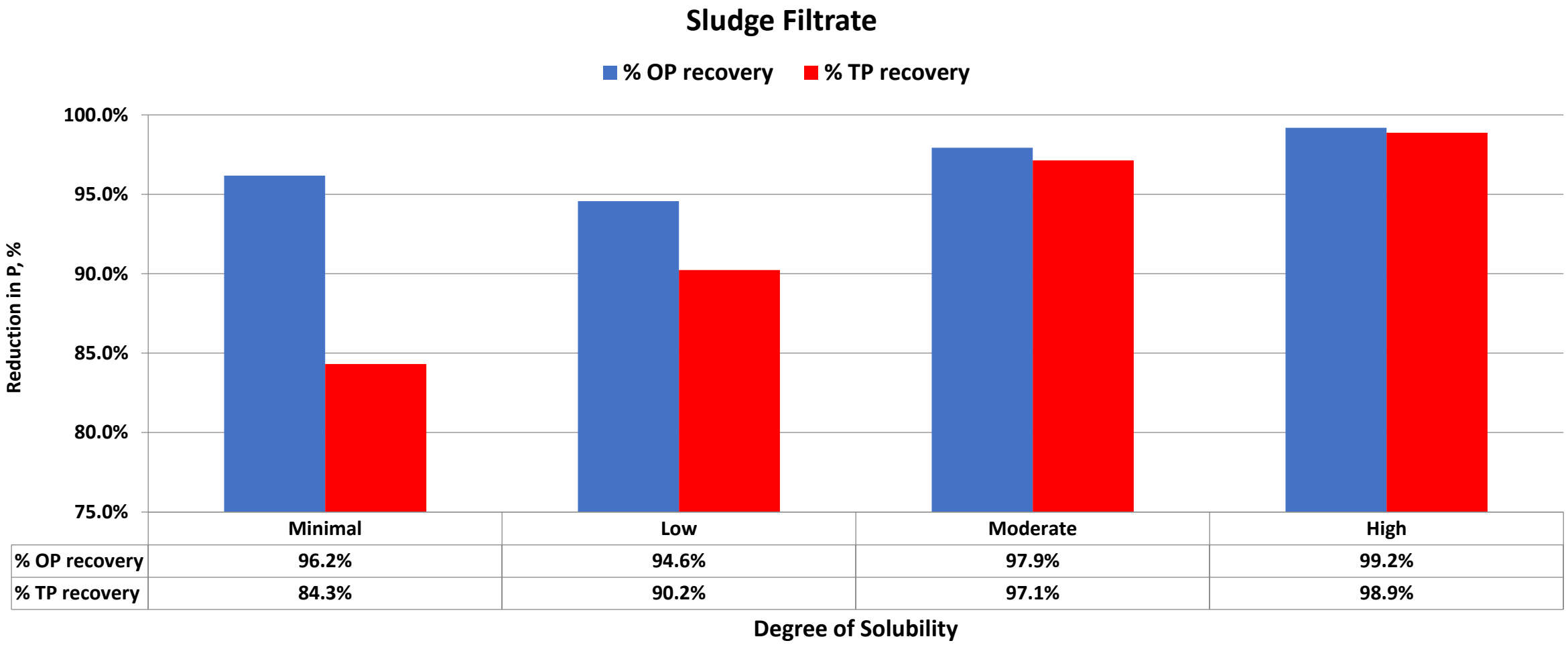
APPLIED ENVIRONMENTAL SOLUTIONS

Dewatered Filtrate Results



	Minimal	Low	Moderate	High
Raw	8.5	65.5	273.0	458.7
Post recovery	1.3	6.4	7.8	5.1

Sludge P recovery



	Minimal	Low	Moderate	High
% OP recovery	96.2%	94.6%	97.9%	99.2%
% TP recovery	84.3%	90.2%	97.1%	98.9%

APPLIED ENVIRONMENTAL SOLUTIONS

Economic Model Assumptions

Criteria	Condition	PWWTP
Average daily flow, MGD	5MGD	4.48MGD
Stream to be treated	Pre-dewatering sludge	Belt Filter Press feed
Average stream flow, GPD	40,000 GPD	35,667 GPD
Days of operation per year	260 (5 days/week)	223 (average ‘16-’18)
Primary influent source	Residential	Residential
Raw TP of treated stream	468mg/L	1242mg/L
% OP of treated stream	58%	59%
Average incoming TP	3.9mg/L	4.5mg/L
Alkalinity of stream to treat	3600mg/L	12,645mg/L
Solubility conversion	95%	96%
Precipitation recovery	99%	98.9%
Polymer usage	98 GPD	98 GPD
Ferrous chloride	334 GPD	334 GPD
Cost of polymer	$0.83/gallon	
Cost of Ferrous chloride	$0.56/gallon	
Cost of 93% sulfuric acid	$0.22/lb	
Cost of mixed Ca/Mg hydrated lime	$0.25/1000 gallons treated	
Value of calcium phosphate produced	$0.05/pound - $0.10/pound	
Present Worth duration	20 years	
Assumed interest rate for PW	5%	

Summary In-Scope Costs

Metric	Estimated Cost
OPEX / Year	
Power @$0.07/kwh	$ 2,347
Acid	$ 5,813
Hydrated Lime	$ 2,600
Total	$ 10,760
OPEX NPV (20 years @5%)	$ 134,090
CAPEX	
In-Scope	$ 313,176
25% contingency	$ 78,294
Total In-Scope Capex	$ 391,470
Total 20 NPV	$ 525,560

Economic Metrics

Metric		Units	Results
Phosphorus Removed		Lbs. P/Day	147
Calcium Phosphate Produced		Lbs. Cal Phosphate/Day	1470
Recycle stream P removed		Lbs. P /Day	8.12
Ferrous chloride savings		$/Day	$4.55
Cost per Lb P removed			
	Capex only	$/lb P removed	$0.597
	Annual Opex only	$/lb P removed	$0.328
	20 yr PW	$/lb P removed	$0.802
Value of Cal P – low		$ (@$0.05/lb)/Day	$73.50
Value of Cal P – high		$ (@$0.10/lb)/Day	$147.00
Total cost recovery			
	Cal P Value (mid-range)	$ (20 yr PW)	$491,715
	Ferrous Chloride savings	$ (20 yr PW)	$20,281
	Total	$ (20 yr PW)	$511,996

Applications - Agricultural

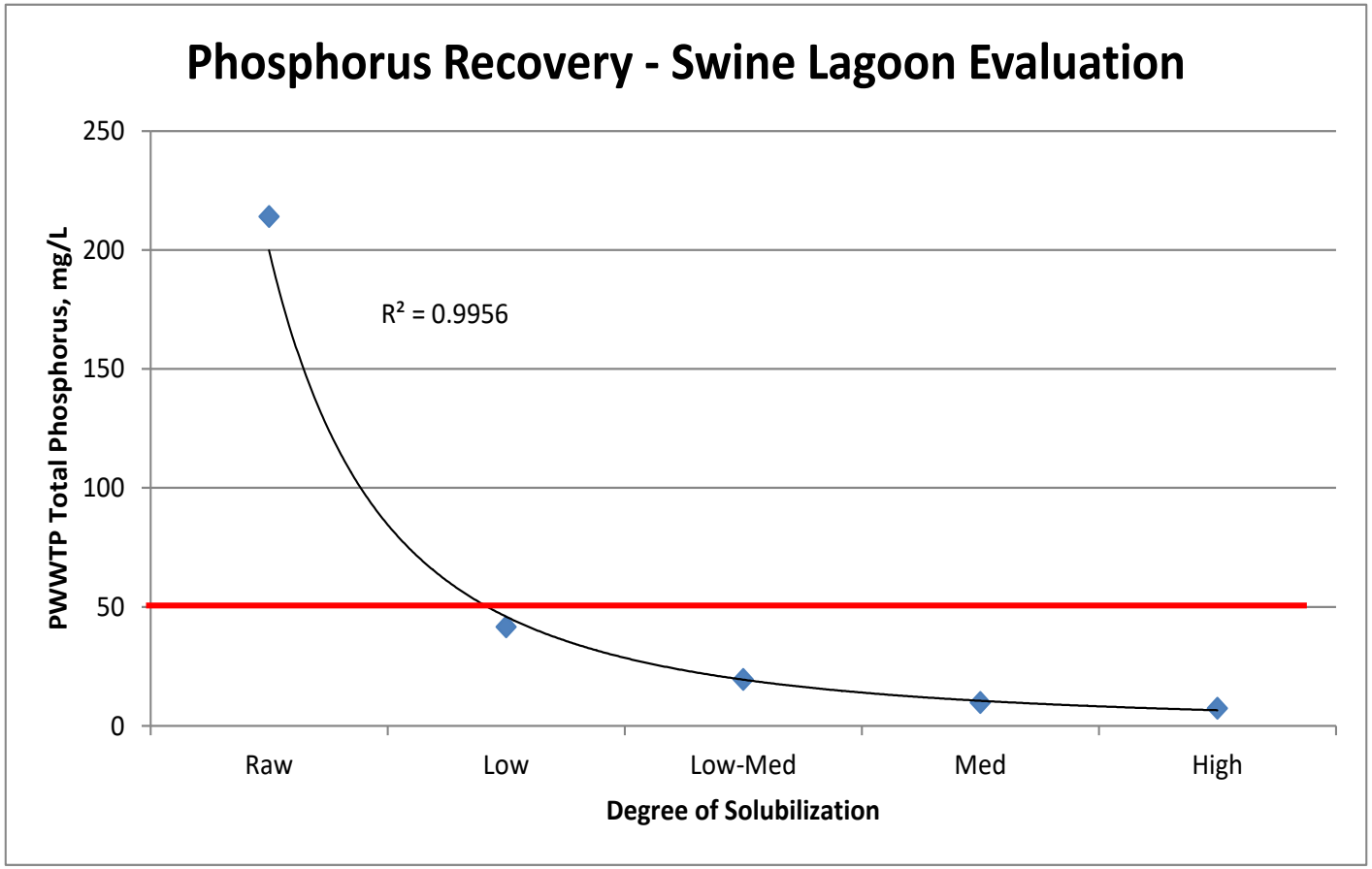
Site 1

- Agricultural anaerobic digester
- 55,000 GPD digestate
- 5 Lagoon treatment train
  - Receiving lagoon
  - 3 holding lagoons
  - 1 large irrigation lagoon
- Current TP in irrigation lagoon: 200-300mg/L
  - Need to reduce to 50mg/L with existing crop rotation and acreage

APPLIED ENVIRONMENTAL SOLUTIONS

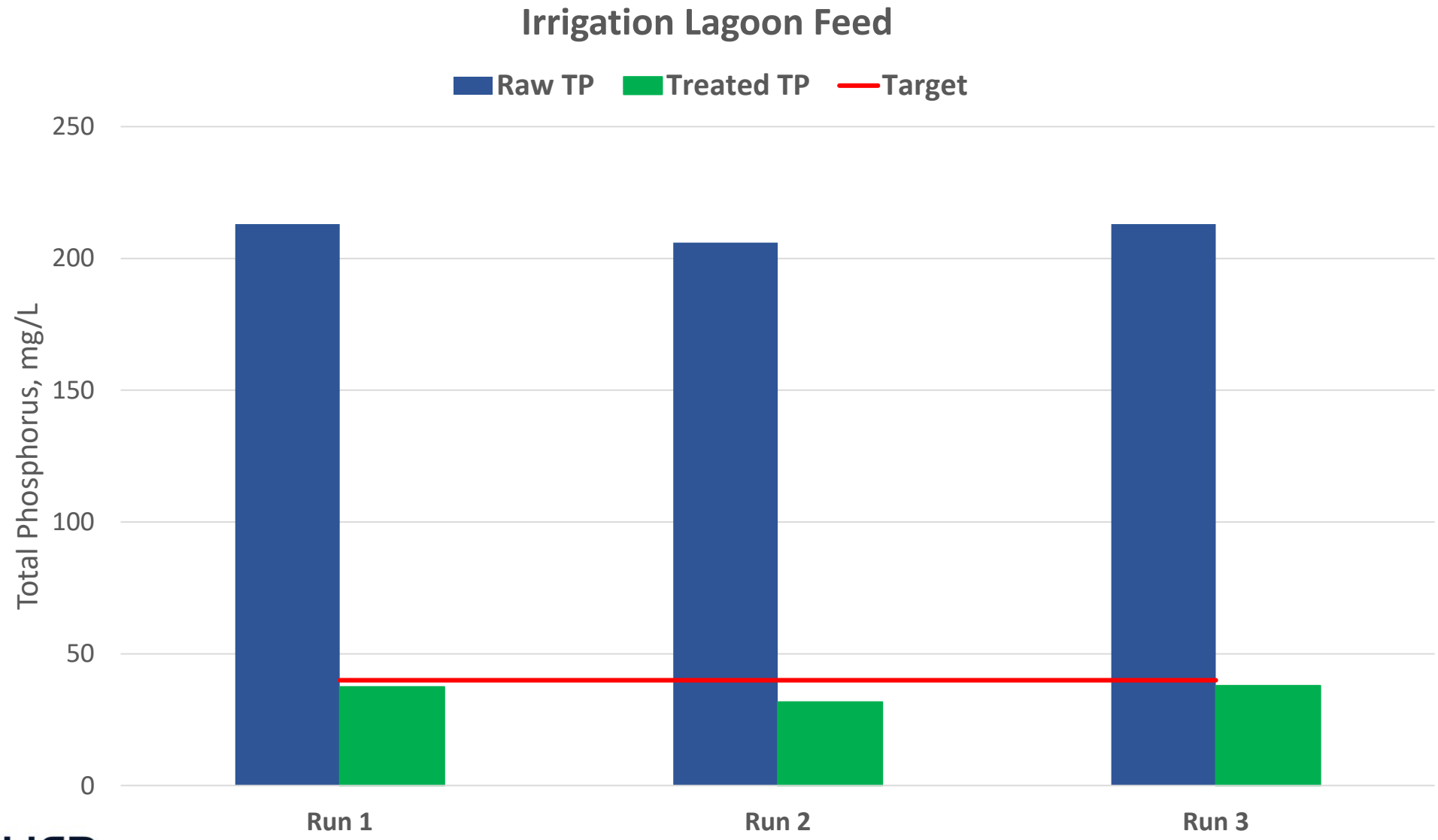
Site 1

- Multiple lagoon treatment train
- Final lagoon to support center pivot irrigation



APPLIED ENVIRONMENTAL SOLUTIONS

Site 1 Performance confirmation



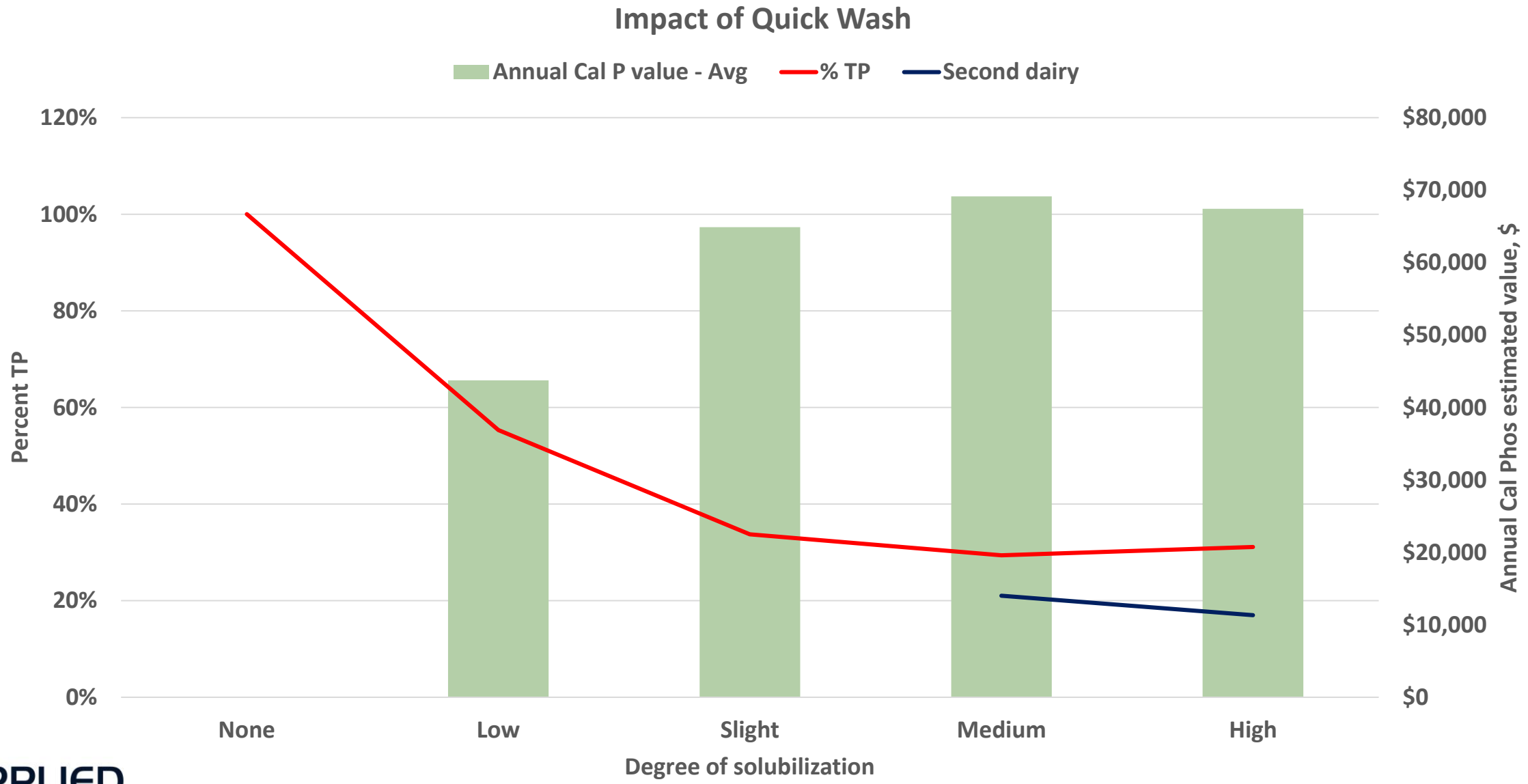
APPLIED ENVIRONMENTAL SOLUTIONS

Site 2

- 4500 Cow Dairy
- 5 Lagoon treatment system
  - L1: Sileage Lagoon
  - L2 & L3: Receiving Lagoons
    - Separated manure (~2% solids)
  - L4: Anaerobic Lagoon
  - L5: Irrigation Lagoon

APPLIED ENVIRONMENTAL SOLUTIONS

Site 2 Initial Results



APPLIED ENVIRONMENTAL SOLUTIONS

Site 3

- Ohio Farm Bureau Demonstration Farm
- 5500 head swine operation
  - Grower and Finisher operation
- Sponsored by Ohio Farm Bureau

APPLIED ENVIRONMENTAL SOLUTIONS

Site 4

- Expanding dairy
- High P in post sand-lane storage
- Sponsored by Ohio Dairy Producers

APPLIED ENVIRONMENTAL SOLUTIONS

Site 5

- Companion facility to Site 1
- Expanding capacity to 72,000 GPD digestate
- Less available land to support high P in center pivot irrigation

APPLIED ENVIRONMENTAL SOLUTIONS

Co-Product value

		% As Is Basis	lbs/ Ton
Total Nitrogen	(N)	0.97	19.40
Total Phosphorus	(P)	1.950	39.00
Avail. Phosphorus	(P)	1.815	36.30
Avail. Phos. as	(P205)	4.159	83.18
Potassium	(K)	0.904	18.08
Potassium as	(K20)	1.089	21.78
Calcium	(Ca)	26.873	537.46
Magnesium	(Mg)	0.202	4.04
Sodium	(Na)	2.340	46.80
		ppm As Is Basis	lbs/ Ton
Boron	(B)	40.69	0.081
Iron	(Fe)	1015.00	2.030
Manganese	(Mn)	103.50	0.207
Copper	(Cu)	35.85	0.072
Zinc	(Zn)	80.55	0.161
pH		8.40	

Summary

- Demonstrated to recover ~95% + of available phosphorus
- Application in municipal and agricultural applications
- Co-product with real and relevant value
- Growing adoption

Questions?

Rick Johnson
Commercial Director
Applied Environmental Solutions
rj@r2hsolutions.com
440.415.2151

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