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Method and Apparatus for Removal of Phosphate from Wastewater Streams

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CAPSTONE DESIGN EXPO 2017

Method and Apparatus for Removal of Phosphate from Wastewater Streams

CLSE 208 | **Team members:** Steven Skeels, Arjun Subedi, Fred Williams | **Faculty adviser:** Dr. Ben Ward |
Sponsor: Church & Dwight, CO. | **Sponsor adviser:** Nick Johnson, Carl Terry

Background

Church and Dwight's wastewater contains high concentrations of phosphate; current non-optimized disposal costs $100K annually.

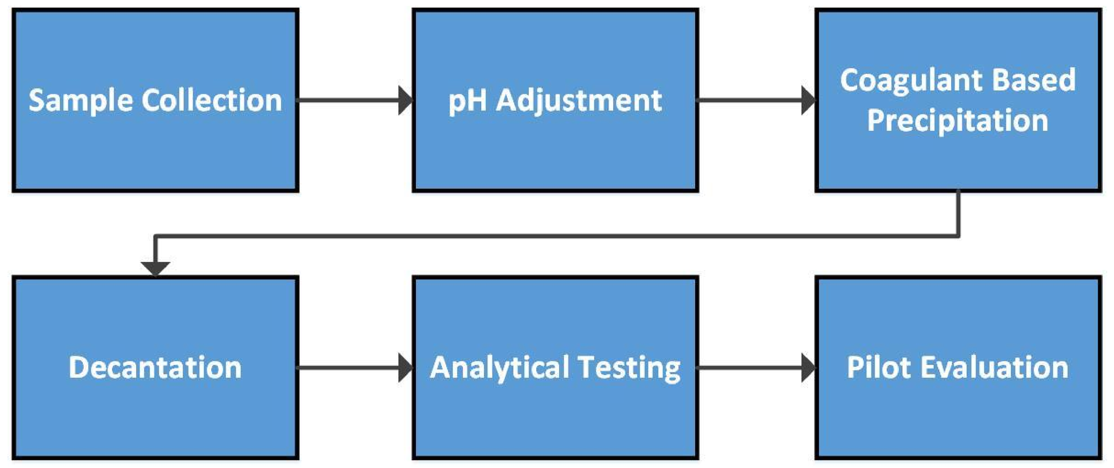
Project Goal - Develop a process to reduce cost of phosphate disposal, which will:

A. Treat varying quantities and concentrations
B. Avoid interfering with downstream processes

Approach

- Separate phosphate via precipitation and filtration
- Develop chemistry by Design of Experiment
- Scale-up and adjust chemistry as needed

Procedure:



Independent Variables

1. Type of coagulant
2. Coagulant ratio
3. With/without Lime
4. pH Adjustment
5. With/without polishing

Dependent Variables

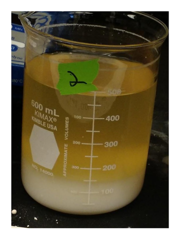
1. Resulting Phosphorus concentration
2. Volume of sludge
3. Consistency of sludge
4. Residence time

VCU Jar Test

Church and Dwight Jar Test

Results

Lab Scale



	PC-1101	Ferric Chloride	Cerium Chloride
Lowest Conc. (as P)	*0 ppm **Nominally:** 0 - 80 ppm	*0 ppm **Nominally:** 50 - 80 ppm	1500 ppm
Sludge	Moderate	Highest	Lowest
Final pH (optimal result)	6.5 - 7	5 - 6	5 - 6

Below detection limit

Pilot Scale

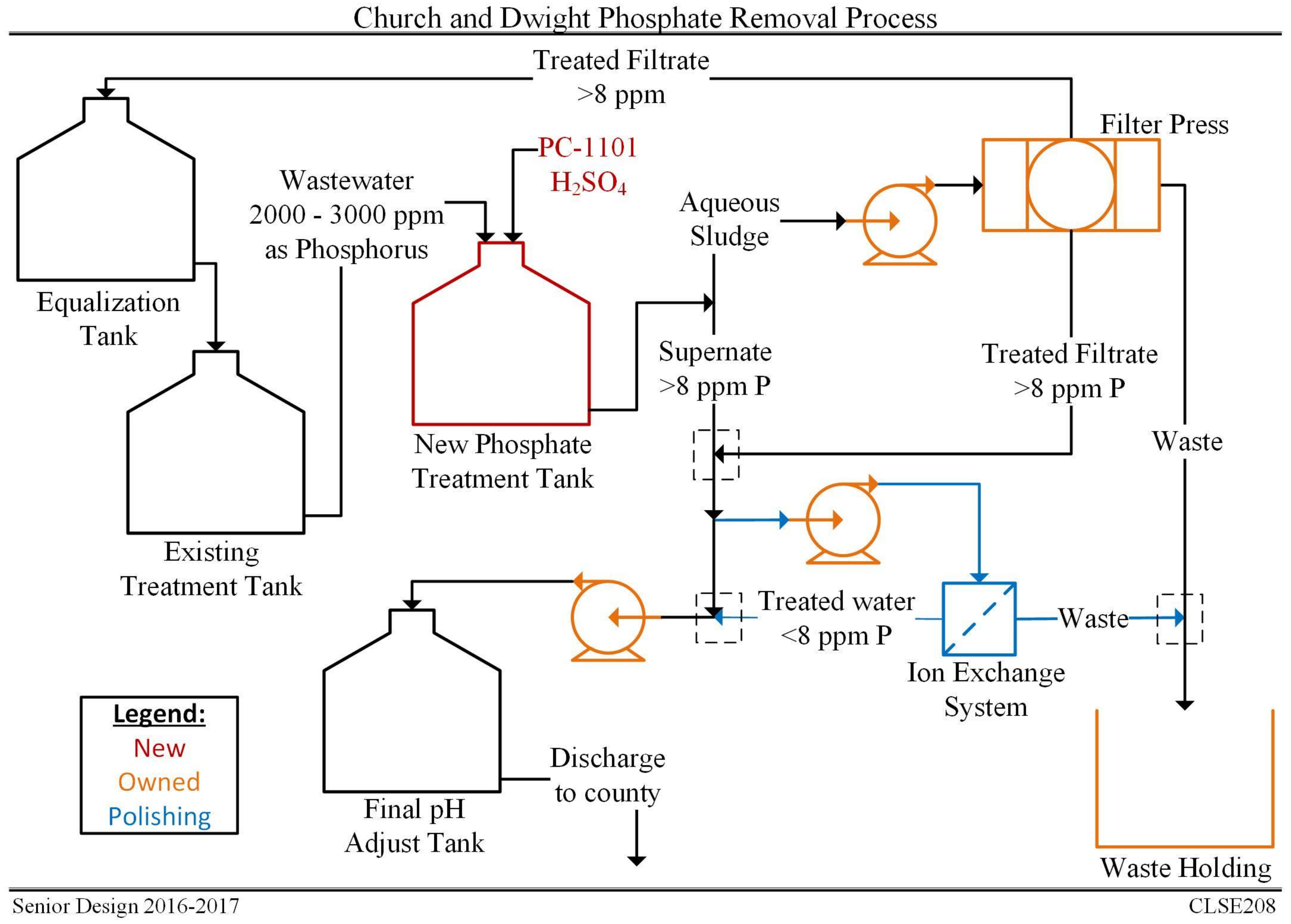
- 200 gallon in-plant trials
- Jar test run in parallel for comparison
- Results validated lab-scale methodology
- Residence time increased

Polishing Step

ChemTreat ion exchange system

- Reduces concentration to 0 ppm after precipitation
- Reduces process variability/guarantee wastewater meets county limits
- High cost limits value added to system

Process Design



Economic Analysis

Capital Cost Estimate

Equipment	#	Old Equipment Estimated Cost	New Equipment Estimated Cost
Contingency	1	$2,000	$2,000
Treatment Tank	1	$18,000	$18,000
Agitator	1	$10,000	$10,000
Filter Press	1	-	$15,000
Solid Waste Holding	1	-	$3,000
Pumps	3	-	$0
Installation	-	$20,000	
Total Capital:		$50,000	$68,000

Operational Cost Estimate

Requirement	Quantity	Estimated Annual Cost
PC-1101	160,000 lbs	$44,800
Sulfuric Acid	20,000 lbs	$2,000
Remaining Phosphorus	~15 ppm discharged	$10,000
Waste Disposal	100 tons	$3,000
Electricity	*TBD Based on Equipment, Minimal Cost*	
Filter Media	*Frequency TBD*	
Polishing Step	1	$40,000
Annual Cost without Polishing:		**$59,800**
With Polishing Step:		**$99,800**

Conclusion

- Precipitation by PC-1101, ~2% by volume per batch
- Optimal pH for precipitation is 6.5 - 7, meeting county requirements
- Demonstrated in-plant pilot trial - validated approach
- Proposed process meets need, saving ~$40K/yr
- Max payback period of 1.32 years
- Avoid polishing step

Requirement	Old Equipment	New Equipment
Capital Cost	$50,000	$68,000
Operational Cost	$59,800	$59,800
PBP (years)	1.32	1.76
ROI	52%	13%
NPV	$25,832	$8,834
Estimated P	0 - 50 ppm	
Strength	Lower cost	Dedicated equipment
Weakness	Relies on downstream dilution May require polishing in the future	Relies on downstream dilution May require polishing in the future High capital cost

Recommendations

- Implement proposed process to save ~$40K/yr
- Examine value of a pretreatment and/or polishing step as needed
- Evaluate coagulant ratios to optimize cost and phosphate removal
- Implement settling technology to lower residence time
- Identify additional methods to remove other total suspended solids (TSS)

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