Optimizing Energy Efficiency at Saint Peter Wastewater Treatment Plant

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Driven to Discover[SM]

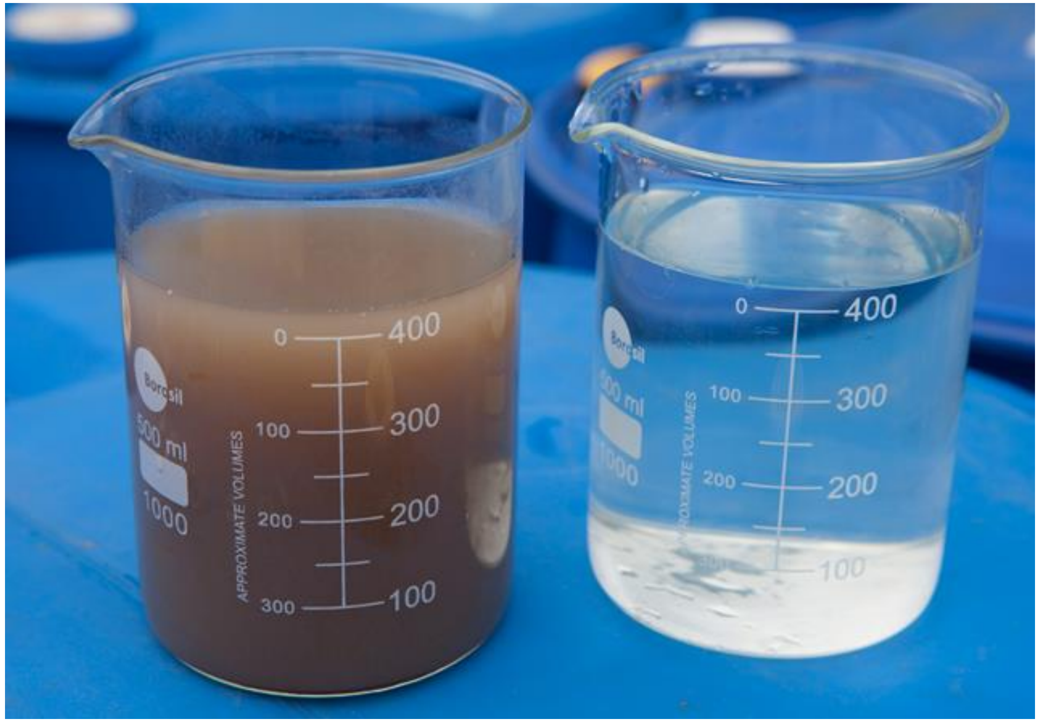
Facility Overview

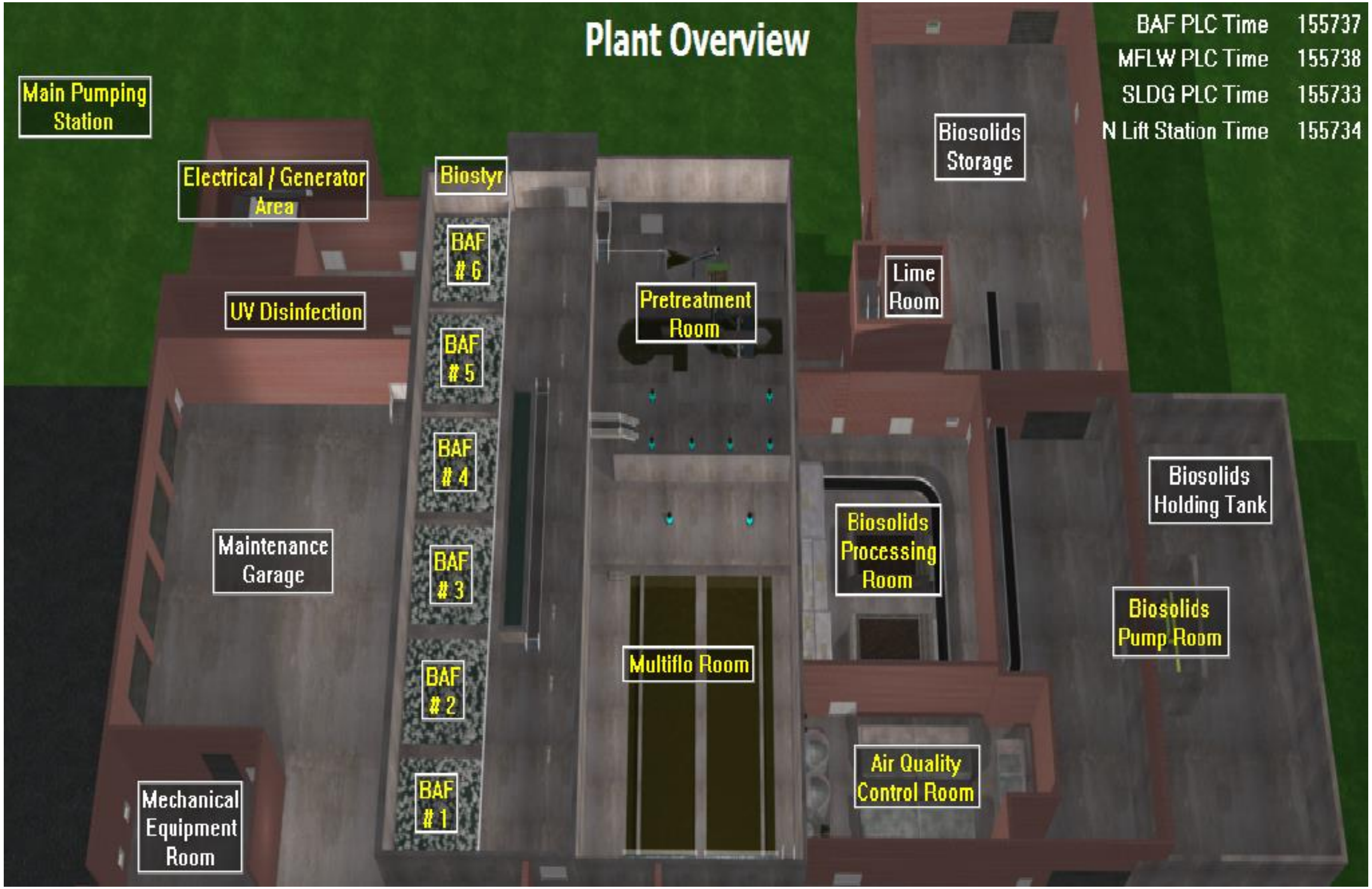
- Provides treatment of wastewater for the city of St. Peter to discharge into Minnesota River
- Originally built in 1961
- Expanded in September 2000
- Designed flow rate: 4 million gallon per day (MGD)
- Energy consumption: ~ 3 million kWh per year

City of Saint Peter
Where History & Progress Meet

Treatment Objective

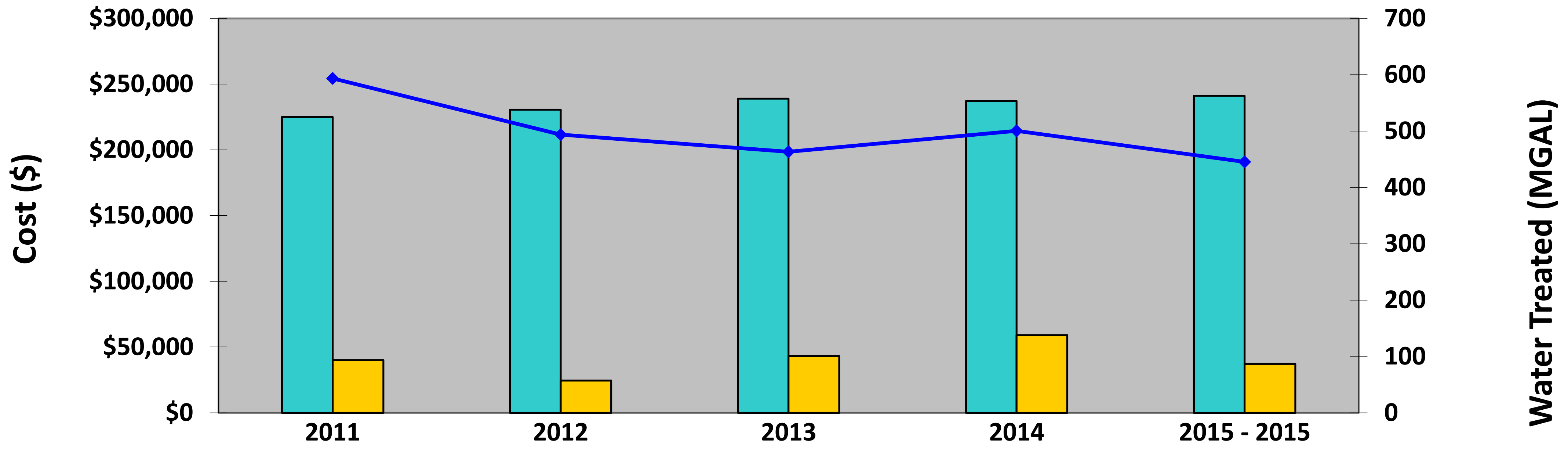
- Solids removal
- Biochemical Oxygen Demand (BOD) removal
- Total Suspended Solids (TSS) removal
- Ammonia Nitrogen removal
- Phosphorous removal
- Pathogen removal




Plant Overview
BAF PLC Time 155737
MFLW PLC Time 155738
SLDG PLC Time 155733
N Lift Station Time 155734
Main Pumping Station
Electrical / Generator Area
Biostyr
BAF # 6
BAF # 5
BAF # 4
BAF # 3
BAF # 2
BAF # 1
UV Disinfection
Maintenance Garage
Mechanical Equipment Room
Pretreatment Room
Multiflo Room
Biosolids Storage
Lime Room
Biosolids Processing Room
Biosolids Holding Tank
Biosolids Pump Room
Air Quality Control Room

Motivations for Change

Utility Costs vs. Water Treated (Major Utilities)



	2011	2012	2013	2014	2015 - 2015
Electric Cost	$224,984	$230,590	$239,005	$237,205	$241,162
Natural Gas Cost	$40,095	$24,566	$43,193	$59,063	$37,199
Water Treated	593	494	463	501	445

Year

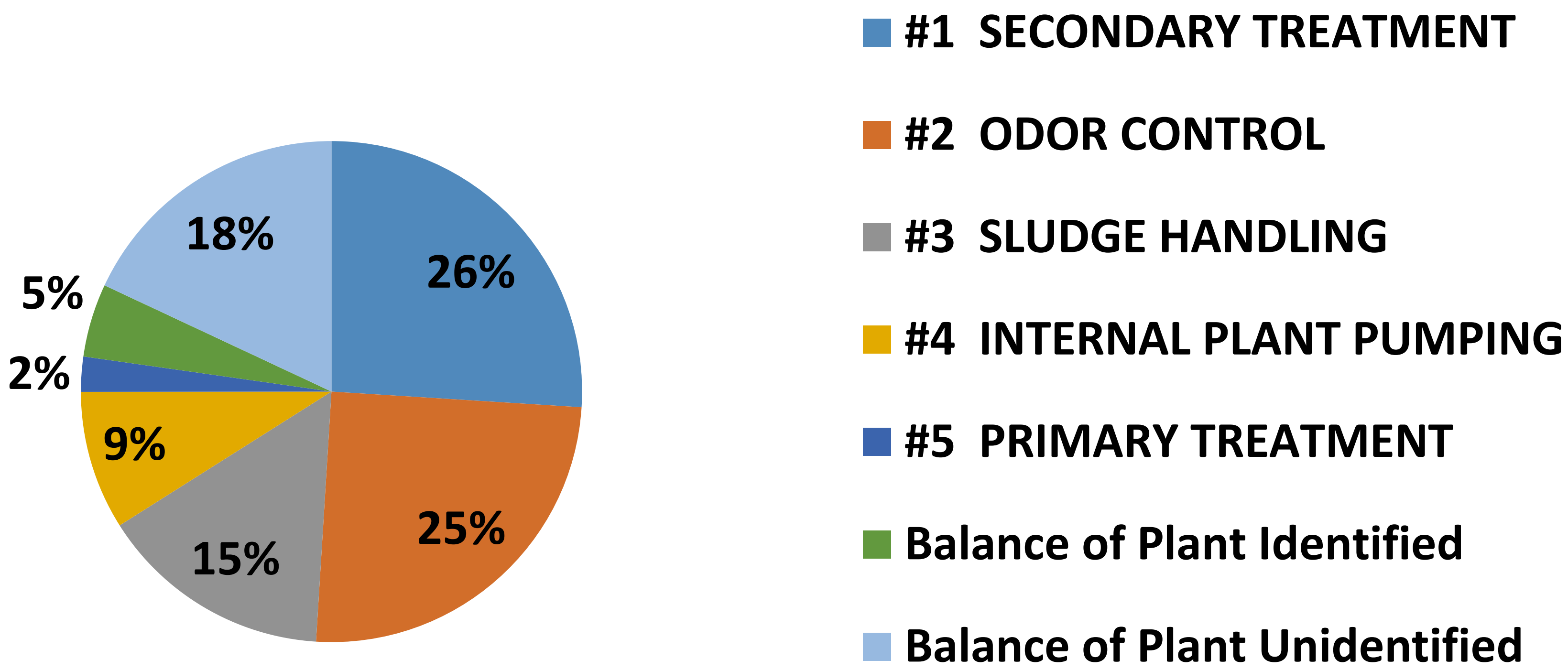
Reasons for MnTAP Assistance

- Identify energy usage of secondary treatment
- Optimize aeration system by reduced Dissolved Oxygen (DO)
- Determine whether the blower can handle the reduction
- Optimize the biosolids blower
- Make recommendations for reducing energy

Approach

- Understand the facility's current energy usage and operating methods
- Use aeration model to quantify energy savings through reduced DO
- Identify how Supervisory Control And Data Acquisition (SCADA) adjustments will impact the aeration energy consumption
- Test for energy reduction recommendations that will insure wastewater treatment requirements

Top Electrical Energy Use Systems

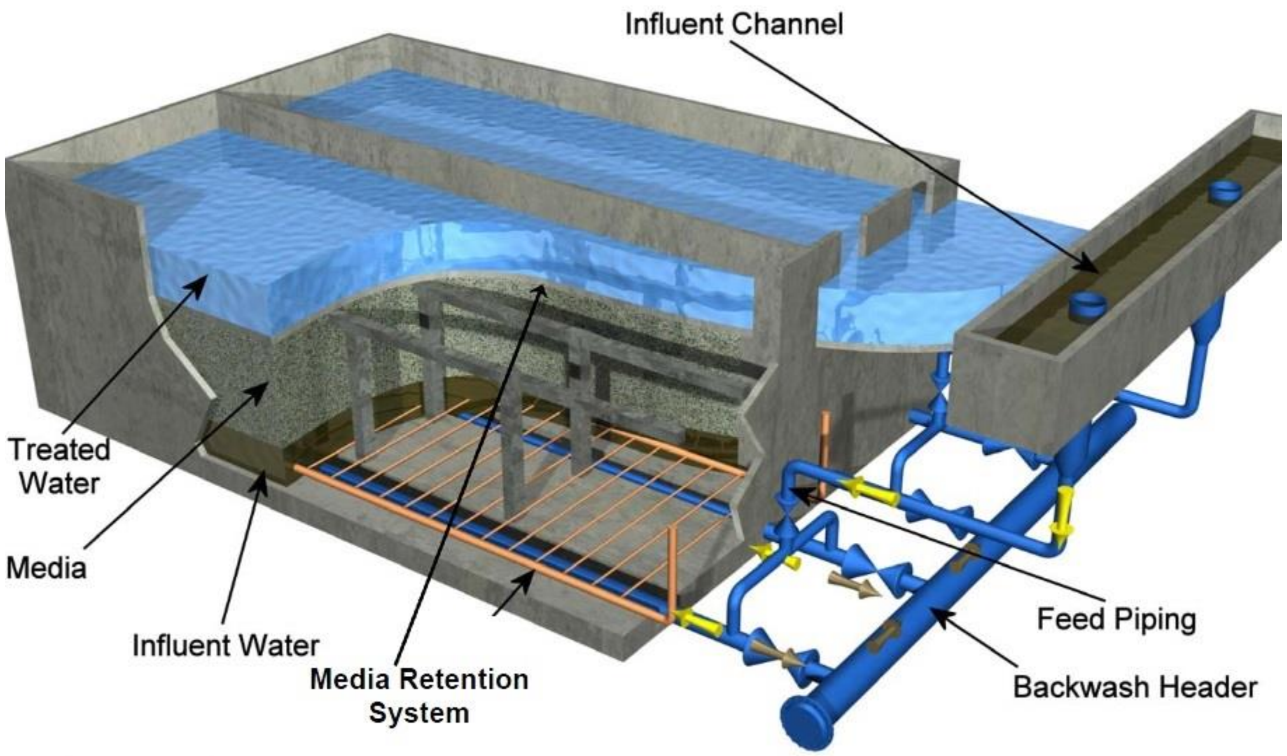


Secondary Treatment → **26%**

Biosolids Treatment → **15%**

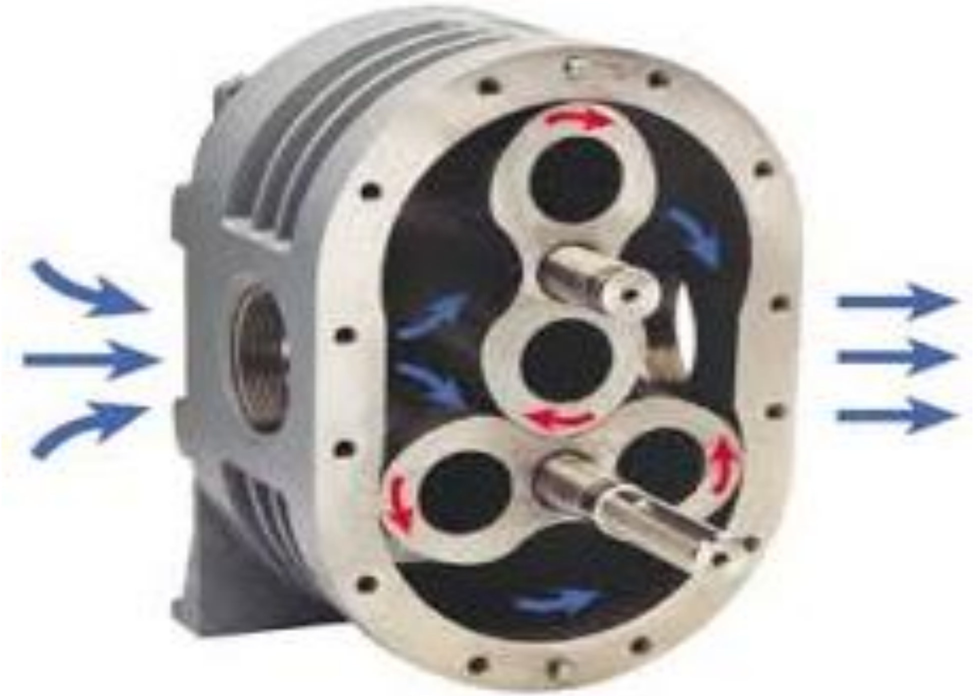
Biological Aerated Filter (BAF)

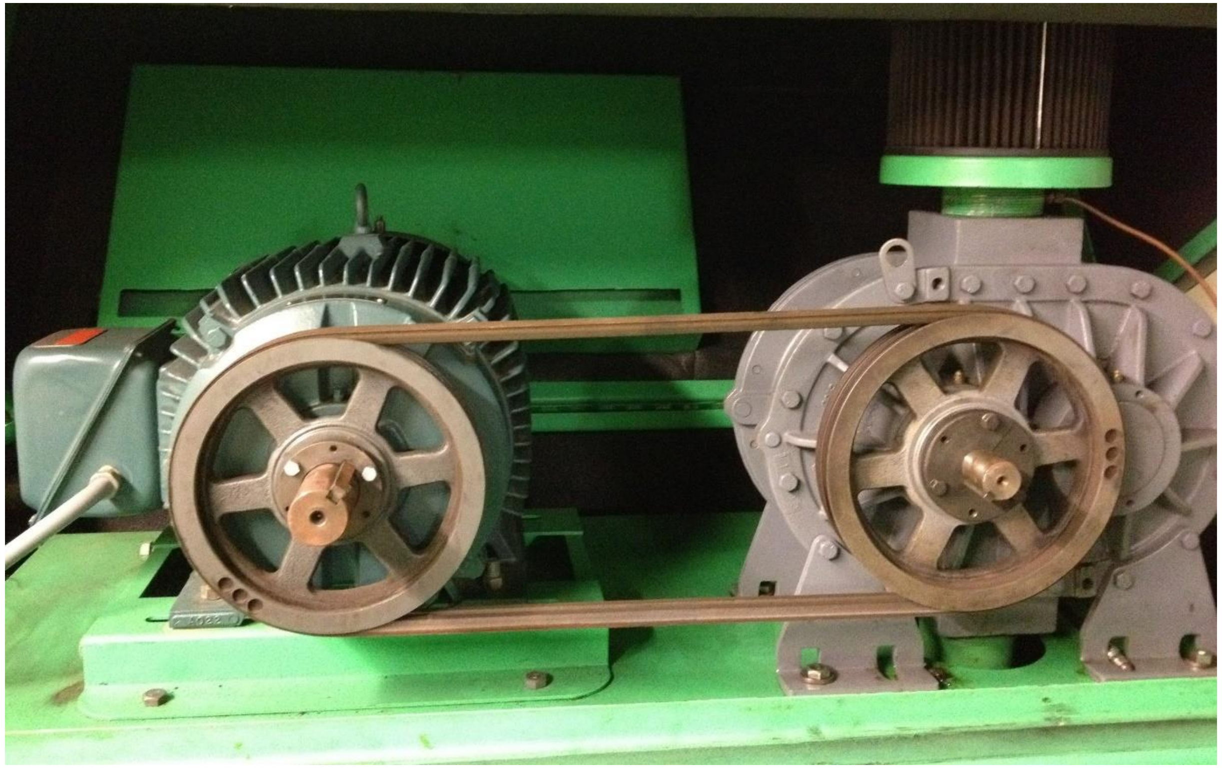
- Ammonia, Phosphorous, BOD, and TSS removal using bacteria
- Bacteria require Dissolved Oxygen (DO)
- Low DO can cause unwanted organisms to develop
- High DO unnecessary for adequate treatment and does not further improve the quality of the effluent water



Blowers

- 7 Positive displacement (PD) belt drive blowers: 50 HP each
- Provide air for the BAF cells



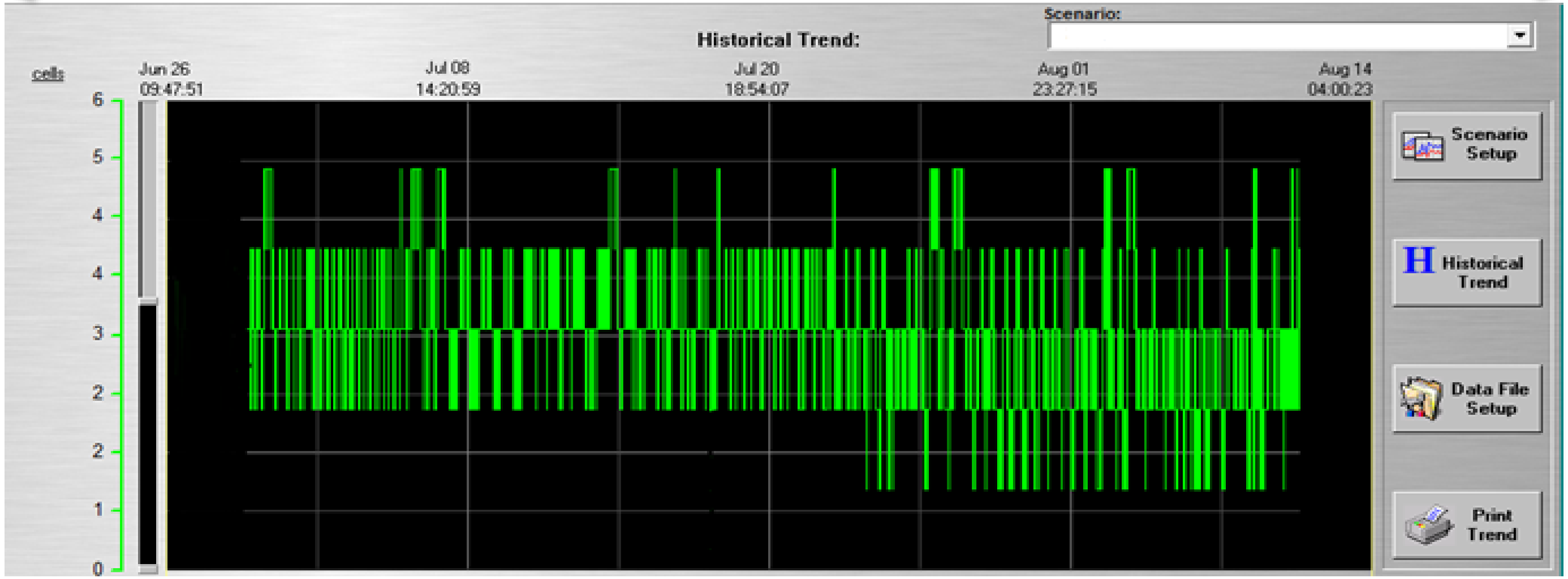


SCADA Adjustment

- BAF system controlled by SCADA
- The number of cells in filtration determined by influent flow and target cell velocity
- Reducing the target cell velocity from 2 gpm/ft^2 to 1 gpm/ft^2 to improve TSS removal at reduced cells
- Allowing the number of cells in filtration to be determined by the influent flow
- Result: Reduction in the average cells in filtration

SCADA Adjustment

Before ← → After



Recommendation	Energy Reduced (per year)	Net Savings (per year)	Implementation Cost	Payback Period (year)	Status
Alternative 1A SCADA Adjustment	153,600 kWh	$12,300	$0	Immediate	Implemented

DO Control System

- Reducing the speed of the blower decreases the airflow
- Reducing the speed decreases the power consumption

Speed, Airflow & Power Relationship	
$$\frac{Q_1}{Q_2} = \frac{N_1}{N_2}$$	Q = flow (cfm) N = speed (RPM)
$$\frac{P_1}{P_2} = \frac{N_1}{N_2}$$	P = power (kW)

DO Control System

Installing Variable Frequency Drive (VFD)

- **Reduce the blower speed from 1,682 RPM to 1,122 RPM**
- **Reduced average effluent DO from 11 mg/L to 7 mg/L**
- **Decrease the blower energy consumption by 25%**

Recommendation	Energy Reduced (per year)	Net Savings (per year)	Implementation Cost	Payback Period (year)	Status
Alternative 1B: Installing VFD	173,600 kWh	$13,900	$27,200	2	Recommended

Combination of SCADA Adjustment and DO Control System

- **SCADA adjustment and installing VFDs**
- **Decrease the blower energy consumption by 41%**

Recommendation	Energy Reduced (per year)	Net Savings (per year)	Implementation Cost	Payback Period (year)	Status
Alternative 1C combination of 1A & 1B	289,600 kWh	$23,200	$27,200	1.2	Recommended

Biosolids Blower

- Biosolids Blower: 100 HP consumes 407,200 kwh/year
- Reducing the blower speed along with the liquid level by using VFD
- Decrease the blower power consumption by 61%

Recommendation	Energy Reduced (per year)	Net Savings (per year)	Implementation Cost	Payback Period (year)	Status
Opportunity 2: Installing VFD & controlling on tank level	246,500 kWh	$19,700	$18,000	0.9	Recommended

Successful Process Changes

Recommendations	Energy Reduced (per year)	Implementation Cost	Net Savings (per year)	Payback Period (year)	Status
Opportunity 1: Biological Aerated Filter Blower Efficiency					
1A: SCADA Adjustment	153,600 kWh	N/A	$12,300	Immediate	Implemented
1B: Installing VFD	173,600 kWh	$27,200	$13,900	2	Recommended
1C: (1A &1B) SCADA Adjustment And Installing VFD	289,600 kWh	$27,200	$23,200	1.2	Recommended
Opportunity 2: Biosolids Storage Aeration Blower Efficiency					
Opportunity 2: Installing VFD	246,500 kWh	$18,000	$19,700	0.9	Recommended

Potential Future Projects

- To Model the aeration system with 5mg/L effluent DO

    Saving: 300,000 kWh/year, $25,000/year

- To test the aeration system with 1.5 gpm/ft^2 target cell velocity and 7mg/L reduced effluent DO

    Saving: 400,000 kWh/year, $32,000/year

- To optimize odor control system: consumes 25% of the total energy

Personal Benefits

- Real-world engineering experience
- Understanding in process control of wastewater treatment
- Equipment energy usage and optimization
- Communication skills
- Small town life experience

Questions?

This project was sponsored in part by the Southern Minnesota Municipal Power Agency