Benchmarking Case Studies for Water and Wastewater Facilities

Marvin Gnagy, P.E., President

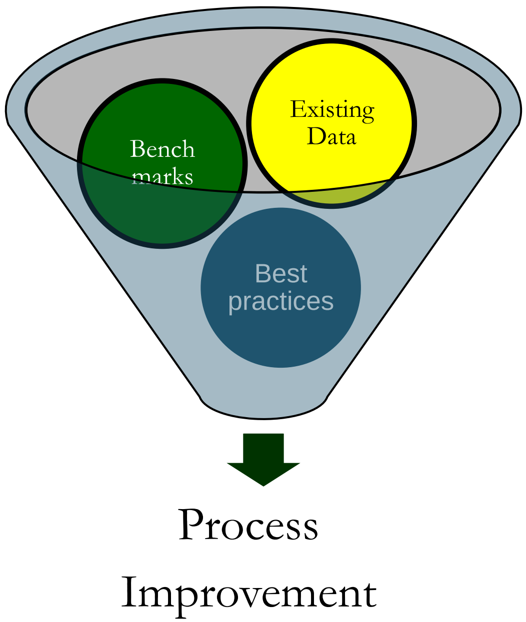
PMG Consulting, Inc.

OTCO Procrastinator's Workshop

December 11, 2012

Agenda

- Benchmarking and best practices
- Benchmarking opportunities
- Baseline development
- Benchmarking metrics
- Gap analysis
- Business case documentation
- Case Studies



Benchmarking and Best Practices

Benchmarking and Best Practices

American Water Works Association Research Foundation (AwwaRF)

- ***"Benchmarking is the process of identifying, sharing, and using knowledge and best practices. It focuses on how to improve any given business process by exploiting topnotch approaches rather than merely measuring the best performance. Finding, studying and implementing best practices provides the greatest opportunity for gaining a strategic, operational and financial advantage."***

American Water Works Association (AWWA)

- ***A benchmark is "something that serves as a standard by which others may be measured or judged".***

Water Environment Research Foundation (WERF)

- ***Benchmarking is a continuous process of improvement using comparison and change.***

Benchmarking and Best Practices

- Systematic methods to improve operational efficiencies
  - Self assessment
  - Baseline development
  - Gap analysis
  - Business case opportunities
- Measuring performance against your peers
  - Any process (treatment, management, maintenance, etc.)
  - Established metrics
  - Maintain consistent performance
  - Identifying opportunities

Benchmarking and Best Practices

- Implementing change to achieve goals
  - Targeted ease of implementation and greatest impact
  - Continuous improvement
  - Best industry practices
- Improving financial leverage
  - Reducing costs
  - Investing capital to gain operational efficiency (ROI)
  - Gaining competitive utility management

Benchmarking and Best Practices

Specific

Measurable

Attainable

Realistic

Time-related

SMART procedures used to affect change in any process

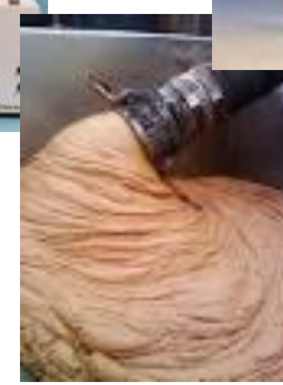
Benchmarking Opportunities

Benchmarking Opportunities

- Increased process efficiencies
- More consistent compliance
  - Regulatory and target goals
- Better water quality
- Lower energy usage
- Increased revenues
- Improved operating and monitoring efficiencies
- Reduced operating costs
- Reduced chemical consumption
- Reduced labor and maintenance costs
- Reduced waste handling
- Reduced water loss or non-revenue water
- Less non-productive time

Benchmarking Opportunities

- Top Priorities
  - Energy
  - Chemicals
  - Residuals
  - Labor
  - Maintenance
  - Laboratory

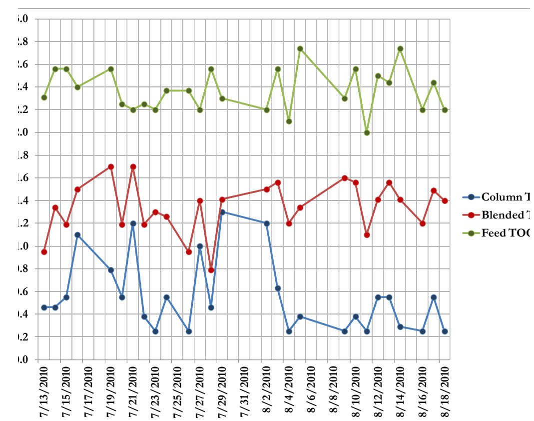


Baseline Development

Baseline Development

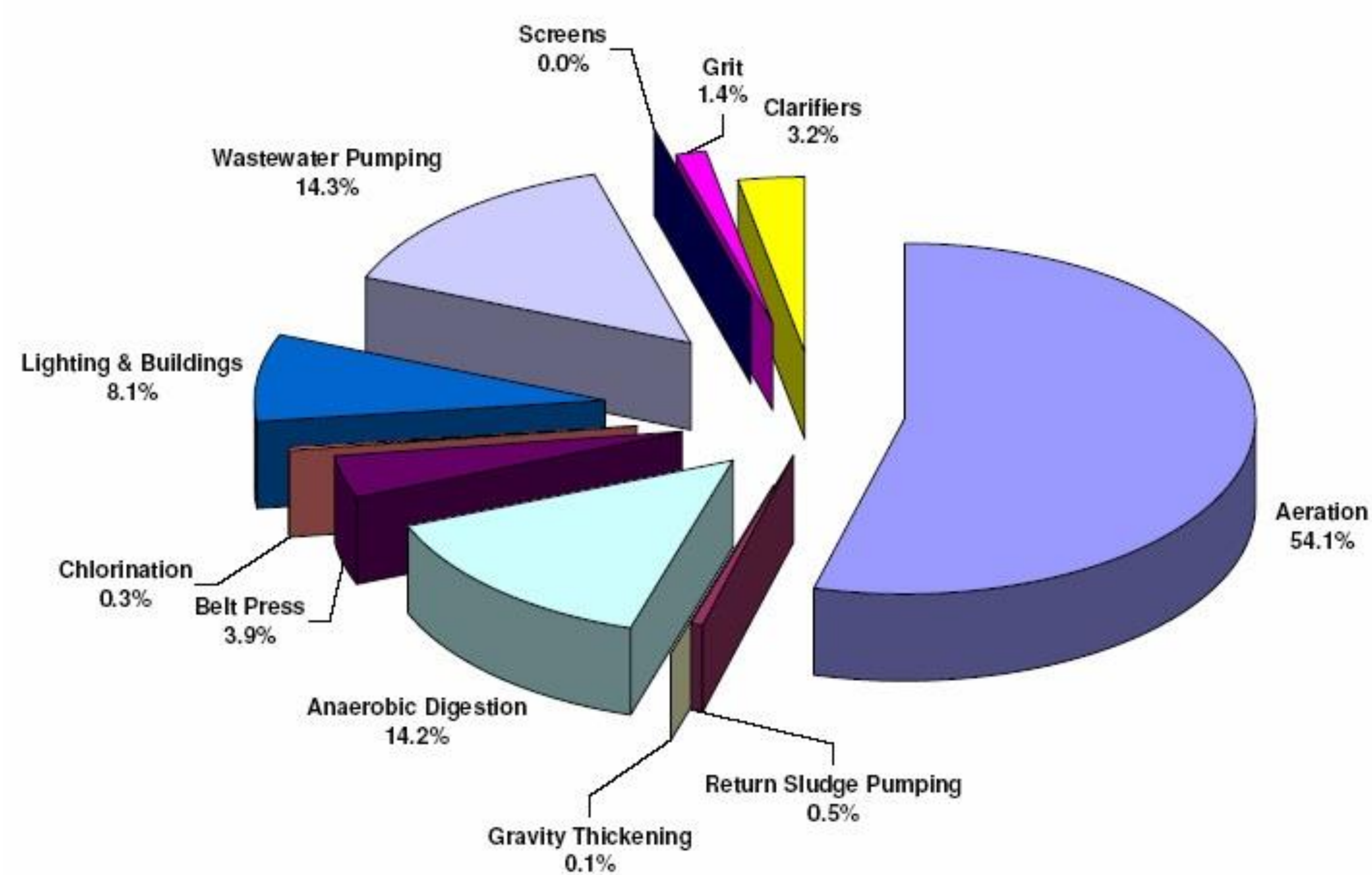
- One year minimum data collection
  - MORs
  - Process performance
  - Chemicals
  - Energy usage
  - Utilities (water, wastewater, etc.)
  - Labor (in-house and contracted)
  - Lab results
  - Waste handling
  - Trending reports
  - Investigative reports

Operating data shows trend information used for assessments



Graphical presentations identify current operating conditions

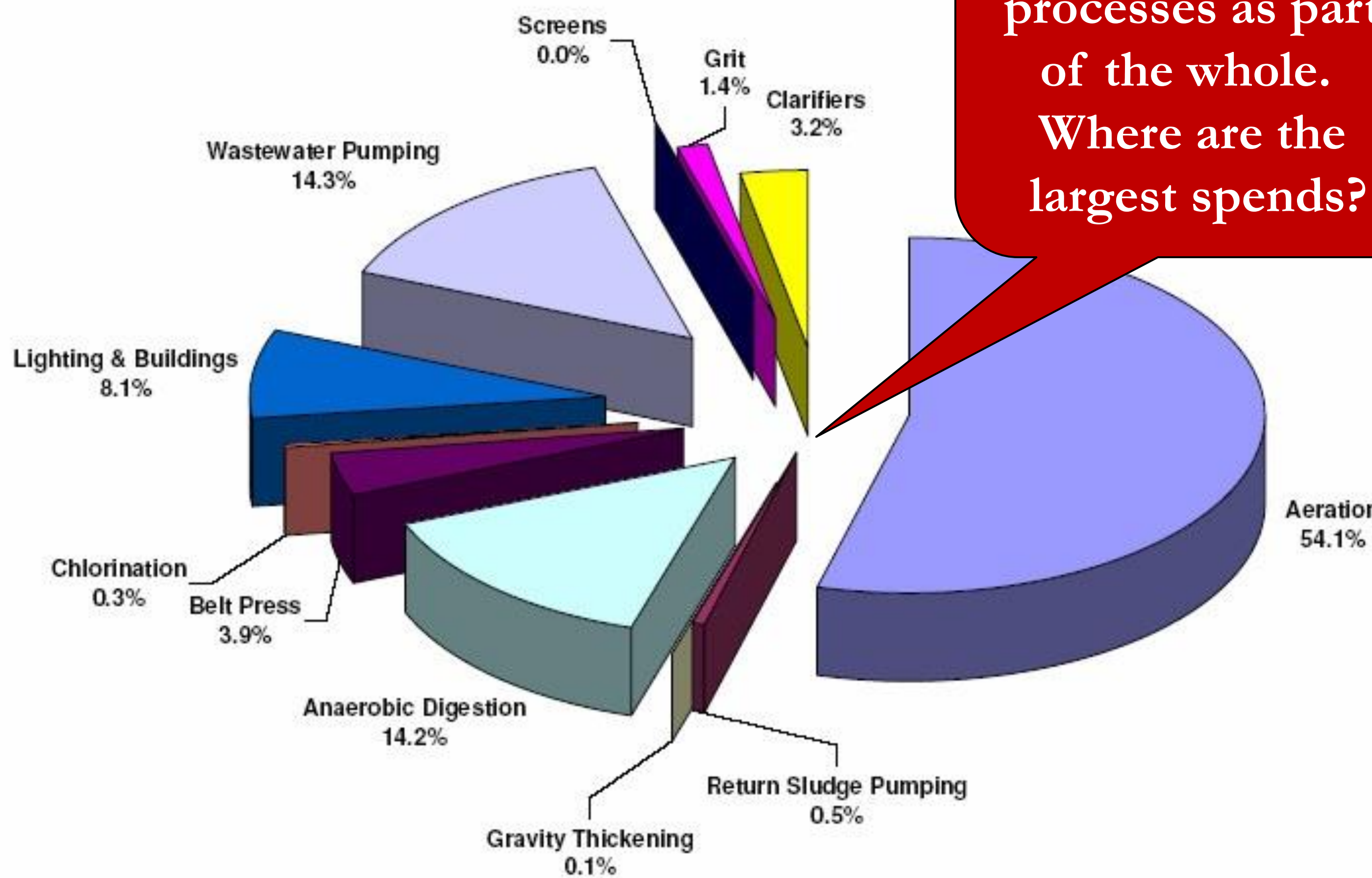
Baseline Development



Typical Power Consumption in Activated Sludge Processes

Baseline Development

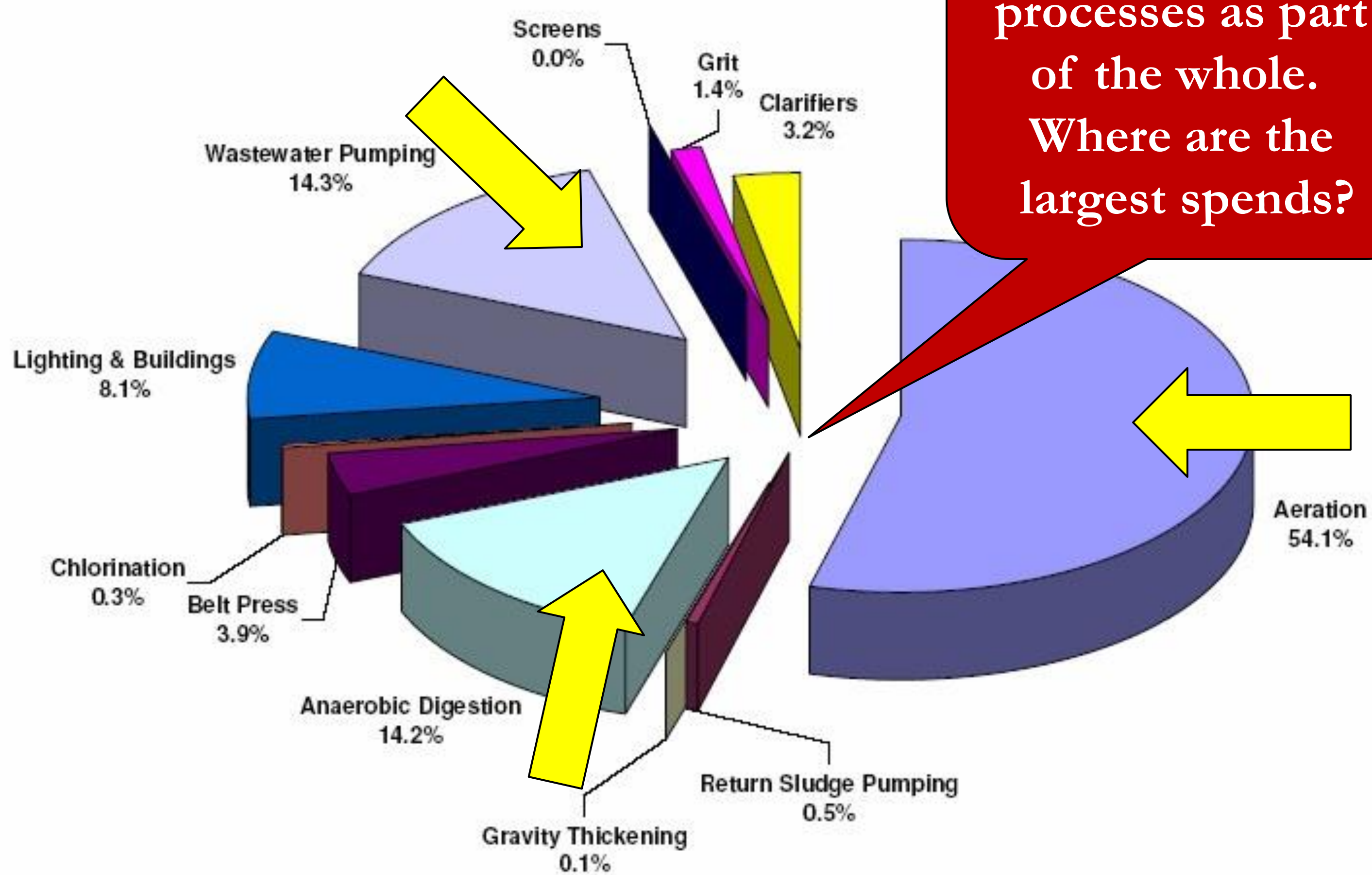
Divide individual processes as part of the whole. Where are the largest spends?



Typical Power Consumption in Activated Sludge Processes

Baseline Development

Divide individual processes as part of the whole. Where are the largest spends?



Example Power Consumption - Activated Sludge Processes

Baseline Development

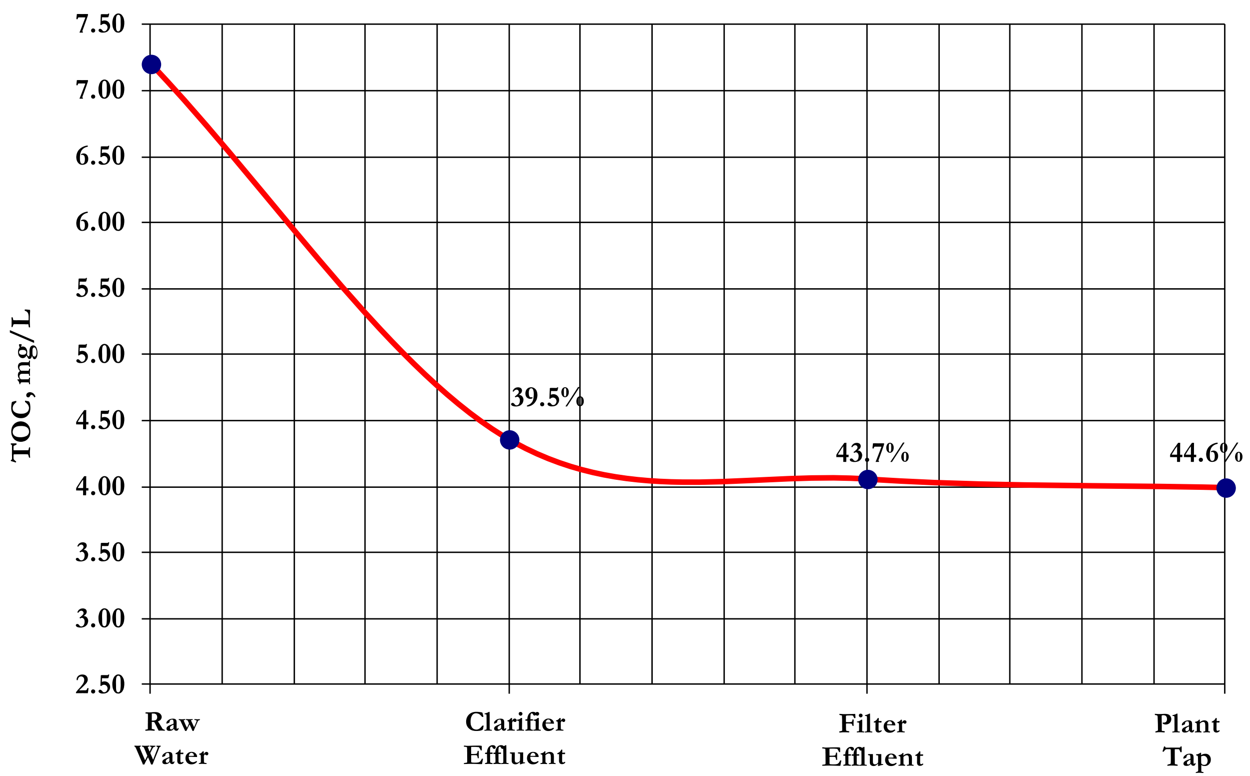
Current Operating Costs Example	
Electric	$1,338,283
Chemicals	$141,125
Contract labor	$148,267
Repair/maintenance	$111,397
Annual debt service	$240,000
Equipment replacement	$532,500
Total Costs	**$2,511,572**

Baseline Development

Establish cost breakdown per item to compare against metrics

Cur	sts 2012
Electric	$1,338,283
Chemicals	$141,125
Contract labor	$148,267
Repair/maintenance	$111,397
Annual debt service	$240,000
Equipment replacement	$532,500
Total Costs	**$2,511,572**

Baseline Development



Illustrate individual process parameters to assess where treatment efficiencies exist

Benchmarking Metrics

Benchmarking Metrics - Costs

Water Treatment

- Chemical $/MG
- Production $/MG
- Power $/MG
- Lab $/MG
- Pumping $/MG
- Staff/MG
- KWH/MG
- % production vs. % design

Wastewater Treatment

- Chemical $/MG
- Production $/MG
- Power $/MG
- Lab $/MG
- Staff/MG
- KWH/MG
- KWH/1,000 # BOD
- Diffuser head loss
- % production vs. % design

Benchmarking Metrics - Costs

Water Treatment

- Chemical $/MG
- Production $/MG
- Power $/MG
- Lab $/MG
- Pumping $/MG
- Staff/MG
- KWH/MG
- % production vs. % design

Wastewater Treatment

- Chemical $/MG
- Production $/MG
- Power $/MG
- Lab $/MG
- …G
- …000 # BOD
- Diffus… head loss
- % production vs. % design

Operating less than 50% of design can cost up to 250% more than operating near design capacity

Benchmarking Metrics - Process

Water Treatment

- Average day/Peak day demands
- Average WQ parameters
- Chemical dosages
- Floc size/settleability
- Settled water NTU, FI
- Filters GWP, washwater usage
- % of MCL values
- Mixing turnover
- Overflow rates

Wastewater Treatment

- Average day/Peak day flows
- Average WQ parameters
- Chemical dosages
- MCRT/DO/NH_3 & P reduction
- cfm /#BOD removed
- # ds/MG
- ft^3 gas/#VS
- # Cl_2 or gal hypo/MG
- % of permit limits
- Overflow rates

Benchmarking Metrics - System

Water Treatment

- Consumption per capita
- Main breaks per mile pipe
- % system flushed annually
- % valves exercised annually
- WQ complaints per 1,000 people
- Hours treated water storage at average demand
- Non-revenue water % (water loss)
- O&M $/mile pipe

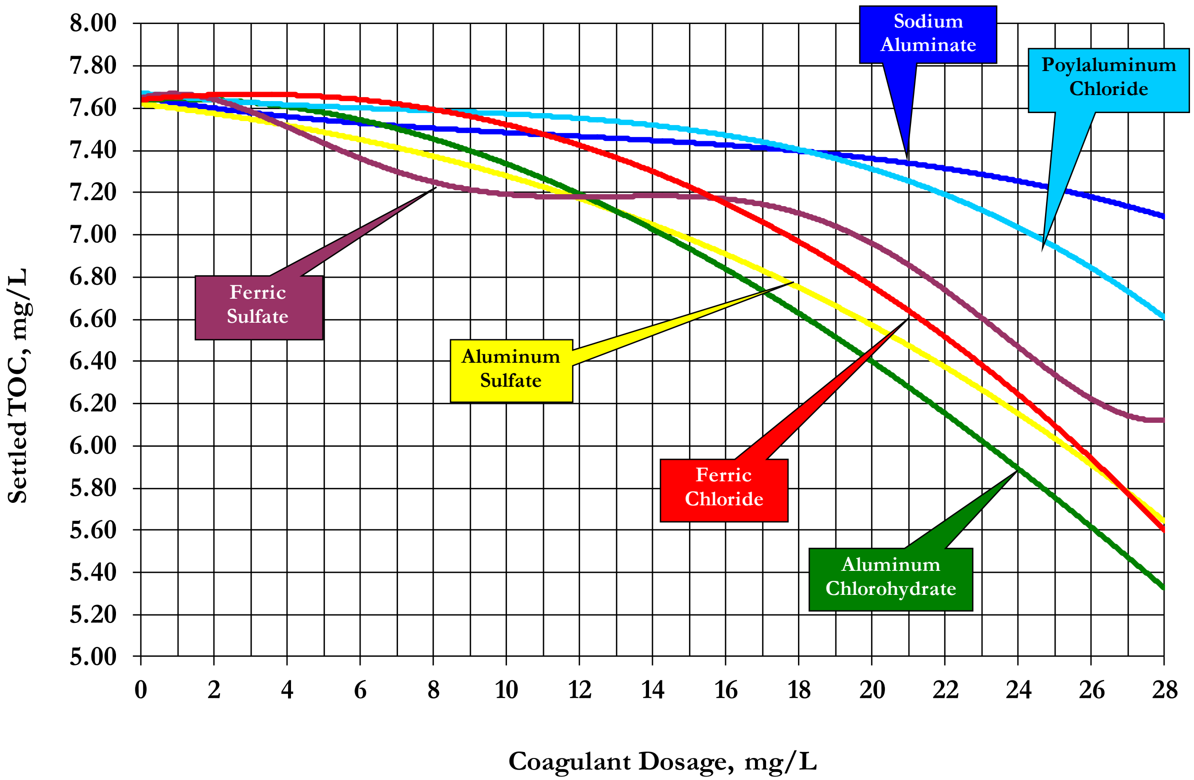
Wastewater Treatment

- Flow per capita
- Sewer blocks per mile
- Service blocks/ 1,000
- % system cleaned/CCTV annually
- % manholes inspected annually
- Pump Station $/HP
- # overflows / mile sewer
- Odor complaints /1,000 people
- O&M $/mile sewer

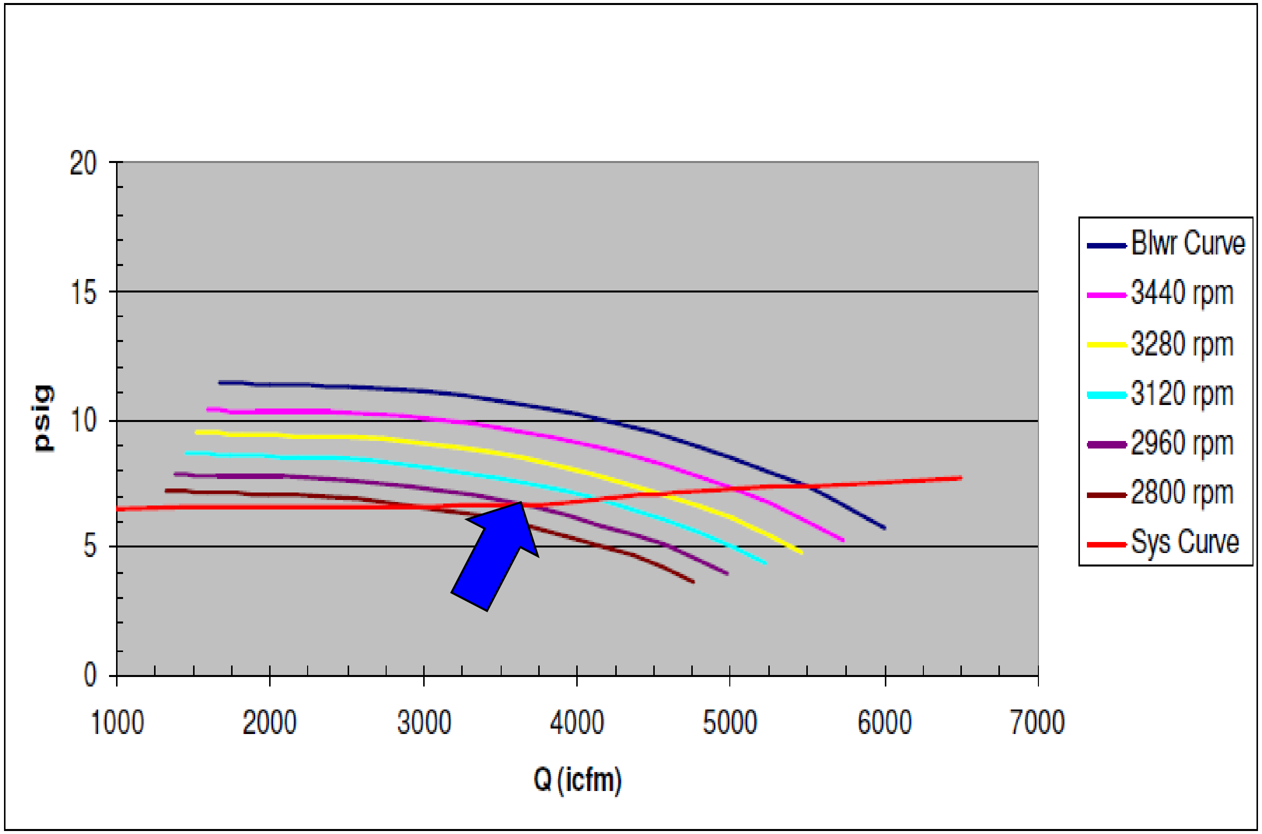
Gap Analysis

Gap Analysis

Evaluating different sets of data against benchmark metrics illustrates opportunities that exist to affect improvements



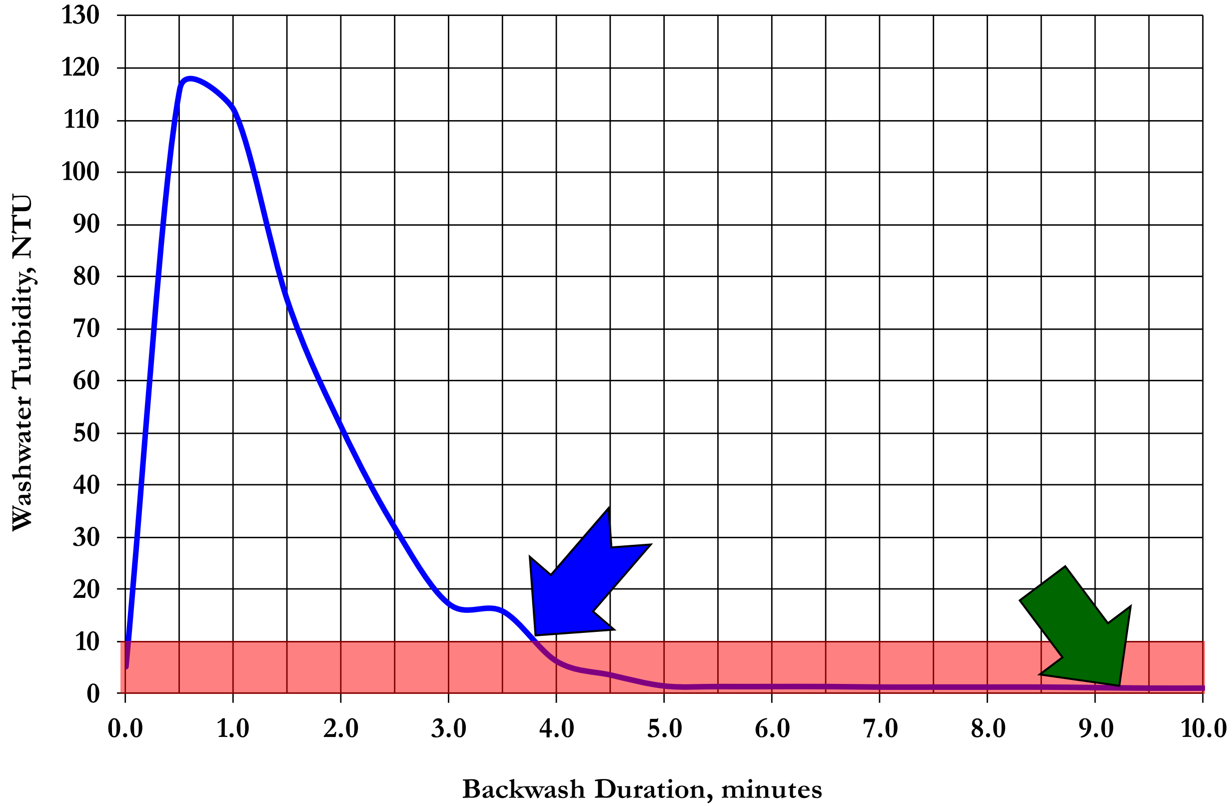
Gap Analysis



Changing process operations can identify optimal conditions that meet process needs and reduce costs

Gap Analysis

Graphical data often demonstrates where conditions do not match benchmarks (identified gaps)

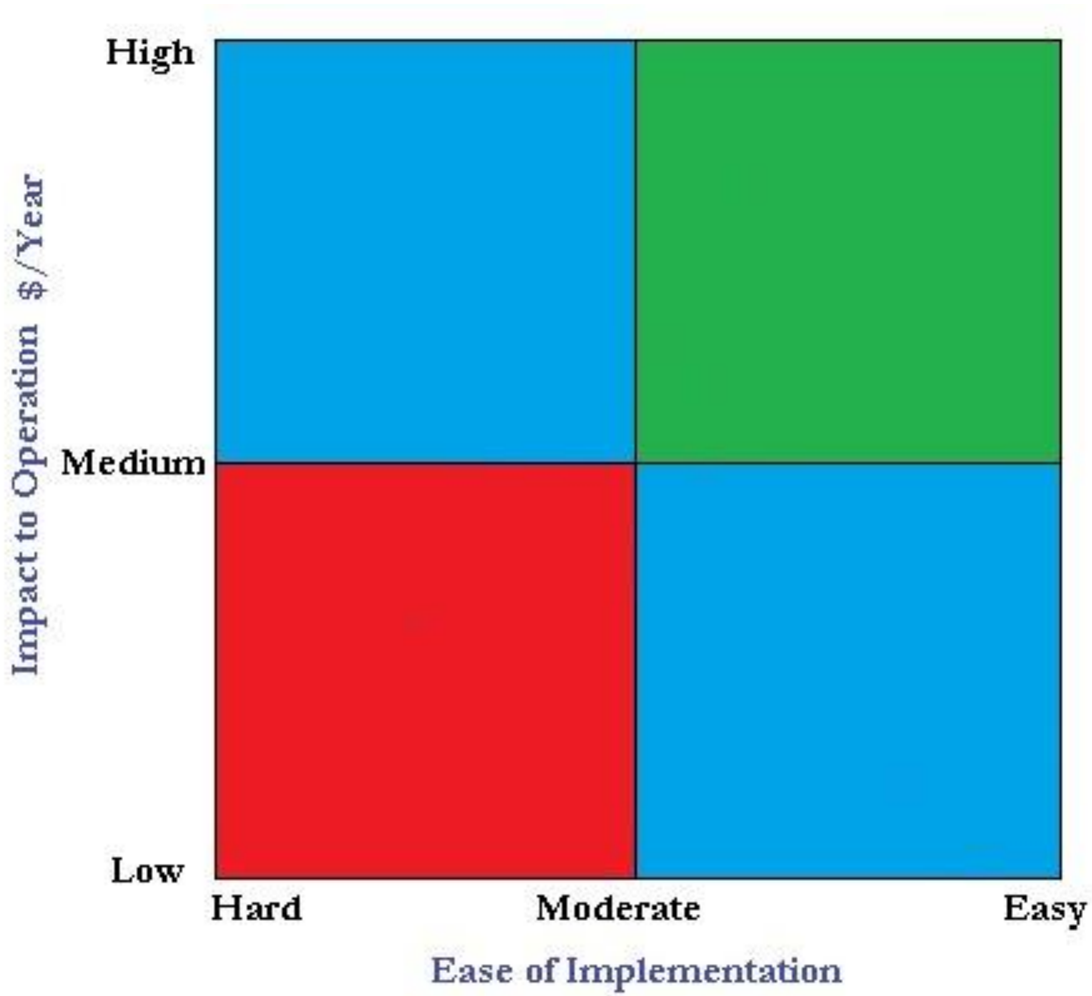


Gap Analysis

Matrix prioritization can be used for multiple opportunities to define the most beneficial impact to operations

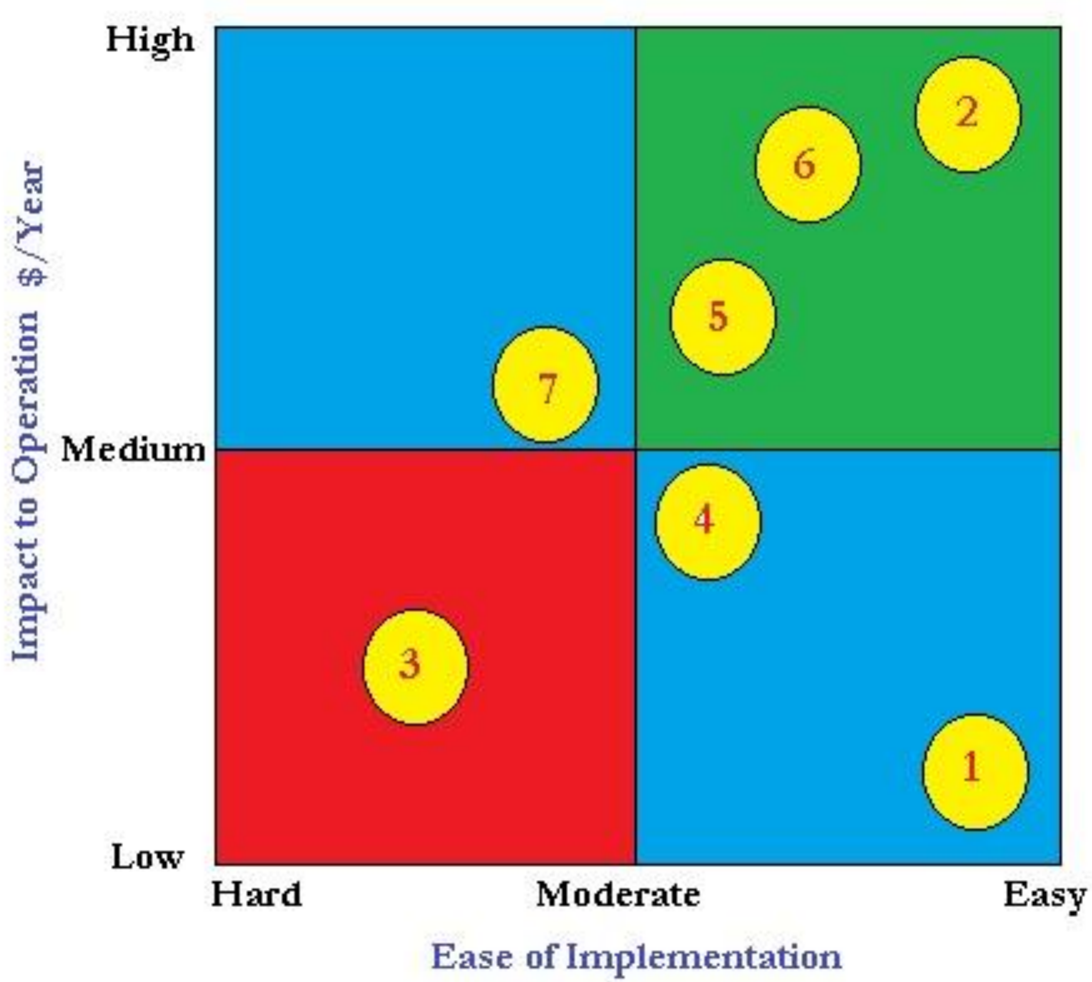
Gap Analysis

Matrix prioritization can be used for multiple opportunities to define the most beneficial impact to operations



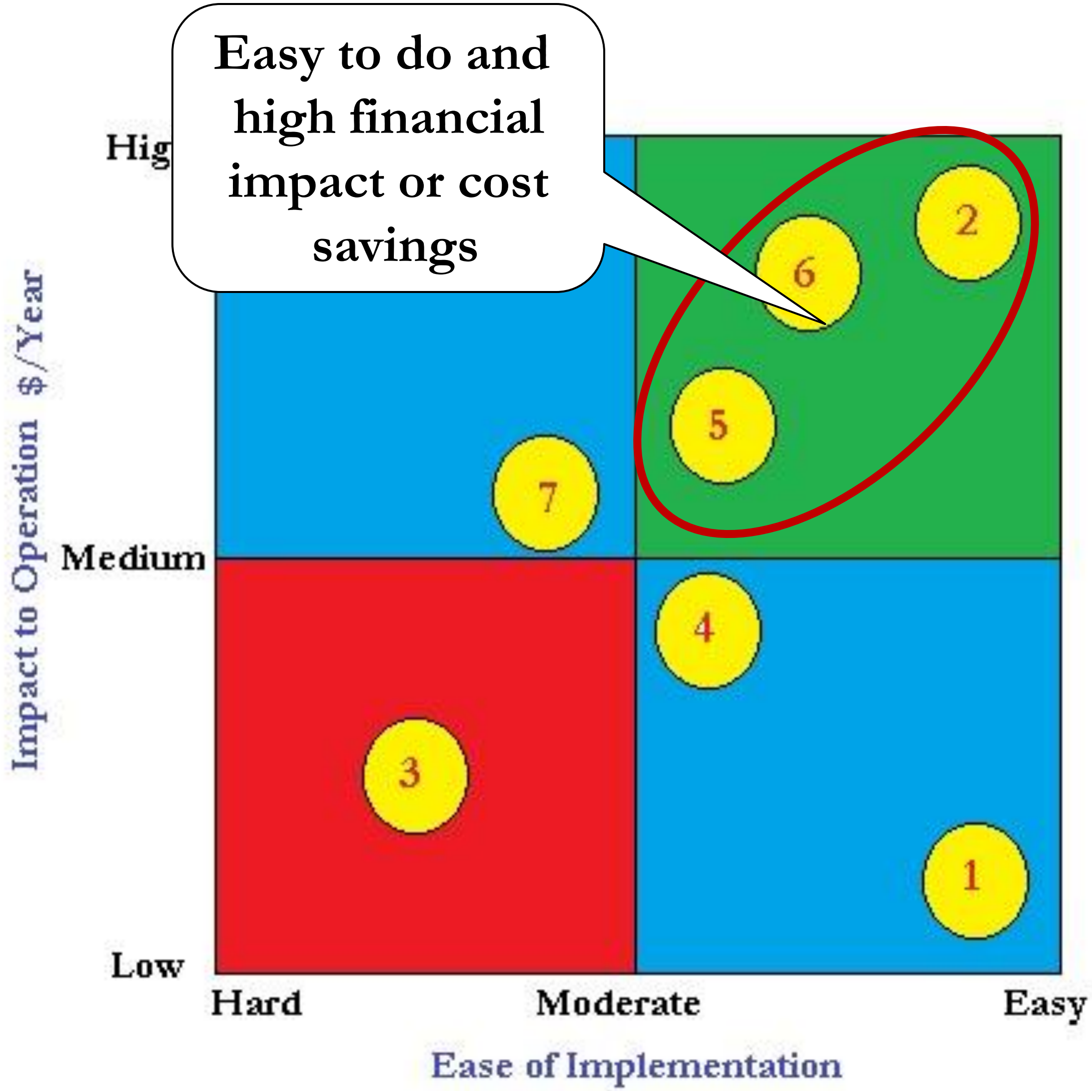
Gap Analysis

Prioritization of opportunities based on ease of implementing the idea and financial impact (cost savings) provided



Gap Analysis

Starting point to gain most cost savings up front at lowest implementation cost



Business Case Documentation

Business Case Documentation

- Written business case document
  - Current conditions
  - Benchmark data
  - Gap analysis
  - Opportunity for cost savings or increased efficiency
  - Capital costs (if needed)
  - Return on investment (ROI < 5years)
  - Time to full implementation
  - Responsibilities for implementation
  - Follow-up verification cost savings/efficiency gain

Business Case Documentation - Example

- Non-copper algaecide application
  - Finished water open reservoir supplies membrane filter plant
  - Copper sulfate used to treat algae
    - 1,500 pounds/week April-October
    - Spread by boat, safety issues exist
    - Annual cost identified
    - Copper attachment on membrane pottings
    - Additional membrane cleanings 7 per month (14 total/month)
    - Membrane cleaning costs above baseline identified
    - Total costs for algae season identified

Business Case Documentation - Example

- Non-copper algaecide application
  - Non-copper chemical applications
    - No residual copper to attach to membranes
    - Peroxide technology based materials
      - Soda ash, oxygen, water byproducts
      - Proposed dosing 550 pounds per week
    - Application changes, gravity feed from totes around periphery
    - Annual cost identified
    - Membrane cleaning costs above baseline $0
    - Capital costs expected $0
    - Total annual cost identified

Business Case Documentation - Example

Non-copper algaecide application

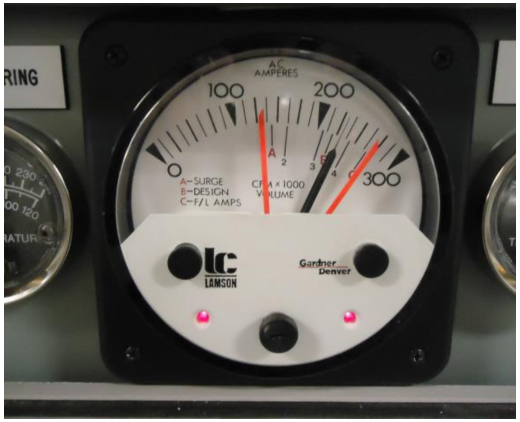
Item	Copper sulfate	Non-copper algaecide
Pounds chemical per week	1,500	550
Application period per year	22	22
Annual chemical usage	30,000	12,100
Unit cost per pound	$1.23	$1.15
Annual chemical cost	$40,590	$13,915
Additional CIP annual cost	$10,235	$0
Total annual cost	$50,825	$13,915
Projected annual savings		**$36,910**

Case Study - Wastewater

Case Study Wastewater

- Aeration blower evaluation
  - 250 HP multi-stage centrifugal blower
    - 3,370 scfm, 10.5 psig, 3,600 rpm design
    - Inlet valve throttled 30%
    - Discharge valve throttled 20%
    - Blower operated 16 hours/day cycling on and off to maintain DO
    - Discharge 7.1 psig, 275 amps draw
  - Aeration MLSS and DO held as necessary for secondary treatment
    - DO maintained about 2.4 mg/L

Inlet valve throttled 30%



Ammeter readings above design

Case Study Wastewater

- Aeration cycles illustrated air demand for operations
  - BioWin modeling conducted
  - 3,560 scfm under constant blower discharge
  - Minimum pressure for aeration 6.8 psig
  - On/off cycles eliminated with constant blower operations
- Existing blower likely oversized for daily operations
  - Valve throttling routine operations
  - Relatively high power draw for aeration

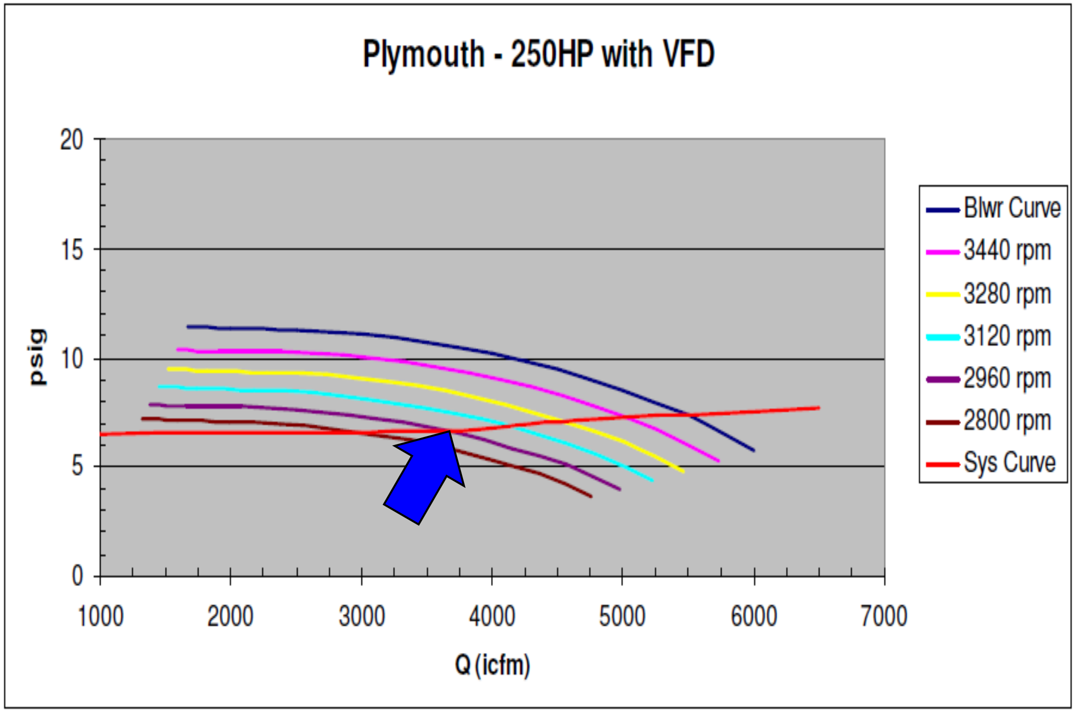
Case Study Wastewater

- Blower testing confirmed oversized unit for operations

Discharge valve % open	100	100	100
Inlet valve % open	30	40	50
Discharge pressure, psig	6.6	6.8	7.1
Air flow, scfm	3,560	4,170	4,640
Power draw, amps	225	245	262
Power, KW per hour	152	166	177
Horsepower produced	204	222	237

Case Study Wastewater

- Evaluated VFD for blower to reduce air flow and power consumption
  - Affinity Laws state power varies by speed^3
  - Calculated blower output and pressure at various speeds
- Calculated speed curves illustrate air demand met
  - 2,960 rpm
  - 3,570 scfm
  - 7.3 psig discharge pressure
  - 92 kW/h
  - 124 HP



VFD appears suitable for optimizing aeration costs

Case Study Wastewater

- Business case data
  - VFD could reduced power usage and costs for aeration
  - Local utility incentive for reducing kW consumption $0.21/kWH
  - Current power cost $0.14/kWH
  - VFD cost installed and tuned **$51,500**

	Current @ 3,600 rpm	Proposed @ 2,960 rpm	Savings
kW per hour	152	92	60
kWH per year	855,925	537,280	318,645
Annual cost	$124,439	$75,219	$49,220
Utility Incentive	$0	$73,829	$73,829
Savings per year			**$123,049**

Case Study Wastewater

- Capital investment costs
  - $51,500
- Annual projected cost savings
  - $123,049
- Return on Investment (ROI)
  - 0.42 years (5 months)
  - $123,049 annual savings thereafter
  - Optimizes aeration costs based on actual demand to maintain DO and MLSS suspension
  - Get paid to reduce power draw from grid

Case Study - Water

Case Study Water

- Two-stage flocculation process
  - Vertical mixers with VFDs
  - High rate settling
  - Dual media filtration

- Floc characteristics
  - Stage 1 G 22 sec^{-1}
  - Stage 2 G 9 sec^{-1}
  - Detention time 62 minutes
  - Floc diameter about 2 mm, fluffy and jagged
  - Floc settleability 0.43 gpm/ft^2

Case Study Water

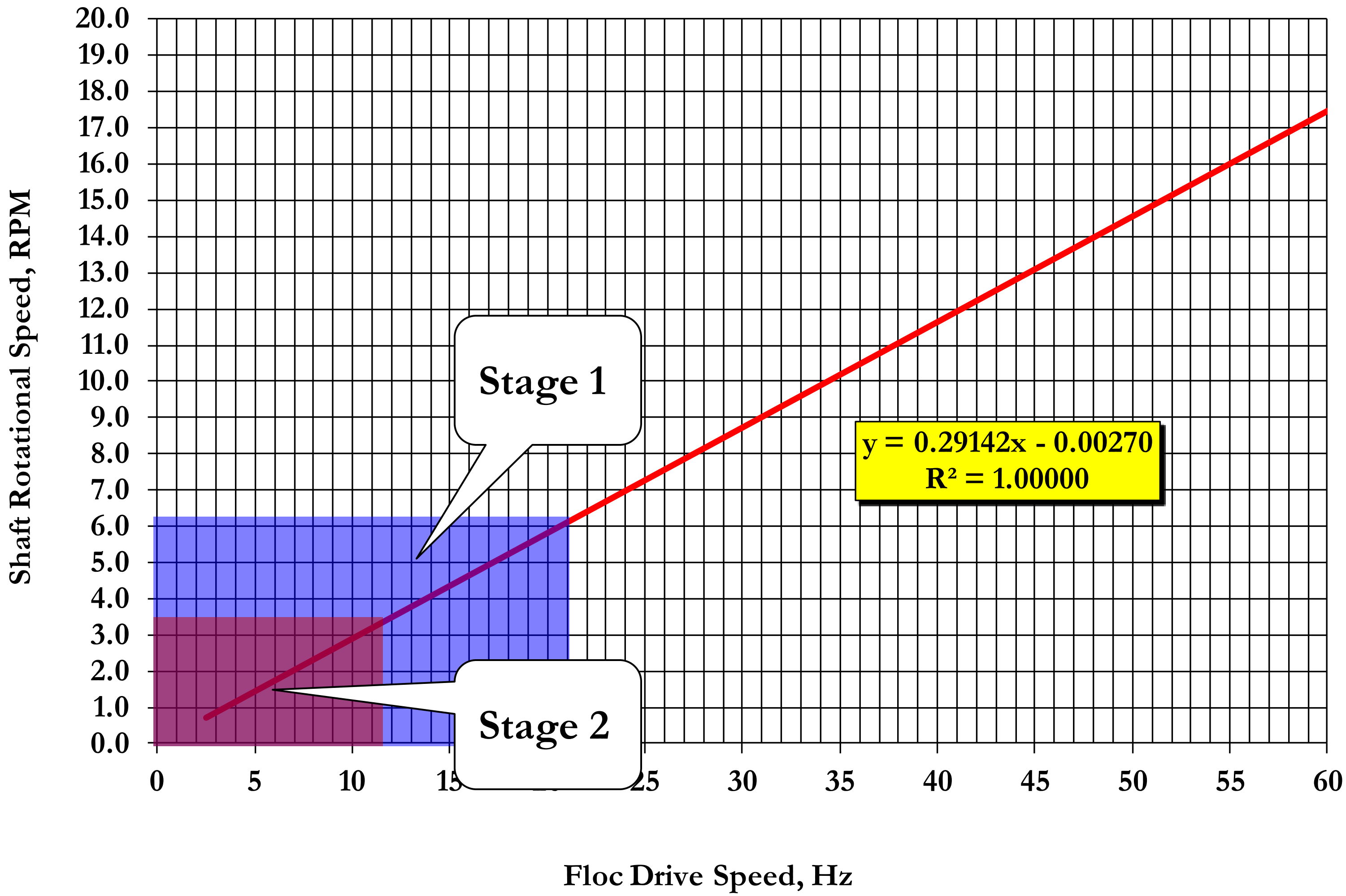
- High rate settling with tubes
  - SOR 0.78 gpm/ft^2
  - WOR 1.56 gpm/ft
  - Detention time 86 minutes
  - Settled water 0.5 NTU average

- Filtration (dual media)
  - 100 hour run times @ 1.45 gpm/ft^2
  - GWP 8,700 gal/sf/run
  - FE 97.6%
  - Head loss at end run 2.5 feet
  - Washwater consumption 209 gal/ft^2

Case Study Water

- Jar testing identified more effective G values for flocculation
  - Stage 1 G 45 sec^{-1}
  - Stage 2 G 35 sec^{-1}
  - Floc size about 5 mm, spherical
  - Floc settleability 0.85 gpm/ft^2
- VFD data collected to determine speed settings to match jar test G values

Case Study Water



Case Study Water

- Floc drive speeds determined from VFD curves
  - Stage 1, 34 Hz
  - Stage 2, 28.5 Hz
- Reset VFD speeds, observed floc development
  - Within 20 minutes floc diameter about 5 mm
  - Settleability 0.93 gpm/ft2
  - Within 60 minutes settled turbidity 0.36 NTU

Case Study Water

- Follow-up data collection and verification
  - Reduced coagulant dosage 4.5%
  - Settled 0.27 NTU average
  - Increased TOC removal 11.4%
    - More particle collisions capturing TOC
  - Filter run times increased to 145 hours
    - Lower solids loading to filter media
  - GWP increased above 12,000 gal/sf/run
  - FE increased above 99%
  - Washwater usage declined 35%

Conclusions

- Benchmarking can be used to assess any process
  - Often improves water quality and/or reduces operating costs
  - Sometimes demonstrates no improvement needed, optimized process
  - Customary improvements without capital spend
- Assess current conditions
- Benchmark with proper process metrics
- Conduct gap analysis to indentify opportunities
- Develop business case and ROI as needed
- Implement optimized plan

Questions

Marvin Gnagy, PE
PMG Consulting, Inc.
pmgconsulting@bex.net
419.450.2931