Aeration System Improvements with a 5-Year Payback

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One Water

HAZEN AND SAWYER
Environmental Engineers & Scientists

Wastewater Treatment Aeration Timeline

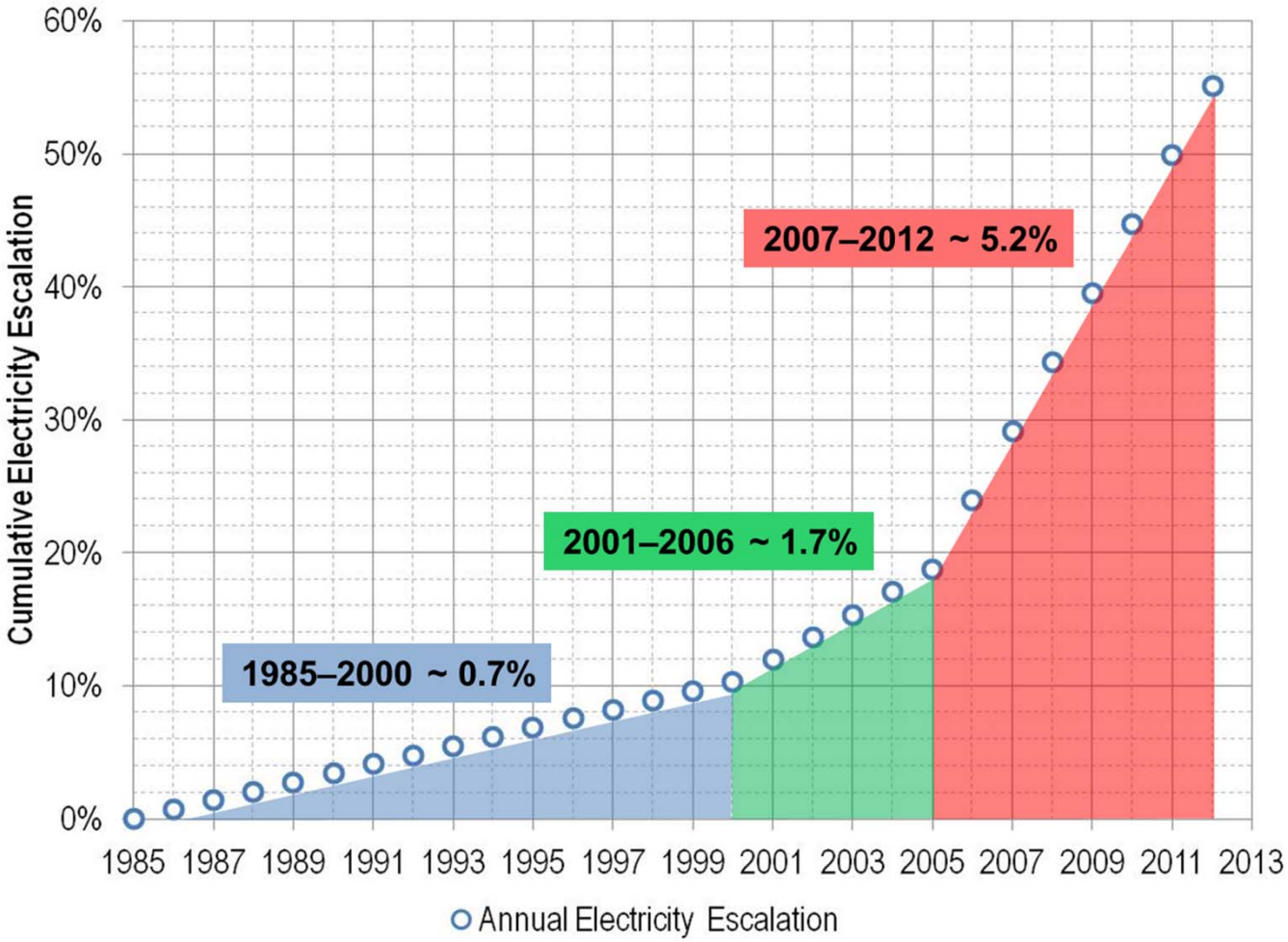
- 1970's
  - Major infrastructure investment
  - "Quick and cheap" solutions
    - Coarse bubble diffusers & PD/MS blowers
- 1980's
  - Construction and operation of WWTP
  - Introduction of fine bubble diffusers
- 1990's
  - Widespread adaptation of fine bubble diffusers
    - Blower inefficiencies (higher pressures & operational gaps)
  - Introduction and implementation of controls
    - Further Blower inefficiencies
- 2000's
  - Stricter nutrient limits (NH_3-N and TN)
  - Blowers reaching end of useful life
  - Advancement of blower technologies & controls

Energy Management
"The Perfect Storm"

- Energy costs are rising
- Rising treatment regulations
- Economy influence
- Social and environmental influences
  - CO_2 Emissions
  - Air Quality
- Federal and local government energy policies
  - Renewable energy portfolio standards
  - Grants and funding for "green" projects

Electricity Escalation

Midwest U.S. – 1985 through 2012



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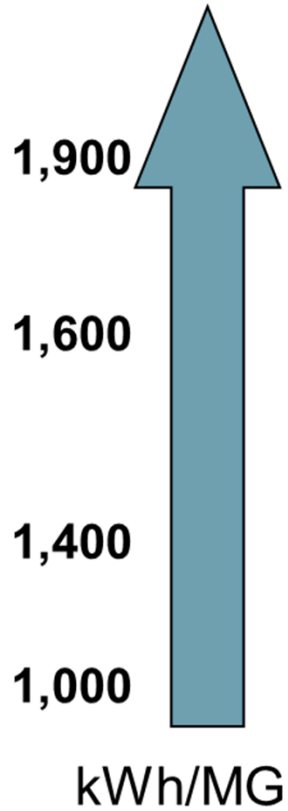
Water Quality Requirements & Impacts

Secondary Treatment

- Activated Sludge with advanced treatment and nitrification
- Activated Sludge with advanced treatment, no nitrification
- Activated Sludge with no advanced treatment or nitrification
- No Activated Sludge
  - Trickling Filter

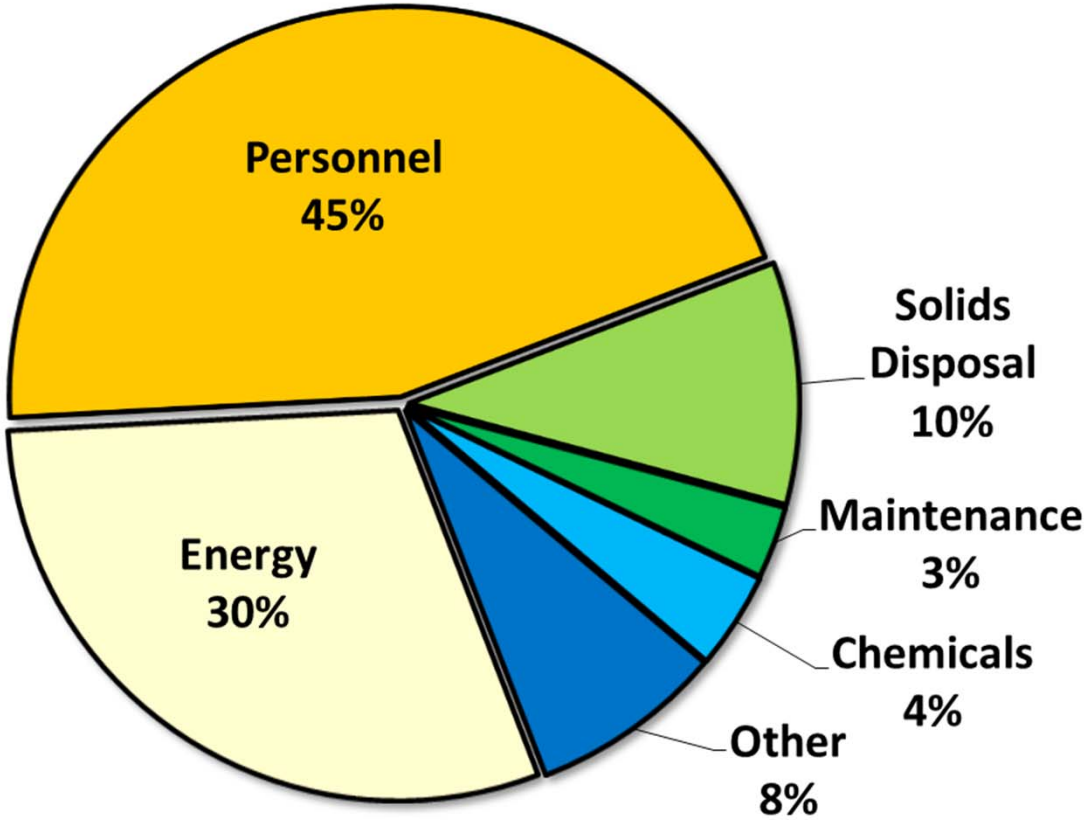


Average is

1,800 kWh/MG

Energy Consumption in W/WW Industry

- W/WW 3% of the nations energy use (Source-EPA)
- W/WW loads typically largest energy user for municipal utilities
- Operating budgets stagnant or declining
  - More automation (lower personnel $)
  - Reduce energy

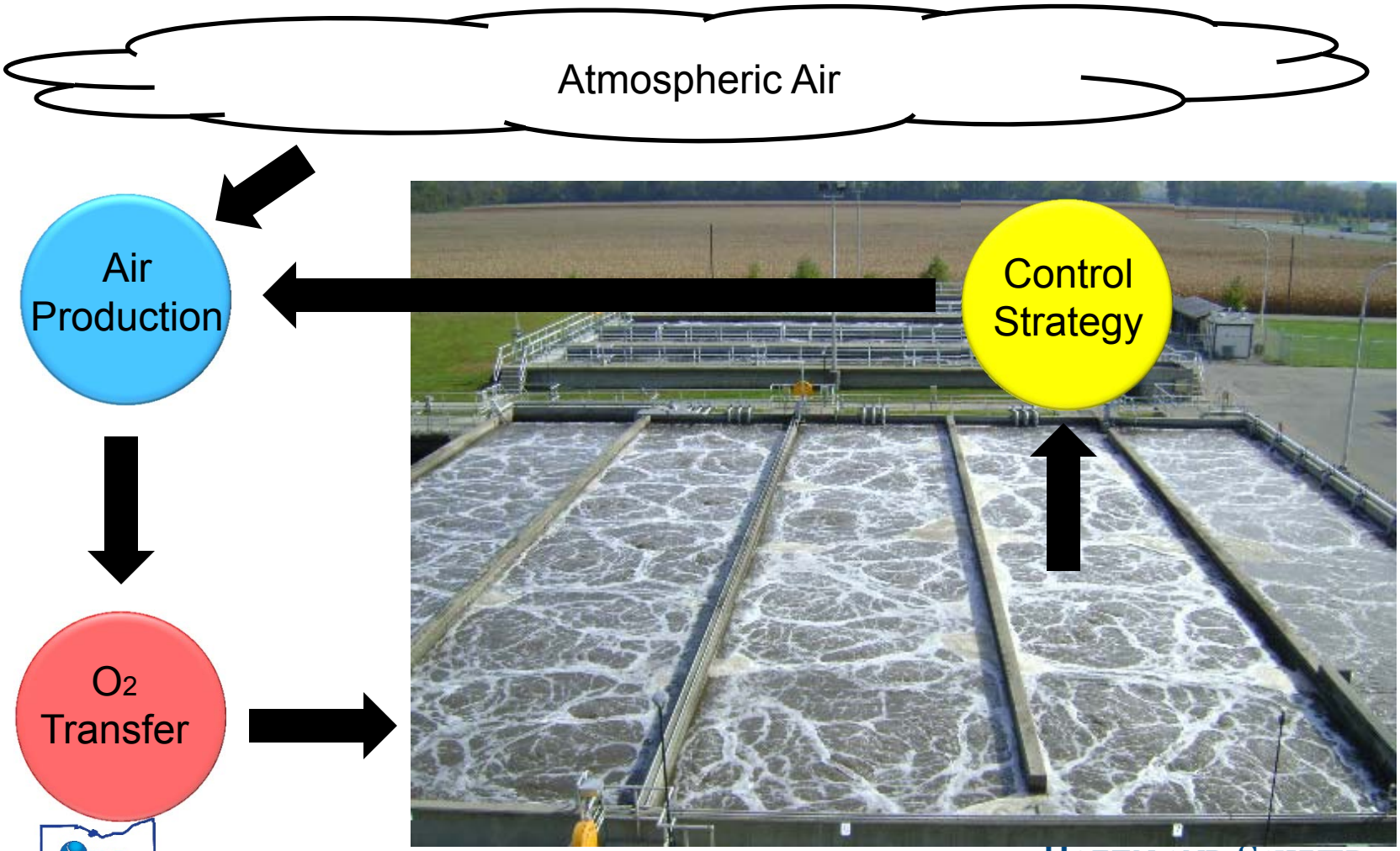


Yesterday's Thinking

"Energy = Electrical Power"

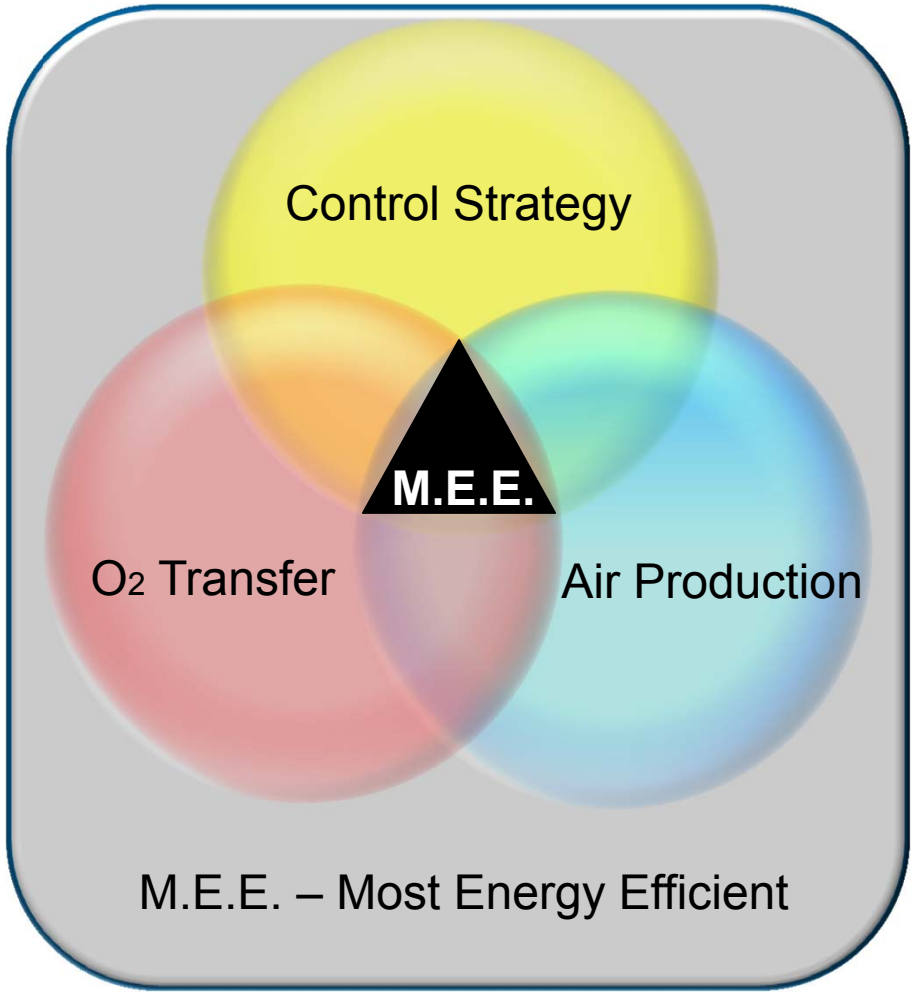
Potential Energy	• Denitrification • Primary clarifier enhancement • Primary sludge fermentation
Energy Sinks	• Aeration improvements • High efficiency motors • Pump VFD • Reduce chemical use
Energy Harvesting	• Anaerobic digestion • Gas recovery • Nutrient recovery • Co-gen • Heat recovery

What is an Aeration System?



Aeration System
Most Energy Efficient Operation

- Three systems must work together
- Environmental & operational conditions control frequency in M.E.E triangle
- Improvements to one +/- impacts other two "circles"



Aeration System Evaluation
Step–by–Step Checklist

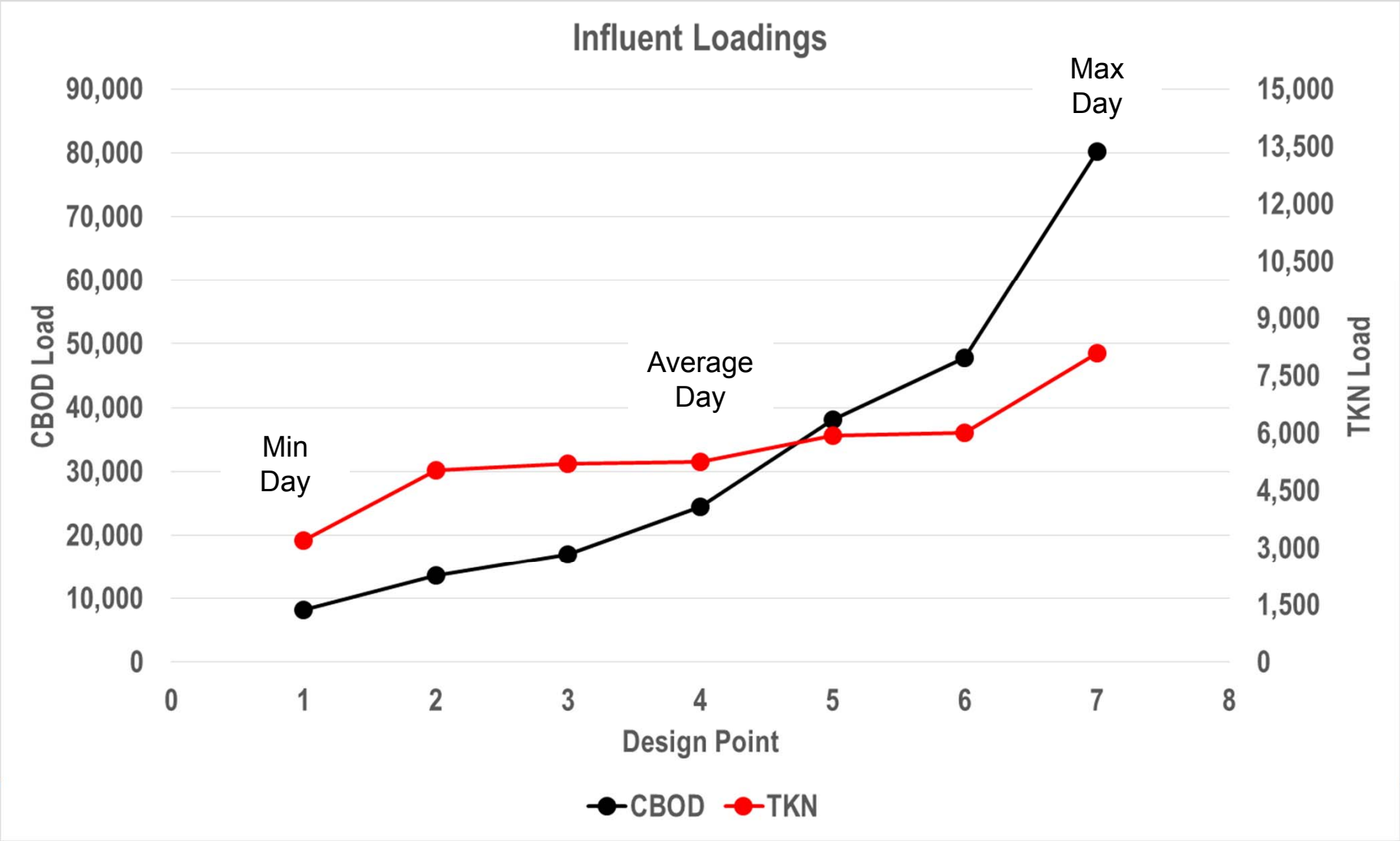
1. Blower curve conversion & efficiency
   - Design vs. operating pressure
   - Mechanical vs. electrical efficiency
2. Data analysis
   - Raw + PC performance + recycles
3. Oxygen transfer (diffuser) evaluation
   - Alpha, fouling factor ($\alpha * F$)
4. Aeration demands
   - Daily, weekly, and monthly variations
5. Seasonal analysis
   - Winter, summer and transitional time periods
6. Present worth & LCC

Case Study #1

Criteria	Case Study #1
Location	Kentucky
Treatment Configuration	Conventional Nitrifying Activated Sludge
Existing Blowers	3,000 hp Multi-Stage (w/ Vanes)
Capacity	20,000 – 40,000 scfm (2) 10,000 – 20,000 scfm (1)
Minimum Mixing	5,400 scfm
Diffuser	Tube
Purpose	Smaller blower motor failed. Get smaller blower operational?

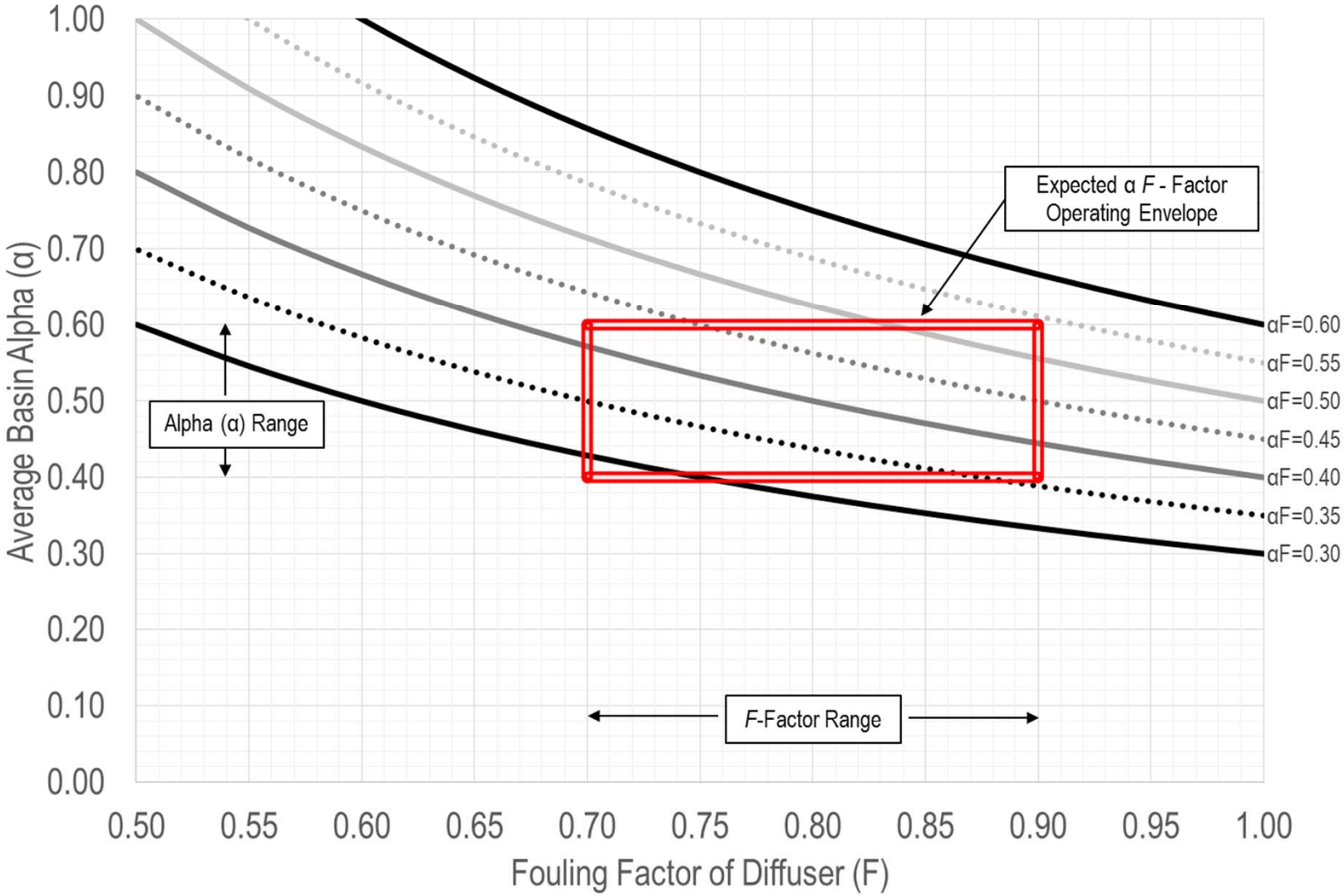
Case Study #1

Aeration Tank Influent Loads



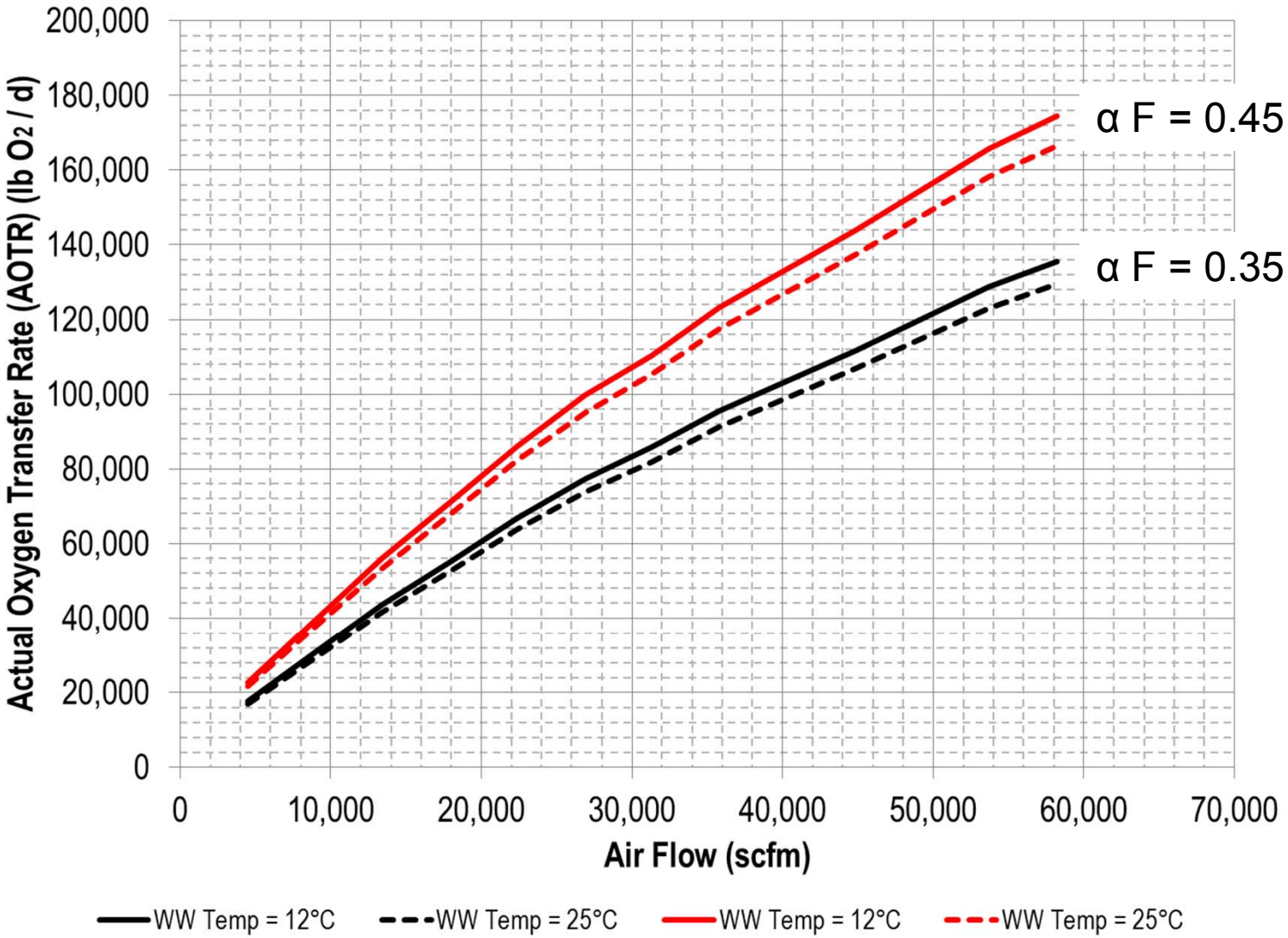
Case Study #1

α *F* Determination



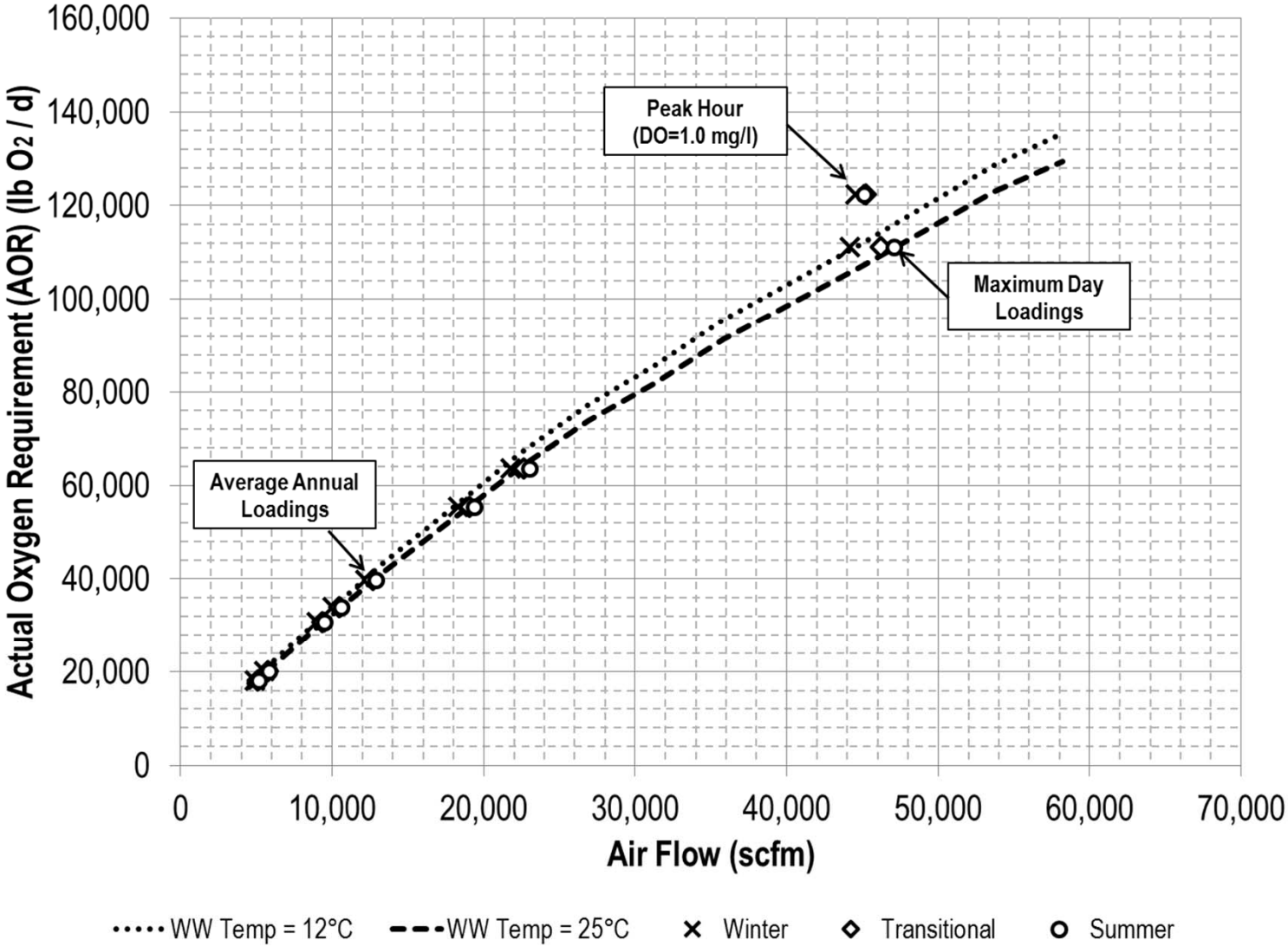
Case Study #1

Impact of α*F* on Oxygen Transfer Capacity



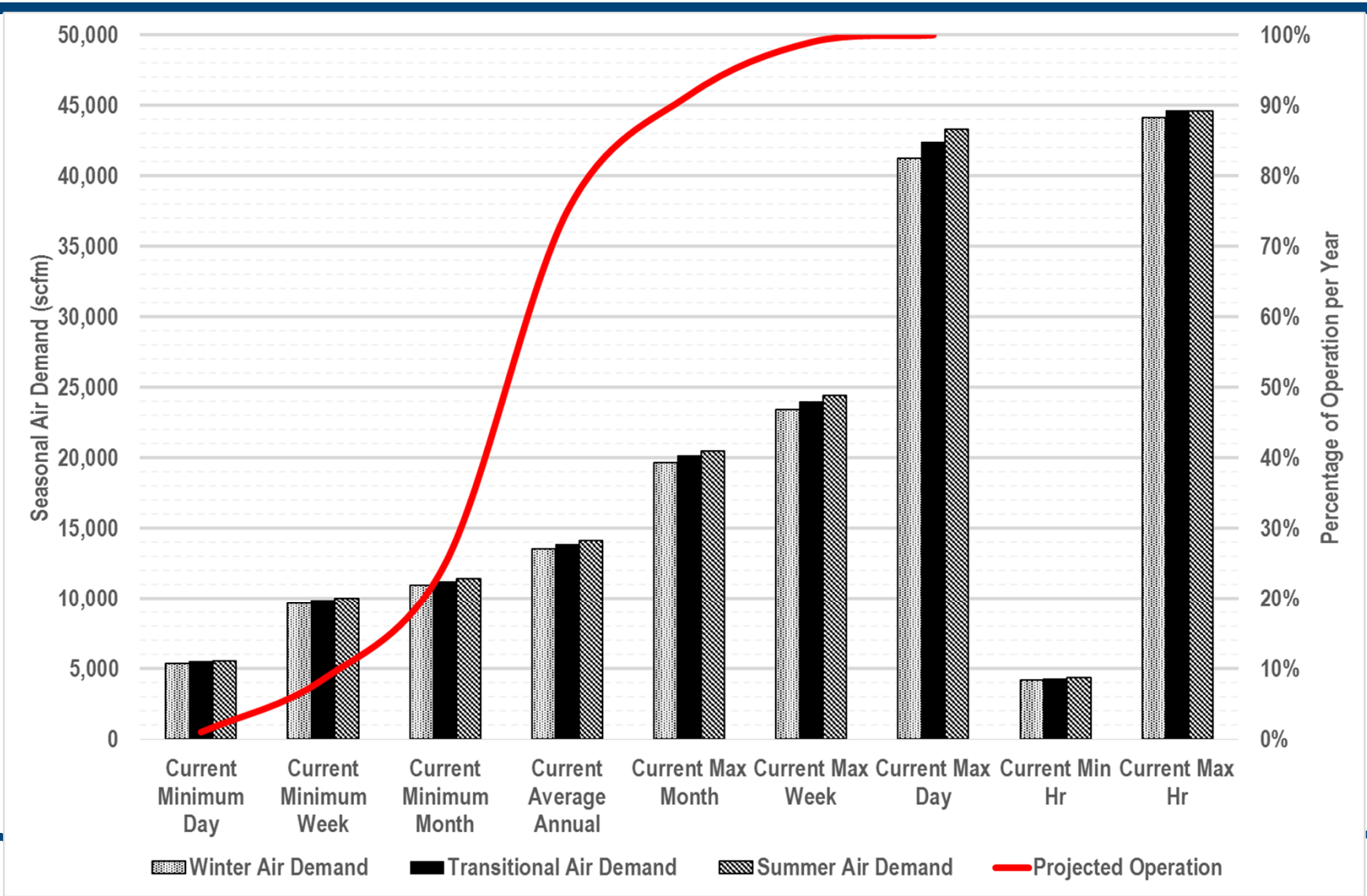
Case Study #1

AOR vs. Air Flow (α*F* = 0.35)



Case Study #1

Air Flow Projections (α*F* = 0.35)



Case Study #1
Summary of Evaluation

Functioning Blowers	Duty Blower	α *F*	TOTAL (kW-hr/yr)	ANNUAL ELECTRICAL COST
Blowers 1 & 2	1 or 2	0.35	9,680,000	$570,000
Blowers 1, 2 & 3	3	0.35	6,460,000	$380,000
Potential Savings with Conservative α *F*				$190,000
Blowers 1 & 2	1 or 2	0.45	9,270,000	$550,000
Blowers 1, 2 & 3	3	0.45	4,930,000	$290,000
Potential Savings with Aggressive α *F*				$260,000

Operating Blower #3 provides 33% savings compared to Blowers #1 or #2 based upon current air demand

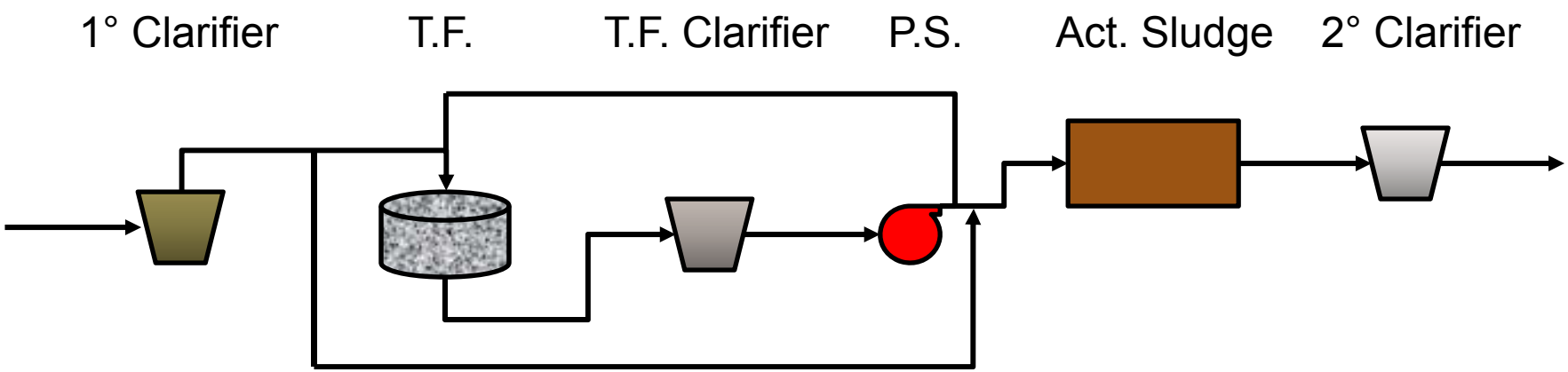
- Assumptions:
  - Electrical = $0.059 /kW-hr
  - D.O. = 2.0 mg/l
  - Six aeration tanks in operation
  - Blower 1 or 2 required to operate ~ 10% annually

Case Study #2

Criteria	Case Study #2
Location	Ohio
Treatment Configuration	Tricking Filters + Nitrification Activated Sludge
Existing Blowers	1,500 hp Single-Stage Gear
Capacity	20,000 – 44,000 scfm (4)
Minimum Mixing	12,000 scfm
Diffuser	Ceramic Disc
Purpose	Turndown, over aeration. More efficient system?

Case Study #2

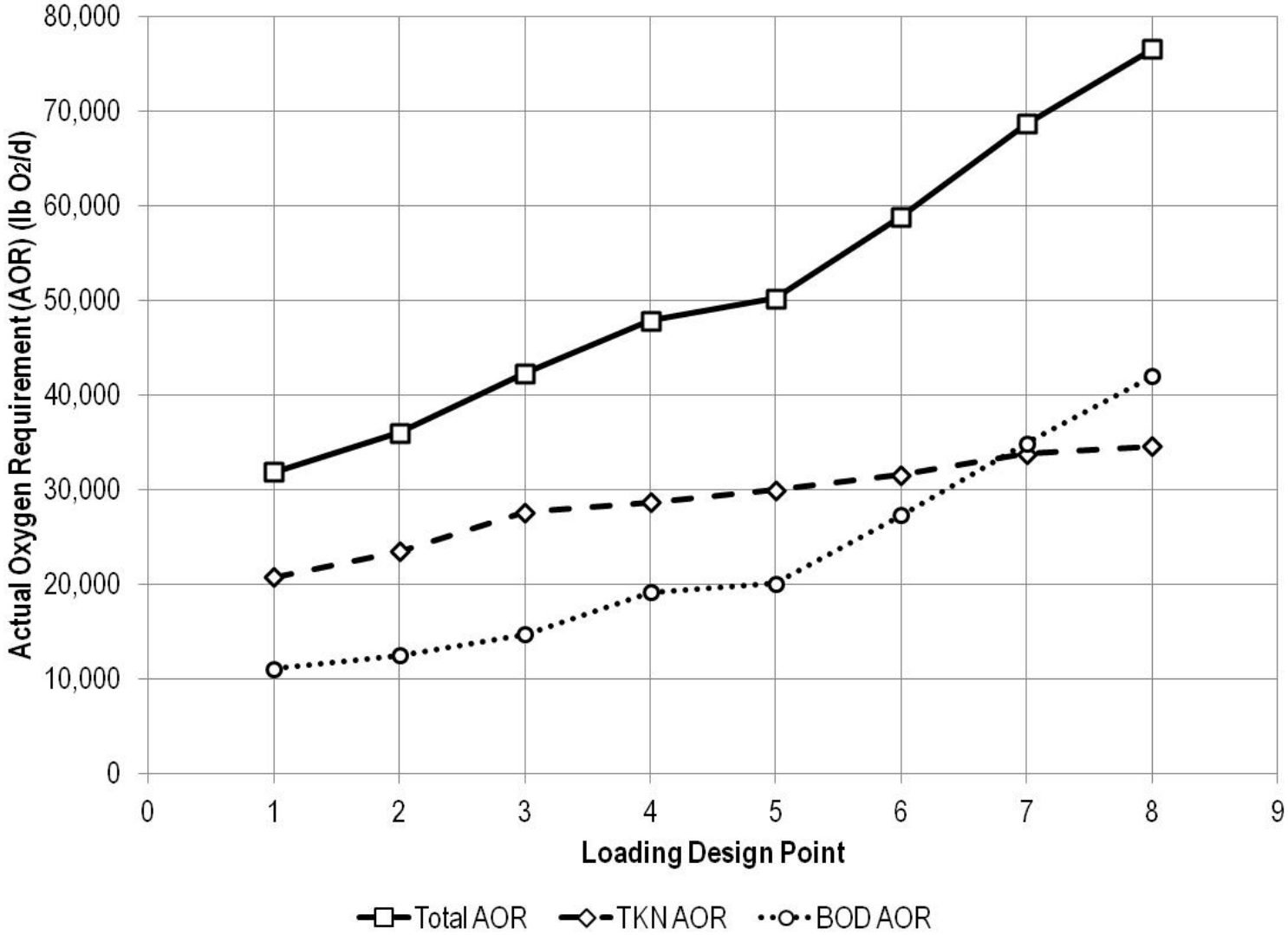
Trickling Filter + Nitrification Activated Sludge



Criteria	T.F. Effluent	Dewatering	Total
Flow	37.0 mgd	0.3 mgd	37.3 mgd
BOD_5	12,700 lb/d (41 mg/l)	Negligible	12,700 lb/d
TKN	7,100 lb/d (23 mg/l)	270 lb/hr	9,200 lb/d

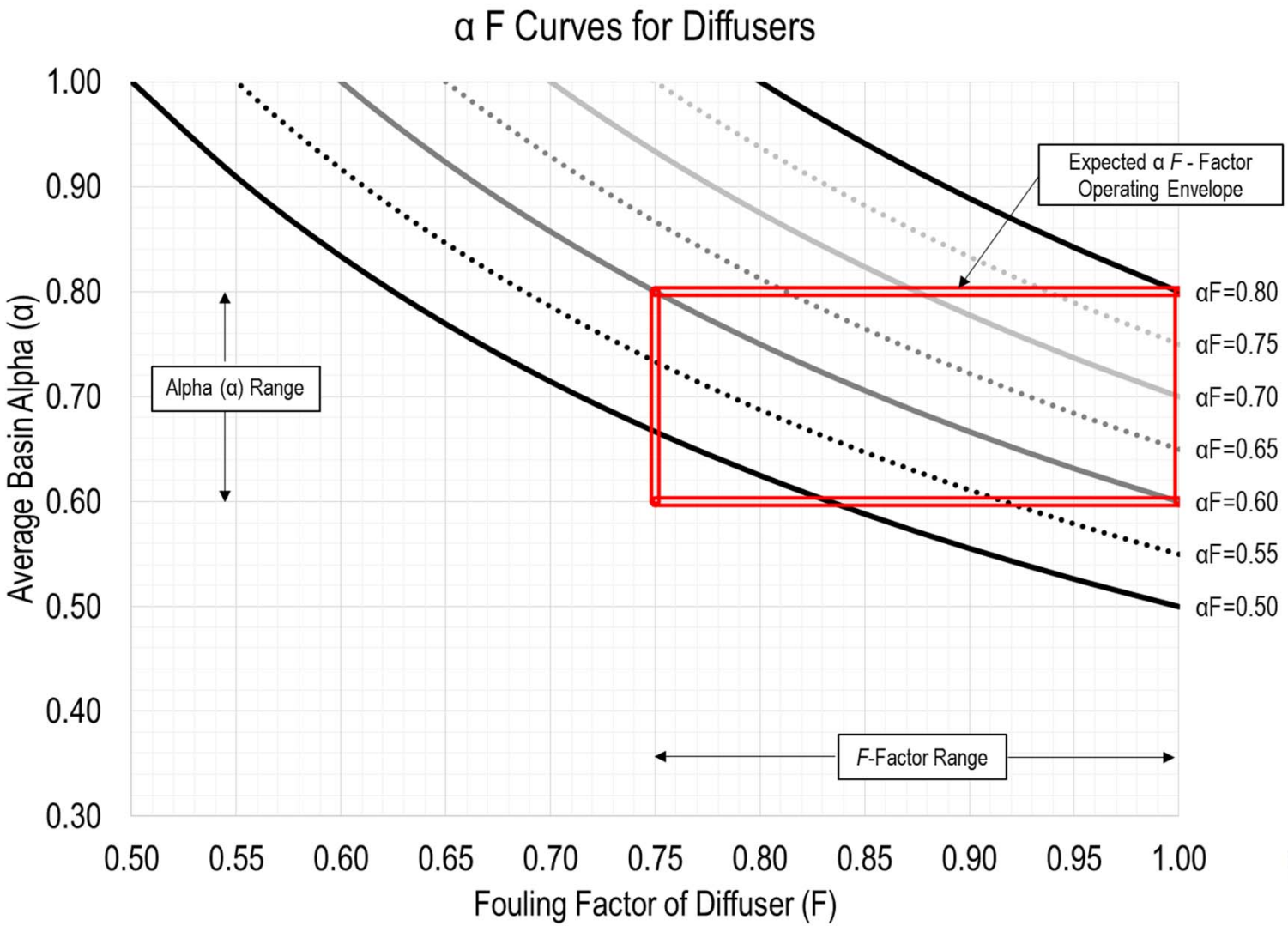
Case Study #2

Loading Design Points – AOR



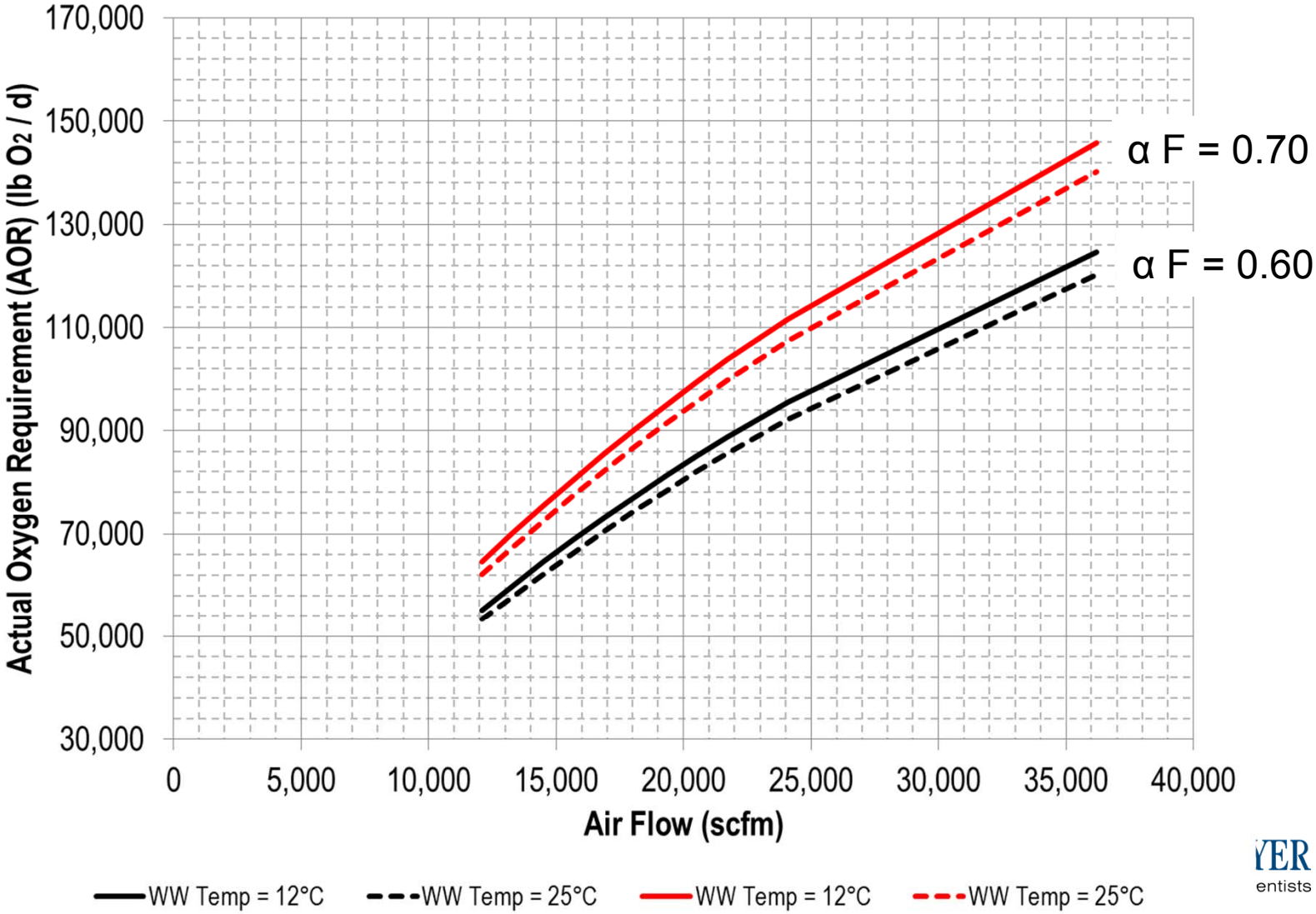
Case Study #2

α *F* Determination



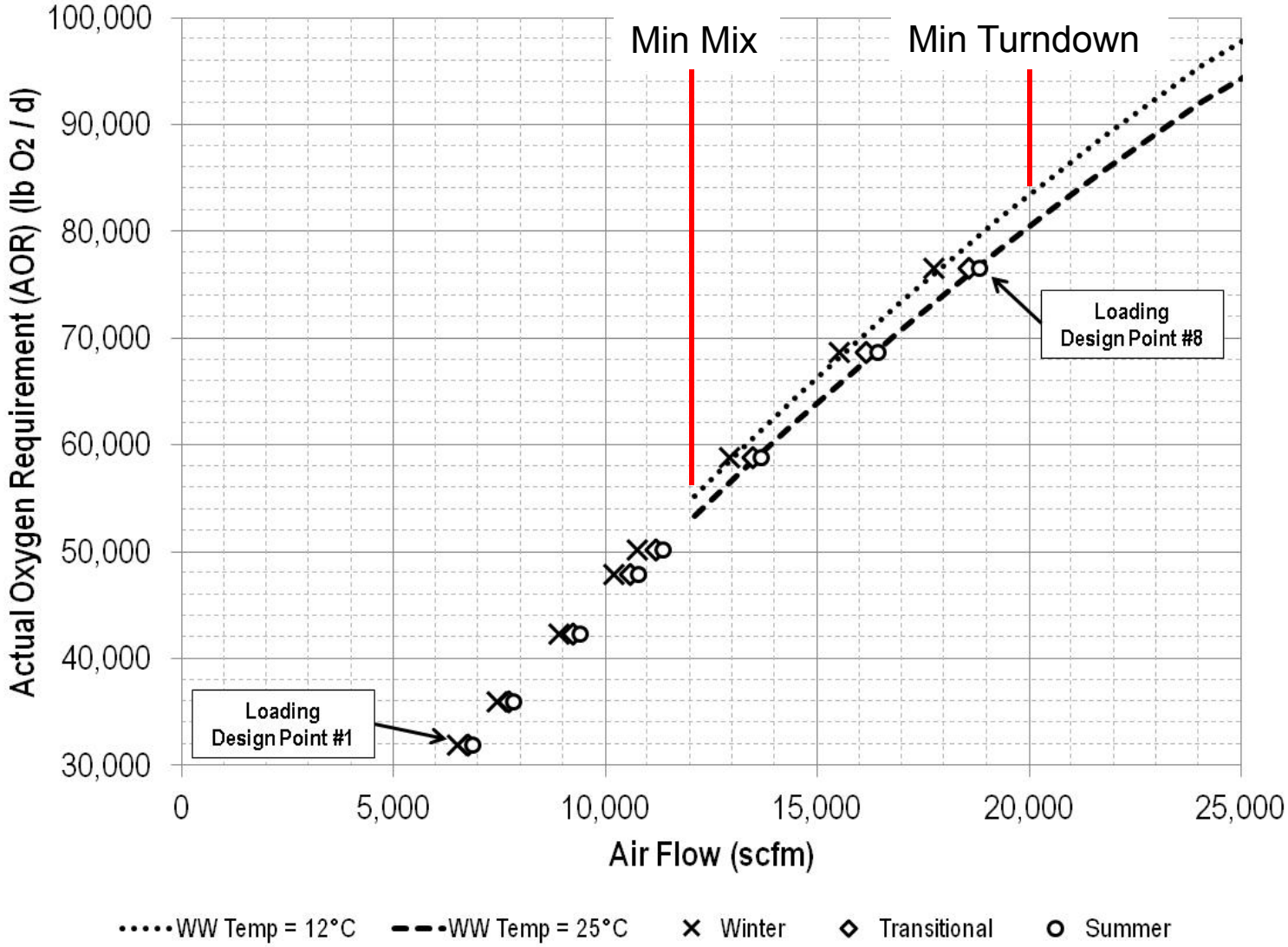
Case Study #2

Impact of α*F* on Oxygen Transfer Capacity



Case Study #2

AOR vs. Air Flow (α*F* = 0.6)

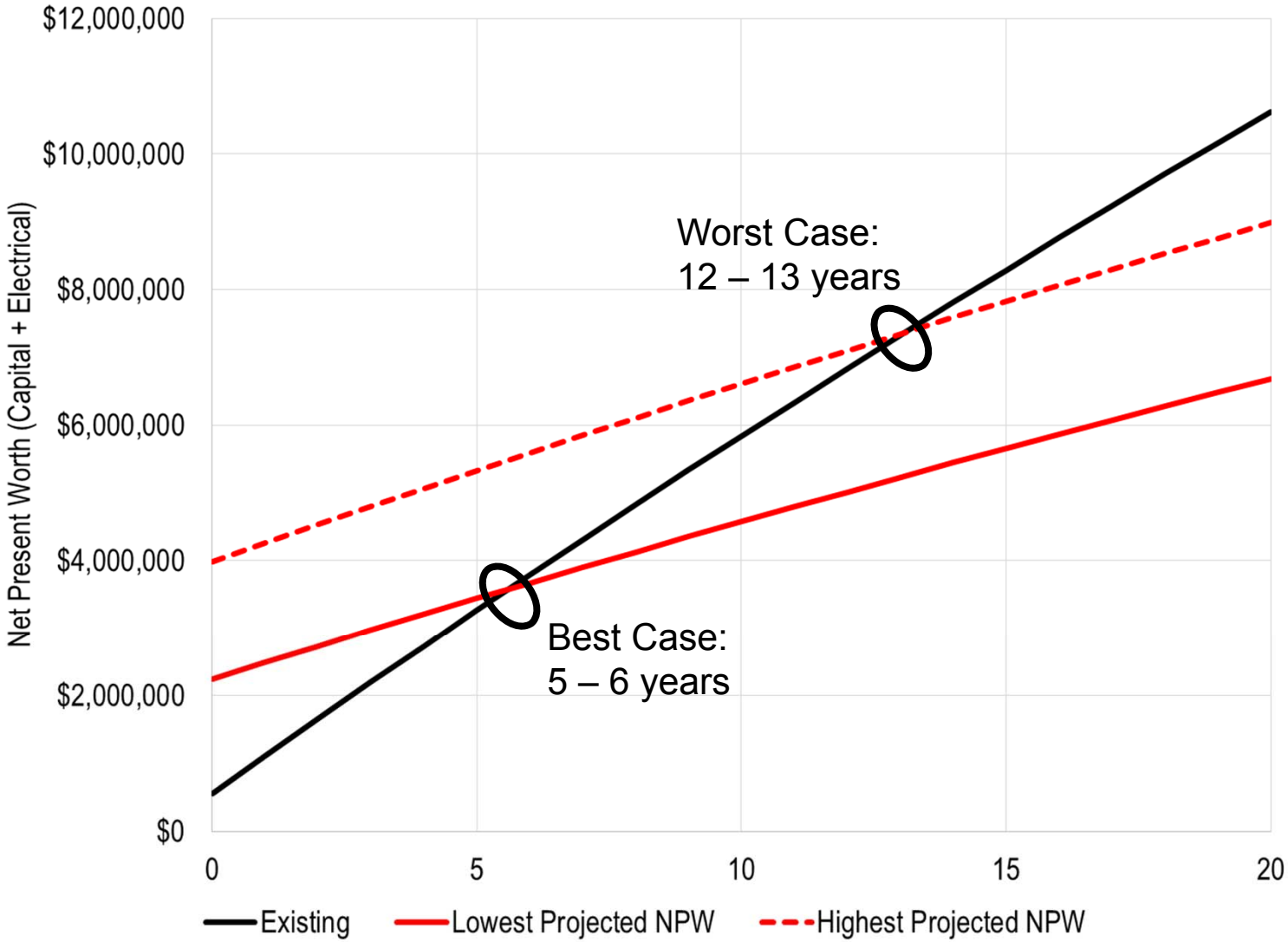


Case Study #2
Aeration Blower Evaluation

- Three types of blowers
  - Magnetic bearing
  - Air bearing
  - Oil bearing
  - Base loading multi-stage
- Seven configurations evaluated
  - 5,000 – 12,000 scfm blower capacities
  - 250 – 600 hp
  - Average KW power demand ~ 460 KW (vs. 950 KW current)
  - Average electrical demand ~ 4,030 MW/yr (vs. 8,300 MW/yr)

Case Study #2

Net Present Worth and Payback



Case Study #2
Project Status

- Design completed in March 2014
  - Significant electrical upgrades
  - Pre-selected blower manufacturer
- Bid in April 2014
  - Pre-negotiated blower equipment and services
  - Engineer's OPCC ~ $2.73 million
  - Bid ~ $2.56 million
- Awarded in July 2014
- Substantial completion in 4Q 2015

Summary

- Aeration system evaluation
  - Impacts of dewatering
  - α *F* selection
  - Impacts of mixing
- Evaluate entire system
  - Control setpoints (i.e. DO, ORP, NH_3-N)
  - Oxygen transfer (i.e. diffusers)
- Blower payback difficult a majority of the time
  - Typically, need to change two system components

Questions