Designing for Efficiency: New Plants and Major Renovations

September 28, 2023

SEDAC
SMART ENERGY DESIGN ASSISTANCE CENTER

ILLINOIS ENVIRONMENTAL PROTECTION AGENCY

ILLINOIS SUSTAINABLE TECHNOLOGY CENTER
PRAIRIE RESEARCH INSTITUTE

Who We Are

We assist buildings and communities in achieving energy efficiency, saving money, and becoming more sustainable.

We are an applied research program at University of Illinois.

Our goal: Reduce the energy footprint of Illinois and beyond.

ILLINOIS ENVIRONMENTAL PROTECTION AGENCY

ILLINOIS SUSTAINABLE TECHNOLOGY CENTER
PRAIRIE RESEARCH INSTITUTE

SEDAC
SMART ENERGY DESIGN ASSISTANCE CENTER

ISTC Mission

To encourage and assist citizens, businesses and government to prevent pollution, to conserve natural resources, and to reduce waste to protect human health and the environment in Illinois and beyond.

About the IEPA PWI Energy Efficiency Program

The Illinois EPA Public Water Infrastructure Energy Assessment Program helps municipalities reduce the cost of water and wastewater treatment.

- NO-COST energy assessments and technical assistance
- Comprehensive report listing:
  - Cost of upgrades
  - Estimated payback period
  - Any applicable incentives or funding opportunities
- Operator continuing education events

Apply at: www.smartenergy.Illinois.edu/water

Funding provided in whole or in part by the Illinois EPA Office of Energy. This program is in partnership with the U.S. Dept. of Energy Sustainable Wastewater Infrastructure of the Future (SWIFT) Accelerator for energy efficiency in wastewater treatment.

Illinois Environmental Protection Agency

U.S. Department of Energy | Energy Efficiency & Renewable Energy

Illinois Sustainable Technology Center, Prairie Research Institute

SEDAC Smart Energy Design Assistance Center

Webinar Objectives

1. Recognize common-sense designs that reduce energy consumption
2. Identify hidden efficiency designs that improve operating efficiency
3. Review examples of plants that designed for efficiency
4. Discuss potential funding sources for resiliency projects

ILLINOIS ENVIRONMENTAL PROTECTION AGENCY

SEDAC
SMART ENERGY DESIGN ASSISTANCE CENTER

Designing WWTPs for Efficiency

Webinar Speakers

Shawn Maurer
Technical Director
SEDAC - UIUC

Amanda Streicher
Asst. Wastewater Dept. Manager
Baxter & Woodman

ILLINOIS SUSTAINABLE TECHNOLOGY CENTER
PRAIRIE RESEARCH INSTITUTE

SEDAC
SMART ENERGY DESIGN ASSISTANCE CENTER

Apply for an Energy Assessment!

Step 1: Initial Application – Pre-Qualification

- Apply at www.smartenergy.illinois.edu/water
  - Be located in Illinois and be publicly-owned
  - Allow SEDAC/ISTC to visit site
  - Be willing to share facility information
  - Share final assessment report with Illinois EPA

Step 2: Data Collection – We're here to assist!

- Facility information
  - Process flow diagram, types of processes, etc.
- 2 years of utility bills and DMRs

Step 3: Site Visit Scheduled

Step 4: Receive Comprehensive Report

ILLINOIS ENVIRONMENTAL PROTECTION AGENCY

ILLINOIS SUSTAINABLE TECHNOLOGY CENTER
PRAIRIE RESEARCH INSTITUTE

SEDAC
SMART ENERGY DESIGN ASSISTANCE CENTER

Why Complete an Energy Assessment?

Existing System or No Previous Assessments?

Identify missed opportunities

Plan for capital improvements

Uncover what is possible

3rd party support for personnel's ideas

New or Recently Upgraded?

Always more to improve

Plan for future opportunities outside the scope of recent projects

New technologies and processes always in development

Identify opportunities for repairs or upgrades and associated funding!

ILLINOIS ENVIRONMENTAL PROTECTION AGENCY

ILLINOIS SUSTAINABLE TECHNOLOGY CENTER
PRAIRIE RESEARCH INSTITUTE

SEDAC
SMART ENERGY DESIGN ASSISTANCE CENTER

Keys to Designing for Efficiency

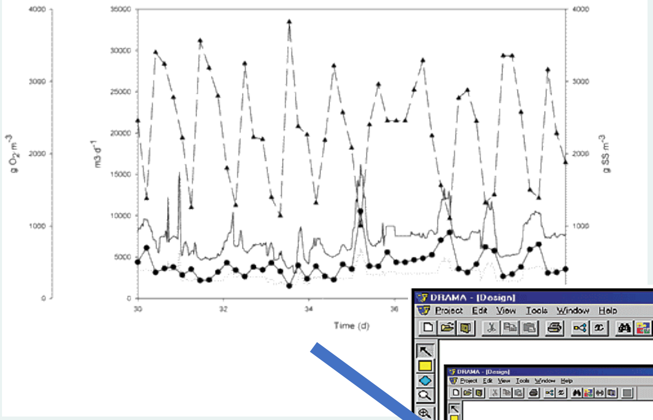
- Use Wastewater Data!
- Don’t Fight Gravity!
- Minimize Recycle Pumping (fights gravity!)
- Optimize Pumping Staging
- Proper Equipment Sizing
- Employ Variable Speed Devices or Timer Systems
- Improved Aeration Controls
- Decouple mixing and aeration

Using Wastewater Data

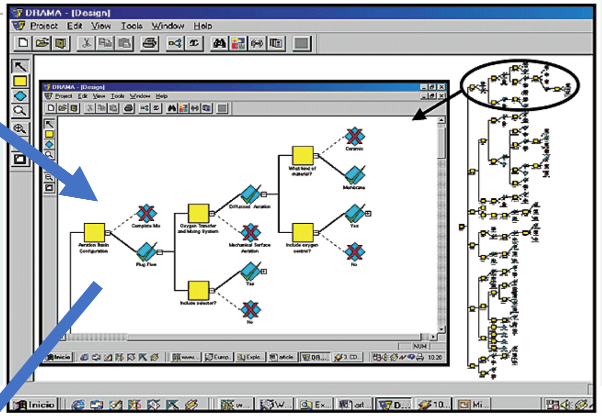
Nutrient removal coming for most plants!

Requires more tuning and precision than planning for just BOD and ammonia removal

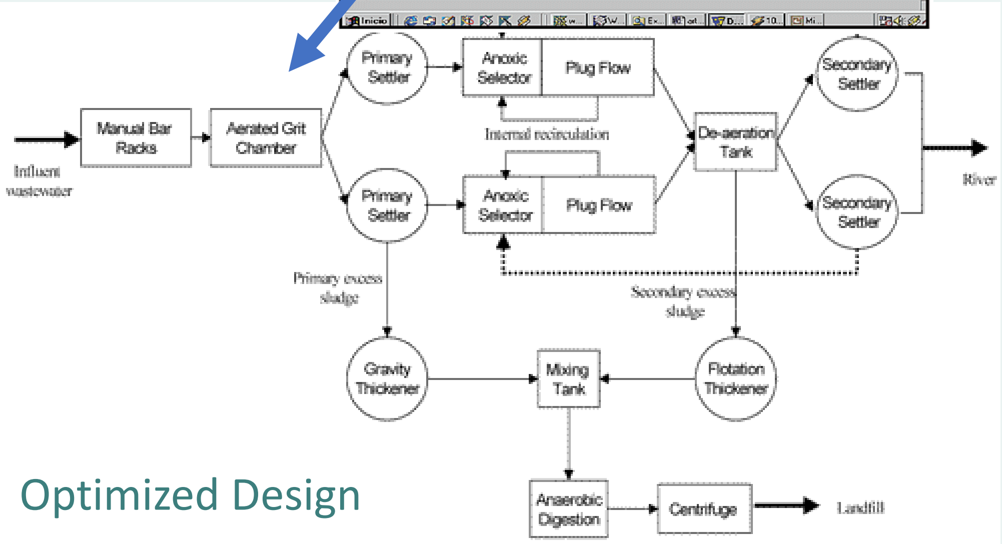
- Phosphorus and Nitrogen removal is coming for most plants!
- Knowing existing strength and flow profiles can better tune process.
    - 10 States or other design standards tend to overdesign for loading – better for future growth estimates



Raw Nutrient Loading Data

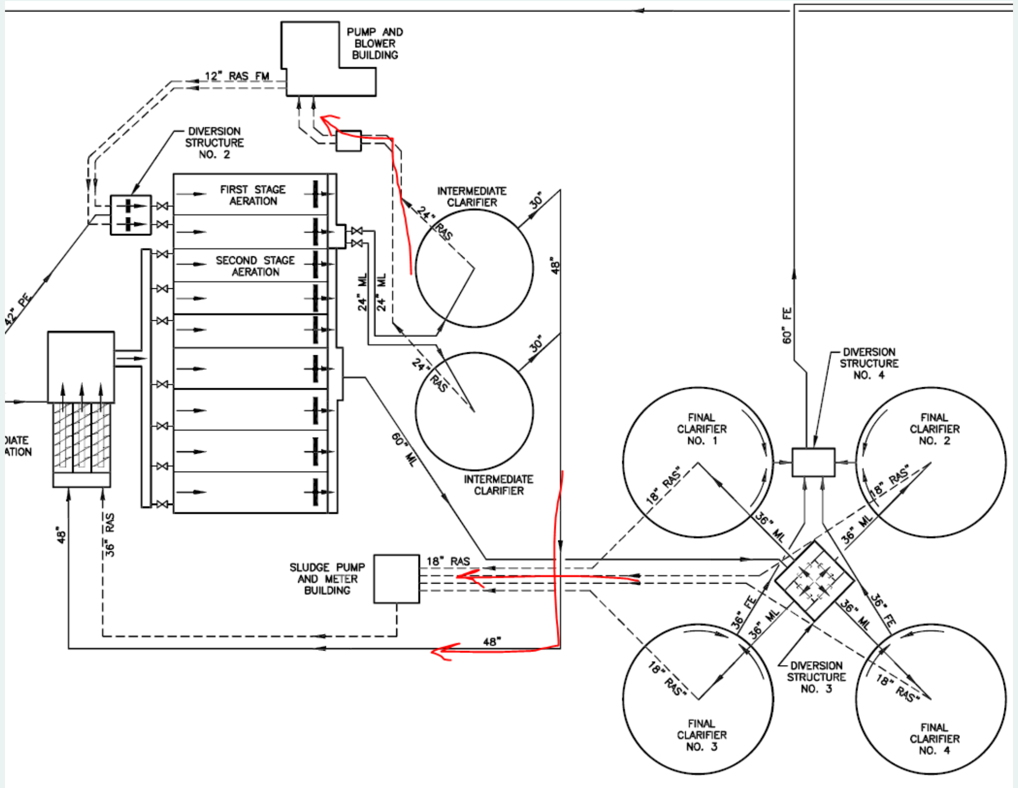


Process Model



Optimized Design

Don't Fight Gravity!

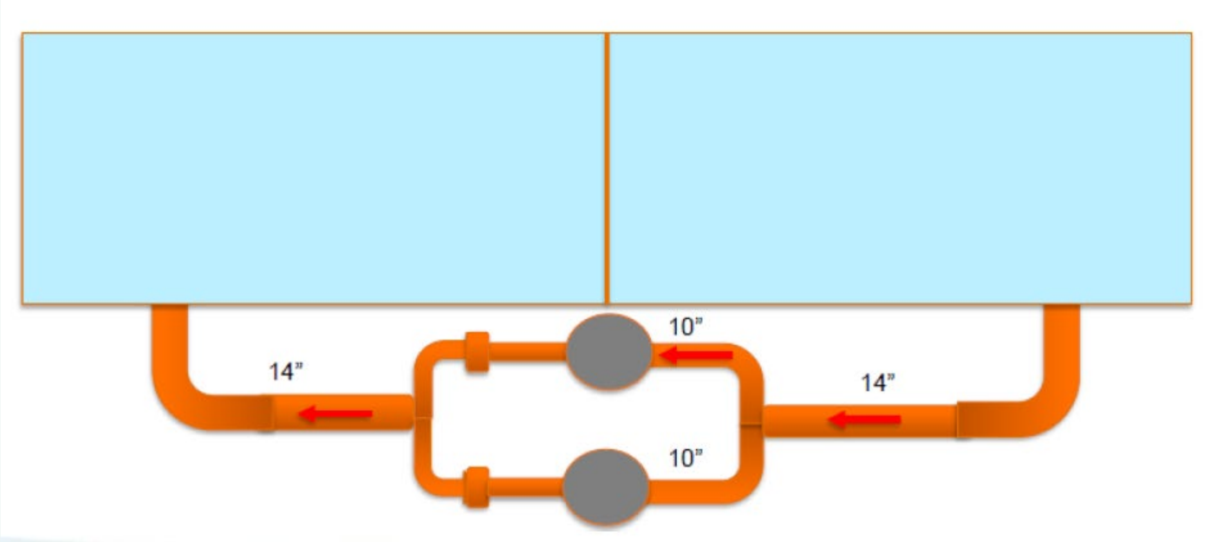


- Raised denitrification tower for storage space
  - Permanent increase in pumping head of 15-20ft!
- Recycle-intensive process
  - 2 sets of RAS plus aeration recycle!

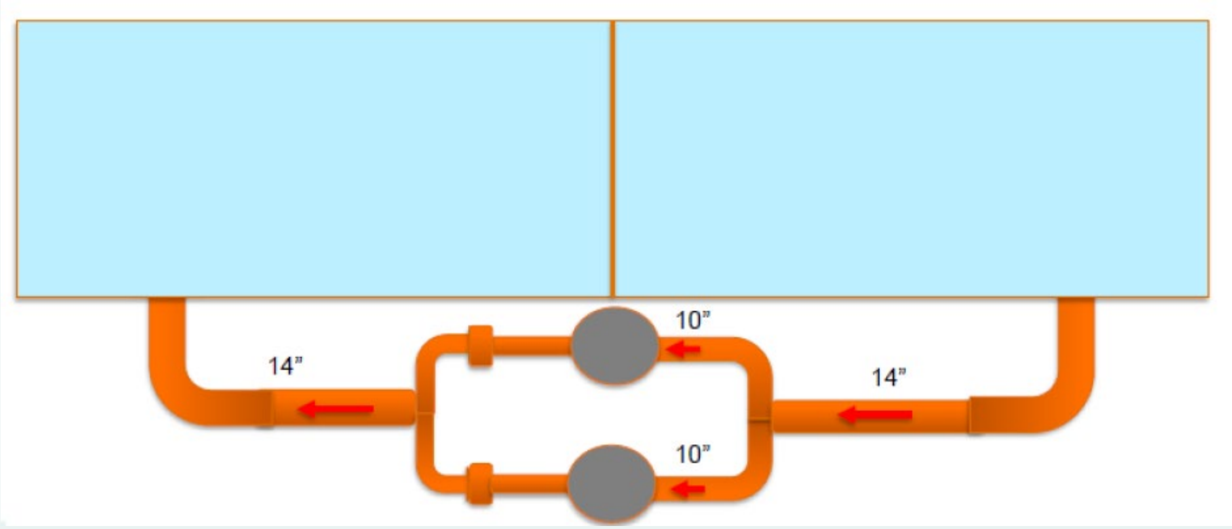
ILLINOIS SUSTAINABLE TECHNOLOGY CENTER
PRAIRIE RESEARCH INSTITUTE

SEDAC
SMART ENERGY DESIGN ASSISTANCE CENTER

Optimize Pump Staging

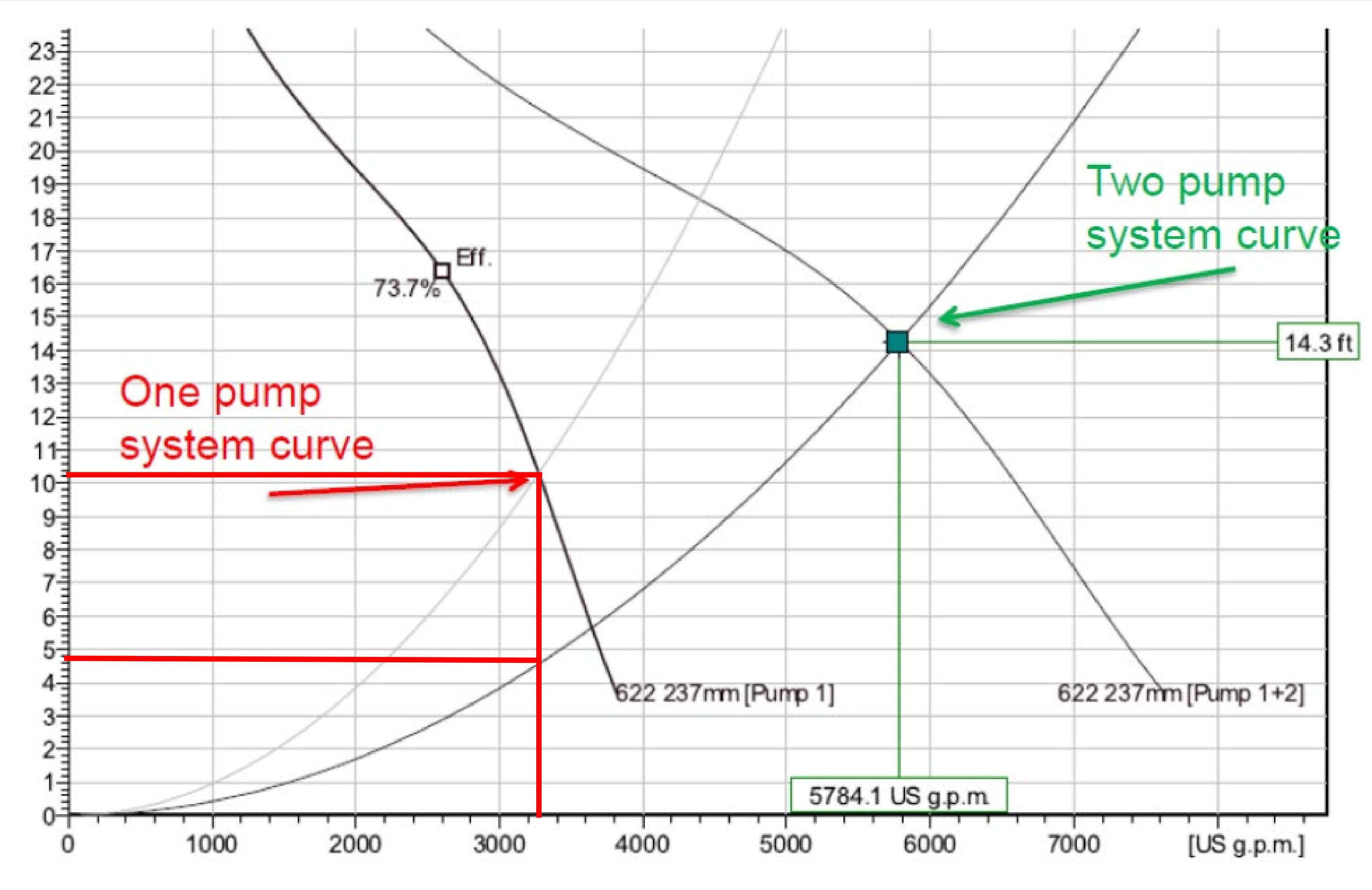


Higher flow in narrow pipe = higher head loss



Flow split between two pipes, reduces flow rate and associated head loss

Optimize Pump Staging



	Flow	Head	Shaft power	Hydr.eff.	Specific Energy
2 pumps	3370 US g.p.m	4.83 ft	5.73 hp	71.9 %	26.5 kWh/US M
1 pump	3270 US g.p.m	10.3 ft	13.9 hp	61.2 %	60.3 kWh/US M

Annual Energy Consumption

1 Pump:
107.3 MWh/yr

2 Pumps:
47.4 MWh/yr

~$6,000 annual savings at $0.10/kWh

ILLINOIS SUSTAI
TECHNOLOGY CE
PRAIRIE RESEARCH INS

Build-In Modularity – Size For Current Need

- 5 small blowers – 2 operate under normal conditions
  - Remaining 3 are back-up + peak loading blowers.

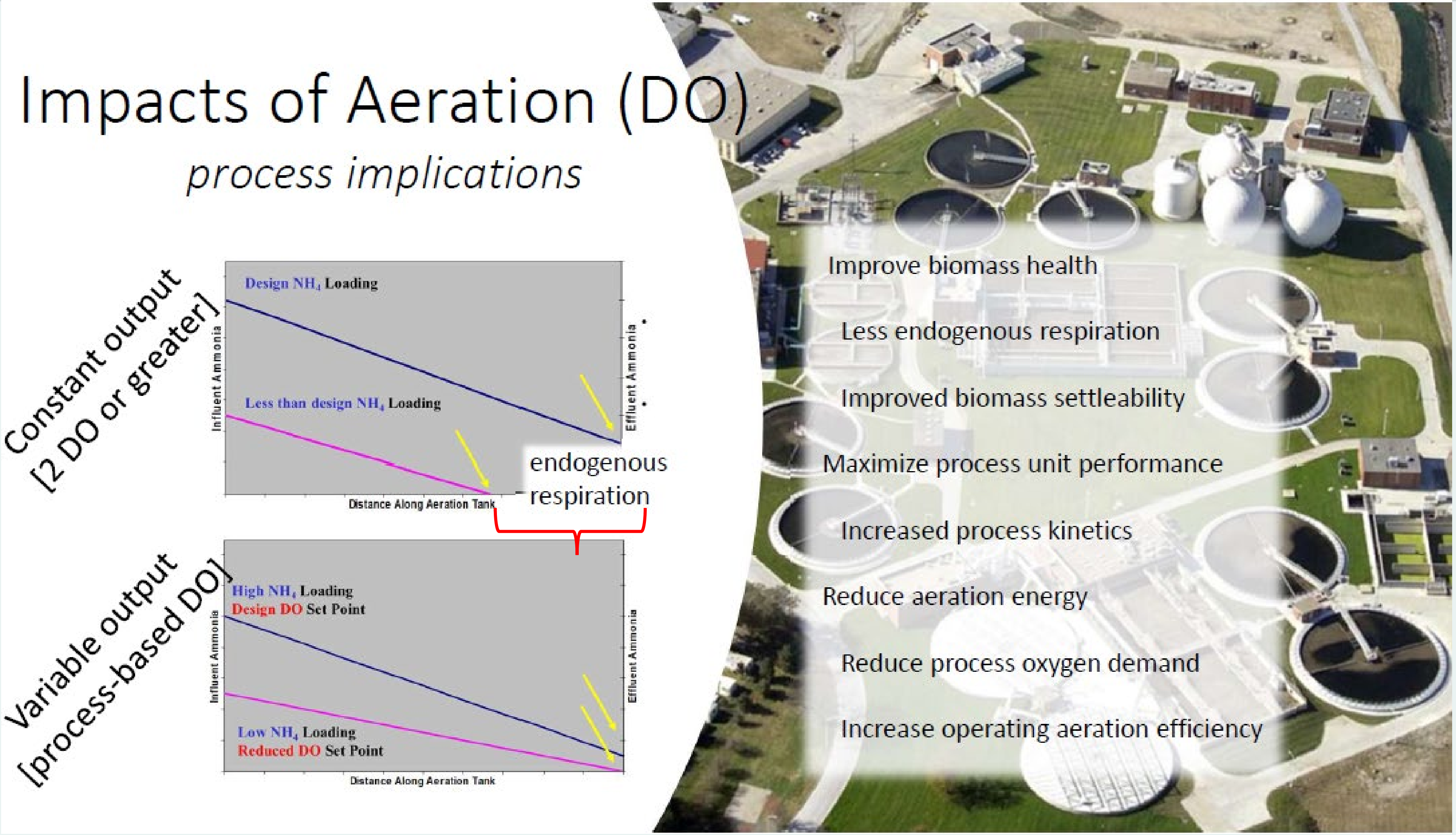
- Two ditches, only 1 used most of the time
  - 2nd ditch for storm flows

ILLINOIS ENVIRONMENTAL PROTECTION AGENCY

ILLINOIS SUSTAINABLE TECHNOLOGY CENTER
PRAIRIE RESEARCH INSTITUTE

SEDAC
SMART ENERGY DESIGN ASSISTANCE CENTER

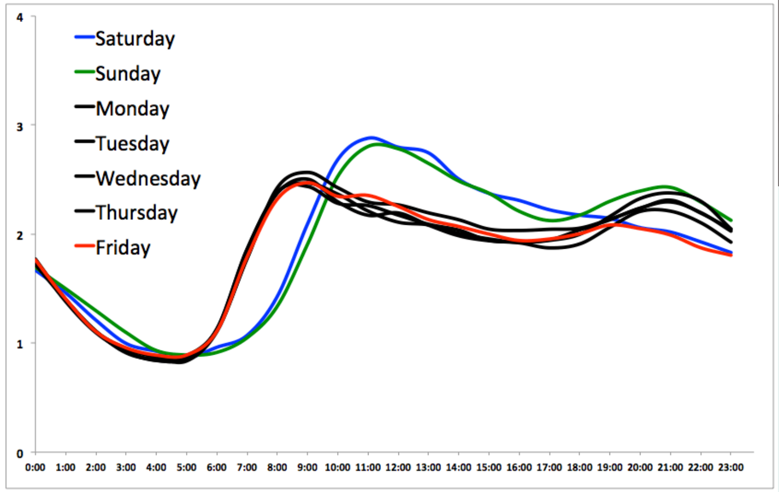
Consequences of Over-Sizing



Content courtesy Randy Chann, EDI, Boone Co. RSD Chair

Employ Variable Speed or Timers

- VFDs improve modularity of equipment



- Timers are an excellent lower-cost aeration control measure

- Both help adjust for diurnal loading

ILLINOIS ENVIRONMENTAL PROTECTION AGENCY

ILLINOIS SUSTAINABLE TECHNOLOGY CENTER
PRAIRIE RESEARCH INSTITUTE

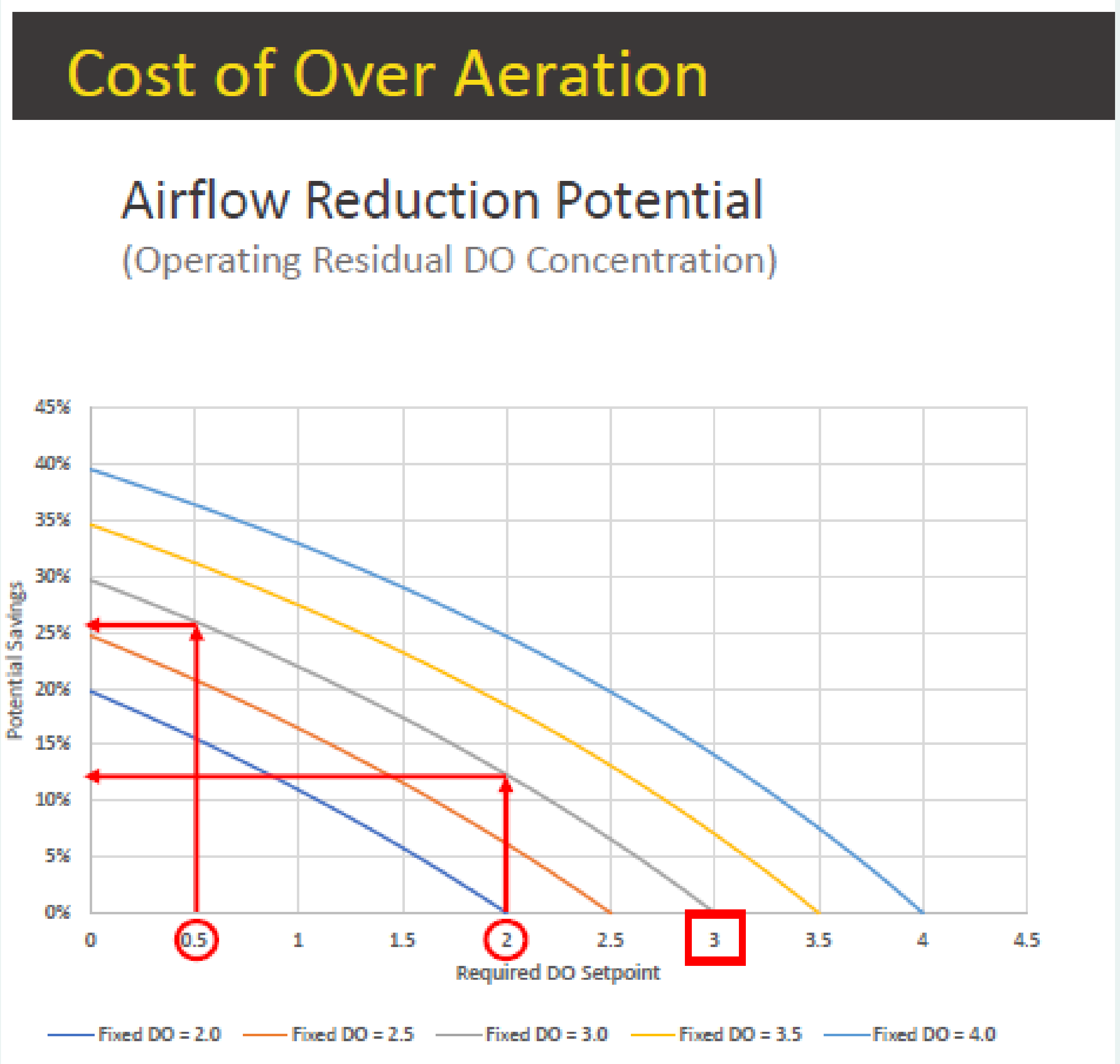
SEDAC
SMART ENERGY DESIGN ASSISTANCE CENTER

Optimizing DO Control

Only Add DO Needed for the process

Chart indicates airflow reduction possible from reducing DO setpoint.

Employ DO Probes, blower VFDs, and automated basin flow valves



Content courtesy Randy Chann, EDI, Boone Co. RSD Chair

Improved Aeration Controls

Many operators manually balance airflow between basins

- Process tanks
- Aerobic digesters
- Tapering airflow in single basin

Modern Designs are more automated

- EBNR Processes
- SBR
- MBR
- MBBR
- SND basins

Controlling each basin optimizes aeration demand

ILLINOIS ENVIRONMENTAL PROTECTION AGENCY

ILLINOIS SUSTAINABLE TECHNOLOGY CENTER
PRAIRIE RESEARCH INSTITUTE

SEDAC
SMART ENERGY DESIGN ASSISTANCE CENTER

Aeration with Most-Open Valve Control

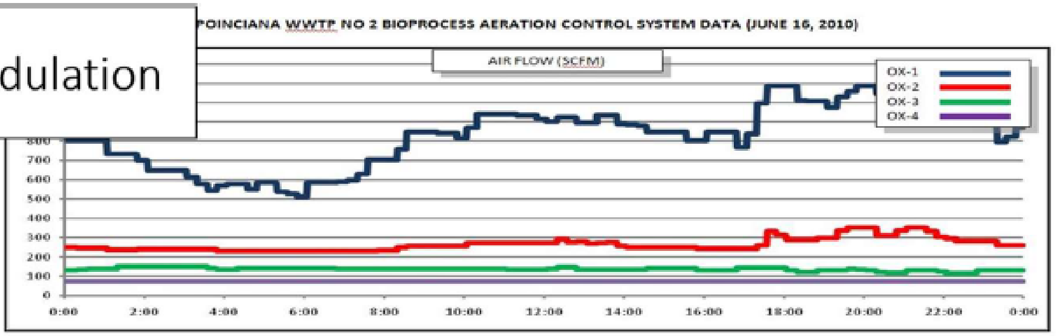
1

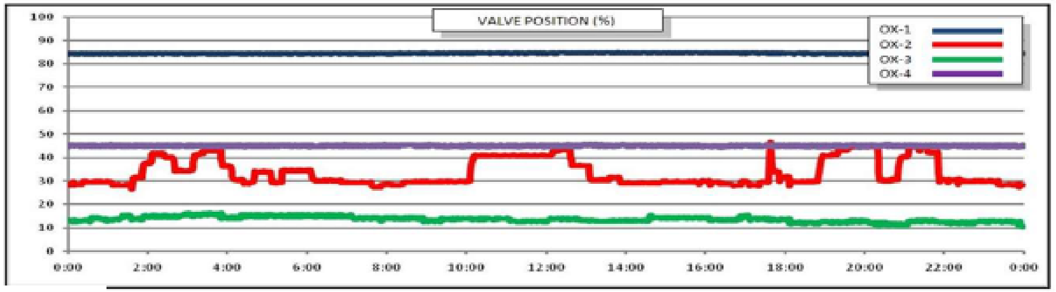
Toho Water Authority (Cyprus West WRF) 2010

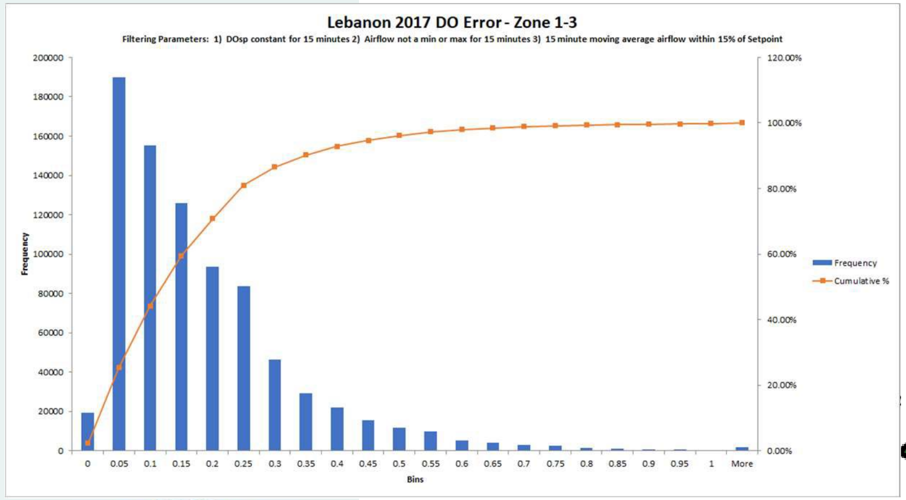
Aeration DO Control

Airflow (valve & blower) Modulation

Mechanical and
Operating Efficiency







Tactical system wide coordination

Reduces wear and tear!

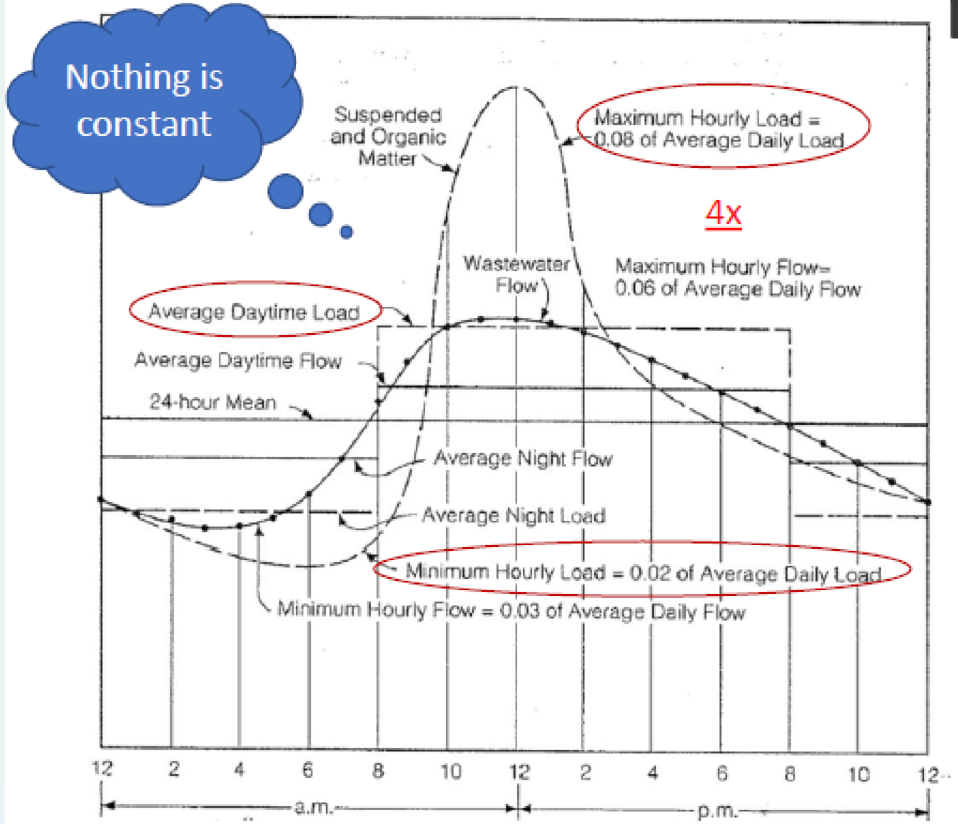
Content courtesy Randy Chann, EDI, Boone Co. RSD Chair

ILLINOIS SUSTAINABLE TECHNOLOGY CENTER
PRAIRIE RESEARCH INSTITUTE

SEDAC
SMART ENERGY DESIGN ASSISTANCE CENTER

Optimizing Aeration Design

How do we run an activated sludge plant?



Impacts of Aeration

Aeration

Constant vs Variable?

How do we operate the aeration system (blowers)?

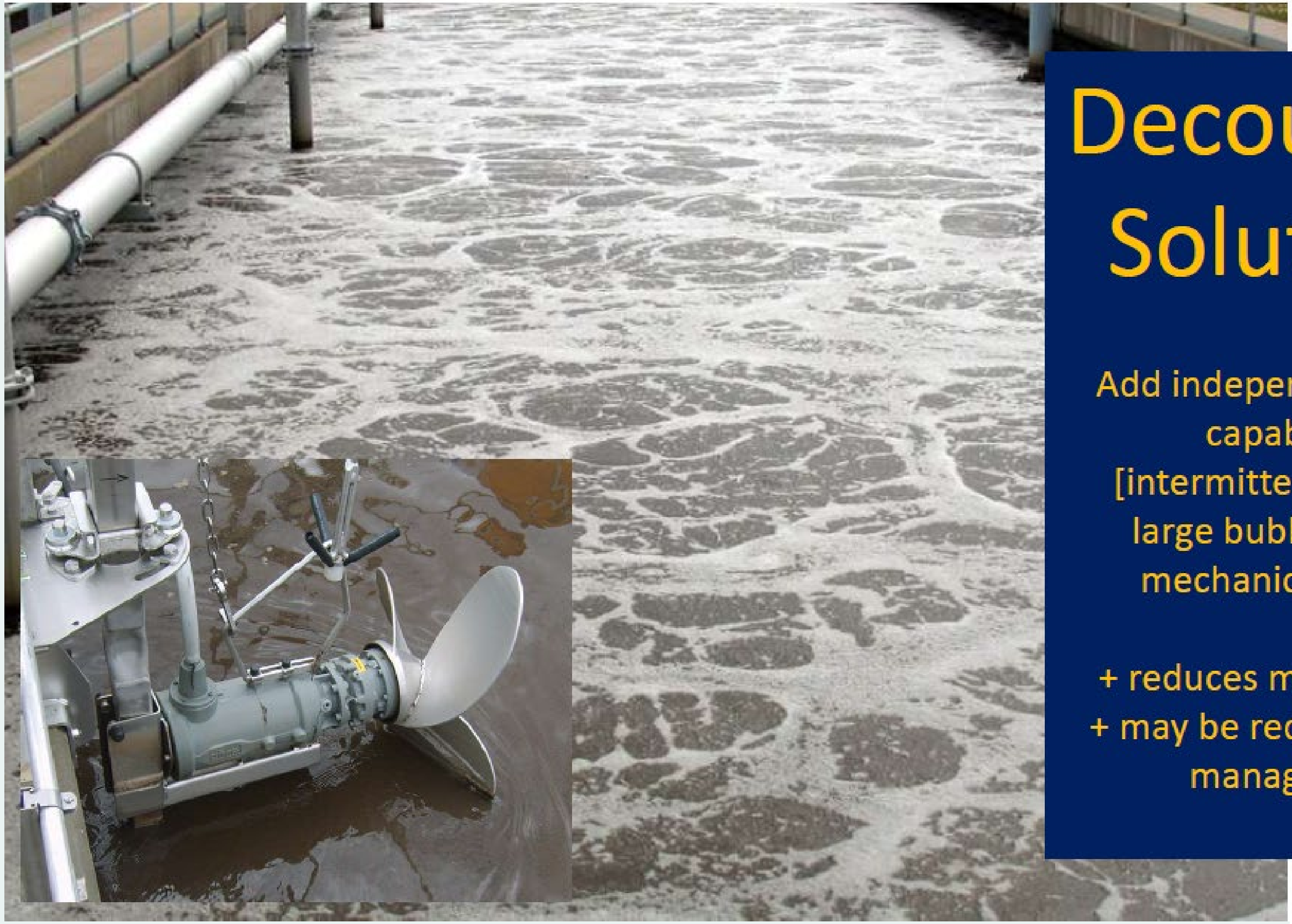
Fixed Output	Operating DO Target, DO, scfm, % reduction			Variable Output	
Max Hourly Load	2	1 – 12%	0.5 – 16%	2	
Average Load	5.9	5.4	5.2	2 – 50%	1.5 – 53%
Min Hourly Load	7.9	7.6	7.5	2 – 75%	1.0 – 78%

Content courtesy Randy Chann, EDI, Boone Co. RSD Chair

ILLINOIS SUSTAINABLE TECHNOLOGY CENTER
PRAIRIE RESEARCH INSTITUTE

SEDAC
SMART ENERGY DESIGN ASSISTANCE CENTER

Decoupling Mixing and Aeration



Decoupling Solutions

Add independent mixing capabilities [intermittent aeration, large bubble mixers, mechanical mixers]

+ reduces mixing energy
+ may be required for DO management

Content courtesy Randy Chann, EDI, Boone Co. RSD Chair

Questions?

Shawn Maurer, PE, CEM
spmaurer@illinois.edu
217-300-1771

Amanda Streicher, Baxter & Woodman

Designing for Efficiency at a WRRF

September 28, 2023

Agenda

- Proper Planning
- Education of Decision Makers
- Preliminary Design and Report
- IEPA required vs Actual Design Conditions
- Large Energy Users
  - Aeration and Activated Sludge
  - Pumping
  - Instrumentation and Automation
- Owner/Staff Support and Champion
- Question/Discussion

Proper Planning

- ❑ **Planning is the First Step**
  - ❑ Facility Planning Report
  - ❑ Facility Assessment (ComEd) – Very high level
  - ❑ Comprehensive Energy Assessment (ComEd funded) – Detail Evaluation
  - ❑ SEDAC Assistance and Resources
  - ❑ Master Plan
    - ❑ Include a section on Energy
    - ❑ Identify big picture things to consider in design
  - ❑ Energy Neutrality Plan
    - ❑ Focus specifically of energy usage

ComEd. Energy Efficiency Program

Facility Assessment

INVESTIGATION REPORT

WASTEWATER TREATMENT STUDY

ComEd. Energy Efficiency Program

WATER RECLAMATION DISTRICT

Energy Assessment Program

The Illinois EPA Office of Energy has teamed up with SEDAC and the Illinois Sustainable Technology Center (ISTC) to help local municipalities reduce the cost of treating water and wastewater.

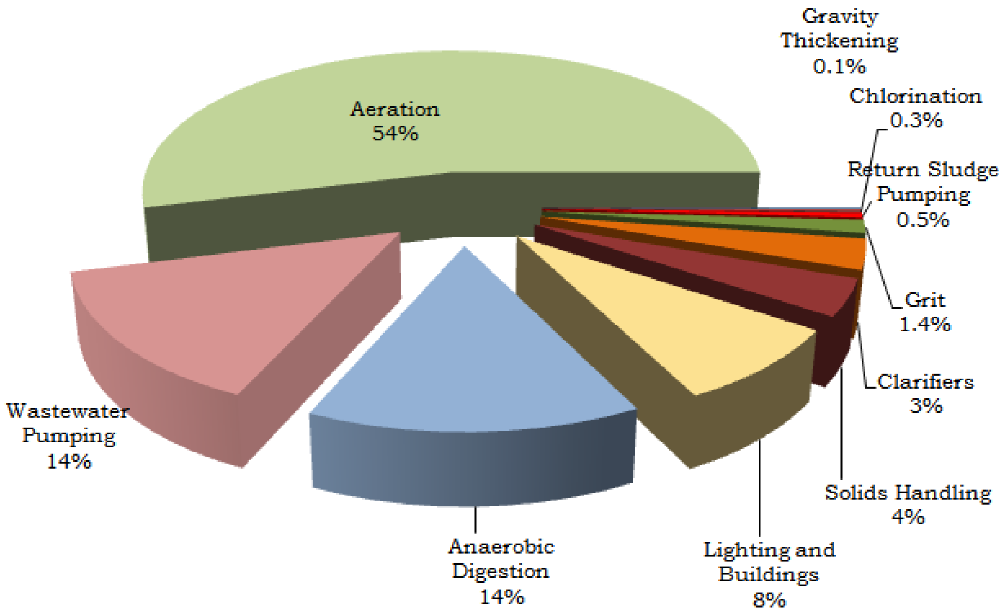
SEDAC and ISTC provide no-cost energy usage assessments to publicly-owned water and wastewater treatment systems across Illinois. Assessment reports break down recommendations for energy efficiency improvements at each facility, including information such as estimated project costs, simply payback periods, funding opportunities, and the resulting energy and monetary savings.

Master Plan for Process Capacity Buildout on the Facility's West Site

Education of Decision Makers

- Communicate Plan and Goals
- Show WRRF to Board or Trustees
- Energy Usage and Costs
- Get Buy-in

Typical Energy Usage



Constellation.
An Exelon Company

Customer Number	Invoice Number	Invoice Date
Current Charges	**Payment Due Date**	**Total Due**
$29,745.58	08/15/2015	$29,745.58

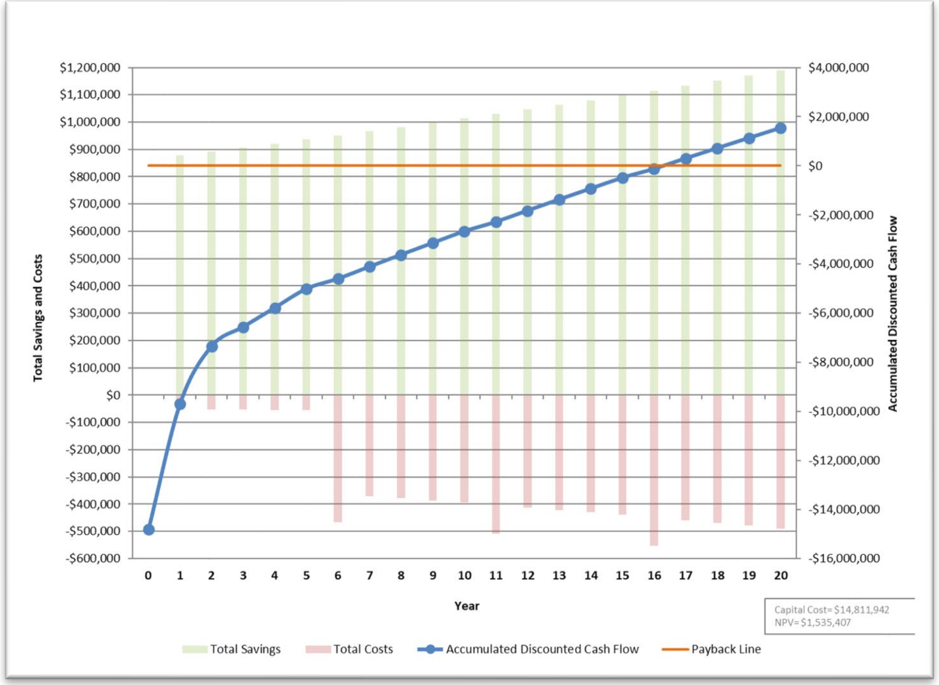
Preliminary Design and Report

- **Equipment Evaluation**
  - Capital Cost
  - Operating Efficiency
  - Energy Usage
  - O&M Requirements
  - Chemical/Polymer Usage
  - Operating Range
- **Life Cycle Cost**
  - Operation and Maintenance
  - Major overhauls
  - Establish total cost of Ownership

Diffuser SOTE Requirements

SOTE		36%	40%	
Air requirement (scfm)		8400	7650	
Max air per blower (scfm)		2800	2550	
Quantity of blowers		4	4	
Blower HP		200	150	
				Difference
Blower Capital				
	Neuros	$ 817,564	$ 645,800	**$171,764**
	ABS Sulzer	$ 638,030	$ 631,960	**$6,070**
Diffusers Capital				
	EDI	$ 140,000	$ 272,500	**($132,500)**
	Sanitaire	$ 200,000	$ 290,000	**($90,000)**
Blower operating cost/year*		$ 121,974	$ 90,404	**$31,570**
Cost wasted for air past mixing		($1,419)	($1,963)	**($544)**

*Using $0.065/kWh



IEPA required vs Actual Design Conditions

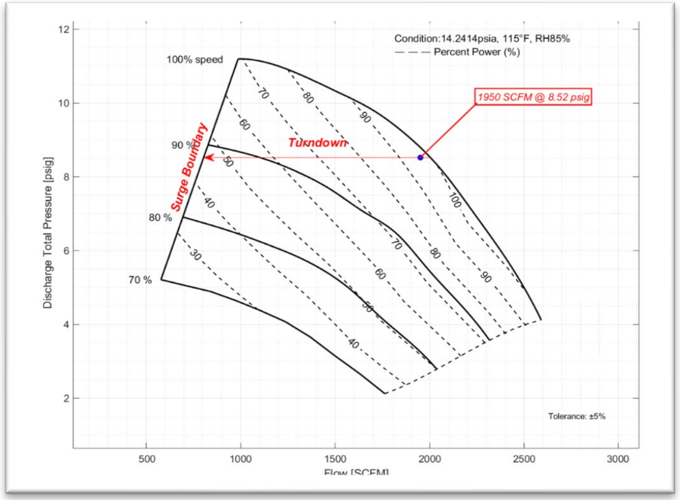
IEPA Required vs Actual Operation Conditions

WASTEWATER CHARACTERISTICS

5-Day Biochemical Oxygen Demand (BOD_5)				IEPA Loading		Actual Loading
Present concentration				204	mg/L	16
Existing loading	60000 PE x 0.17 ppd/PE =			10,200	lbs/day	8,00
Additional future loading						
26300 PE x 0.17 ppd BOD5/PE				4,471	lbs/day	4,47
Sidestream loading						
Gravity Belt Thickener Filtrate		BOD:TSS =	0.25	94	lbs/day	94
Centrifuge Centrate		BOD:TSS =	0.25	134	lbs/day	134
Total BOD_5 loading				14,899	lbs/day	12,57
concentration				207	mg/L	17

Page 1

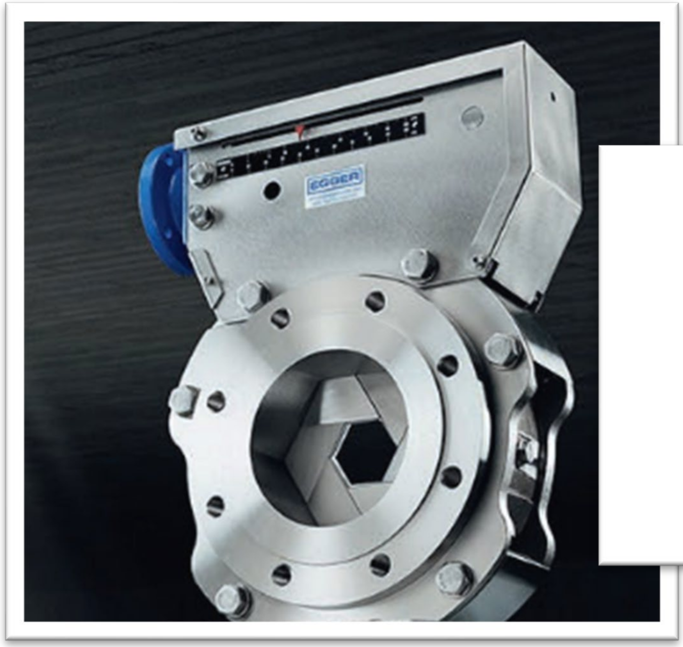
Operating Range

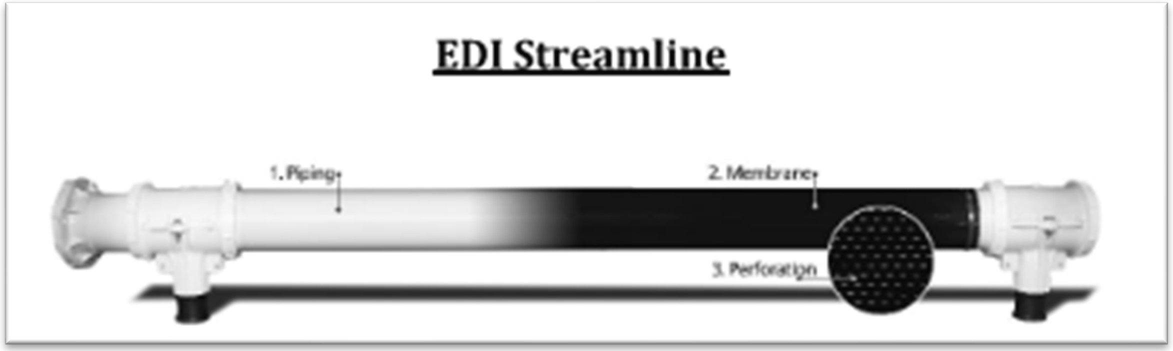


Make sure equipment selected can meat the IEPA requirements and operate efficiently at actual conditions

Large Energy Users – Aeration and Activated Sludge

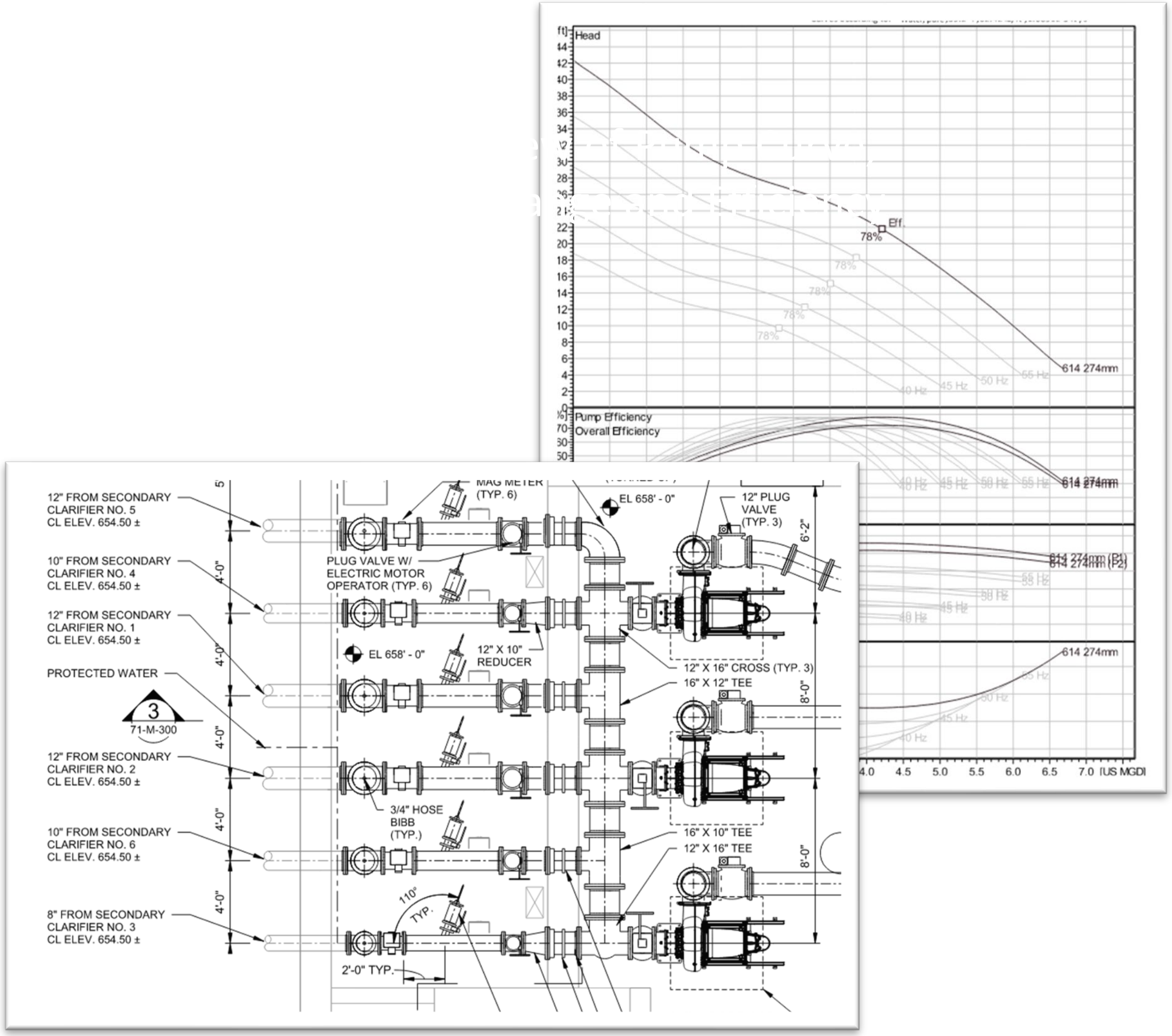
- **Diffusers**
  - SOTE is Critical
  - Cleaning Requirements - Fouling is re
- **Air Control Valves**
  - Iris vs Butterfly
  - Location – Preferred on each drop pipe
  - Actuated is needed to match process demand
- **Blowers**
  - High Efficiency Turbo
  - Screw Hybrid





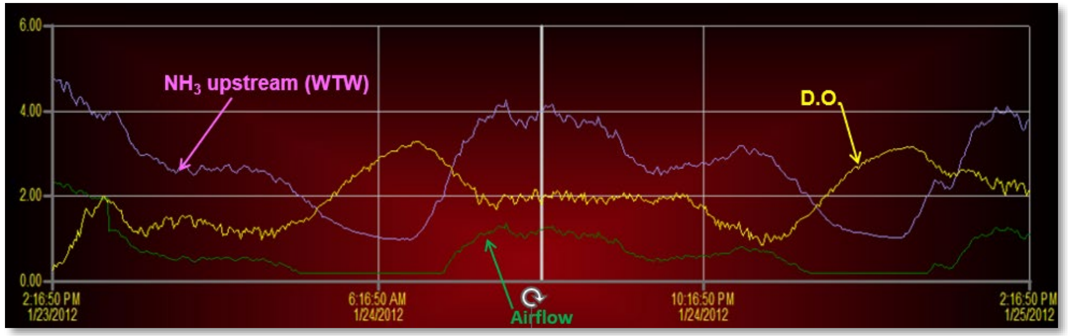
Large Energy Users – Pumping Systems

- Determine Pump for the Process
  - Liquid, sludge, or chemical
- Provide VFD to match process
- Consider RAS direct connection to Final Clarifiers
  - Reduce TDH by using WL in Clarifiers



Large Energy Users – Instrumentation and Automation

- DO, ORP, pH and Ammonia probes allow real-time understanding of the process
- Use Controls & Automation to reduce buffer
  - Could create risk for operators
  - Make sure to collaborate in design
- Incorporate Power Monitoring into MCCs & VFDs
- SCADA is critical for monitoring probes and energy usage
  - Phone and tablet access



Questions/Discussion