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Energy Efficient Retrofits of Existing Oxidation Ditches

Presenter: Timothy D. Brett, P.E.

Presentation Home

1. Various Oxidation Ditches
2. Activated Sludge 101
3. Decoupling Mixing & Aeration
4. Process Design
5. Aeration and Mixing
6. Control System
7. Installations

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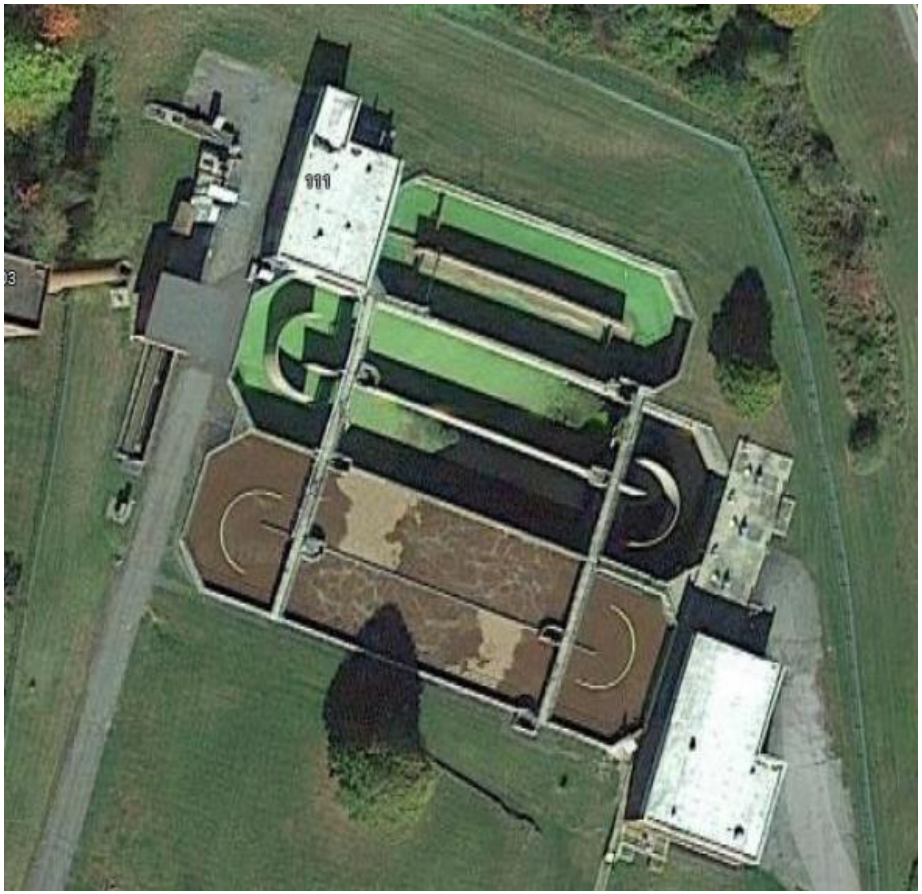
1. Various Oxidation Ditches

Type of Oxidation Ditches

Type of Oxidation Ditches



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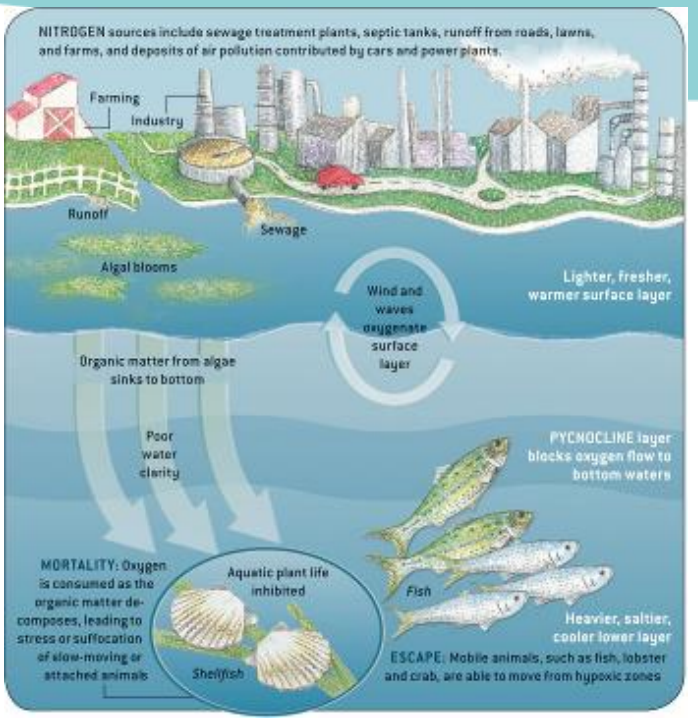
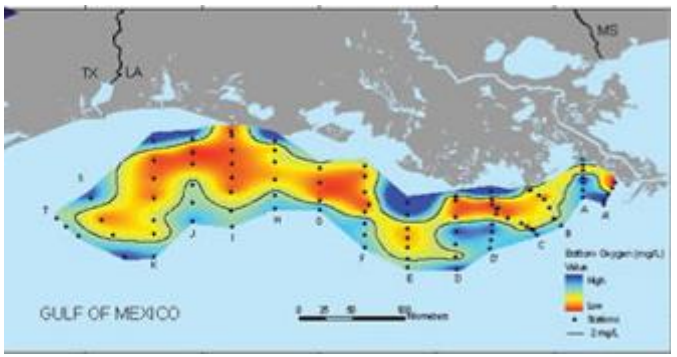
2. Activated Sludge 101

Wastewater—what is the concern?

- Nutrients
  - » Nitrogen
  - » Phosphorus
  - » Promote aquatic plant growth
- Hypoxia
  - » Low dissolved oxygen caused by decaying aquatic plant life
- Point and non-point sources
  - » Point (WWTP)
  - » Non-point (run-off)





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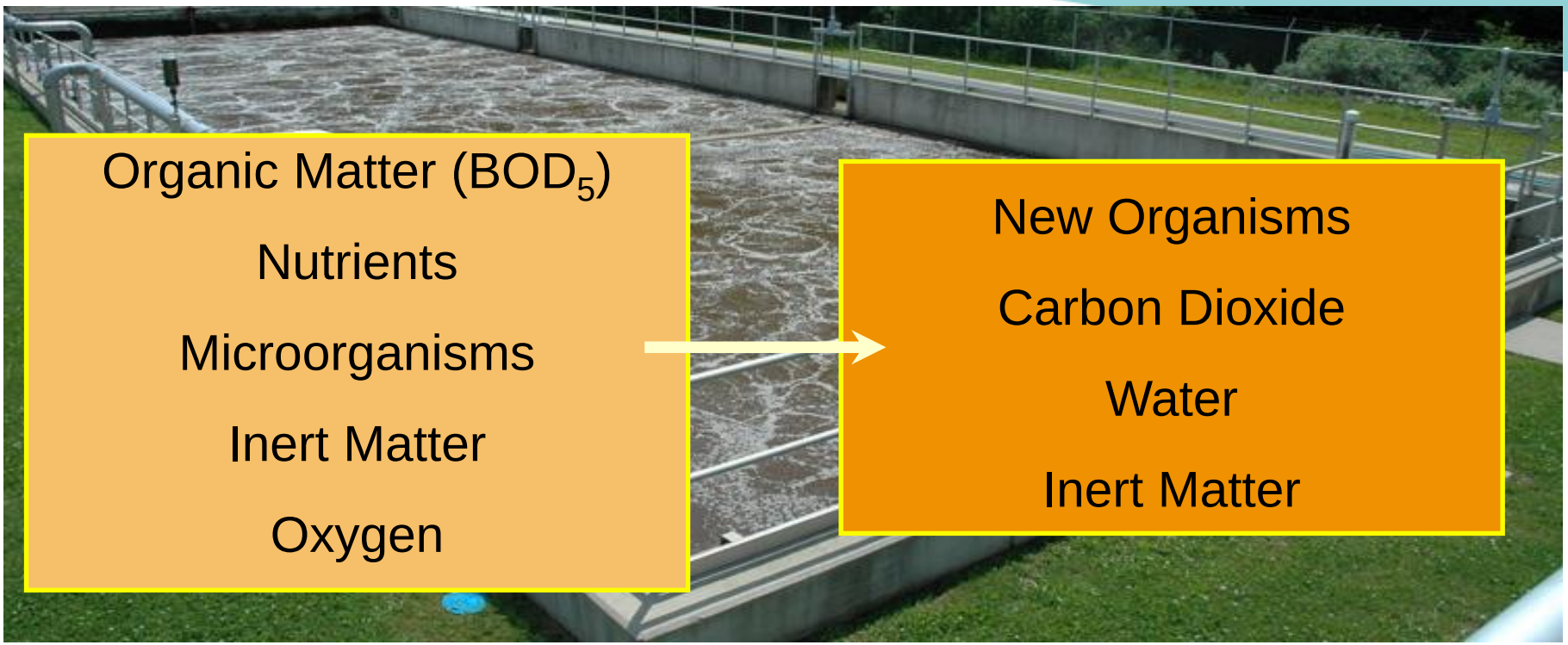
Principles of Biological Treatment



Heterotrophic microorganisms predominate, and use organic matter as food for energy and cell synthesis.

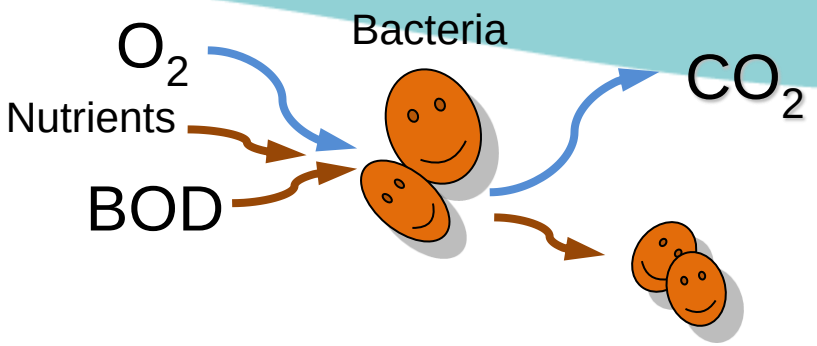
Dissolved oxygen > 0.5 mg/L

Principles of Biological Treatment

Carbon (BOD) removal

Removes the majority of pollutant load

Fast growing bacteria

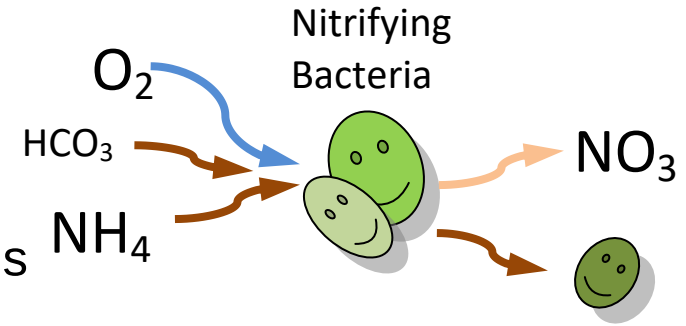


Nitrification

Converts ammonia (NH4) to nitrate (NO3)

Slow growing bacteria - 2 types

Can be flushed out of conventional systems

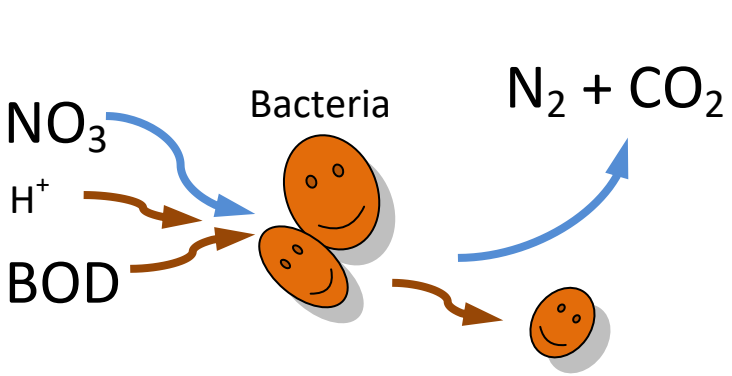


Denitrification

No Oxygen present

Bacteria use oxygen in Nitrate NO3

Nitrogen released as gas



Basic Terminology

MLSS: Mixed Liquor Suspended Solids, biomass or microorganism mass including other particulates.

F/M Ratio: "F" is the food or biodegradable organic matter (BOD_5). "M" are the microorganisms or MLSS.

SRT (or MCRT): solids retention time or mean cell residence time is the average duration of time an organism spends in the system. Often the first step in plant design, dictated by need to nitrify and wastewater temperature.

Need to have basic understanding of the determinants and process understanding to be able to talk about biological systems.

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3. Decoupling Aeration & Mixing

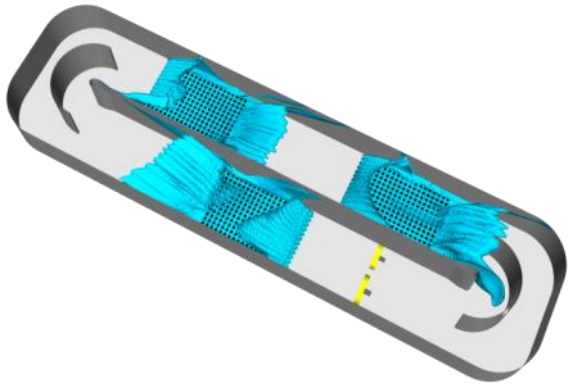
Combining Mixing and Aeration

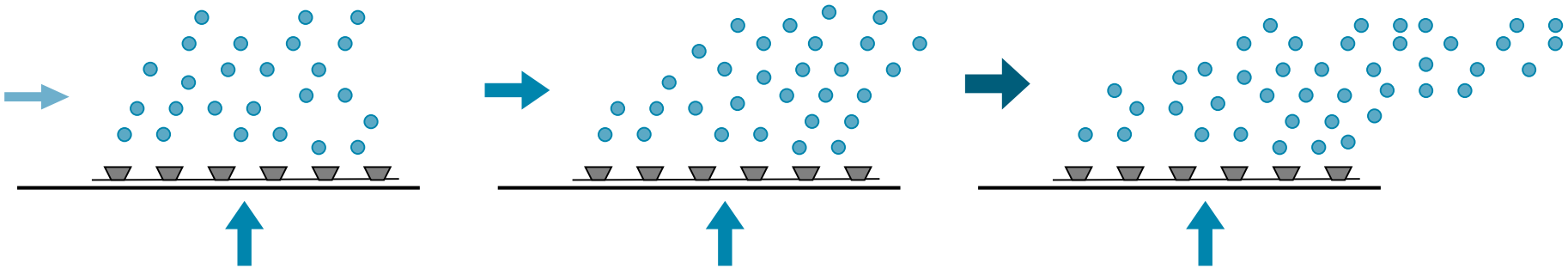
Optimized combination of aeration and mixer design is vital for the total efficiency

Liquid velocity to overcome losses caused by aeration

Optimize bubble retention time in the water

Minimizing local energy losses with optimized placement of mixers and aeration





Advantages – Energy Savings

1. Fine bubble aeration is more efficient than mechanical aeration
- Up to 50% less power required

2. Fine bubble + horiz. mixers results in the horizontal flow effect (HFE)
   - Reduces power to 10-30% less than fine bubble alone

3. Independent control of mixing and aeration allows energy input to be turned down to match demand while maintaining treatment.

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Advantages – Maintenance

4. Oxidation ditches with fine bubble aeration can be designed in deeper tanks for reduced space requirements in comparison to mechanical aerators

5. Aerosols and the need to frequently perform maintenance of mechanical equipment in the basin are eliminated

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4. Process Design

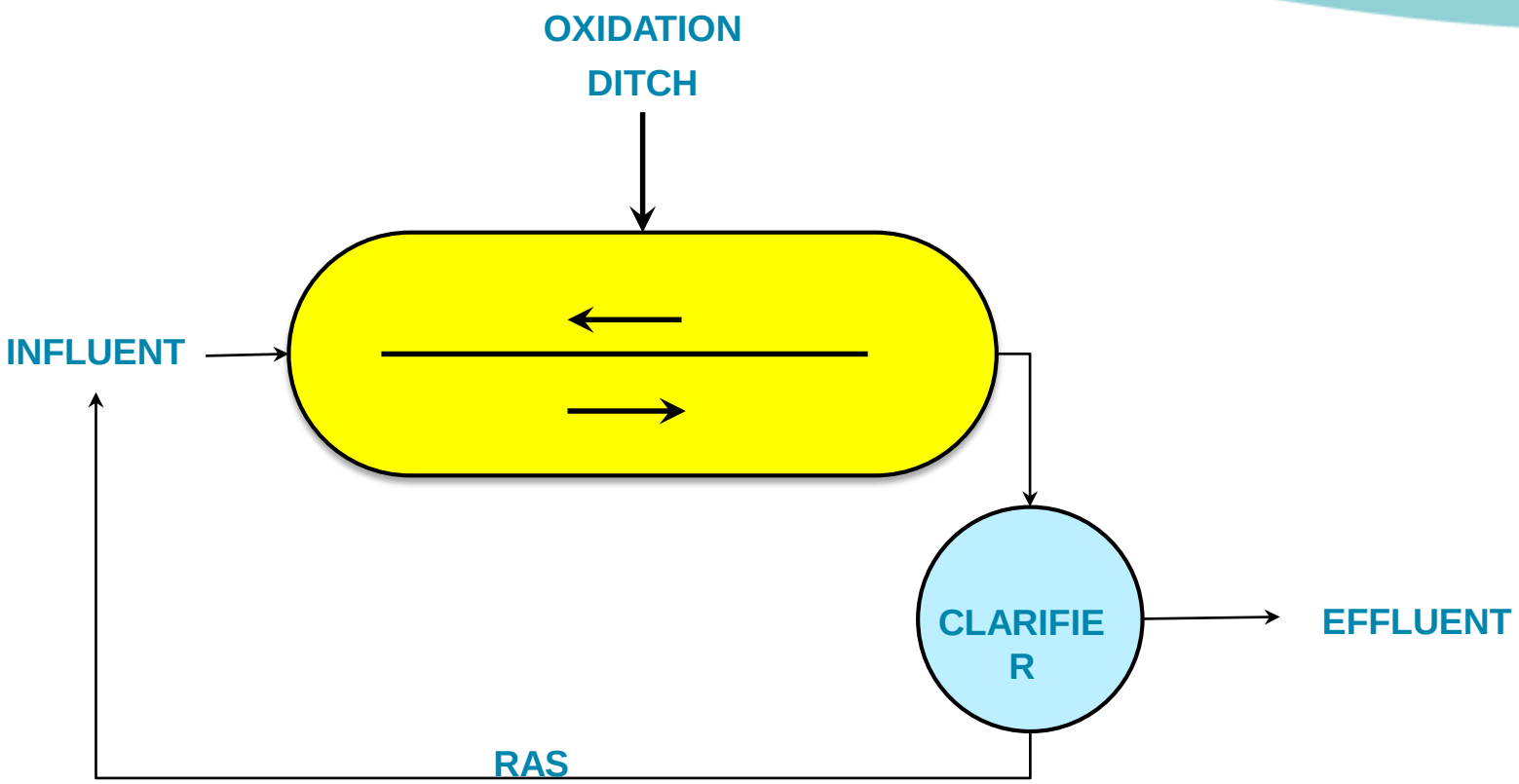
Process Tailored Process Design

Multiple process configurations:

- **NIT:** aerobic only
- **MLE (Modified Ludzack-Ettinger):** anoxic + aerobic
- **A^2O:** anaerobic + anoxic + aerobic
- Bardenpho 4-stage: MLE + post anoxic
- Bardenpho 5-stage: A2O + post anoxic
- **SNDN** (Simultaneous Nitrification & Denitrification): Ditches in series

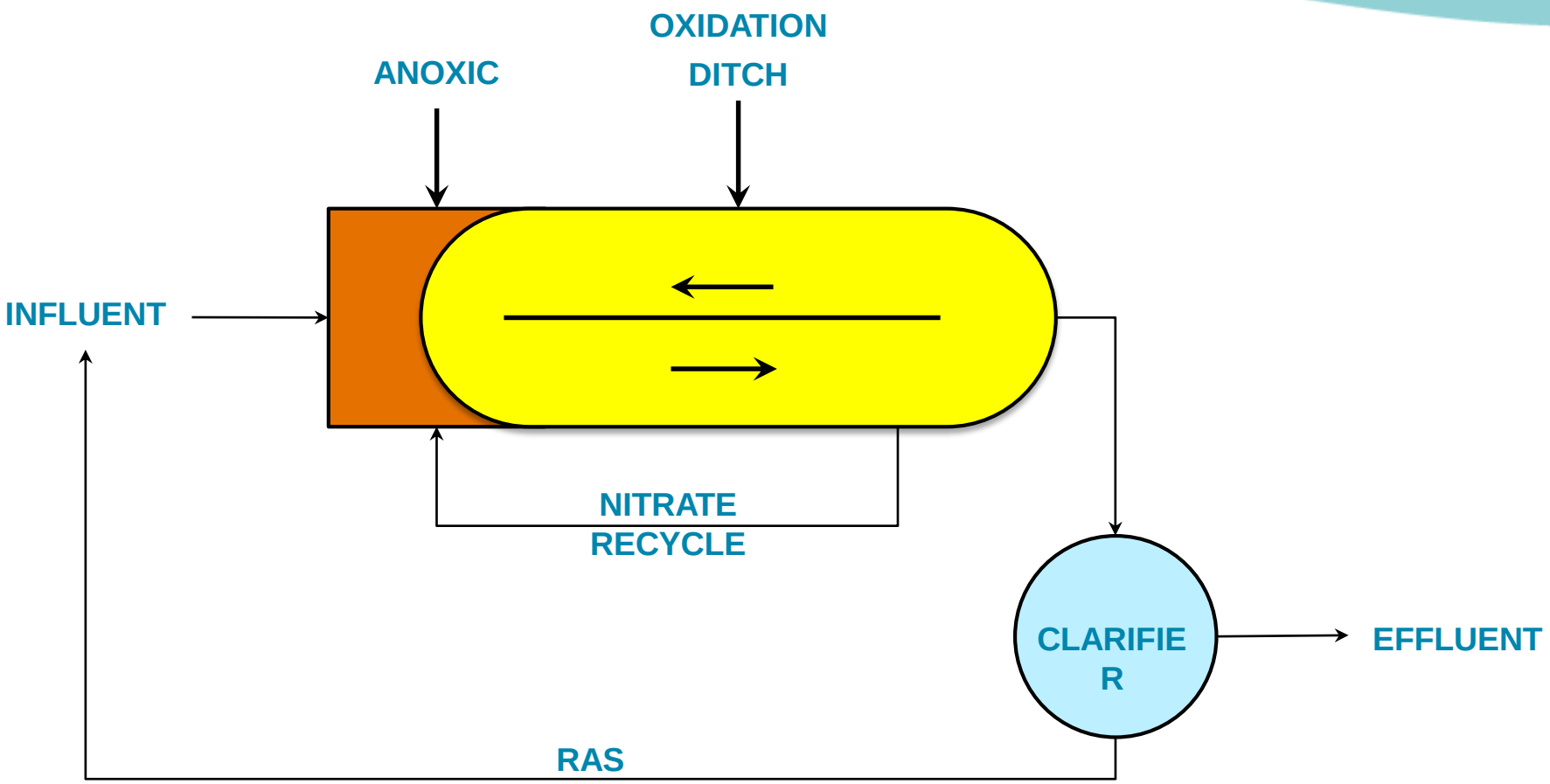
Process Configurations

NIT



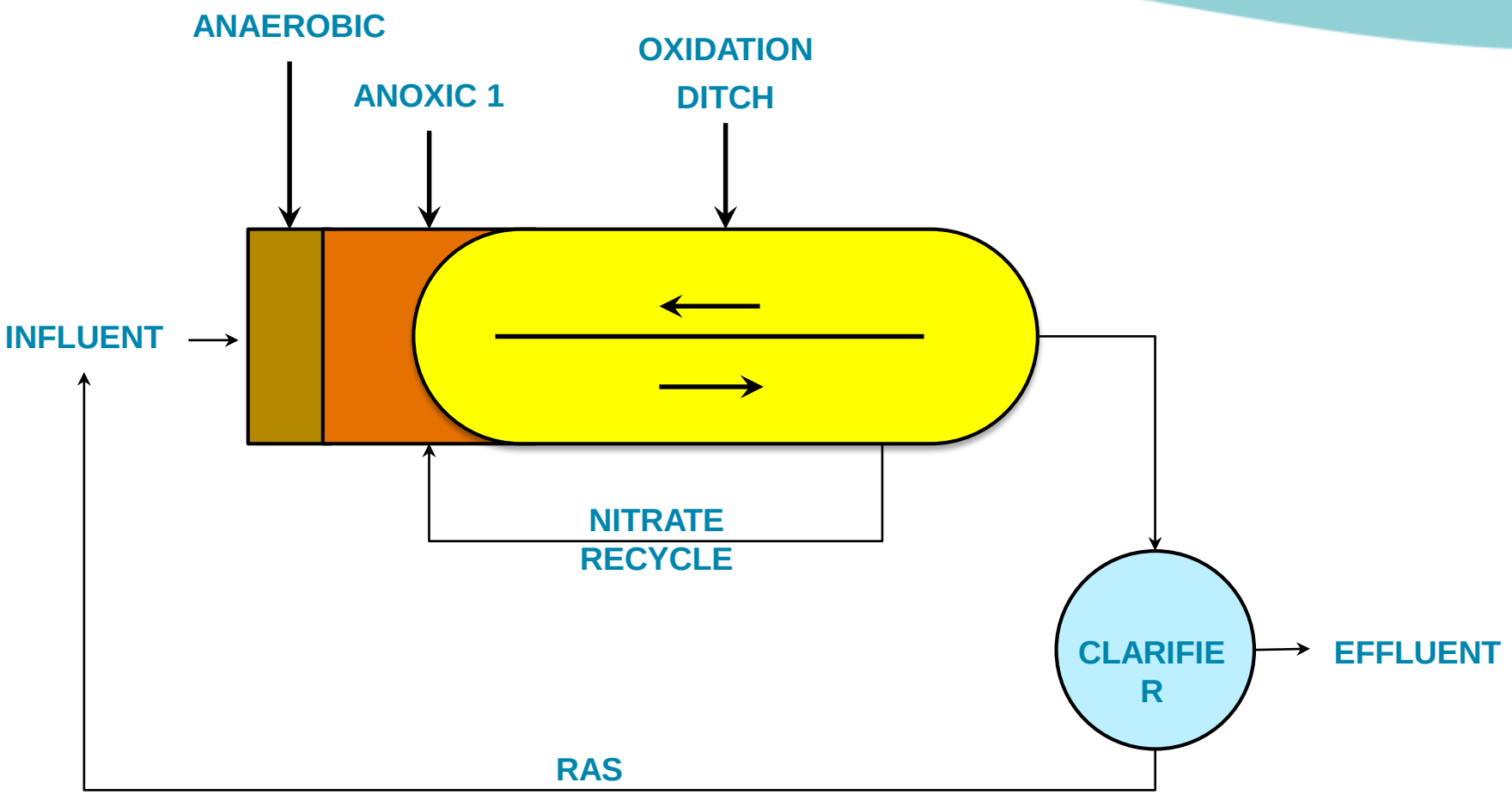
Process Configurations

Modified Ludzack-Ettinger (MLE)



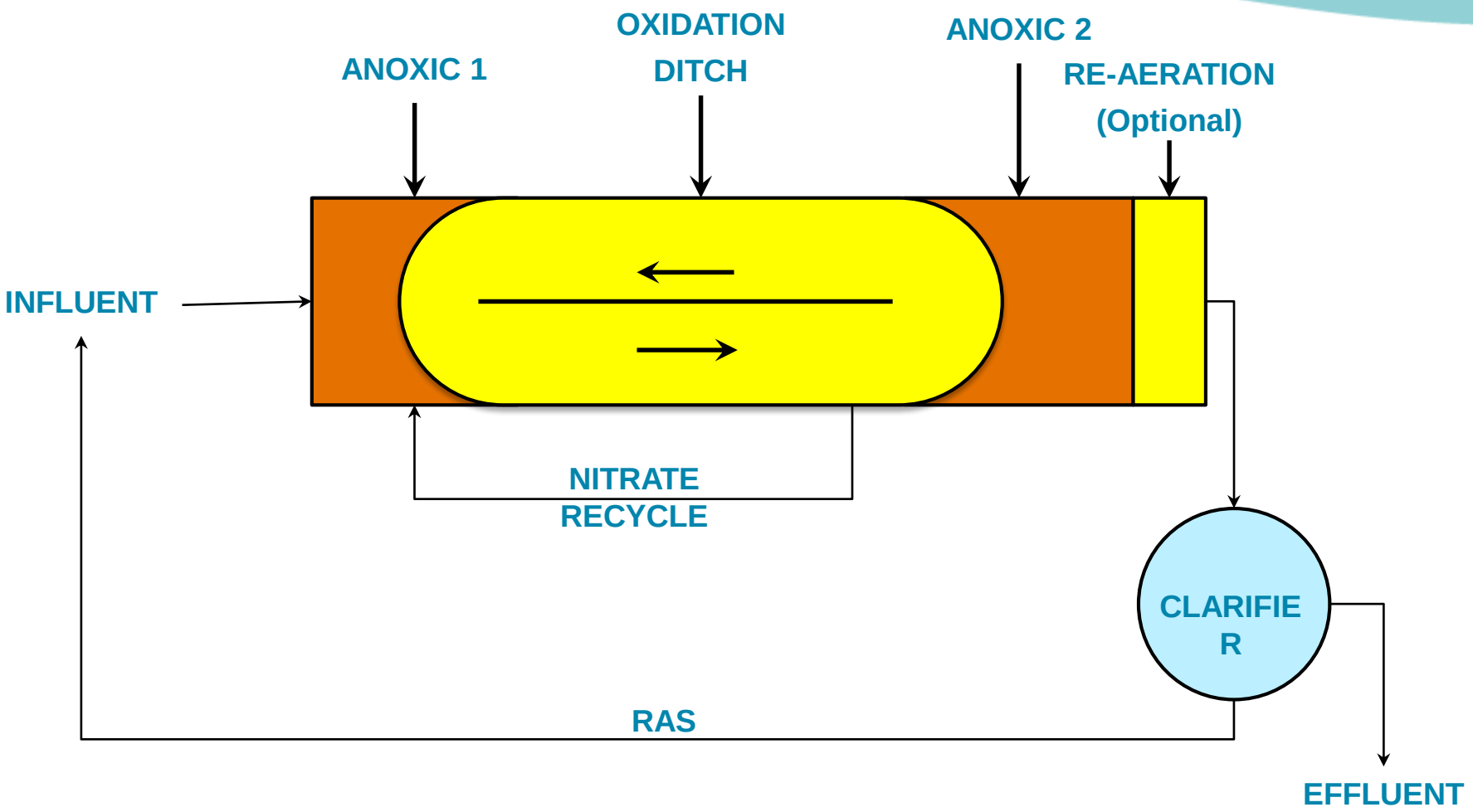
Process Configurations

A^2O



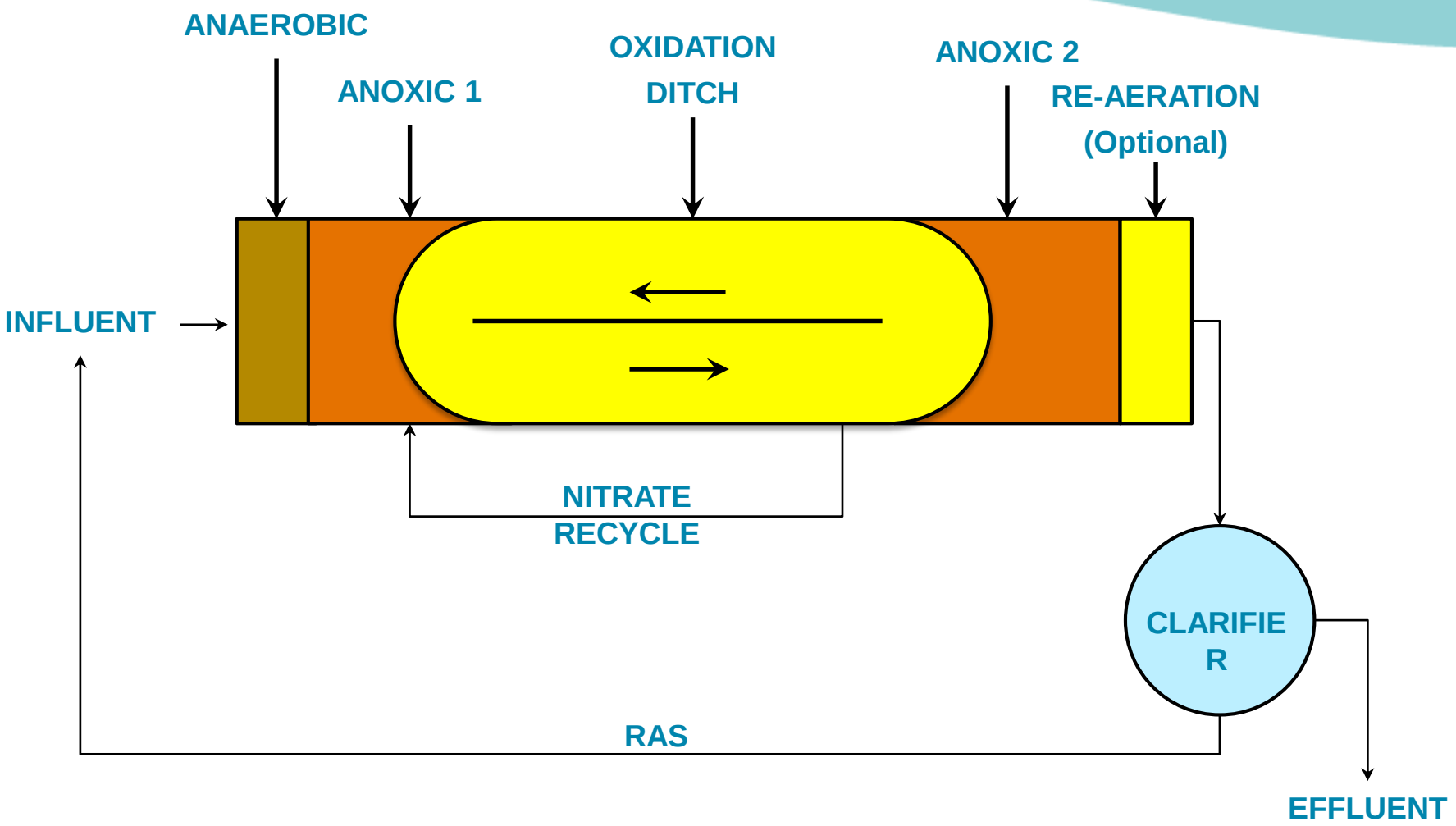
Process Configurations

Bardenpho 4-stage (w/ optional reaeration)

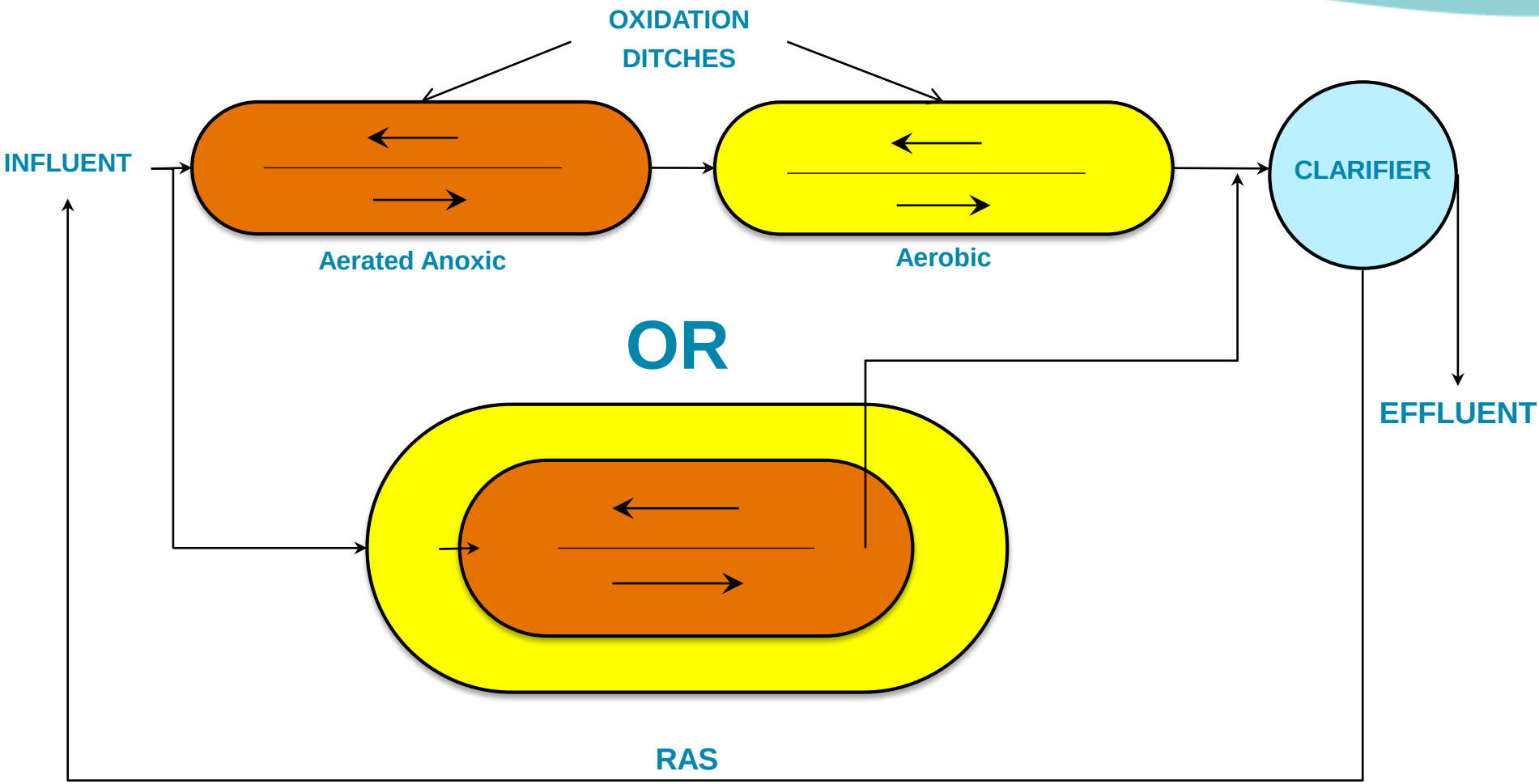


Process Configurations

Bardenpho 5-stage (w/ optional reaeration)



Bioloop SNDN Process



Process Comparison

	BOD & TSS	NH_3	TN	Bio-P	Pros	Cons
NIT	X	X			• Low Capital Cost	• Higher Energy Cost • Potential for Poor Settling • Supplemental Alkalinity may be needed
MLE	X	X	< 8 mg/L		• High F:M in Anoxic Zone selects out filamentous bacteria • Denitrification recovers alkalinity	• Increased capital cost to add anoxic zone and mixers
A_2O	X	X	< 8 mg/L	X	• Same as MLE • Reduced chemical costs to meet P-removal requirements	• Same as MLE, with extra capital cost of anaerobic zone
Bardenpho 4-stage	X	X	< 3 mg/l		• Same as MLE, except lower effluent TN is possible	• Same as MLE, with extra capital cost of post-anoxic & re-aeration zones
Bardenpho 5-stage	X	X	< 3 mg/l	X	• Same as A_2O, except lower effluent TN and TP is possible	• Same as A2O, with extra capital cost of post-anoxic & re-aeration zones
SNDN	X	X	< 5 mg/L	Bio-P if anaerobic zone included	• High F:M in Aerated Anoxic Zone selects out filamentous bacteria • Lower construction cost without anoxic reactor or nitrate recycle • Lower power consumption, with significant oxygen transfer in low DO zone	Requires two or more ditches in series

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5. Aeration & Mixing

Aeration

Sanitaire aeration system

- Energy efficient aeration
- Minimal maintenance
- Time proven durability

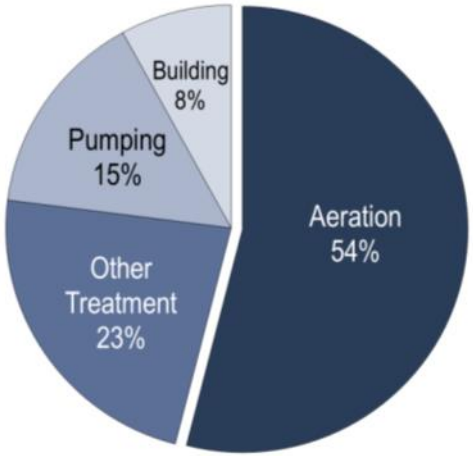
Fine Bubble Membrane Diffusers

Mechanical Features

- Advanced membrane material engineered for domestic and industrial applications
- Piping system accommodates thermal expansion and contraction
- Fixed joints prevent air leakage, pipe separation and distributor rollover
- Rugged stainless steel supports, infinitely adjustable within their range

Aeration Equipment

Largest Performance Data Base in the Industry Substantiates Aeration System Design



- Fine bubble diffused aeration
- Full floor coverage
- Flexible aeration range
- Highly efficient aeration transfer
- Will guarantee aeration efficiency

Significant Cost Savings Gained Through Efficient Design of Aeration System and Control

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Submersible Mixers

- Flexible installation & positioning
- Proven in wastewater applications
- Over 100,000 in operation worldwide
- Energy efficient
- Variety of sizes and options
- Nutrient removal

Submersible Mixers

- Slow speed—large diameter
- Perfect for maintaining velocity in oxidation ditch
- Energy efficient
- Variety of sizes and options
- Flygt dependability

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6. Control System

OSCAR Process Performance Optimizer

Analyze and optimize performance

Oxygen control

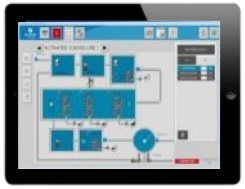
Biomass control (SIMS/SRT)

Water quality control

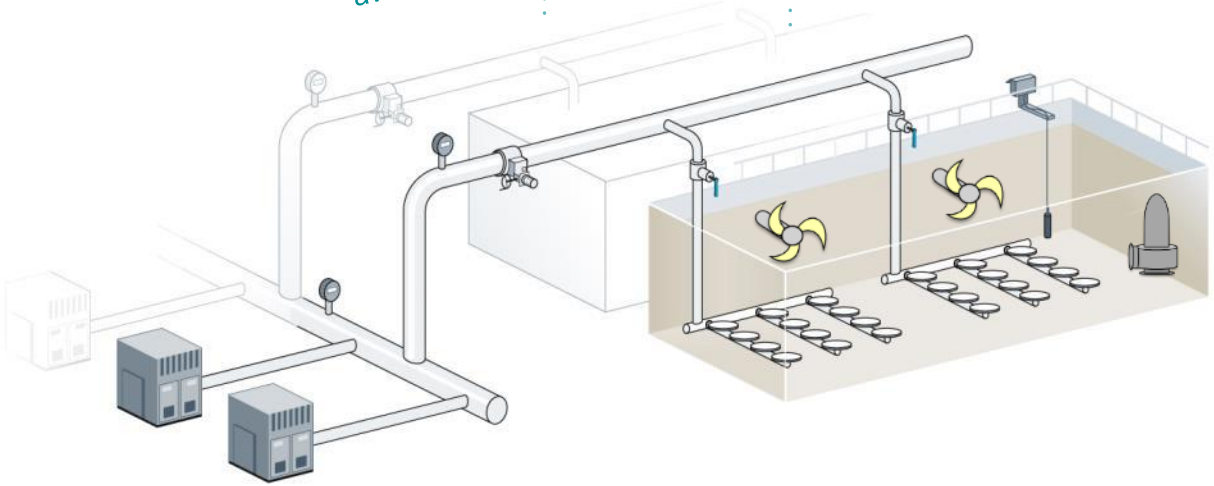
Sufficient oxygen availability

Stabilize process

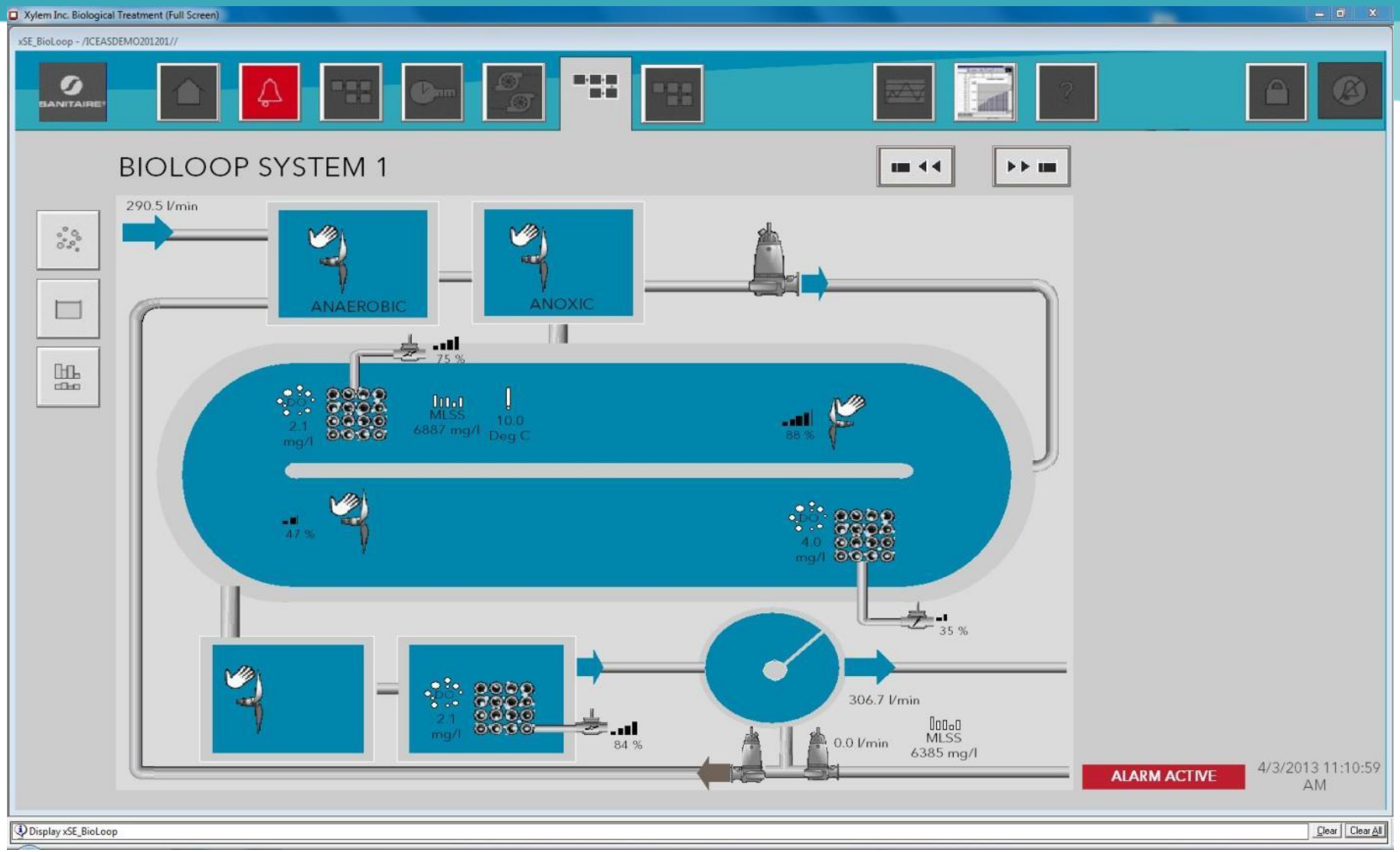
Stabilize effluent qualities



Performance and compliance reporting



Oxidation Ditch - GUI design



IQ SensorNet Probes

PO_4

Conductivity

pH / ORP

Turbidity / TSS

DO

ISE:

- Ammonium, Nitrate, Chloride, Potassium

Optical UV:

- Nitrate
- Nitrite
- COD, BOD TOC, DOC
- UVT-254
  - SAC
  - TSS

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7. Installations

Conversion of Ditches with Mechanical Aerators to Fine Bubble with Submersible Mixers

South Water Reclamation Facility, Orlando, FL – 20 MGD

52% energy savings

Eunice, LA – 1 MGD

50% energy savings

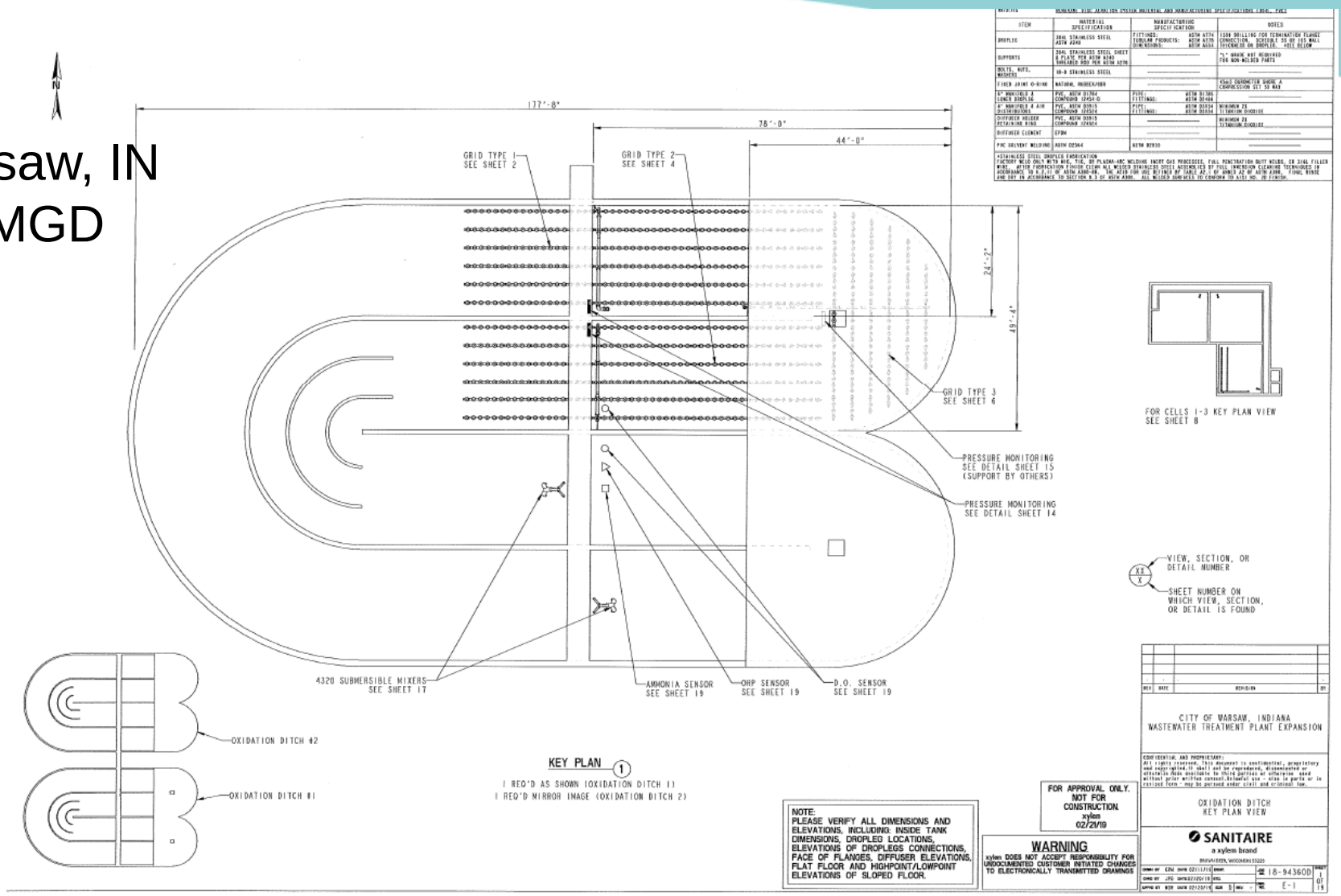
Ditch in Series (SNDN) Retrofit

Tifton, Georgia
6 MGD

- Previous mechanical surface aerator/mixer
- Process design
- System responsibility
- Integrated control package
- DO/ORP control

Ditch in Series (SNDN) Retrofit

Warsaw, IN
3.9 MGD



Ditch in Series (SNDN) Retrofit – Warsaw, IN

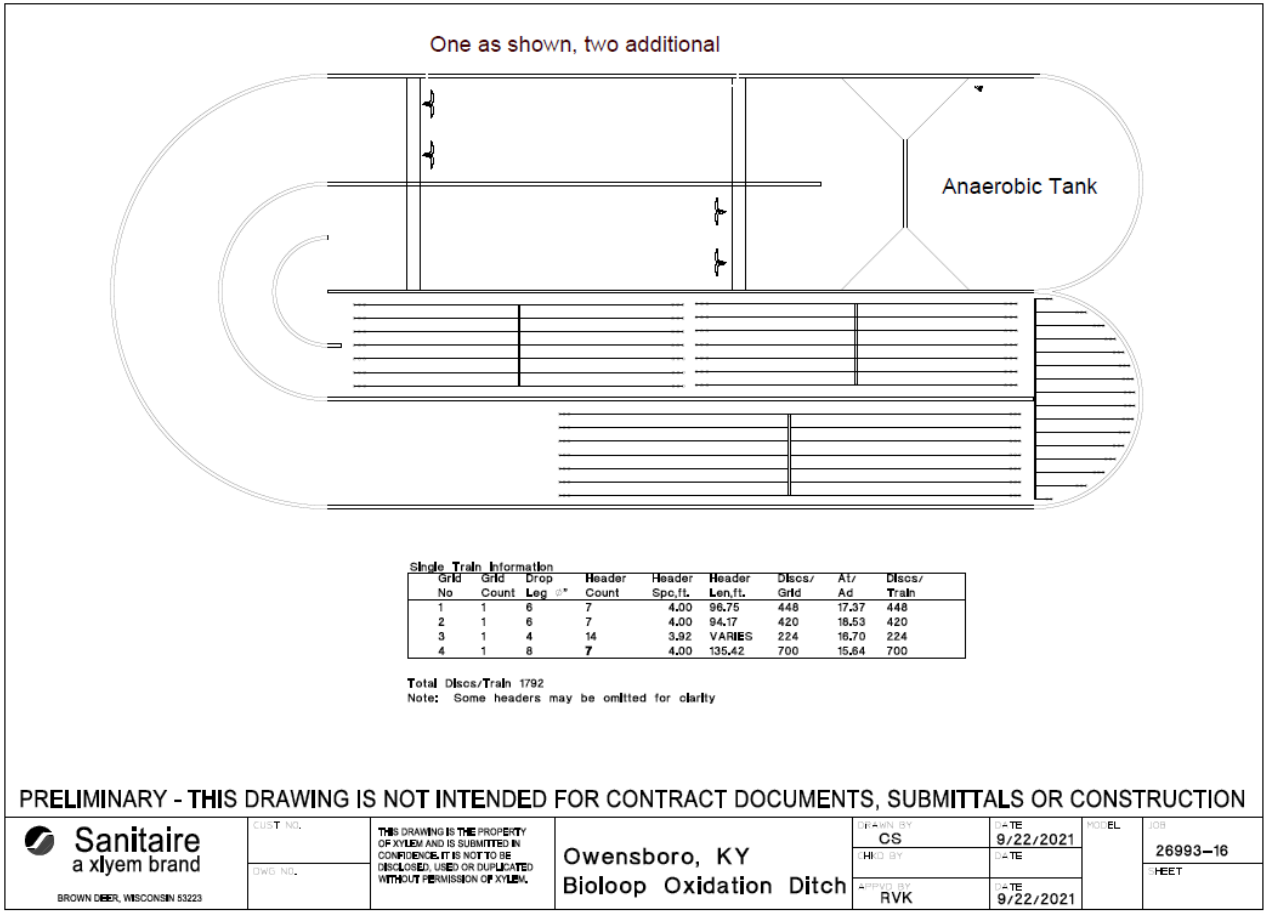
Parameter	2017 before Expansion (Average)	2018 before Expansion (Average)	2021 after Expansion (Jan-May)
Ave Design Flow	3.96	3.88	3.28
Peak Design Flow	6.96	8.38	8.8
Ave Effluent BOD	2.6	2.6	2.3
Ave Effluent TSS	4.5	4.6	3.1
Ave Effluent NH4-N	0.23	0.53	0.35
Ave Effluent TP -	3.2	2.7	0.62

Ditch in Series (SNDN) Retrofit – Warsaw, IN

Parameter (kwh)	2017	2019	2020	2021
Jan	250,000	301,200	292,200	174,400
Feb	276,000	280,200	294,400	196,600
March	282,800	265,600	280,200	264,200
April		323,000	301,600	187,600
May	314,000	311,000	293,800	166,800
June	282,000	335,200	307,000	
July	299,800	320,800	268,200	
August	300,400	325,000	291,200	
Sept	314,800	320,600	233,200	
Oct	306,600	307,200	213,000	
Nov	298,400	306,000	170,800	
December		286,600	185,400	

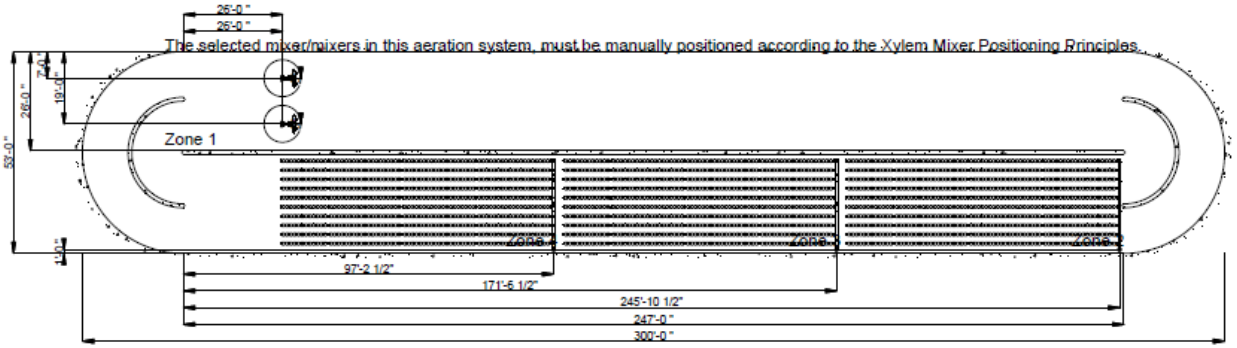
SNDN Retrofit – Owensboro, KY (Max Rhodes)

- 20 MGD capacity
- Competitive Bid based on Present Worth Analysis
- Contract Awarded Feb. 2022
- Construction slated for Q4 2022



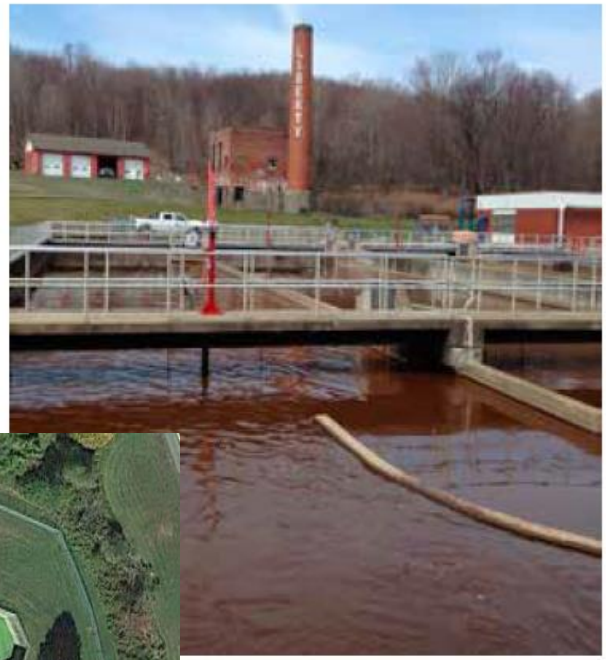
SNDN Retrofit – Owensboro, KY (David Hawes)

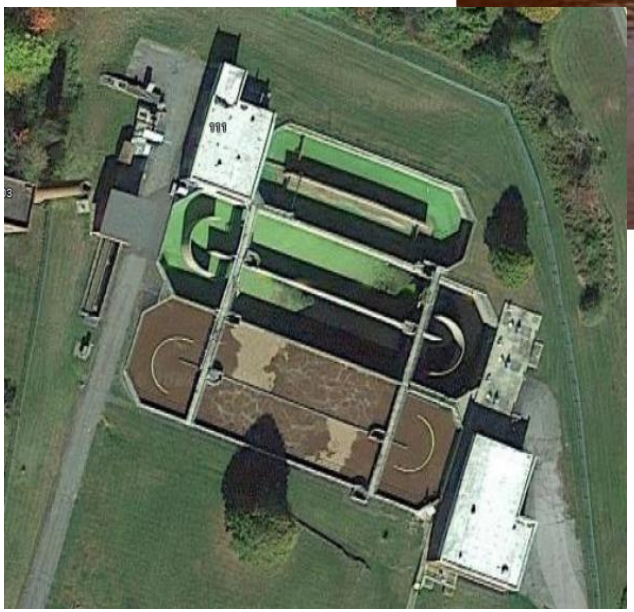
- 4.8 MGD capacity
- Competitive Bid based on Present Worth Analysis
- Contract Pending Award
- Construction slated for Q4 2023



SNDN Retrofit – Liberty, NY

- 2 MGD capacity
- Existing Brush Aerators (100 HP total per basin)
- Two 50 HP blowers and submersible mixers
- Reduced energy by 43% saving $36,000 per year
- More stable treatment





SNDN Retrofit – Tennessee, USA

(Condition audit performed in September 2013)

- 11.5 MGD capacity
- Preliminary sizing calculations predicted energy savings of 52% vs. existing disc aerators

Bioloop SNDN Retrofit – Kentucky, USA

(Calculations performed in April 2014)

- 4.5 MGD capacity
- Preliminary sizing calculations predict energy savings of 36% vs. existing disc aerators

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Let’s solve water