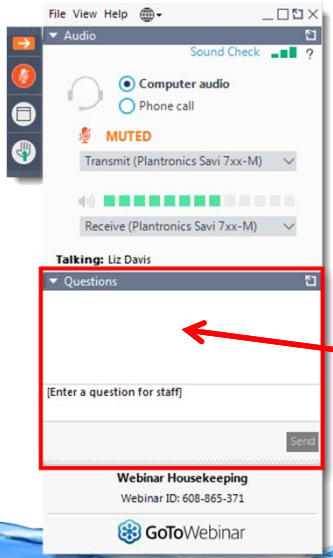
# The Modern Oxidation Ditch

## *We're Not Just Going In Circles!*

TRANSFORMING WATER. ENRICHING LIFE.



## How to Participate Today




- **Audio Modes**
  - Listen using Mic & Speakers
  - Or, select "Use Telephone" and dial the conference (please remember long distance phone charges apply).
- **Submit your questions using the Questions pane.**
- **A recording will be available for replay shortly after this webcast.**

# PRESENTERS

**MIKE DOYLE P.E.**

*38 years in the wastewater industry*

*Senior Process Engineer at Evoqua*

**SERGIO PINO-JELCIC**

*20 years in the wastewater industry*

*Technical Sales Manager for Biological Process Equipment at Evoqua*




# Don't Ditch the Ditch!

## Modern Oxidation Ditches

***Aerial View of the Spring Creek WWTP – Springfield, IL – 32 MGD (121 MLD)***

## Oxidation Ditch – History and Overview

- First used in Holland in 1950's – "Dutch Ditch" by A. Pasveer
- Single race track configuration, shallow depth
- Surface aerator to provide mixing and aeration, horizontal "Kessener" brush
- Extended aeration
  Low load - 15 lb BOD/d/1,000 $ft^3$ (0.24 $kg/m^3/d$), 24 hr HRT
  Long SRT. Low Yield. Stable operation
- Excellent BOD, TSS, $NH_3$ removal but high nitrates and little P removal




## Question: Is the Oxidation Ditch still a Relevant Technology?

- *Old and outdated – OK for BOD/TSS/NH3 but what about BNR?*
- *Uses too much land?*

## WERF State of the Art Review

SECTION ONE

**NITROGEN REMOVAL USING OXIDATION DITCHES**

**H. David Stensel, Ph.D., P.E.**
University of Washington

and

**Thomas E. Coleman**
Thomas E. Coleman Consulting Services

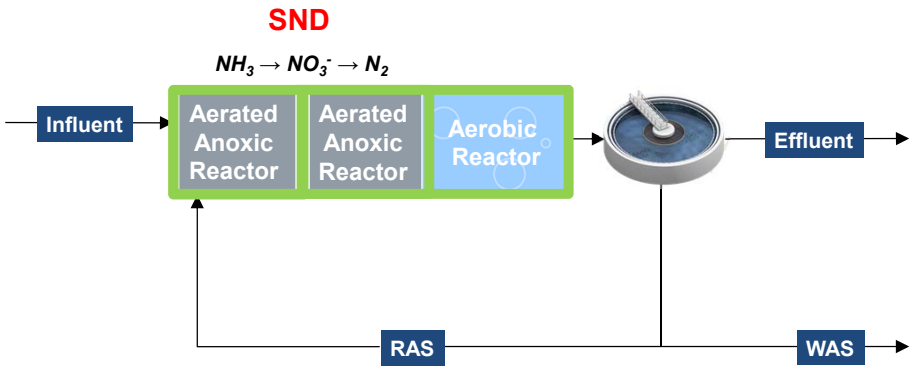
*Previously published as a final report for the project in 2000 (publication number D00309)*




## Conclusions – Stensel and Coleman

- Reviewed installations by Veolia (Kruger Bio-Denitro™), Ovivo (Carrousel®) and Evoqua (Orbal® System)
- Well designed and operated plants with <5 mg/L TIN, many with <3 mg/L
- Generally good settling and thickening sludge
- DO control usually needed
- Categorized systems achieving BNR based on: 1) *control technology*, 2) *use of pre-anoxic tanks*, or 3) *simultaneous nitrification/denitrification*

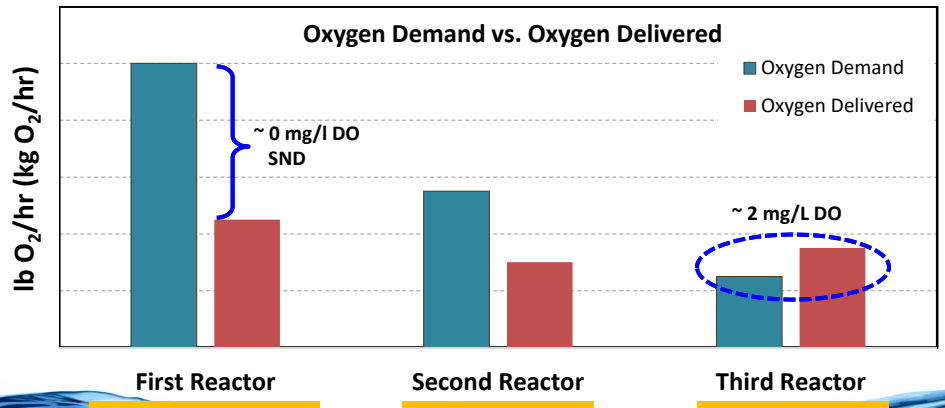
## Simultaneous Nitrification-Denitrification (SND)

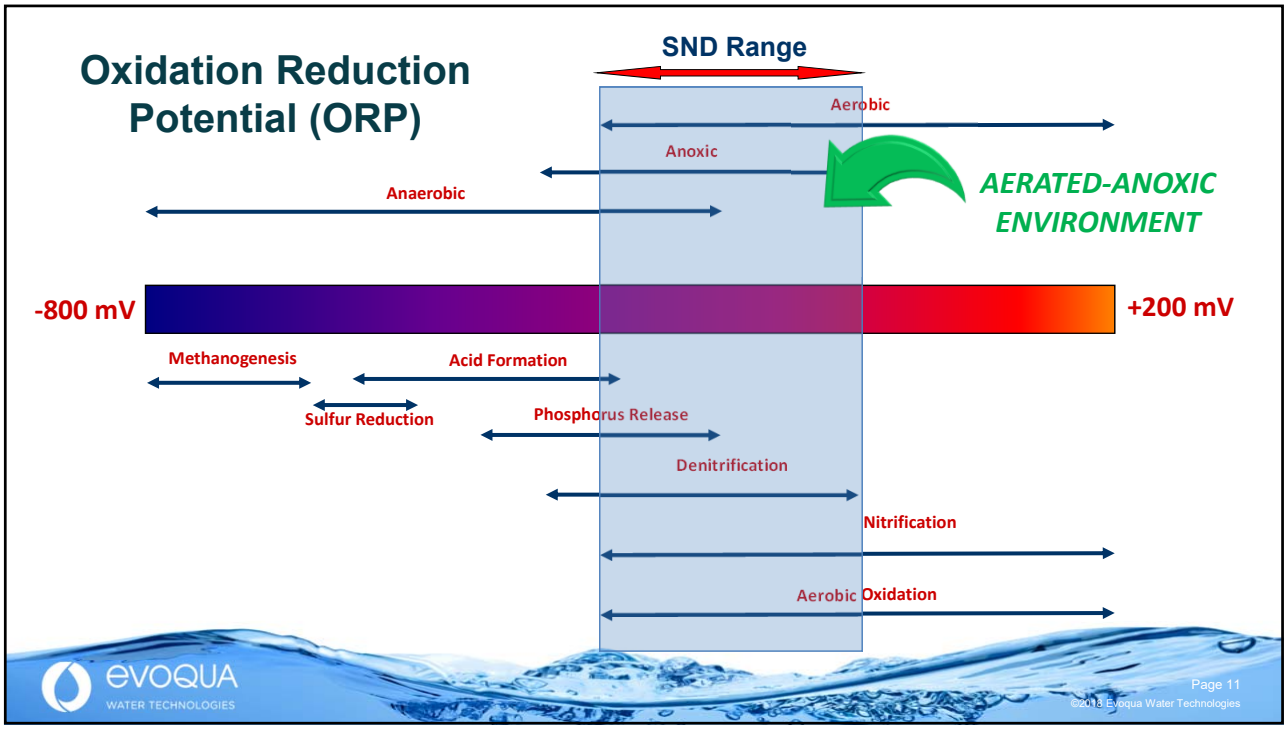



- Up-front reactors with **Aerated-Anoxic** environment. Mild aeration (DO= ~0 mg/L).
- No dedicated anoxic basin required.
- No internal recycle required for total nitrogen removal (80% TN removal).
- Bio-P also achievable in Aerated-Anoxic environment.

## What is Aerated-Anoxic?

- $O_2$ delivered < 75% of $O_2$ demand. Up-front reactors with high substrate.
- Last reactor with low substrate operated with an oxygen residual. $O_2$ delivered > $O_2$ demand




Oxidation Reduction Potential (ORP)
SND Range
Aerobic
Anoxic
Anaerobic
AERATED-ANOXIC ENVIRONMENT
-800 mV
+200 mV
Methanogenesis
Acid Formation
Sulfur Reduction
Phosphorus Release
Denitrification
Nitrification
Aerobic Oxidation
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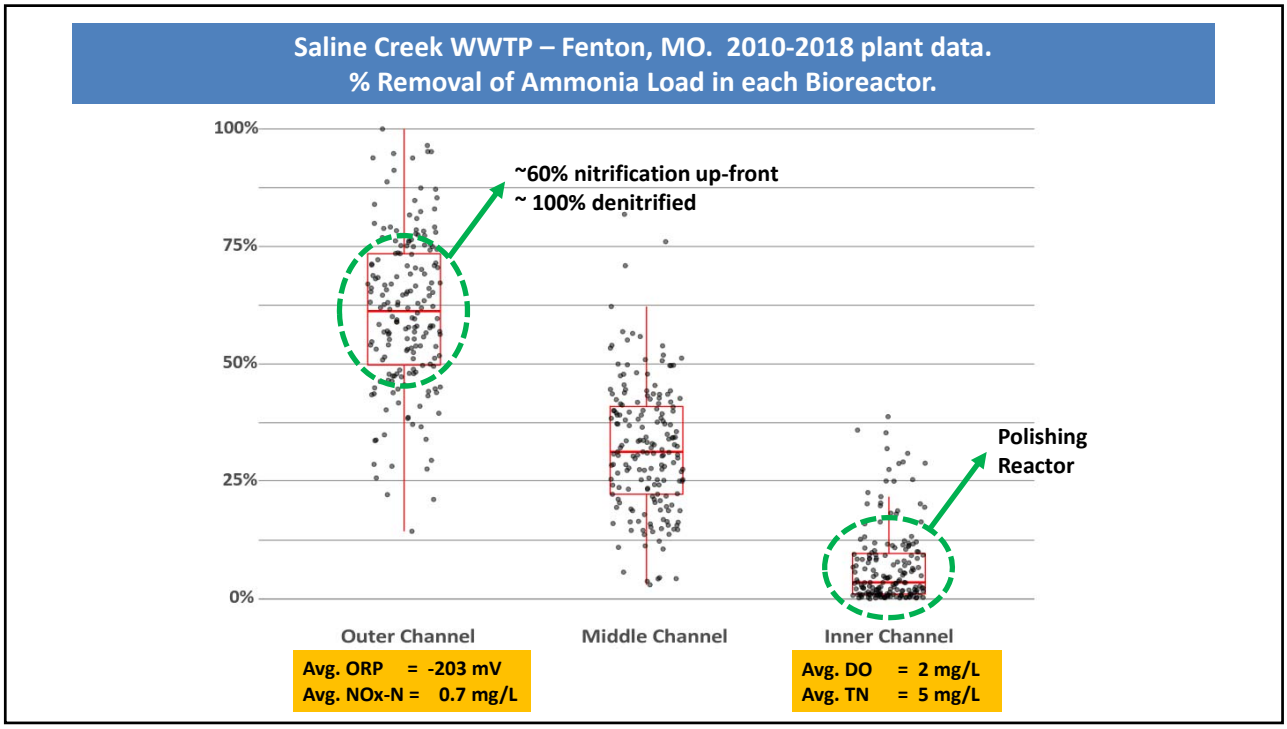

Saline Creek WWTP – Fenton, MO. 2010-2018 plant data.
% Removal of Ammonia Load in each Bioreactor.
100%
75%
50%
25%
0%
~60% nitrification up-front
~ 100% denitrified
Polishing Reactor
Outer Channel
Middle Channel
Inner Channel
Avg. ORP = -203 mV
Avg. NOx-N = 0.7 mg/L
Avg. DO = 2 mg/L
Avg. TN = 5 mg/L

## Orbal® System

Introduced in 1968

Multichannel oxidation ditch operated in series

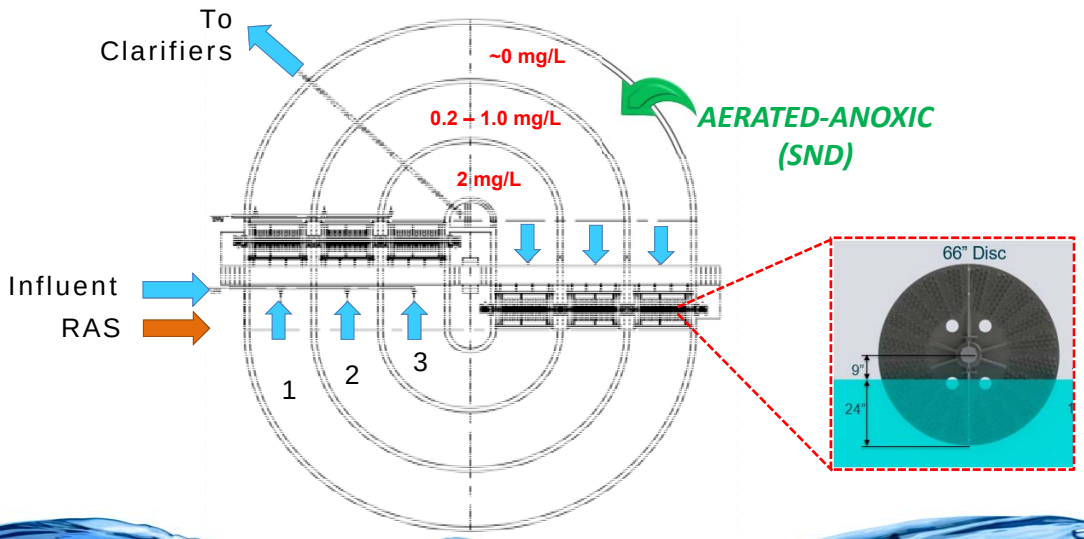
Outer channel is first reactor (aerated-anoxic)

Typical flow: < 3 MGD (11 MLD)

Up to 16’ (4.9 m) SWD

Over 800 installations

## Orbal System Plan View – Flow Pattern and DO profile



## VLR® System

Introduced in 1986

Rectangular reactors operated in series

Up to 25’ (7.6m) SWD

Typical Flow > 5 MGD (19 MLD)

100 installations

## VertiCel® System

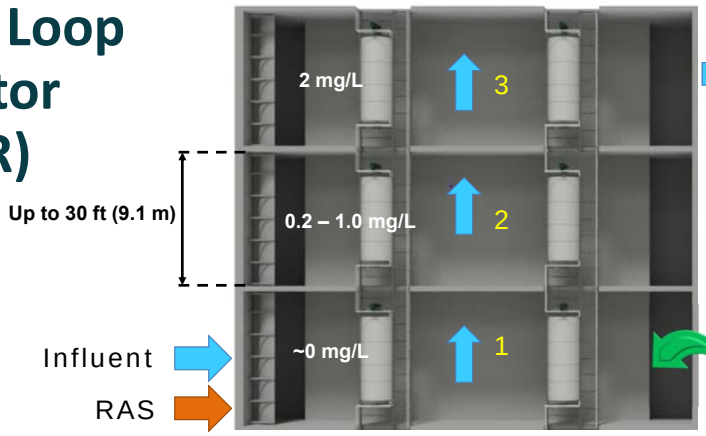
Introduced in 1998

Hybrid Aeration

VLR + FB diffusers

25 installations

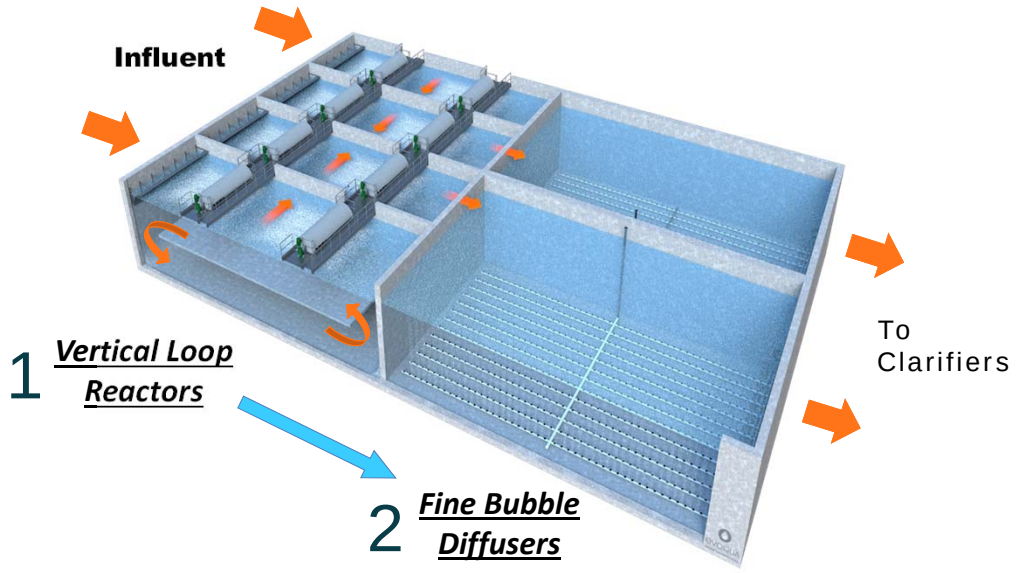
## Vertical Loop Reactor (VLR)




VLR Plan View


VLR Section View

# Hybrid Aeration - VertiCel




# Energy Requirements – Comparison of Aeration Technologies

| | Low Speed Disc Aerator | Fine Bubble Diffuser |
|---|---|---|
| SAE -[lbs $O_2$ / BHP-hr] [kg $O_2$ / kW-hr] | **3.45 (2.1)** | **6-10 (3.6-6)** |

**Standard Aeration Efficiency (SAE):**

- SAE is a measure of the amount of oxygen delivered per unit of energy added (lbs $O_2$ / HP–Hour or kg $O_2$ / kW–Hour).
- Standard conditions exist when the temperature is 20°C, the DO is 0.0 mg/L, and the test liquid is tap water.

## Oxygen Requirements

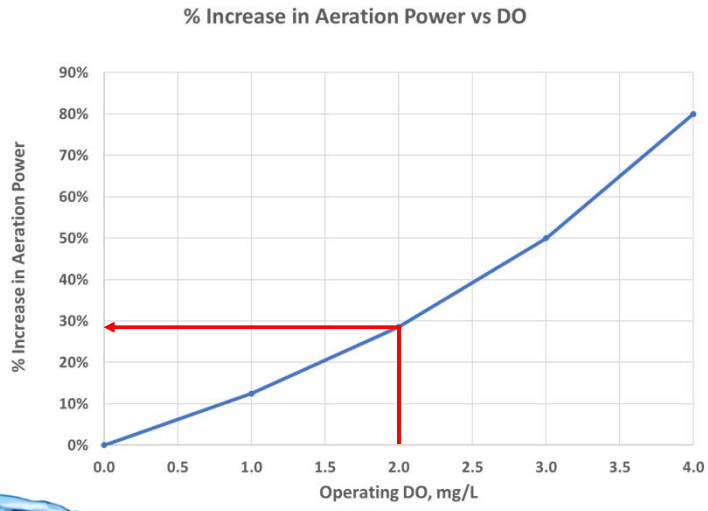
$$\frac{AOR}{SOR} = \frac{\alpha\theta^{(T-20)}\left[\beta C^*_{sat\,20}\left(\frac{P_{site}}{P_{std}}\right)\left(\frac{C_{surfT}}{9.07}\right) - D.O.\right]}{C^*_{sat\,20}} F$$

**Key Parameters:**

- **DO** — The DO concentration that is desired to be maintained within the wastewater process.
- **Alpha** — Alpha is the ratio of the mass transfer coefficient in wastewater to the mass coefficient in tap water.
- **Fouling Factor** — The fouling factor is a measure of the amount of decreased efficiency is anticipated over time due to biological fouling.

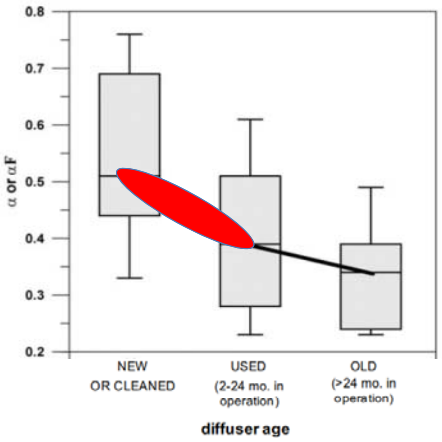


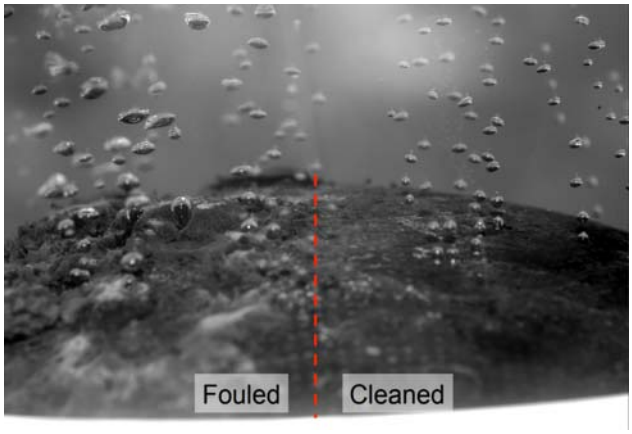

## SND – Delivering $O_2$ at Low DO Saves Aeration HP




*Comparison assumes:*
*Same AOR (lb $O_2$/h or kg/hr)*
*Same SAE (lb $O_2$/BHP-h or kg/kw-hr)*

## Diffuser - Fouling & The Impact on OTE



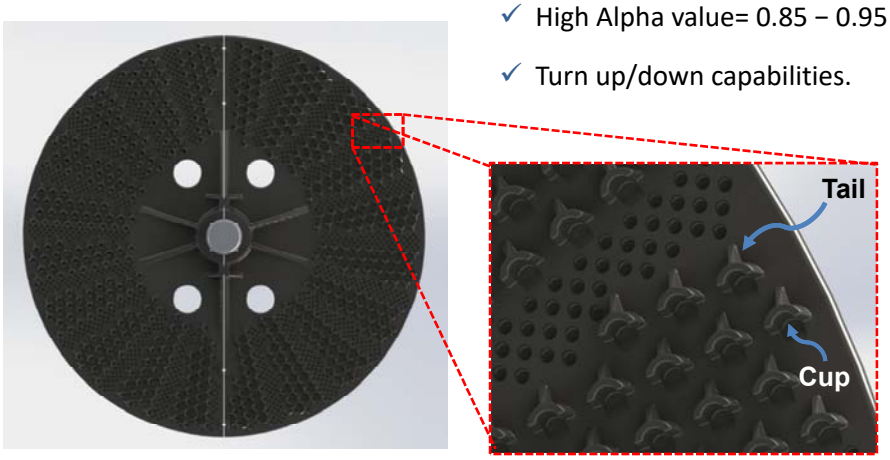

***"Commit to cleaning or do not purchase"***

*Credits: Michael K. Stenstrom*

*From "Aeration Systems Past, Present, and Future. What to Expect From Aeration System Upgrades"*
*Michael K. Stenstrom, University of California Los Angeles copyright 2006*

## Orbal Disc Aerator

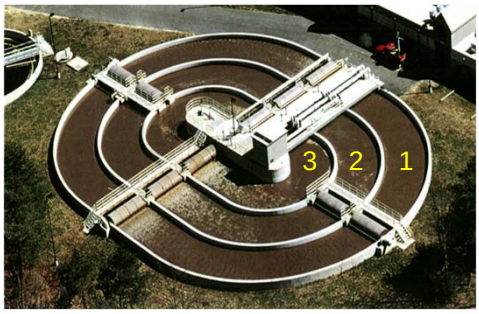
- ✓ No decrease in performance over time (F=1).
- ✓ High Alpha value= 0.85 – 0.95 (FB diffusers= 0.4 – 0.6)
- ✓ Turn up/down capabilities.




- ✓ Flexibility to add or remove discs over time.
- ✓ No need to dewater tank to maintain equipment.
- ✓ Long mechanical life.
- ✓ Provides aeration and mixing. No need for additional mixers.

## Reactors in Series

- ✓ Dedicated zones for precise control of oxygen delivery. Each reactor is completely mixed.
- ✓ Eliminates impact of short circuiting.
- ✓ Reduces sludge bulking (high F/M ratio up-front).
- ✓ Improves kinetics by having higher substrate in the 1st reactor…ie, plug flow kinetics.
- ✓ Provides operational flexibility (redundancy, expansions, and stormflows)







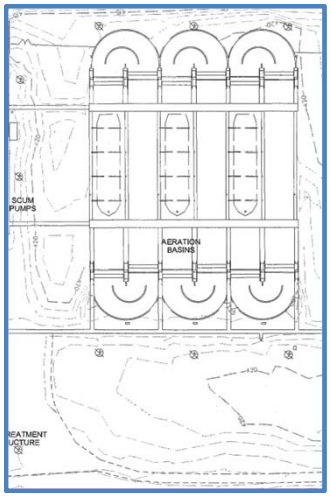
| Configuration | Effluent Quality* |
|---|---|
| 2 reactors in series | < 10 mg/L TN |
| 3 reactors in series | < 10 mg/L TN<br>< 1 mg/L TP |
| 3 reactors in series<br>with internal recycle | < 5 mg/L TN |
| 3 reactors in series<br>with internal recycle and anaerobic selector | < 5 mg/L TN<br>< 1 mg/L TP |
| 3 reactors in series<br>with internal recycle, anaerobic selector, and post-anoxic zone | < 3 mg/L TN<br>< 1 mg/L TP |

** < 10 mg/L BOD and < 10 mg/L TSS. TP w/o chemicals..*

# OK, the "Modern" Ditch is great…
# But should we Ditch the Old Ditch?




## Retrofit Case Study:
## Corinth, MS – BNR Treatment by Converting into Series

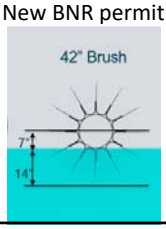



**Original Design:**

- 6 MGD (22.7 MLD)
- 3 parallel ditches, brush aerators, and with boat clarifiers

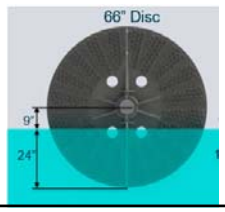
**Challenge:**

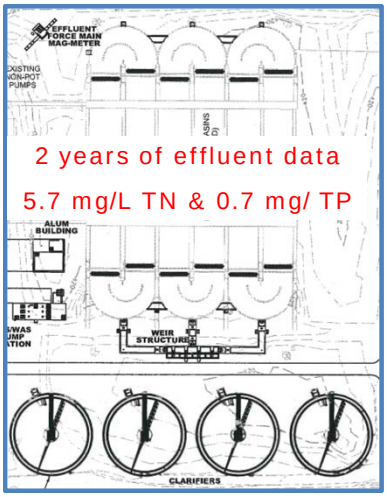
- Increase flow to 8 MGD (30 MLD)
- New BNR permit




**Solution:**

- Operate the 3 ditches in series
- Convert from brush to disc aerators
- Add circular clarifiers




2 years of effluent data

5.7 mg/L TN & 0.7 mg/ TP

## Modern Oxidation Ditch

- ✓ Robust BNR treatment (TN & TP)
- ✓ Nitrification up-front (SND). ORP control.
- ✓ Denitrification credits (SND)
  BOD consumed and alkalinity recovered
- ✓ No or less internal recycle
- ✓ Bulk of $O_2$ delivered at low DO
  20-30% less aeration energy
- ✓ Tanks in series = flexibility & stormflow
- ✓ Deep and rectangular tanks. Hybrid aeration

***Simultaneous Nitrification-Denitrification with Aerated-Anoxic Conditions***

## Thank You!

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