7th Annual Southwest Florida Water & Wastewater Exposition

Region 8

American Water Works Association
AWWA FLORIDA
Florida's Water Professionals
Region V

Florida Water Environment Association
Southwest Chapter

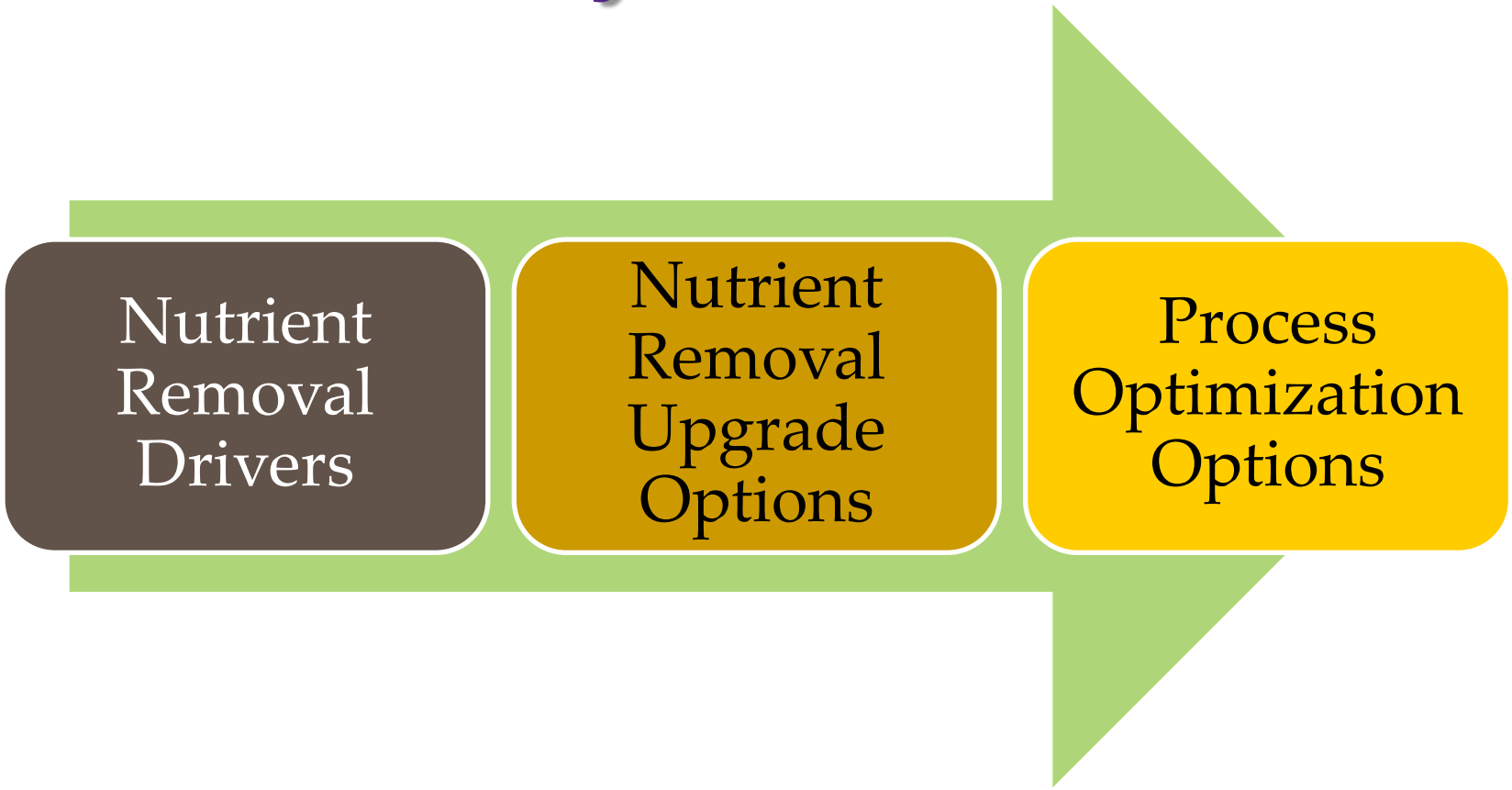
# Getting the Most out of the Ditch:
## Enhanced Nutrient Removal Upgrade Options

Jeffrey S. Lowe, P.E.
Matthew S. Love, P.E.

*September 11, 2014*

McKIM&CREED

# Our Journey




McKIM&CREED

# Enhanced Nutrient Removal Drivers

CHAPTER 369

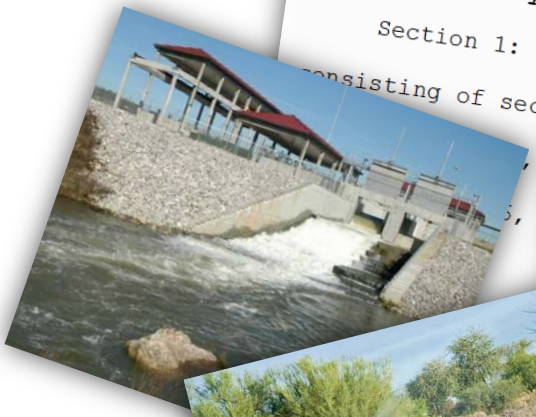
PART IV

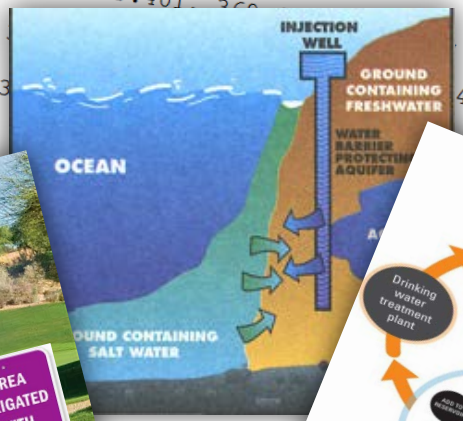
SPRINGS PROTECTION

Be It Enacted by the Legislature of the State of Florida.

Section 1: Part IV of chapter 369, Florida Statutes,

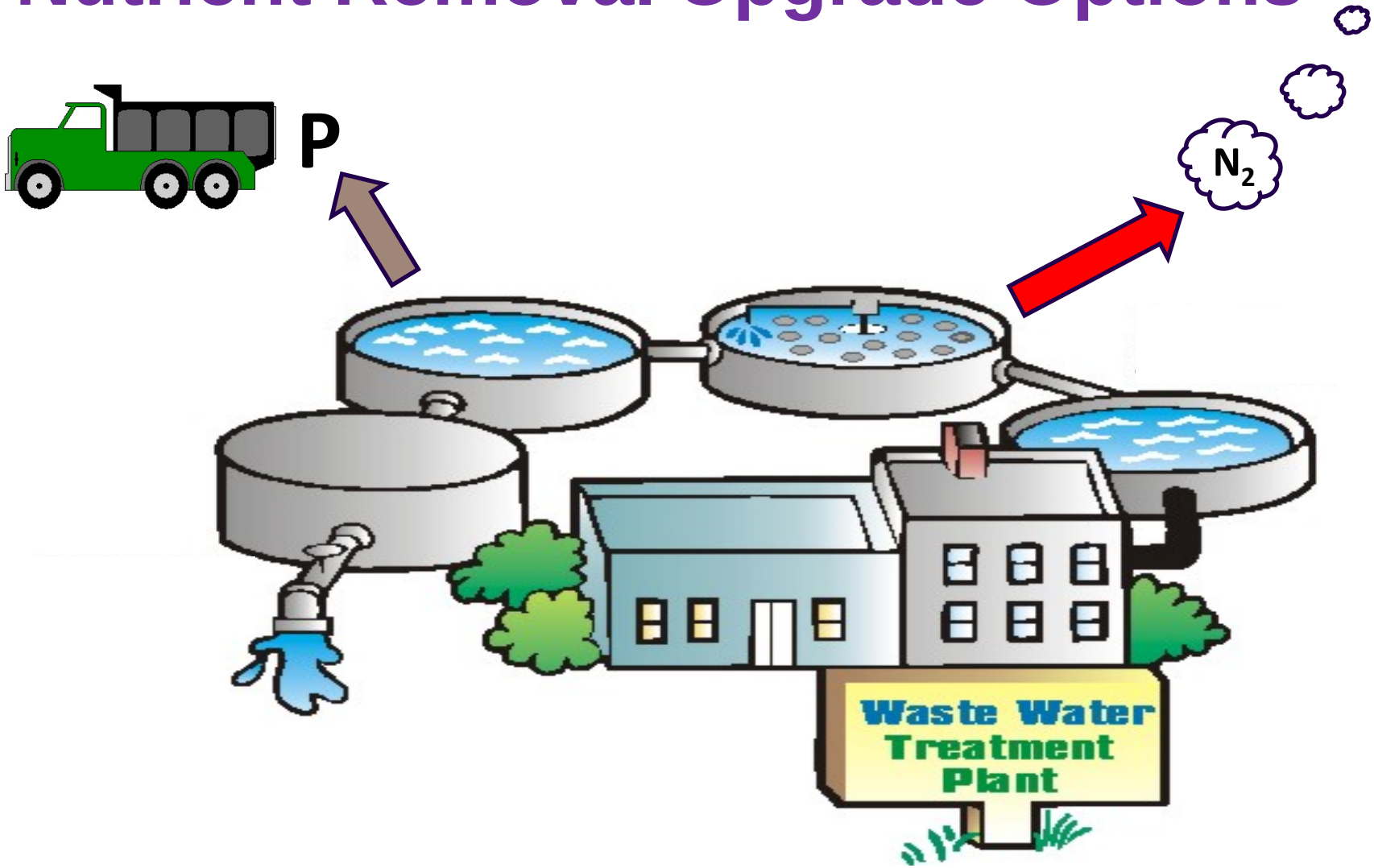
consisting of sections 369.401,





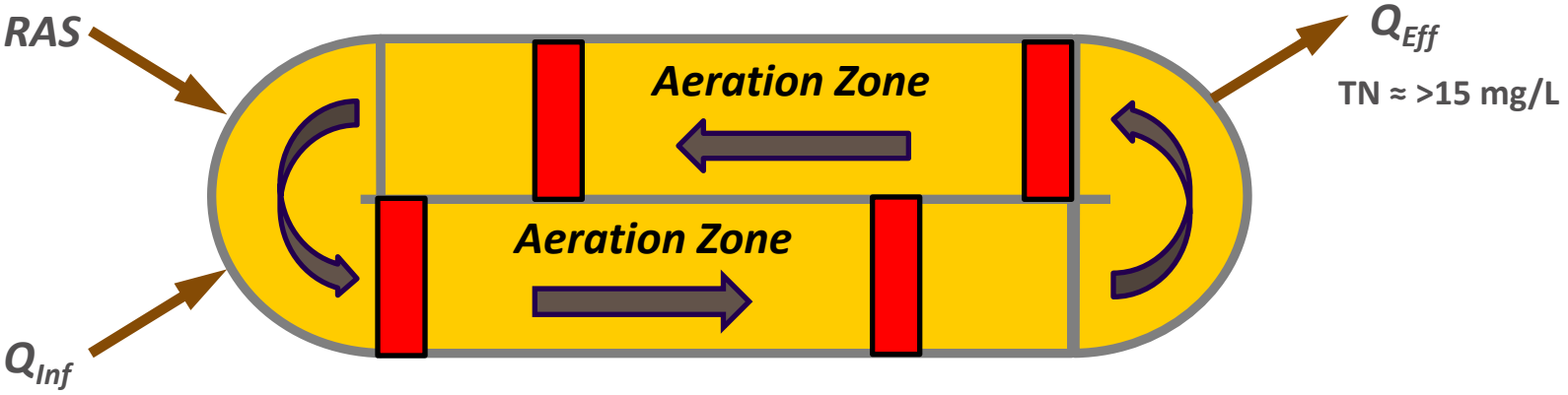
McKIM&CREED

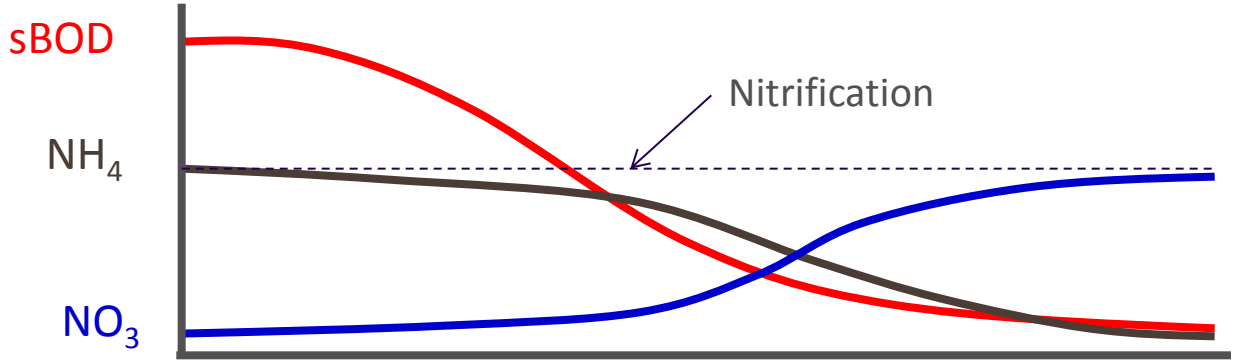
# Nutrient Removal Upgrade Options




McKIM&CREED

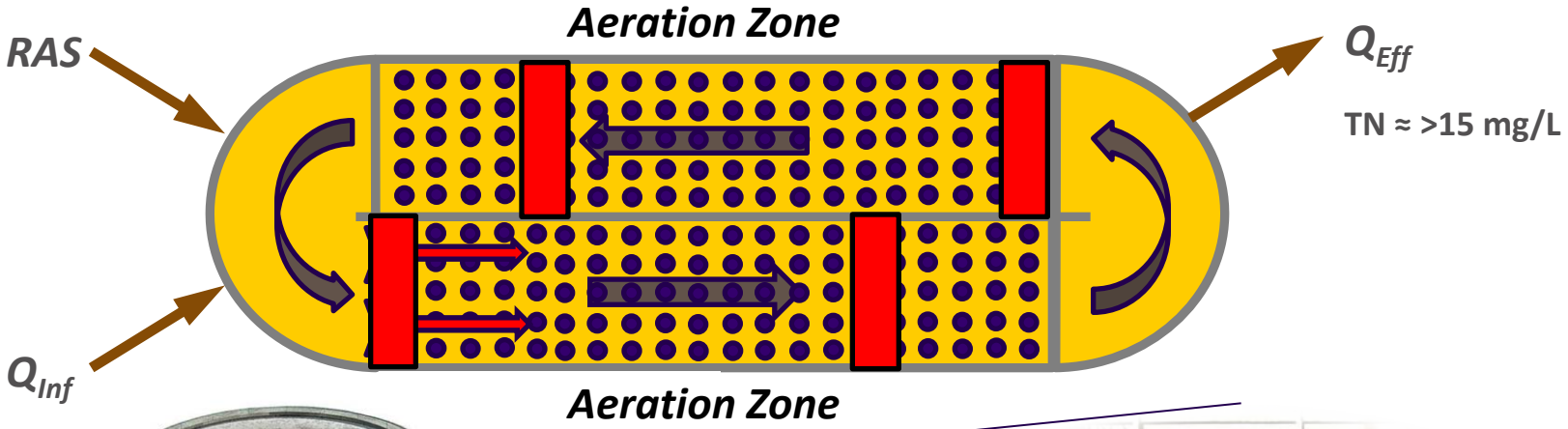
# Conventional Oxidation Ditch




McKIM&CREED

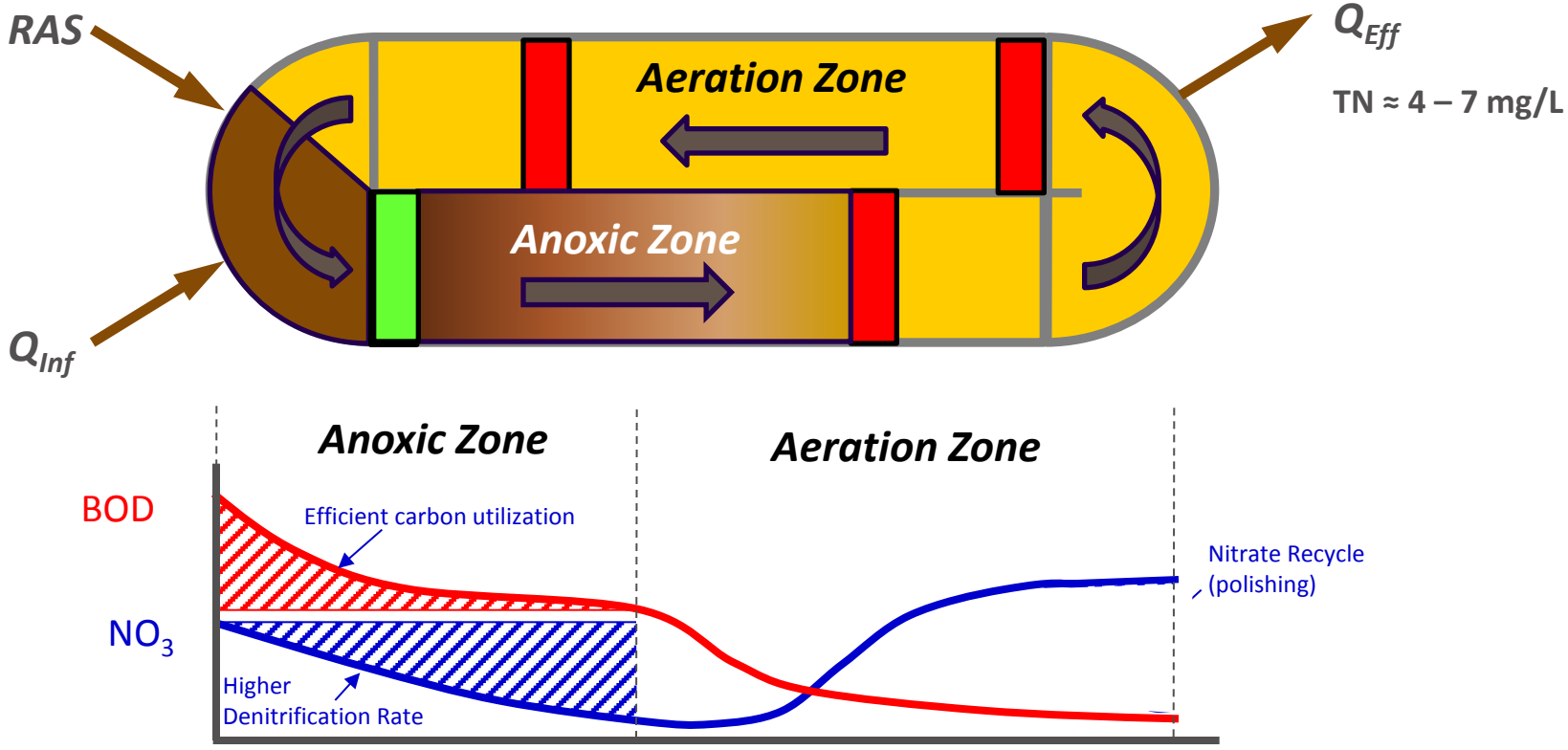
# Fine Bubble Aeration Conversion



Sanitaire Bioloop®

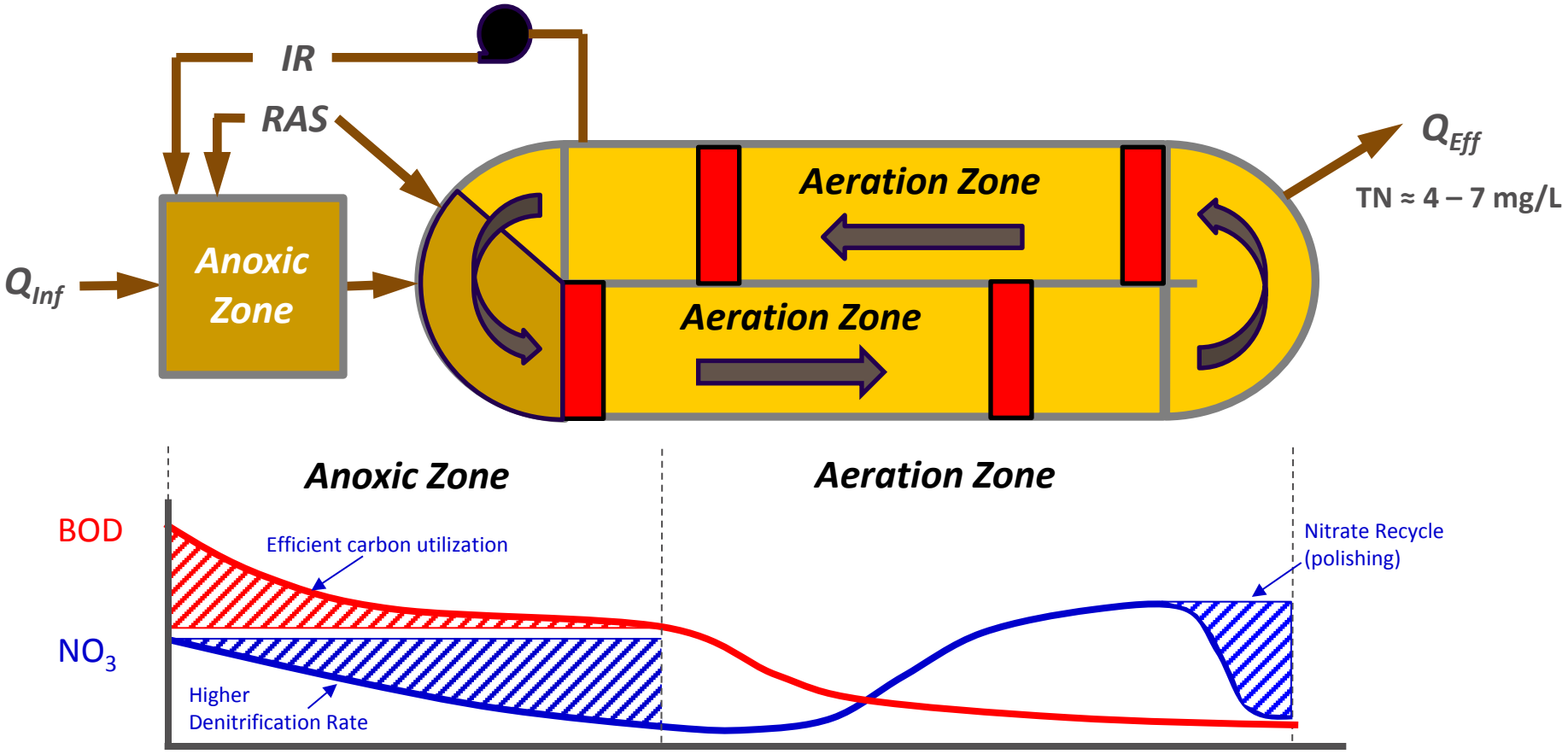
McKIM&CREED

# Modified Ludzack-Ettinger (MLE) In-Channel Anoxic Zone



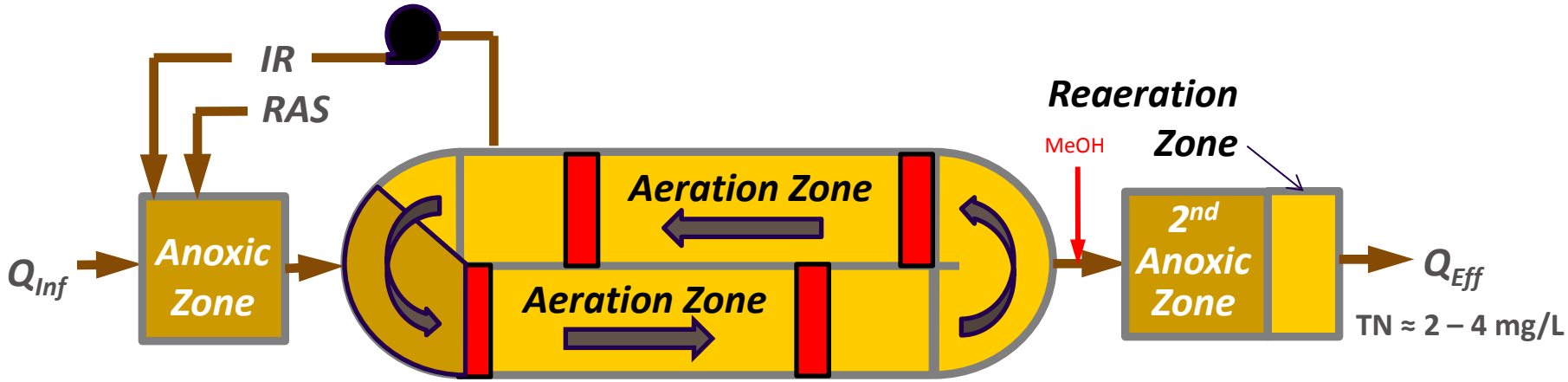

McKIM&CREED

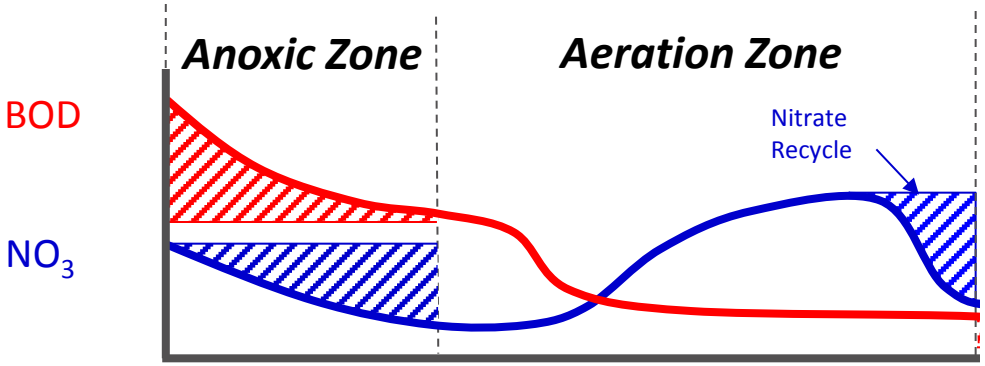
# Modified Ludzack-Ettinger (MLE) External Anoxic Zone




McKIM&CREED

# Advanced Denitrification: 4-Stage Bardenpho

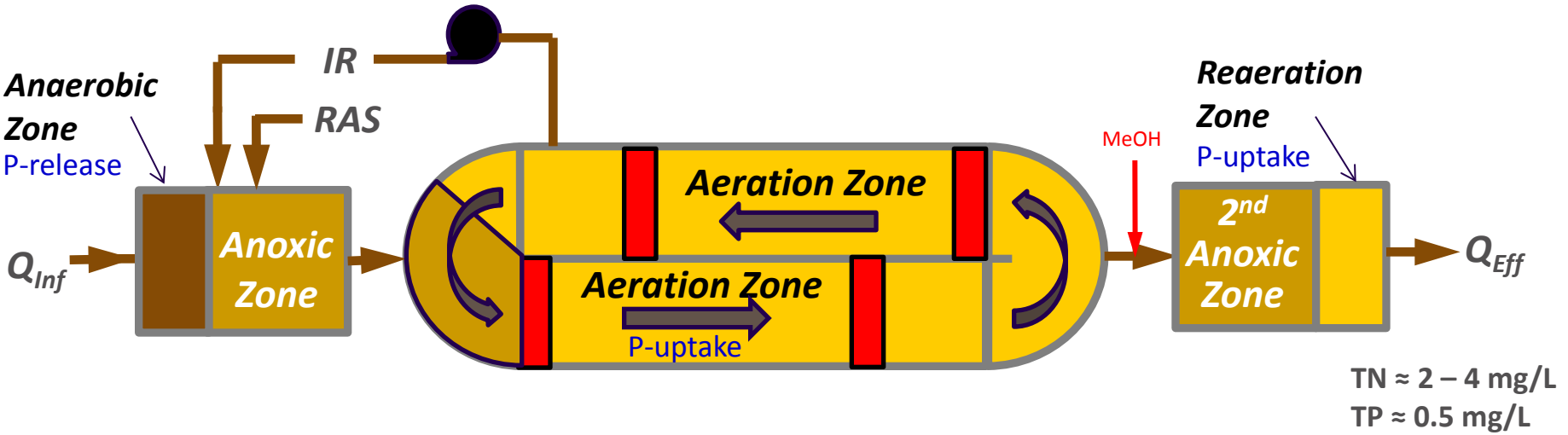


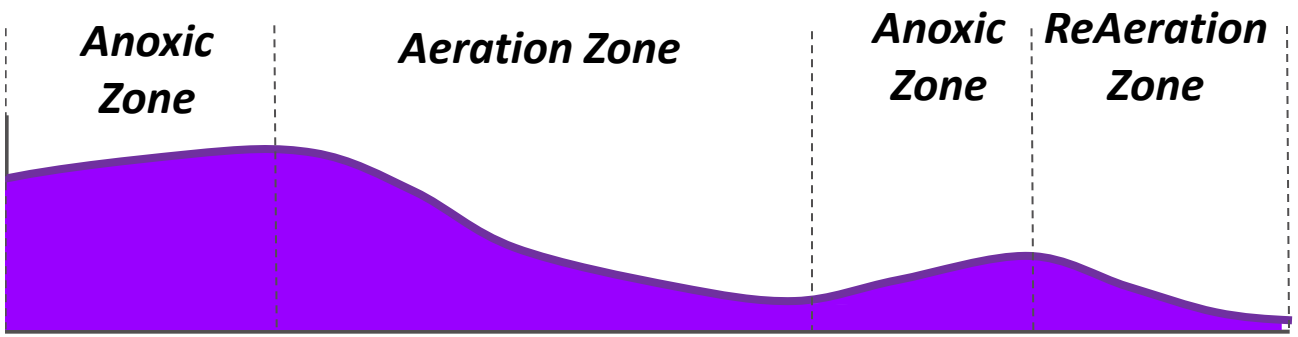




**BOD:TKN > 6 needed for complete denitrification**

McKIM&CREED

# Advanced Nutrient Removal: 5-Stage Bardenpho




McKIM&CREED

# Industry Standard Design Parameters

TABLE 10-5
**Design parameters for activated-sludge processes**

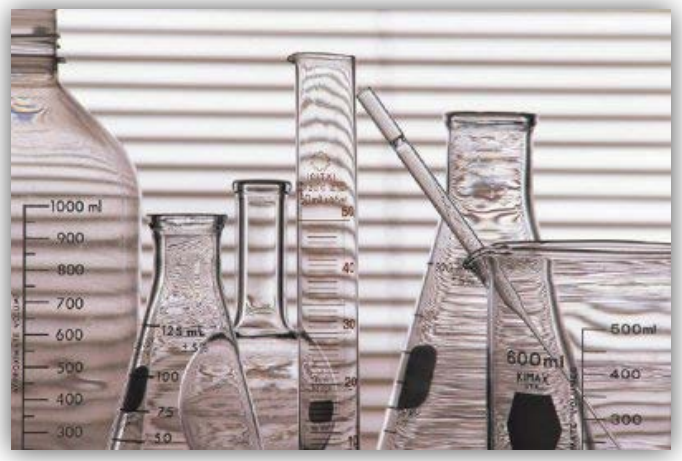
| Process modification | $\theta_c$, d | *F*/*M*, lb $BOD_5$ applied/ lb MLVSS · d | Volumetric loading, lb $BOD_5$/ $10^3$ $ft^3$ · d | MLSS, mg/L | *V*/*Q*, h | $Q_r/Q$ |
|---|---|---|---|---|---|---|
| Conventional plug flow | 5–15 | 0.2–0.4 | 20–40 | 1,200–3,000 | 4–8 | 0.25–0.75 |
| Complete-mix | 5–15 | 0.2–0.6 | 50–120 | 2,500–6,500 | 3–5 | 0.25–1.0 |
| Step-feed | 5–15 | 0.2–0.4 | 40–60 | 1,500–3,500 | 3–5 | 0.25–0.75 |
| Modified aeration | 0.2–0.5 | 1.5–5.0 | 75–150 | 200–1,000 | 1.5–3 | 0.05–0.25 |
| Contact stabilization | 5–15 | 0.2–0.6 | 60–75 | (1,000–3,000)[a]<br>(4,000–9,000)[b] | (0.5–1.0)[a]<br>(3–6)[b] | 0.5–1.50 |
| Extended aeration | 20–30 | 0.05–0.15 | 10–25 | 1,500–5,000 | 18–36 | 0.5–1.50 |
| High-rate aeration | 5–10 | 0.4–1.5 | 100–1,000 | 3,000–6,000 | 2–4 | 1.0–5.0 |
| Kraus process | 5–15 | 0.3–0.8 | 40–100 | 2,000–3,000 | 4–8 | 0.5–1.0 |
| High-purity oxygen | 3–10 | 0.25–1.0 | 100–200 | 3,000–8,000 | 1–3 | 0.25–0.5 |
| Oxidation ditch | 10–30 | 0.05–0.30 | 5–30 | 1,500–5,000 | 8–36 | 0.75–1.50 |
| Sequencing batch reactor | N/A | 0.05–0.30 | 5–15 | 1,500–5,000[d] | 12–50 | N/A |
| Deep shaft reactor | NI | 0.5–5.0 | NI | NI | 0.5–5 | NI |
| Single-stage nitrification | 8–20 | 0.10–0.25<br>(0.02–0.15)[c] | 5–20 | 1,500–3,500 | 6–15 | 0.50–1.50 |
| Separate stage nitrification | 15–100 | 0.05–0.20<br>(0.04–0.15)[c] | 3–9 | 1,500–3,500 | 3–6 | 0.50–2.00 |

Metcalf & Eddy Wastewater Engineering: Treatment, Disposal and Reuse

McKIM&CREED

# Modeling Design Parameters

- Influent Water Quality:
  - $BOD_{inf}$ = 200 mg/l
  - $TKN_{inf}$ = 40 mg/l
  - Phosphorous = 10 mg/l




- Operational Characteristics
  - Mixed Liquor Suspended Solids = 3,900mg/l
  - Return Activated Sludge = 112%
  - Waste Activated Sludge = 2%
  - Side Water Depth = 15 feet

McKIM&CREED

# Nutrient Removal Results

| Process Option | DO (mg/l) | SRT (days) | Volume (MG) | Capacity (MGD) | $BOD_{Eff}$ (mg/l) | $TN_{Eff}$ (mg/l) | $P_{eff}$ (mg/l) | Total HP | Operating $/year | $/MG |
|---|---|---|---|---|---|---|---|---|---|---|
| Conventional Oxidation Ditch | 2.0 | 18.2 | 1.8 | 3.0 | 4.5 | 12.4 | 7.8 | 295 | $212,799 | $8.10 |
| Ox Ditch w/Fine Bubble | **1.5** | 18.2 | 1.8 | 3.0 | 4.6 | 12.6 | 7.8 | **190** | **$137,057** | **$5.22** |
| Ox Ditch w/Reduced SRT | 2.5 | **10.6** | 1.8 | **4.5** | 6.0 | 11.9 | 7.4 | 375 | $270,507 | $6.86 |
| Ox Ditch w/In-Channel Anoxic | **1.5** | 18.2 | 1.8 | 3.0 | 4.6 | **8.8** | 7.8 | 255 | $183,944 | $7.00 |
| Ox Ditch w/External Anoxic | 2.0 | 18.2 | 2.0 | 3.0 | 4.1 | **6.7** | 7.9 | 305 | $220,012 | $8.37 |
| Ox Ditch w/4-Stage Bardenpho | 2.0 | 15.2 | 2.5 | 3.0 | 3.8 | **3.0** | 7.2 | 315 | $227,226 | $8.65 |
| Ox Ditch w/Denite Filters | 2.0 | 18.2 | 1.8 | 3.0 | 4.5 | **3.0** | 7.8 | 295 | $212,799 | $8.10 |
| Ox Ditch w/5-Stage Bardenpho | 2.0 | 15.1 | 2.6 | 3.0 | 3.3 | **3.0** | **0.9** | 325 | $234,439 | $8.92 |

McKIM&CREED

# Enhanced Processes

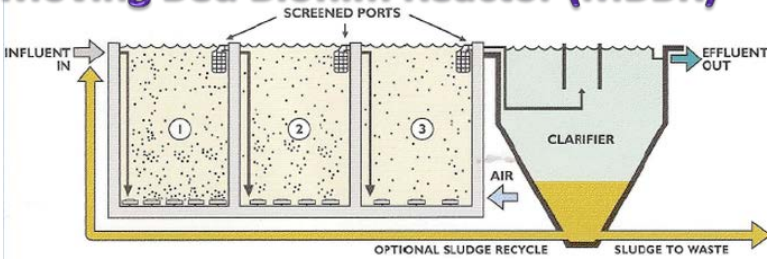
- Enhanced Denitrification Processes
  - Step Feed (2 and 3 Stage)

- Advanced Nutrient Removal Processes
  - $A_2O$
  - University of Capetown (UCT)
  - Modified University of Capetown (MUCT)
  - Virginia Initiative Process (VIP)
  - Johannesburg (JHB)

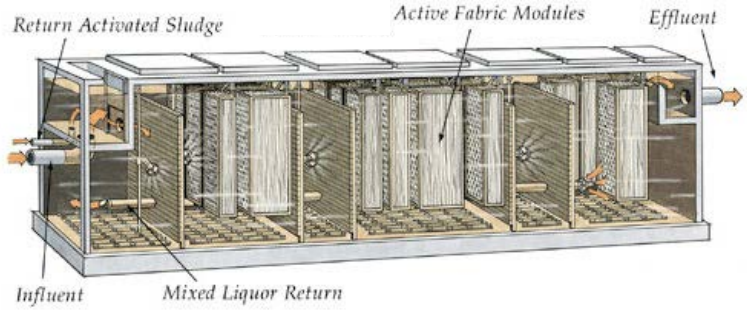
McKIM&CREED

# Alternate Process Configurations

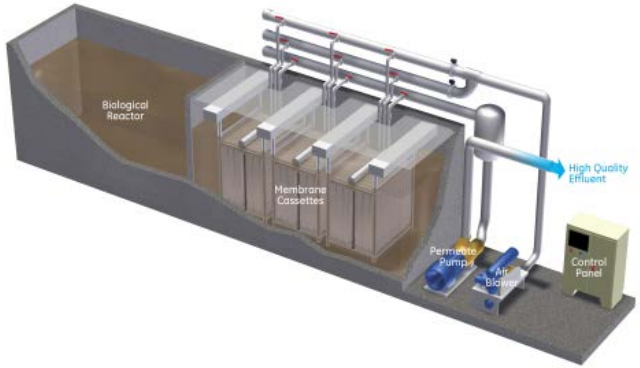
## Moving Bed Biofilm Reactor (MBBR)



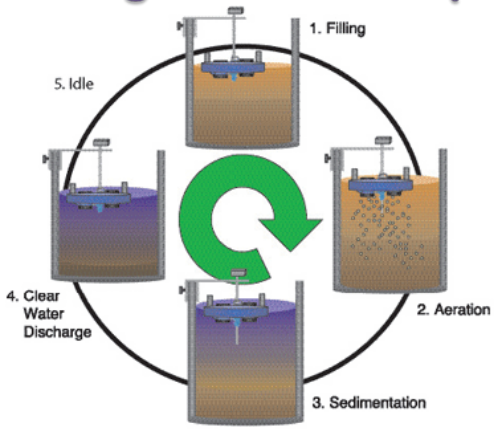

## Integrated Fixed Film (IFAS)



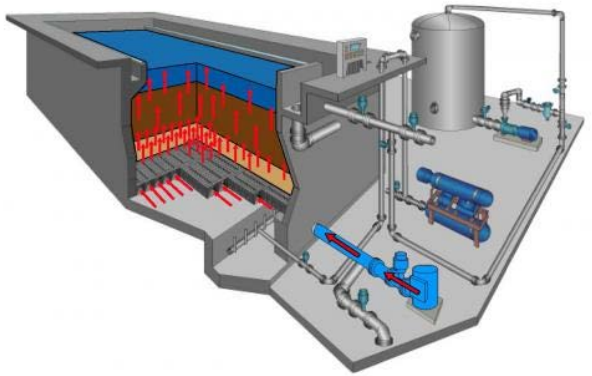

## Membrane Bioreactor (MBR)




## Sequencing Batch Reactor (SBR)

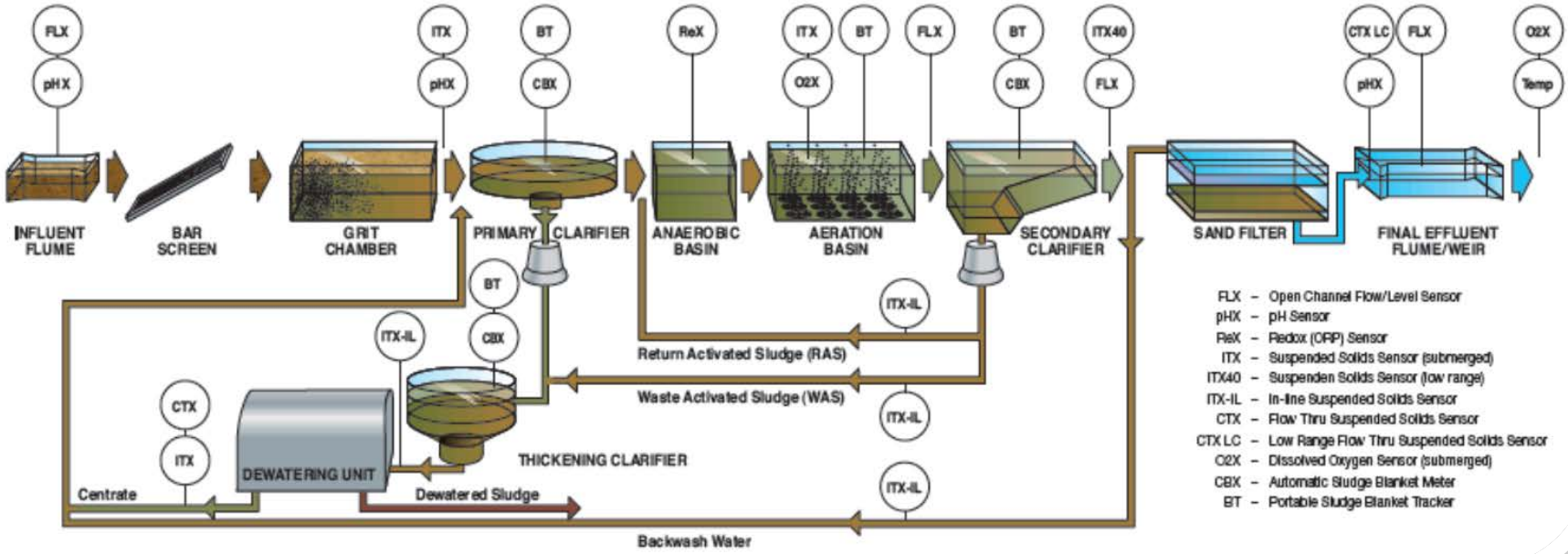



## Denitrification Filters



McKIM&CREED

# Process Optimization Options

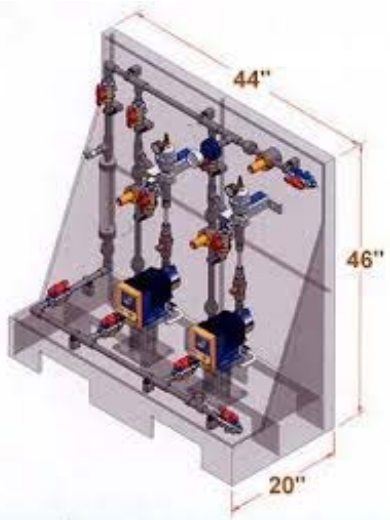


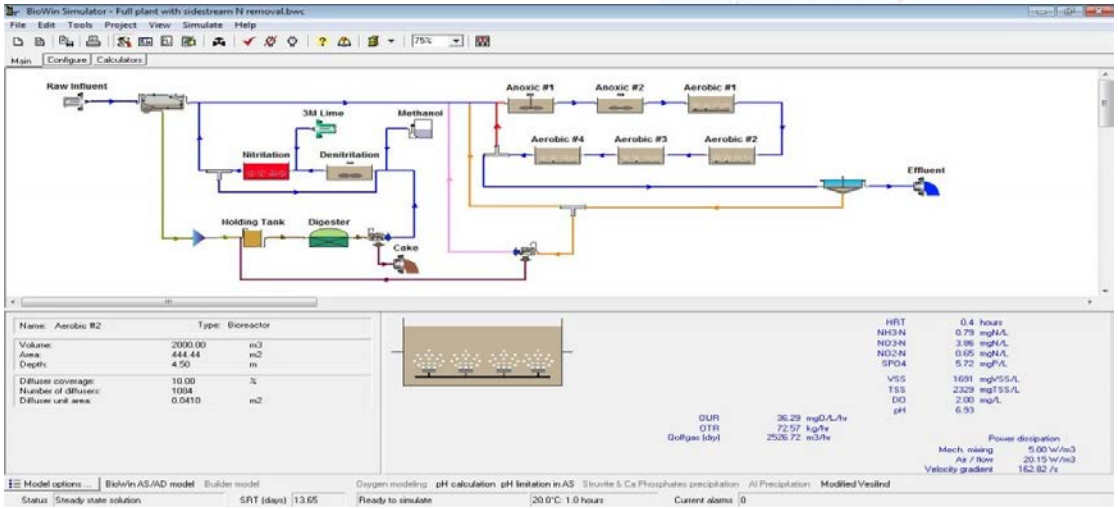

Cerlic Environmental Controls, Inc.

McKIM&CREED

# Process Optimization

- Influent Equalization
- Primary Treatment
- Continuous Wasting
- Chemical Addition
  - Carbon Source
  - Alum
  - Metal Salt
- Process Operations Model



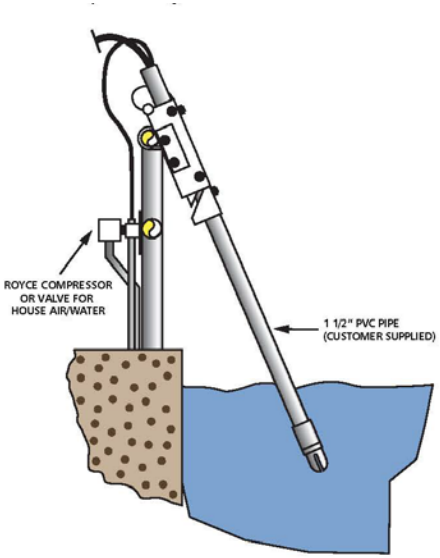




BioWin® EnviroSim Associates, Ltd.

McKIM&CREED

# Process Optimization

- Enhanced Controls
  - Variable Frequency Drives
  - Chemical Loop Controllers
- Enhanced Monitoring
  - Dissolved Oxygen
  - MLSS (Solids Balance)
  - Nitrate Analyzer
  - Sludge Blanket Monitor



McKIM&CREED

Florida Water Environment Association
Southwest Chapter

# 7th Annual Southwest Florida Water & Wastewater Exposition

American Water Works Association
AWWA FLORIDA
Florida's Water Professionals
Region V

F.W.&P.C.O.A. Florida Water & Pollution Control Operators Assoc.
Region 8

# Getting the Most out of the Ditch: Enhanced Nutrient Removal Upgrade Options

Jeffrey S. Lowe, P.E.
Matthew S. Love, P.E.

*September 11, 2014*

McKIM&CREED