# Nitrogen Removal without pH Adjustment in an Alkalinity Deficient Wastewater: Amherst, Massachusetts

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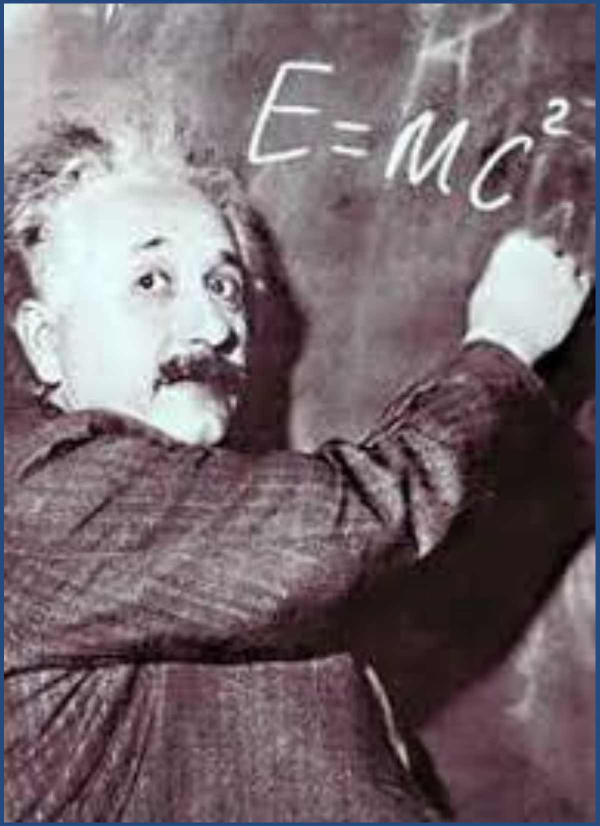
Jim Laford, Superintendent of Amherst WWTP

January 29, 2014

The Water Planet Company

# *Alkalinity and Nitrogen Removal*




The Role of Alkalinity & pH in Nitrogen Removal

Nitrite ($NO_2$)

Controlling Alkalinity & pH

- Chemically
- w/o Chemicals, the Amherst way

Discussion

Adios

# *Ammonia ($NH_4$) Removal: Nitrification*

$$\textbf{Ammonia } (NH_4) \xrightarrow{\text{Oxygen}} \textbf{Nitrite } (NO_2) \xrightarrow{\text{Oxygen}} \textbf{Nitrate } (NO_3)$$

**Alkalinity**

7 mg/L per mg/L $NH_4$ removed

# *Nitrogen Removal: Denitrification*

BOD

Oxygen

**Nitrate ($NO_3$)** → **Nitrogen Gas ($N_2$)**

**Alkalinity**

3.5 mg/L per mg/L $NO_3$ removed

Denitrification returns one-half of the Alkalinity consumed during Ammonia ($NH_4$) Removal …

Therefore, overall …

**3.5 mg/L** of Alkalinity is lost for every 1 mg/L of Ammonia ($NH_4$) converted to Nitrogen Gas ($N_2$)

# *If Not Enough Alkalinity in the Influent*

Oxygen

**Ammonia ($NH_4$)** $\longrightarrow$ **Nitrite ($NO_2$)** $\xrightarrow{X}$ **Nitrate ($NO_3$)**

**Alkalinity**

7 mg/L per mg/L $NH_4$ removed

If not enough Alkalinity…

Nitrite ($NO_2$) will not convert to Nitrate ($NO_3$) and Nitrite ($NO_2$) will increase

## *Nitrite ($NO_2$)*

**<u>Disinfection</u>**

5 mg/L Chlorine for every 1 mg/L of Nitrite ($NO_2$)

- 0.3-0.5 mg/L Nitrite ($NO_2$) will increase Chlorine Demand
- 1-2 mg/L Nitrite ($NO_2$) can overwhelm facility's ability to Disinfect

**<u>Treatment Performance</u>**

Nitrite ($NO_2$) can be "toxic" to mixed liquor and create process upsets

Amherst experienced a mild upset after 2 months of $NO_2$ > 2 mg/L, up to 6 mg/L

## *Chemical Addition to Support Nitrogen Removal*

Oxygen

Oxygen

**Ammonia ($NH_4$)** → **Nitrite ($NO_2$)** → **Nitrate ($NO_3$)**

**Alkalinity**

7 mg/L per mg/L $NH_4$ removed

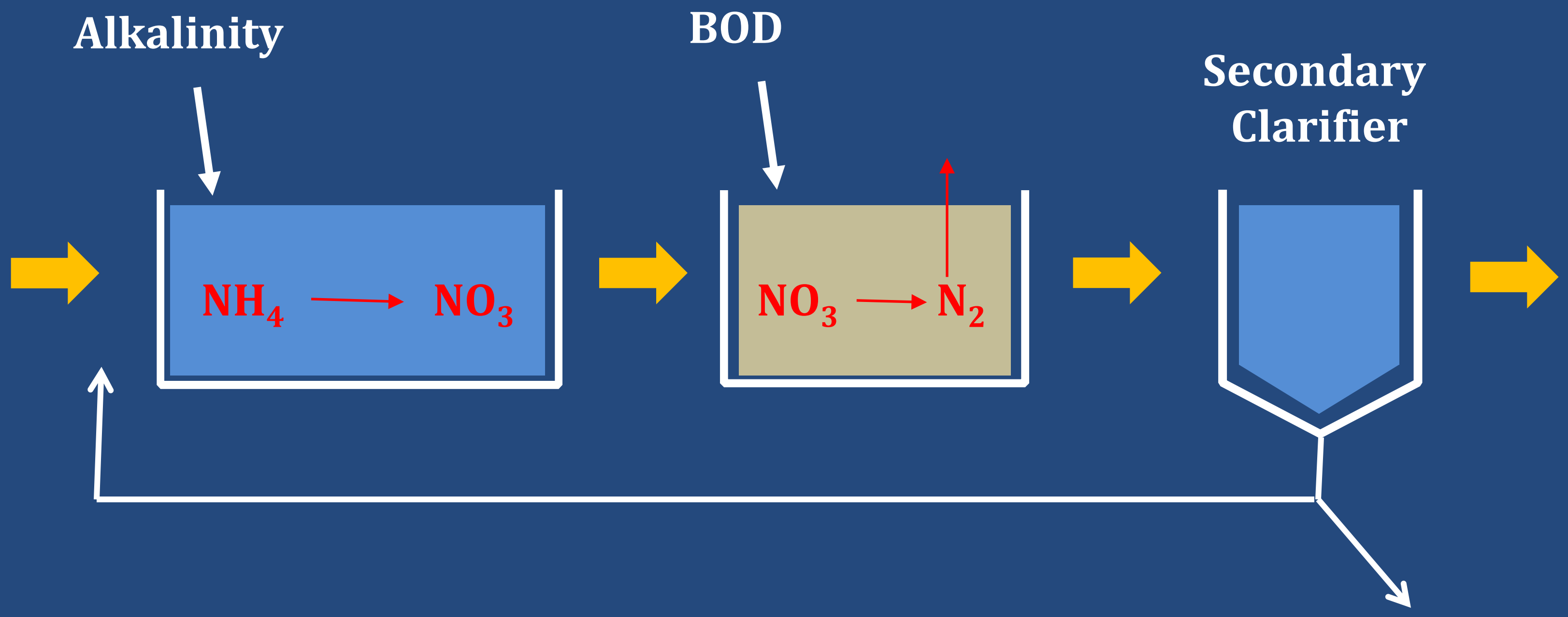
3.5 mg/L net, considering denite

Supplemental Alkalinity required:

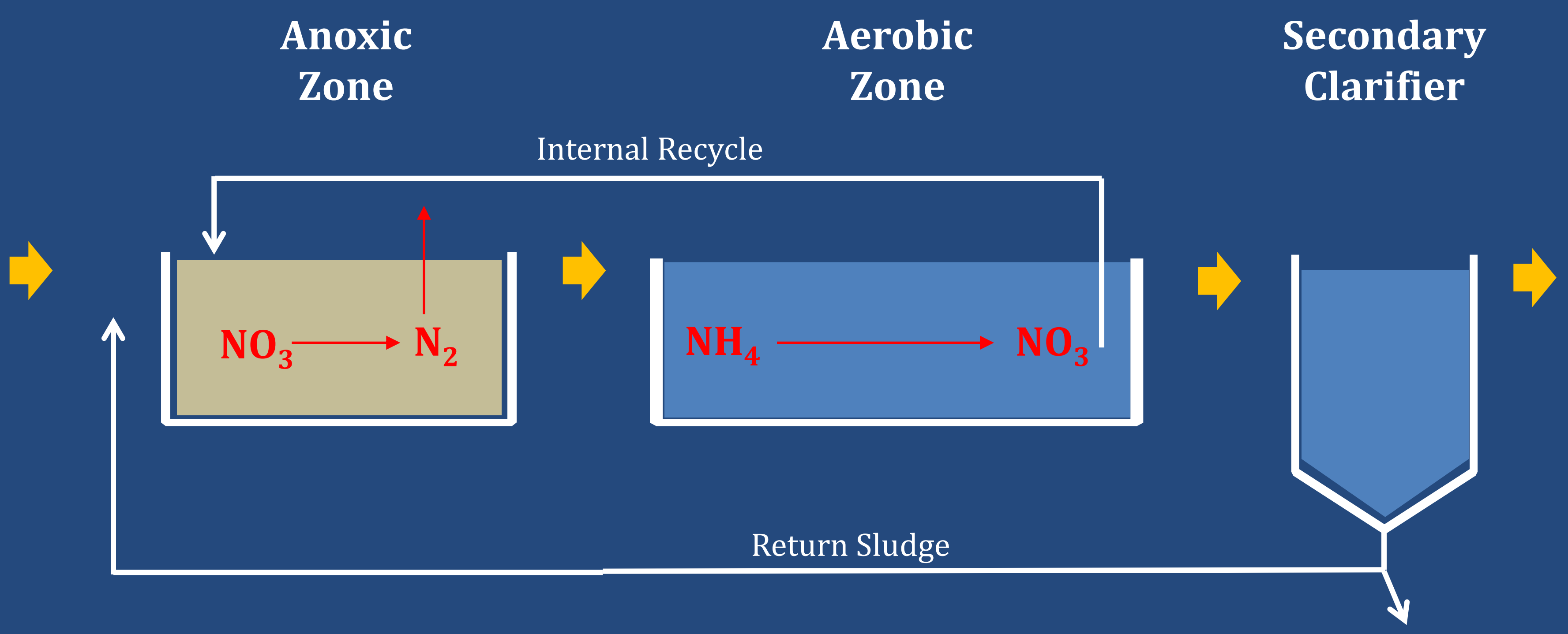
- Magnesium hydroxide
- Caustic soda (sodium hydroxide)

Cost of Chemical Addition to Support Complete Ammonia ($NH_4$) Removal:

~$100,000/yr

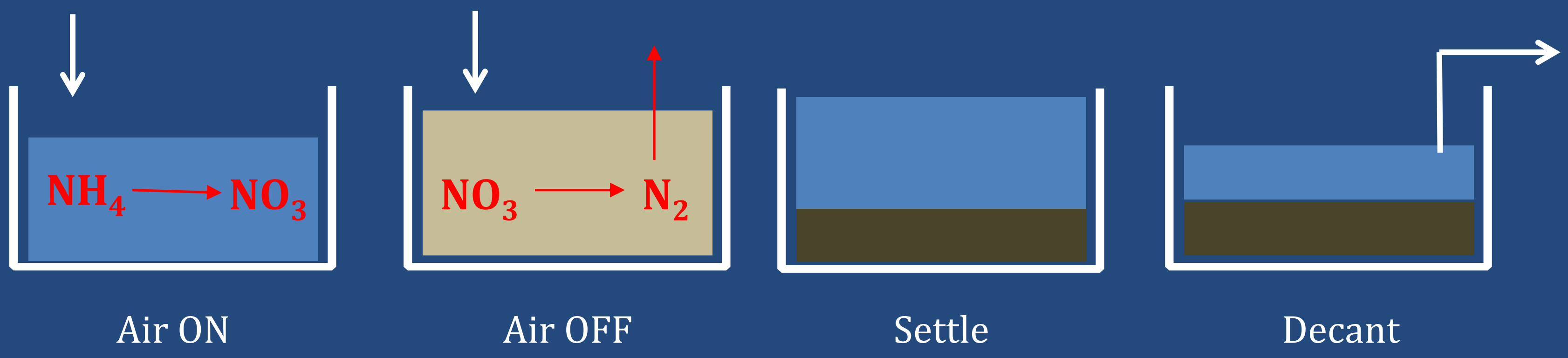



# Post-Anoxic Denitrification




# MLE (Modified Ludzack-Ettinger) Process

# Biological Nitrogen Removal
# Sequencing Batch Reactor

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treatment
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# *Ammonia Removal & Alkalinity*

| | **No Students** | **Students** |
|---|---|---|
| Influent (Raw) Alkalinity | 110 | 140 |
| Influent Ammonia ($NH_4$) | 25 | 50 |
| 10 mg/L $NH_4$ is consumed by MLSS | **15** | **40** |
| **Alkalinity Required to Remove Ammonia** | | |
| 7 mg/L lost per mg/L $NH_4 \rightarrow NO_3$ | 105 | 280 |
| 3.5 mg/L gained per mg/L $NO_3 \rightarrow N_2$ | - 52 | - 140 |
| Net | **53 mg/L** | **140 mg/L** |
| **Alkalinity Remaining after Ammonia Removed** | | |
| Alkalinity Required (Raw– Req'd) | 57 | 0 |
| Alkalinity Buffer to support Bac-t | - 60 | - 60 |
| **Supplemental Alkalinity Required** | **3 mg/L** | **60 mg/L** |

## *Permit Limit*

Instead of adding $100,000 of Alkalinity in order to convert all of the Ammonia ($NH_4$) to Nitrogen Gas ($N_2$), might Amherst meet its permit limit by converting only as much Ammonia as the available Alkalinity will support?

<u>Discharge Limit</u>

**546.5 lbs/day**: total-Nitrogen limit, as twelve month rolling average

**13 mg/L** @ 5 MGD during school year

**21 mg/L** @ 3 MGD during summer months

Which means, with an influent nitrogen of 25-50 mg/L …

Amherst needs to remove a little more than one-half of the influent nitrogen to meet permit.

# *Nitrogen Removal: the Amherst way*

**Ammonia ($NH_4$) Removal**

Remove only as much $NH_4$ as the available Alkalinity will support.

**Nitrate ($NO_3$) Removal**

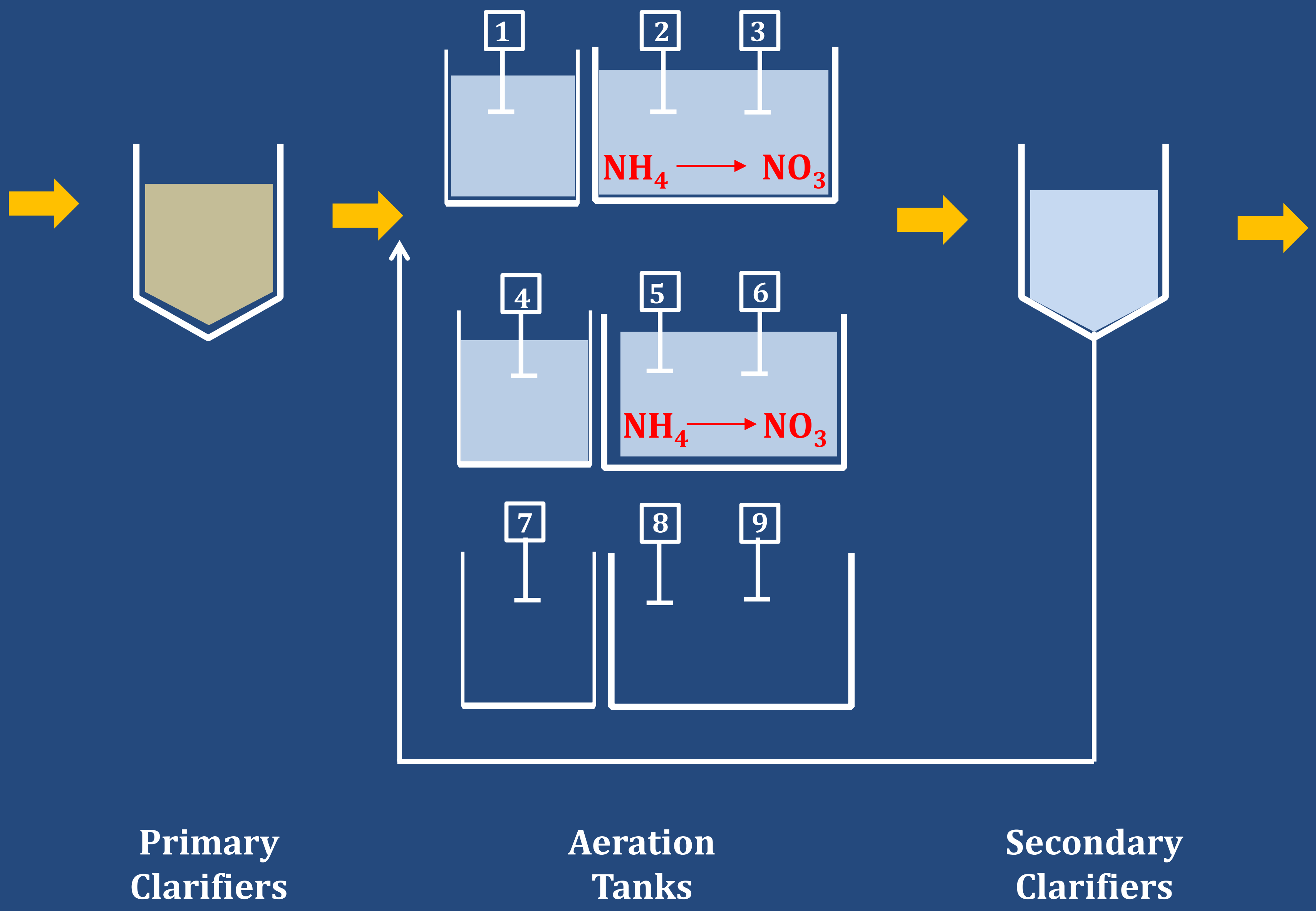
Optimize $NO_3$ Removal in order to get back as much Alkalinity as possible.

**Nitrite ($NO_2$) Control**

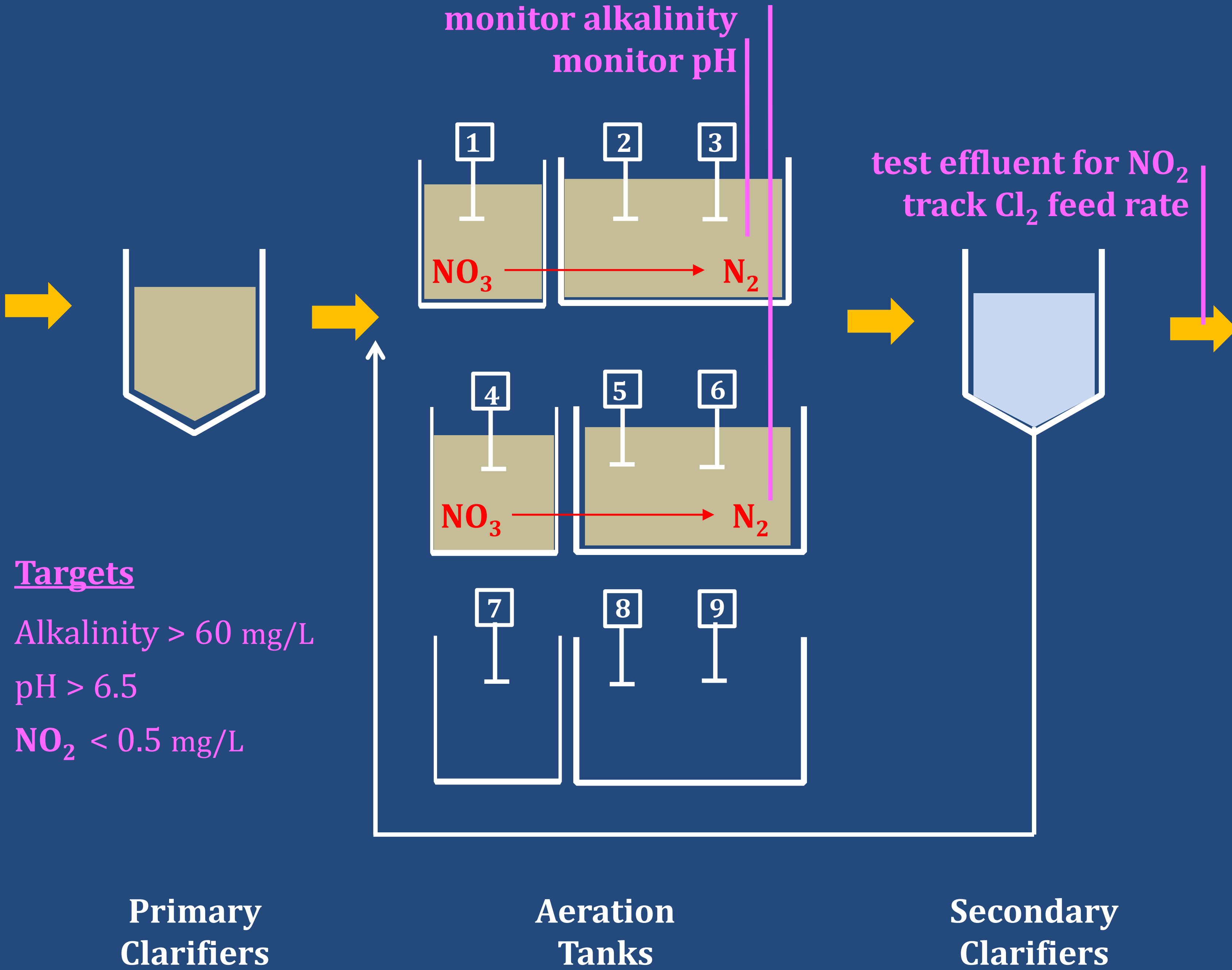
Monitor effluent $NO_2$

Track chlorine demand during April - October


Imagery Date: 9/18/2011



1
2
3
$NH_4 \rightarrow NO_3$
4
5
6
$NH_4 \rightarrow NO_3$
7
8
9
Primary Clarifiers
Aeration Tanks
Secondary Clarifiers

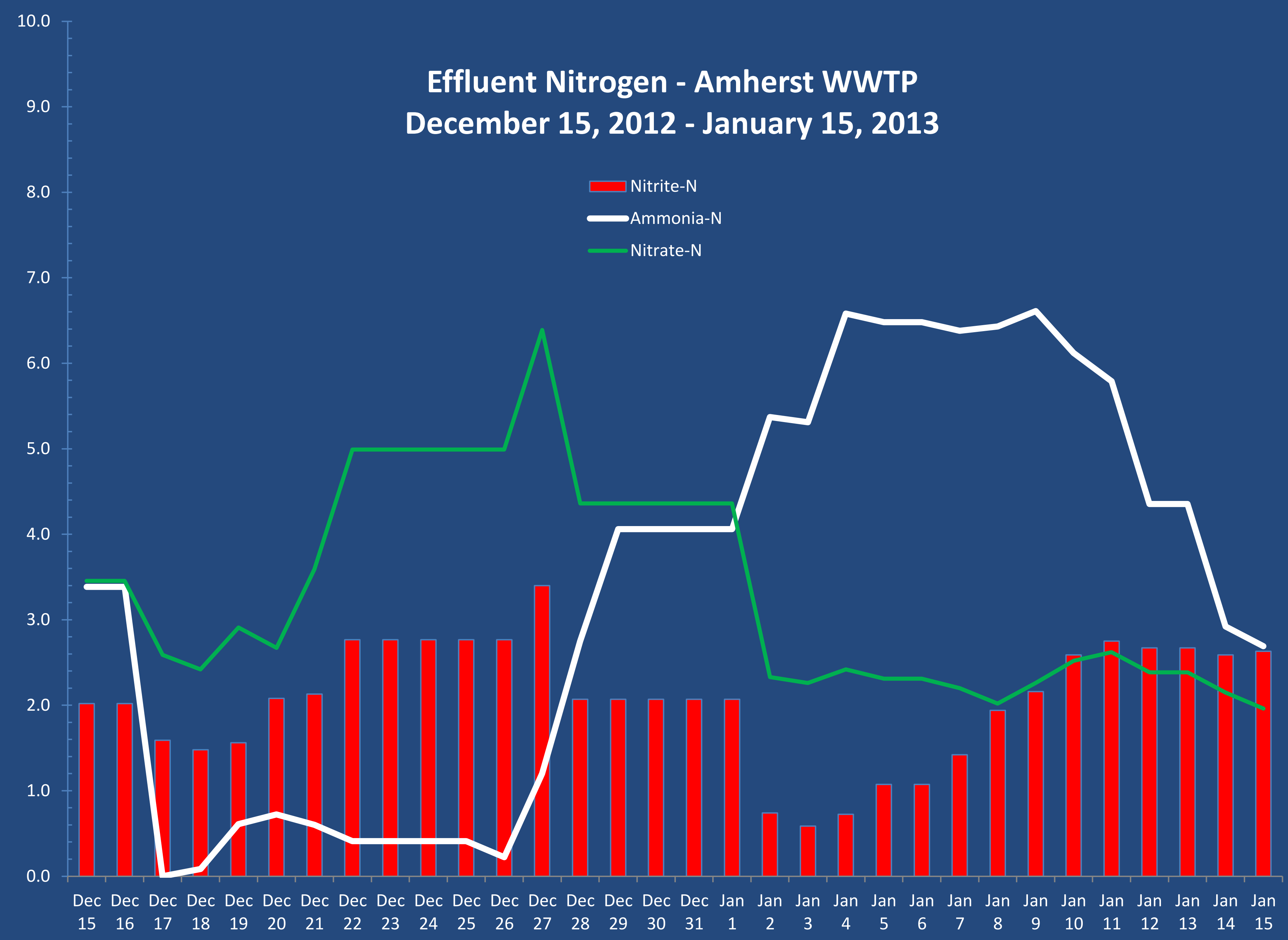



**Targets**

Alkalinity > 60 mg/L

pH > 6.5

**$NO_2$** < 0.5 mg/L


Effluent Nitrogen - Amherst WWTP
December 15, 2012 - January 15, 2013
Nitrite-N
Ammonia-N
Nitrate-N
10.0
9.0
8.0
7.0
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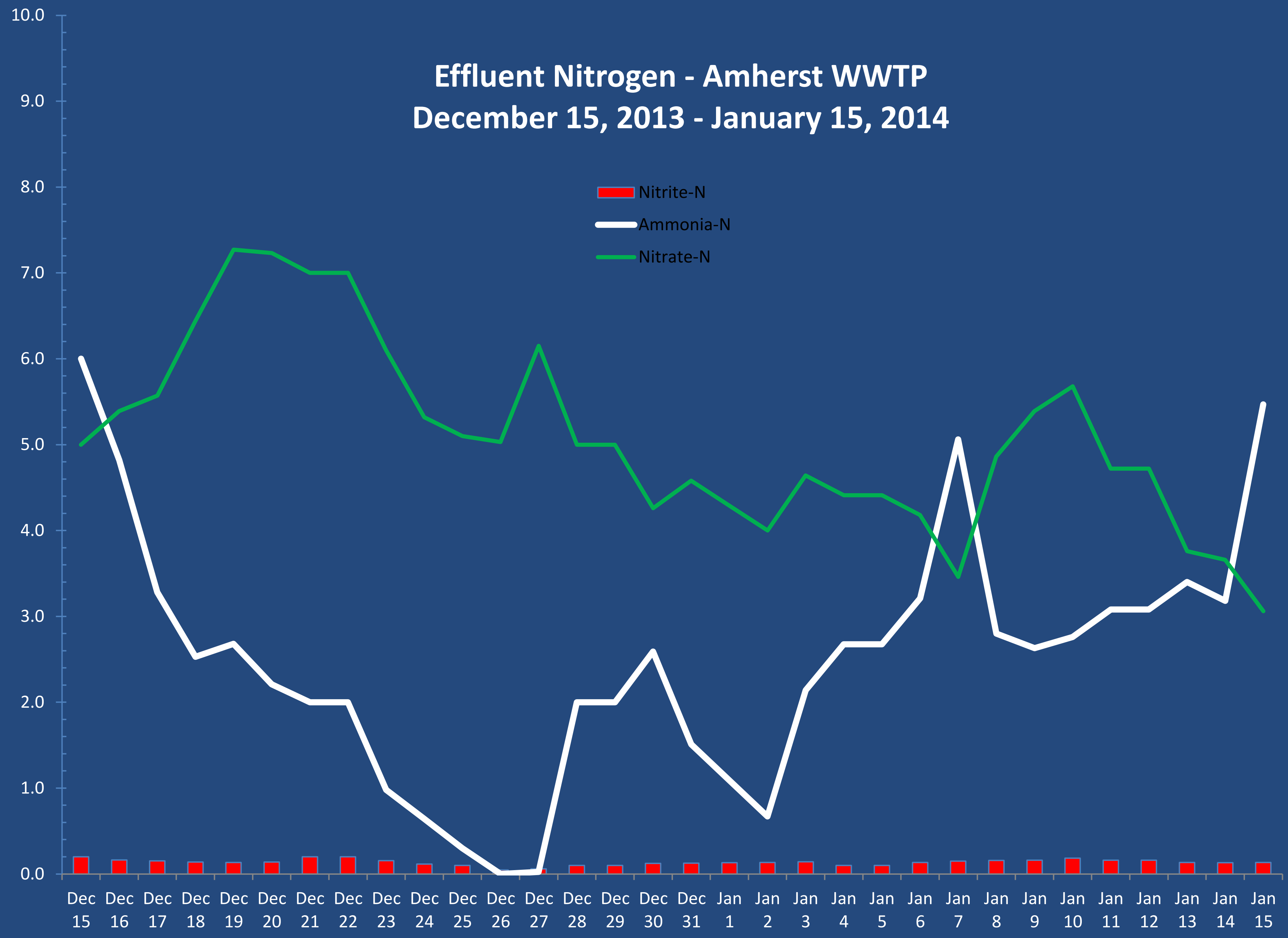

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# *Nitrogen Removal w/o Chemical pH Adjustment*

Without enough Alkalinity, Nitrite ($NO_2$) can increase

- chlorine disinfection
- process upsets

Traditional ways of adding Alkalinity:

- Pre-denite / cycling aeration to capture Alkalinity released by $NO_3 \rightarrow N_2$
- Chemical Addition

Amherst's approach:

- Maximize $NO_3 \rightarrow N_2$
- Restrict $NH_4 \rightarrow NO_3$

# THE WATER PLANET COMPANY

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Thank You!

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