# Facility Tour and Technical Presentation

## City of Dover, New Hampshire

## Phase I Upgrade and MLE Conversion Pilot Program

NEWEA Specialty Conference in Dover, NH
August 24, 2016

Presented by:
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Project Manager

WRIGHT-PIERCE
Engineering a Better Environment

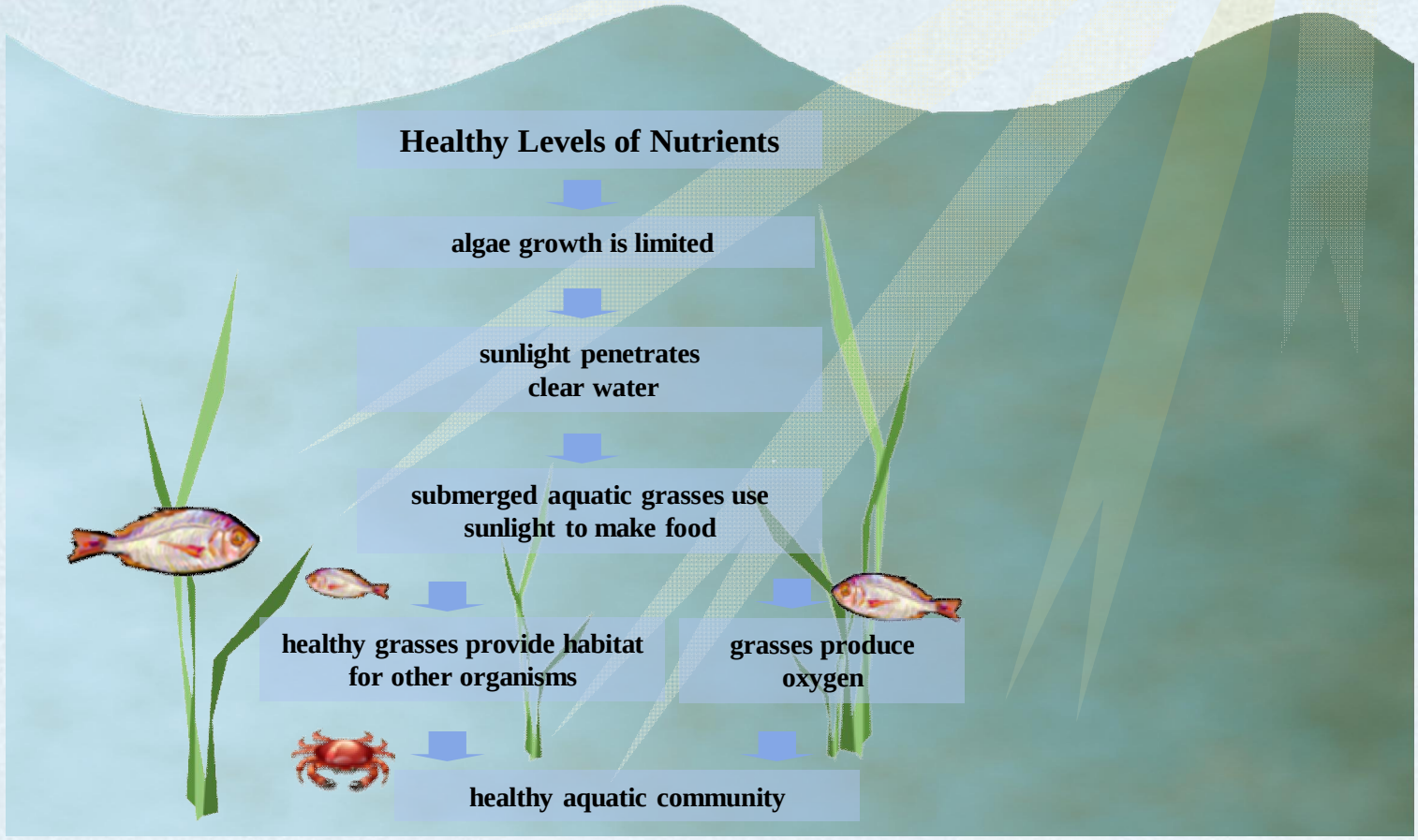
# Presentation Overview

- Why Remove Nitrogen
- Nitrogen Removal Basics
- Facility Planning and Phase I Upgrade
- Modified Ludzack-Ettinger Pilot Program
  - Pilot Program Background
  - Nitrogen Removal
  - Construction
  - Preliminary Results
- Questions

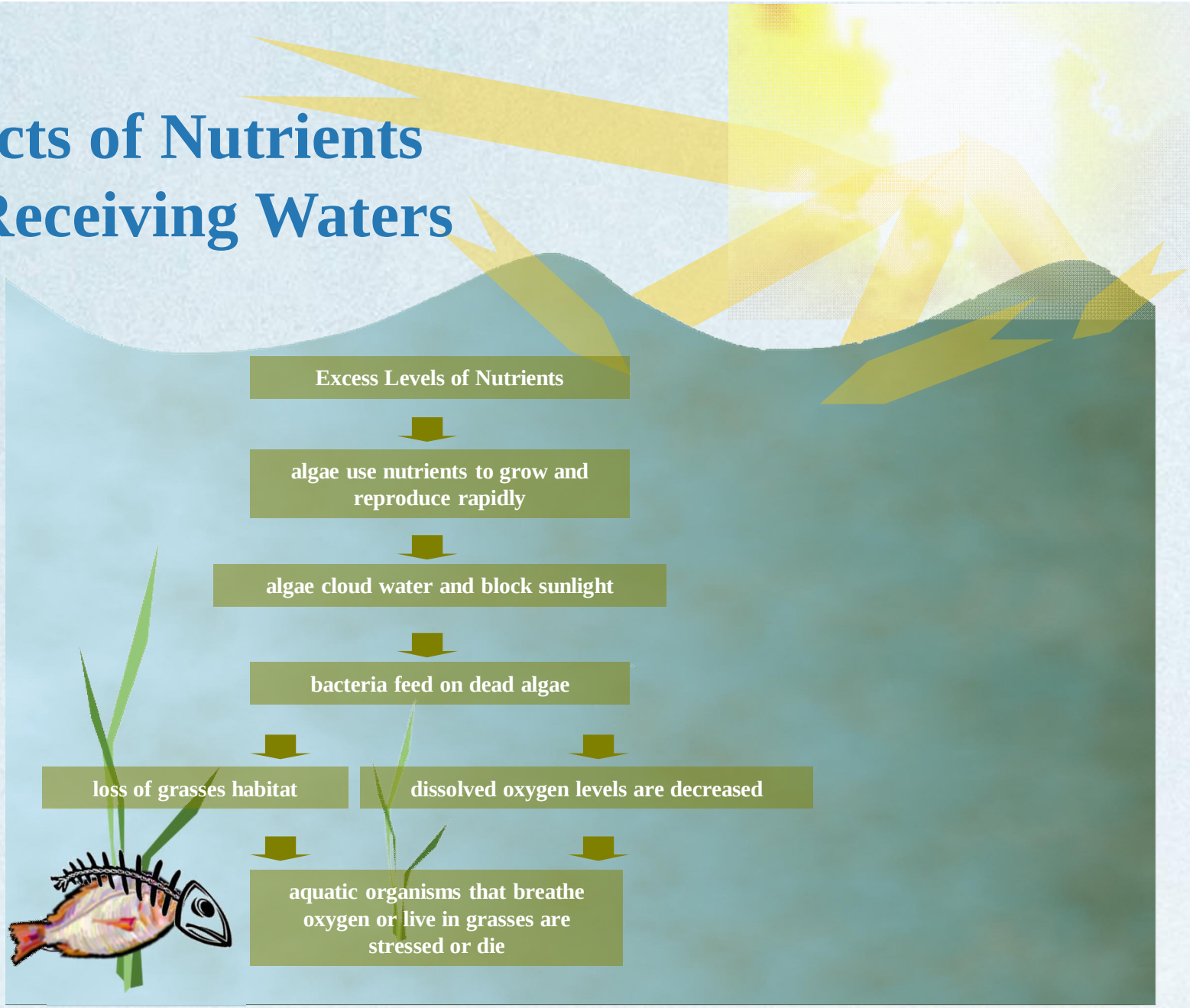
# Why are nutrients an issue in the environment?

- Stimulates algae and plant growth
- Creates dissolved oxygen issues
- P – limiting fresh water nutrient
- N – limiting marine water nutrient

# Effects of Nutrients in Receiving Waters



# Effects of Nutrients in Receiving Waters



# How Much Estuary Nitrogen is Too Much?

- Typical threshold nitrogen concentration
  **~ 0.2 to 0.5 ppm**
- Governed by:
  - dissolved oxygen
  - Eelgrass
  - habitat protection
  - hydrodynamics

# Algal Impact on Water Clarity

# Algal Impact
# On Water Clarity

**PART I**
**A. EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS**

1. During the period beginning on the effective date and lasting through the expiration date, the permittee is authorized to discharge from Outfall Serial Number 001 treated domestic, commercial, and industrial wastewater effluent to the Piscataqua River. Such discharges shall be limited and monitored by the permittee as specified below. Samples taken in compliance with the monitoring requirements specified below shall be taken at end of all processes, including disinfection, or at an alternative representative location approved by the EPA and NHDES-WD.

| Effluent Parameter | Effluent Limit | | | Monitoring Requirement | |
|---|---|---|---|---|---|
| | Average Monthly | Average Weekly | Maximum Daily | Frequency | Sample Type |
| Flow, MGD | Report | --- | Report | Continuous | Recorder[1] |
| $BOD_5$; mg/l (lb/d) | [illegible] | [illegible] | 50 (1960) | 2/Week[2] | 24 Hour Composite |
| TSS; mg/l (lb/d) | | | | | 24 Hour Composite |
| pH Range[3]; Standard U | | | | | Grab |
| Fecal Coliform[3,4,7]; colo | | | | | Grab |
| Enterococci Bacteria[3,4,8] | | | | | Grab |
| Total Residual Chlorine | | | | | Grab |
| Total Ammonia Nitroge | | | | | 24 Hour Composite |
| Total Kjeldahl Nitrogen | | | | | 24 Hour Composite |
| Total Nitrate/Nitrite Nit | | | | | 24 Hour Composite |
| Total Nitrogen[9]; mg/l (l | | | | | 24 Hour Composite |
| (Applicable April 1 thro | | | | | |
| Total Ammonia Nitroge | | | | | 24 Hour Composite |
| Total Kjeldahl Nitrogen | | | | | 24 Hour Composite |
| Total Nitrate/Nitrite Nit | | | | | 24 Hour Composite |
| Total Nitrogen[9]; mg/l (lb/d) | Report | --- | Report | 2/Week | 24 Hour Composite |
| (Applicable November 1 through March 31) | | | | | |
| Whole Effluent Toxicity | | | | | |
| LC50[10,11,12]; Percent Effluent | --- | --- | 100 | 1/Year | 24 Hour Composite |
| Total Recoverable Aluminum[13]; mg/l | --- | --- | Report | 1/Year | 24 Hour Composite |
| Total Recoverable Cadmium[13]; mg/l | --- | --- | Report | 1/Year | 24 Hour Composite |
| Total Recoverable Chromium[13]; mg/l | --- | --- | Report | 1/Year | 24 Hour Composite |
| Total Recoverable Copper[13]; mg/l | --- | --- | Report | 1/Year | 24 Hour Composite |
| Total Recoverable Lead[13]; mg/l | --- | --- | Report | 1/Year | 24 Hour Composite |
| Total Recoverable Nickel[13]; mg/l | --- | --- | Report | 1/Year | 24 Hour Composite |
| Total Recoverable Zinc[13]; mg/l | --- | --- | Report | 1/Year | 24 Hour Composite |

| | | |
|---|---|---|
| **Total Ammonia Nitrogen[9]; mg/l** | | Report |
| **Total Kjeldahl Nitrogen[9]; mg/l** | | Report |
| **Total Nitrate/Nitrite Nitrogen[9]; mg/l** | | Report |
| **Total Nitrogen[9]; mg/l (lb/d)** | | 3.0 (118) |
| **(Applicable April 1 through October 31)** | | |
| **Total Ammonia Nitrogen[9]; mg/l** | | Report |
| **Total Kjeldahl Nitrogen[9]; mg/l** | | Report |
| **Total Nitrate/Nitrite Nitrogen[9]; mg/l** | | Report |
| **Total Nitrogen[9]; mg/l (lb/d)** | | Report |

# Forms of Nitrogen

- Ammonia-N
  - NH3, NH4+
- Organic Nitrogen
- Nitrite (NO2)
- Nitrate (NO3)

# Forms of Nitrogen

Total Kjeldahl Nitrogen (TKN)

- Ammonia-N
  - NH3, NH4+
- Organic Nitrogen

- Nitrite (NO2)
- Nitrate (NO3)

# Forms of Nitrogen

Total Nitrogen (TN)

- Ammonia-N
  - NH3, NH4+
- Organic Nitrogen
- Nitrite (NO2)
- Nitrate (NO3)

# Forms of Nitrogen

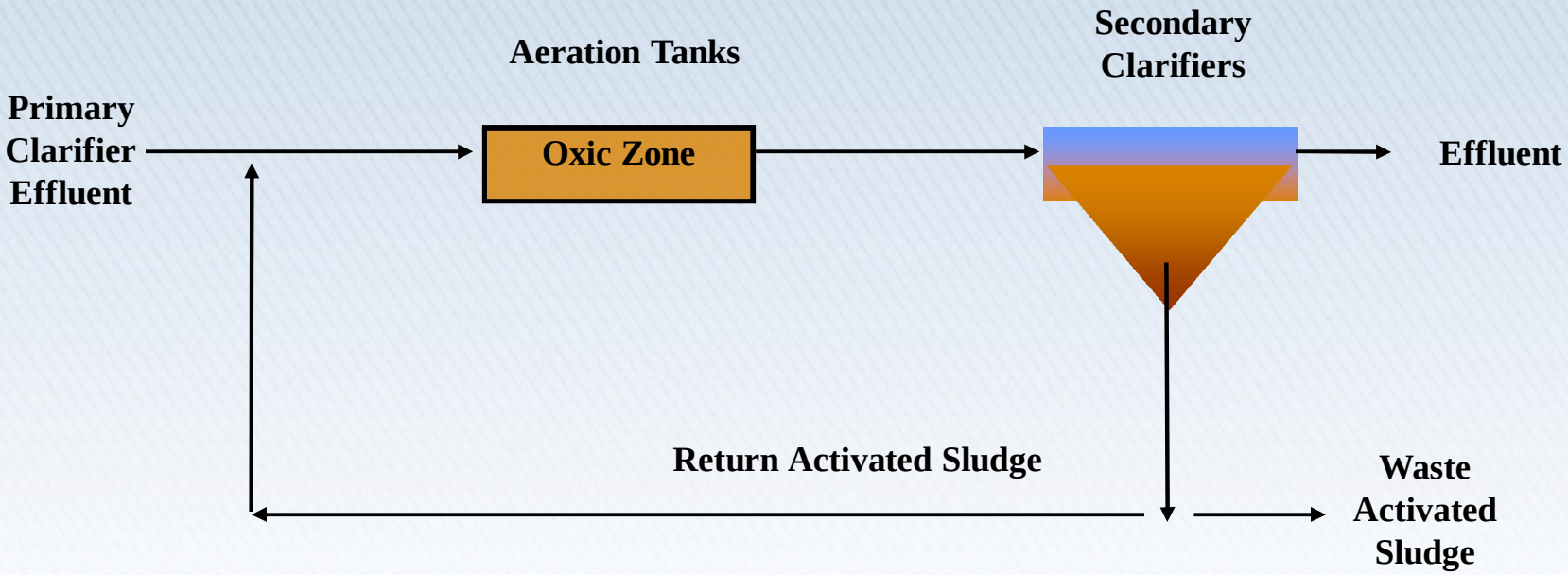
Total Inorganic Nitrogen (TIN)

- Ammonia-N
  - NH3, NH4+
- Nitrite (NO2)
- Nitrate (NO3)
- Organic Nitrogen

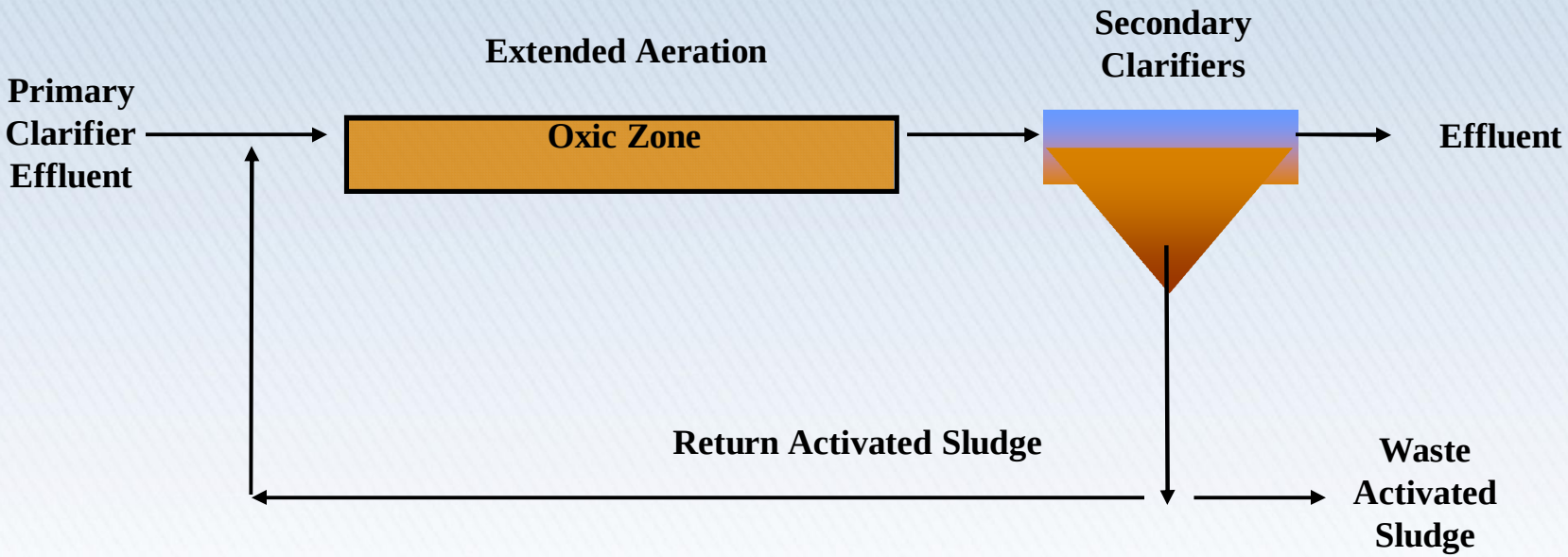
# Typical Nitrogen Wastewater Concentration

| | | % removal |
|---|---|---|
| Typical influent sewage | 40 ppm | |
| Typical secondary effluent | 32 ppm | 20% |
| Level 1-N removal | 8 ppm | 80% |
| Level 2-N removal | 5 ppm | 87.5% |
| Level 3-N removal | 3 ppm | 92.5% |

# Conventional Activated Sludge

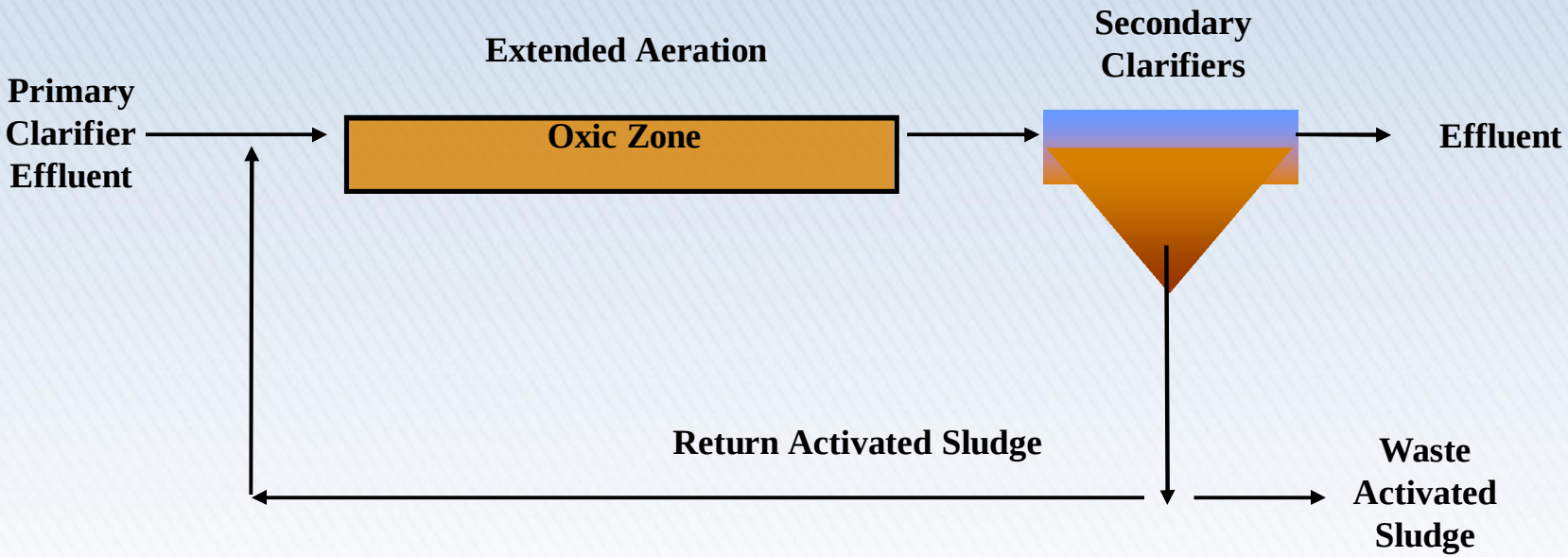


# How to Upgrade for Ammonia Removal

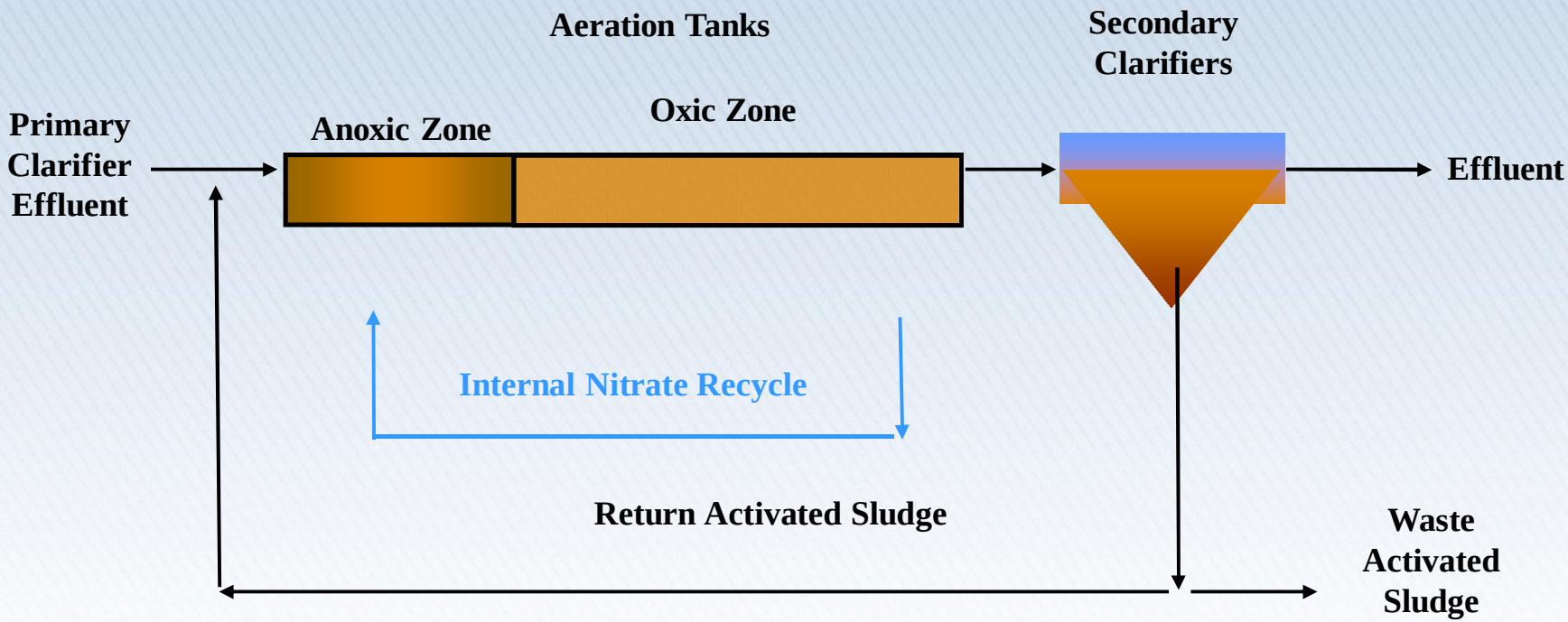


# How to Upgrade for Ammonia Removal

NH3 à NO2 à NO3

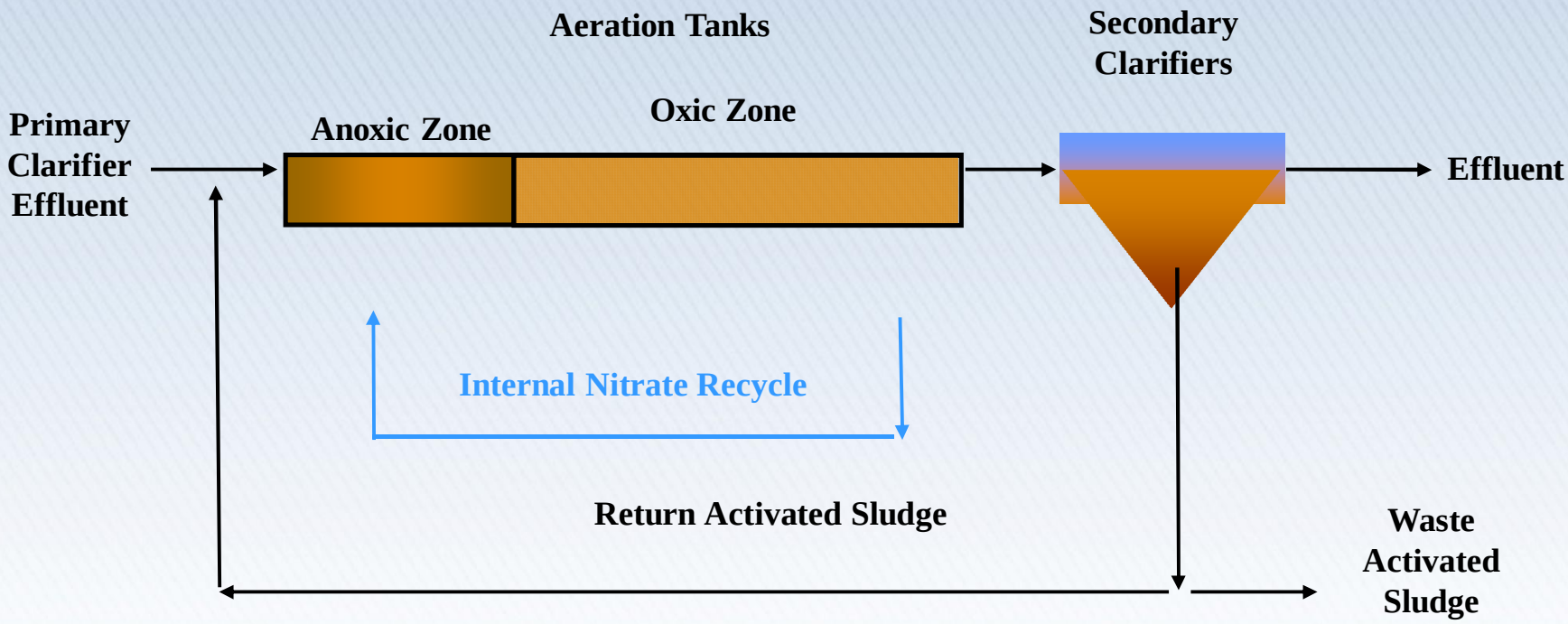


# How to Upgrade for TN Removal MLE Process



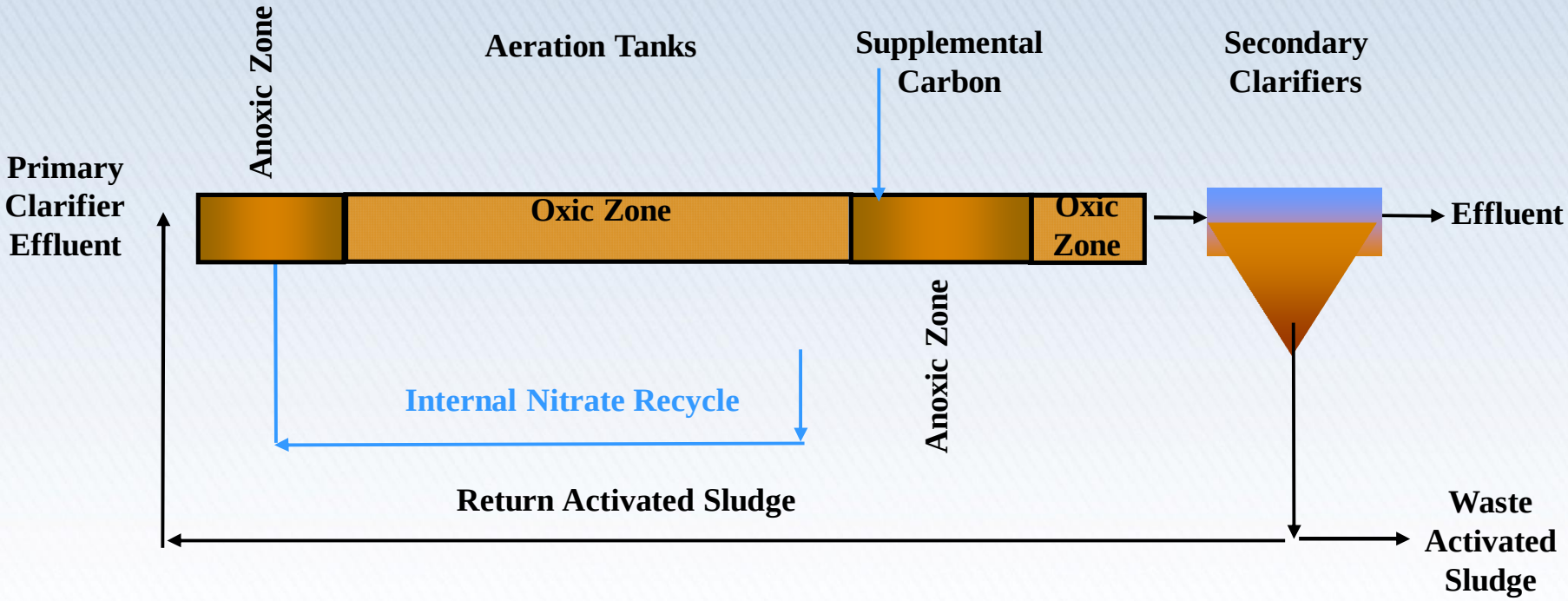
# How to Upgrade for TN Removal MLE Process

NH3 à NO2 à NO3 à N2+O2



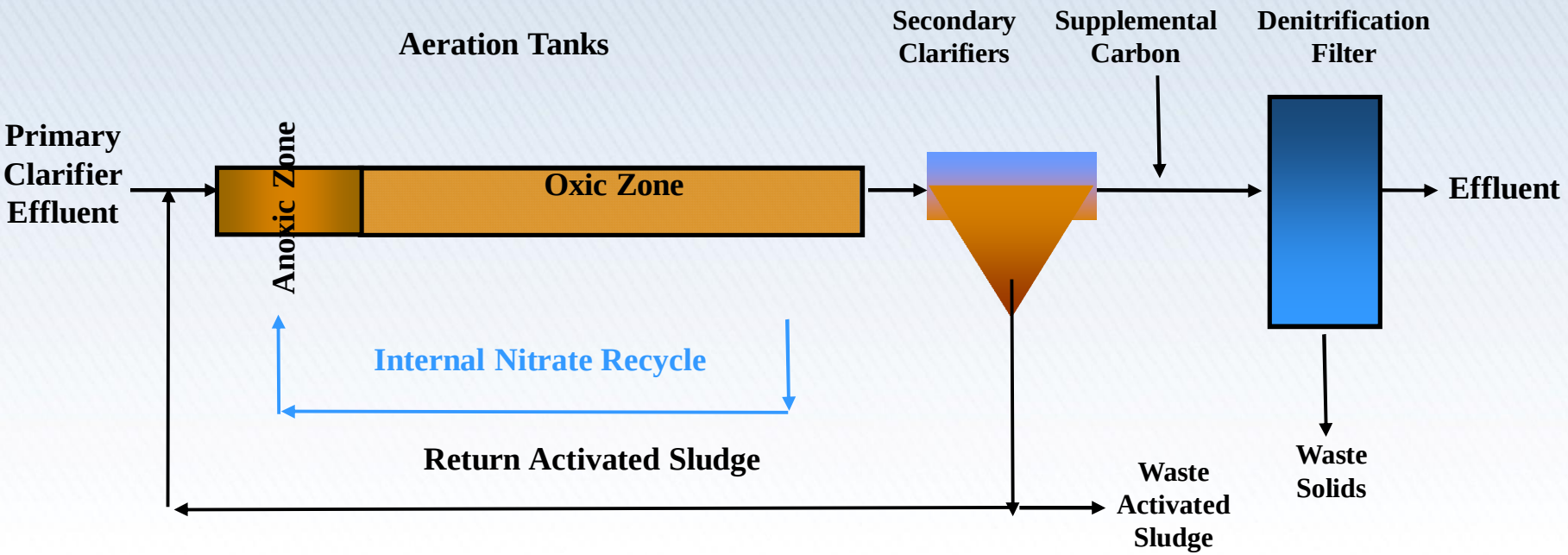
# How to Upgrade for Higher TN Removal (3 to 5 mg/1TN)

## Four-Stage Bardenpho Process



# Alternative Approach to TN Limits (3 to 5 mg/1 Range)

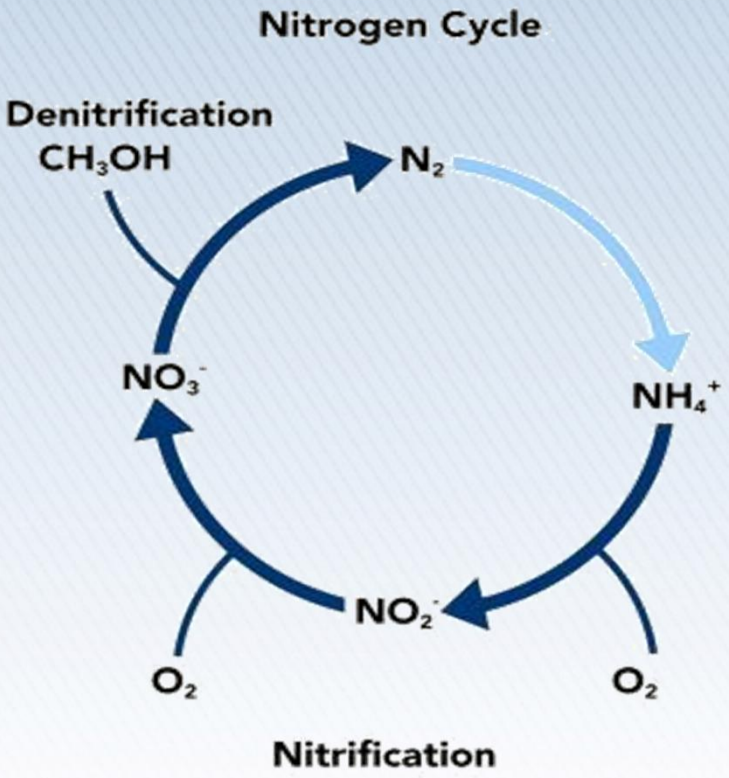
## MLE Process Coupled with Denitrification Filter



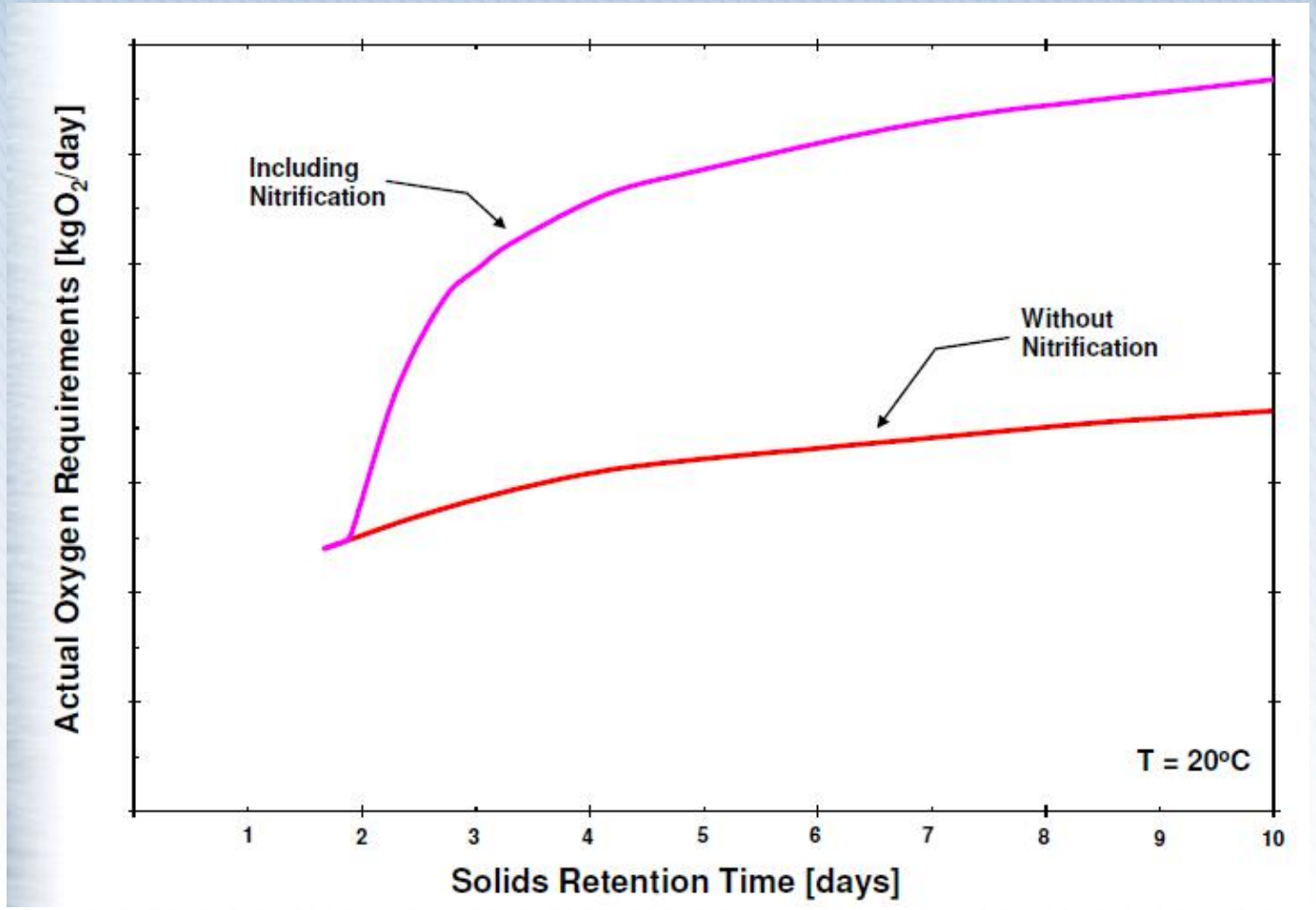
# Nitrogen Removal

**3-Step Process:**

- Ammonification:
  - urea & organic N ® $NH_4$-N
- Nitrification (aerobic)
  - $NH_4$-N + $O_2$ ® $NO_3$-N
  - *Autotrophic bacteria*
  - -4.57 mg/L $O_2$ (consumption)
  - -7.14 mg/L Alk (consumption)
- Denitrification (anoxic)
  - $NO_3$-N ® $N_2$-
  - *facultative bacteria*
  - +3.57 mg/L Alk (gain)
  - +2.86 mg/l $O_2$ (credit)



# SRT/Nitrification Impact on $0_2$ Demand



# Nitrification Requirements

| Parameter | BOD Removal | Nitrification |
|---|---|---|
| MCRT (days) | 0.5 – 1.0 | 4 – 15 |
| DO (mg/L) | > 0.5 | > 2.0 (optimal) |
| Temperature (°C) | > 0 | 25 (optimal) |
| pH | 5 – 9 | 6.5 – 8 (optimal)<br>More alkalinity |

# Requirements for Denitrification

- Need nitrate to be formed
  - Nitrate is formed during nitrification
  - As long as system is nitrifying, this criterion is met
- Need “denit” or anoxic zone in system:
  - Nitrate
  - Bacteria
  - Substrate (Food/BOD)
  - No oxygen, but mixing to retain biomass in suspension

# Conditions in the Anoxic Zone

- DO less than 0.3 mg/l
  - No aeration
  - Low aeration
  - Cyclical aeration
- Carbon source
  - Primary effluent
  - Endogenous
  - Methanol or other chemicals
- Mixing
  - Pulsed or cycled air
  - Submersible mixers
  - Vertical mixers

# City of Dover

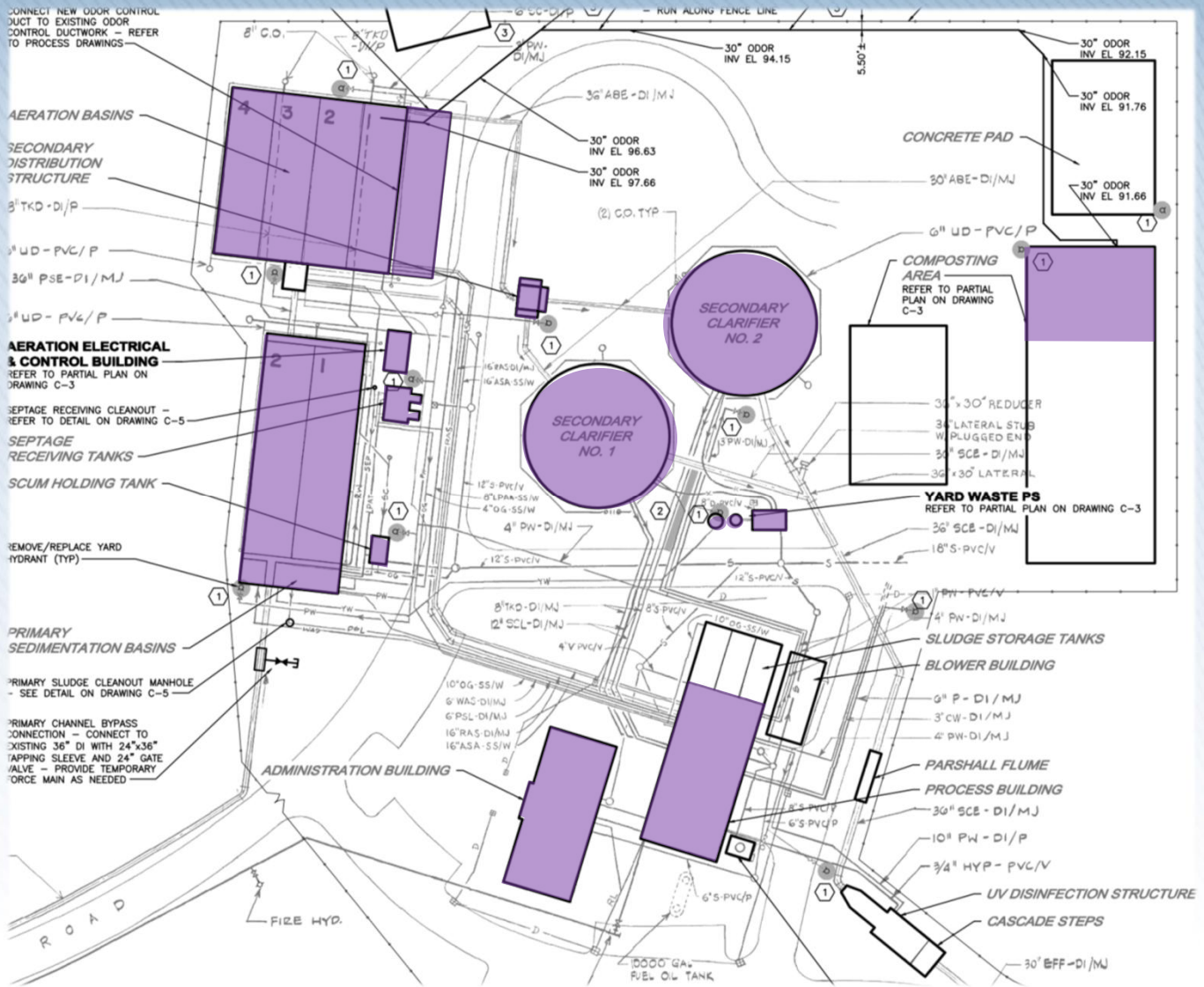
- Great Bay Issues
- Pending TN Limit
- Facility Planning  Efforts

# Project Overview

- Wastewater Facilities Plan
  - Equipment Assessment
  - Building System Assessment
  - Alternatives for removing TN
- Prioritized Improvements
  - Phase I Upgrade
  - Pilot Program to lower effluent TN

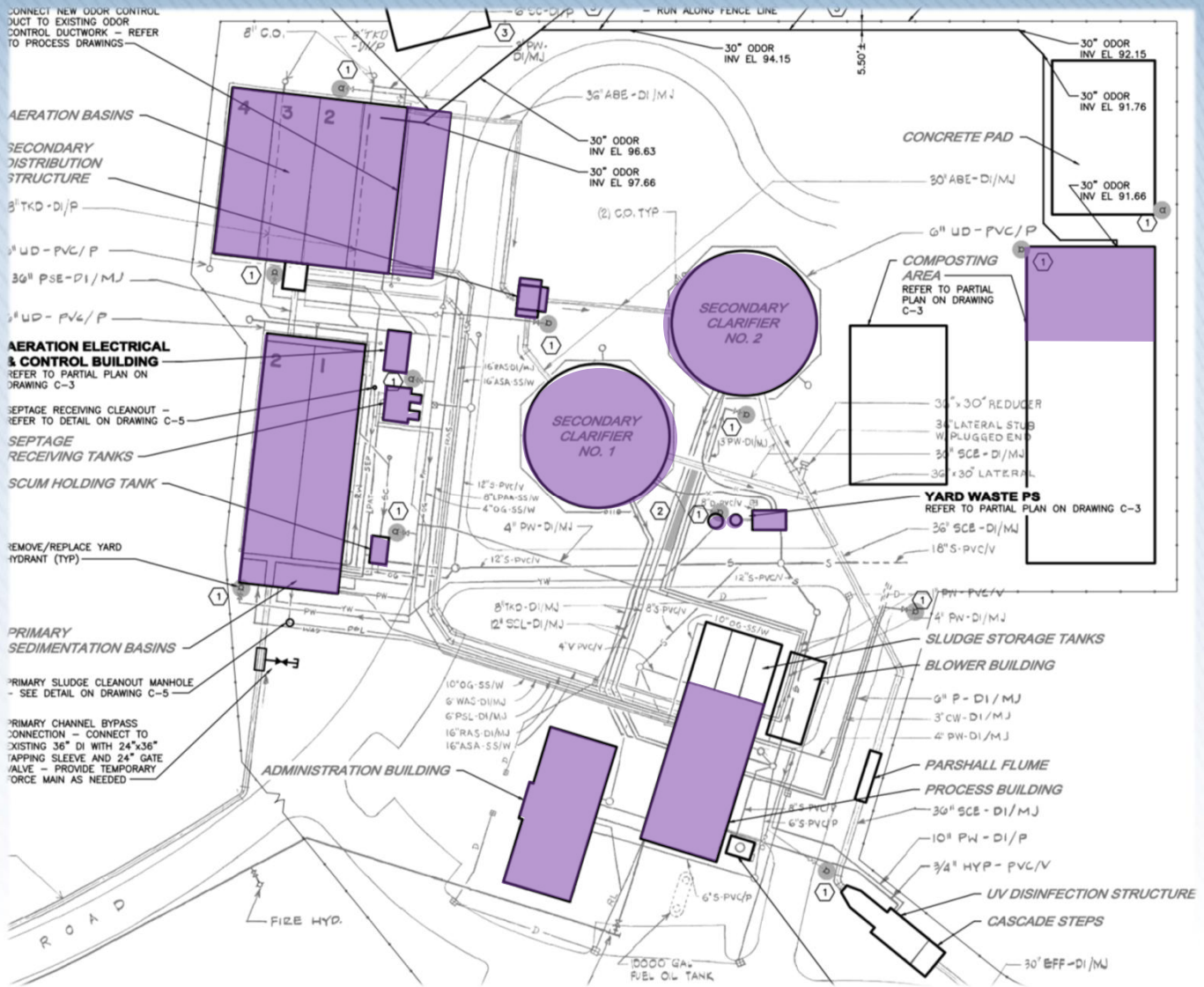
# Project Overview

## Phase I Upgrade



# Project Overview

## Primary Sedimentation Basins/ Primary Gallery



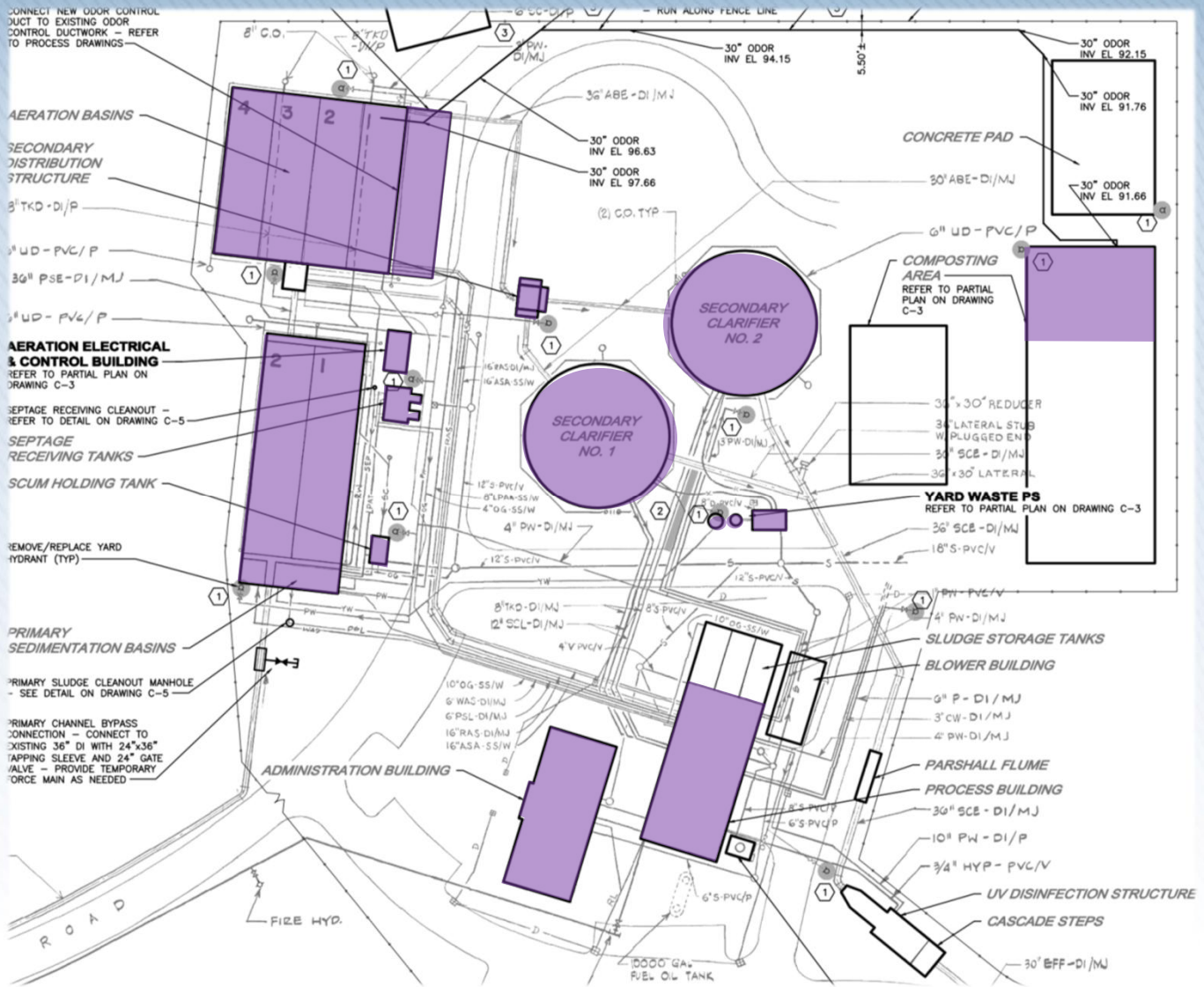
# Project Overview

## Primary Sedimentation Basins/ Primary Gallery

- $H_2S$ resistant coatings
- Chain + Flight mechanisms
- Primary sludge pumps, grinder, actuated valves
- Channel air blowers

# Project Overview

## Septage/ Scum Tanks



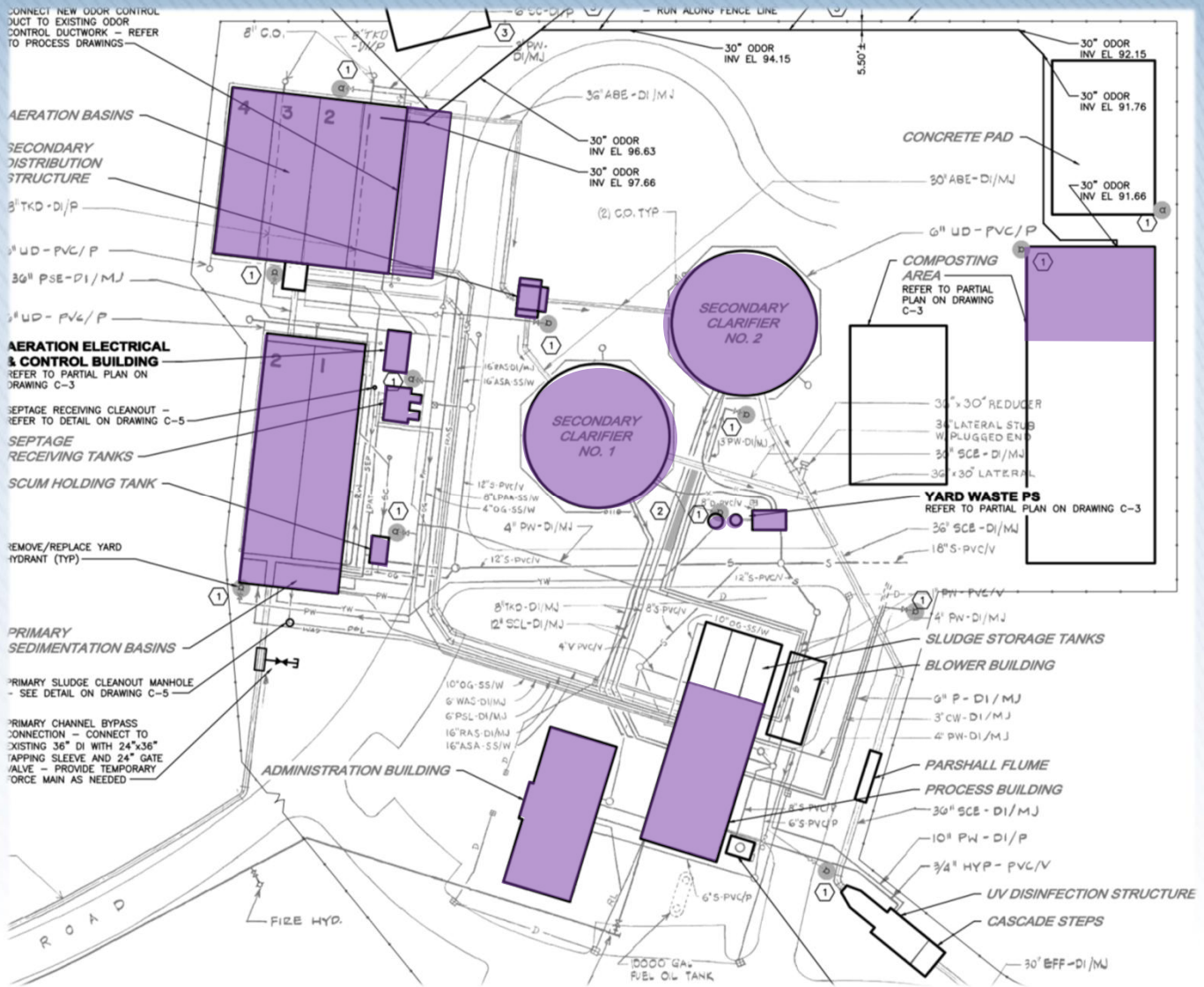
# Project Overview

## Septage/ Scum Tanks

- Septage pumps
- Septage blowers
- Radar level instruments
- $H_2S$ resistant coatings
- New hatches

# Project Overview

## Aeration Basins/ Aeration, Electrical, and Control Building

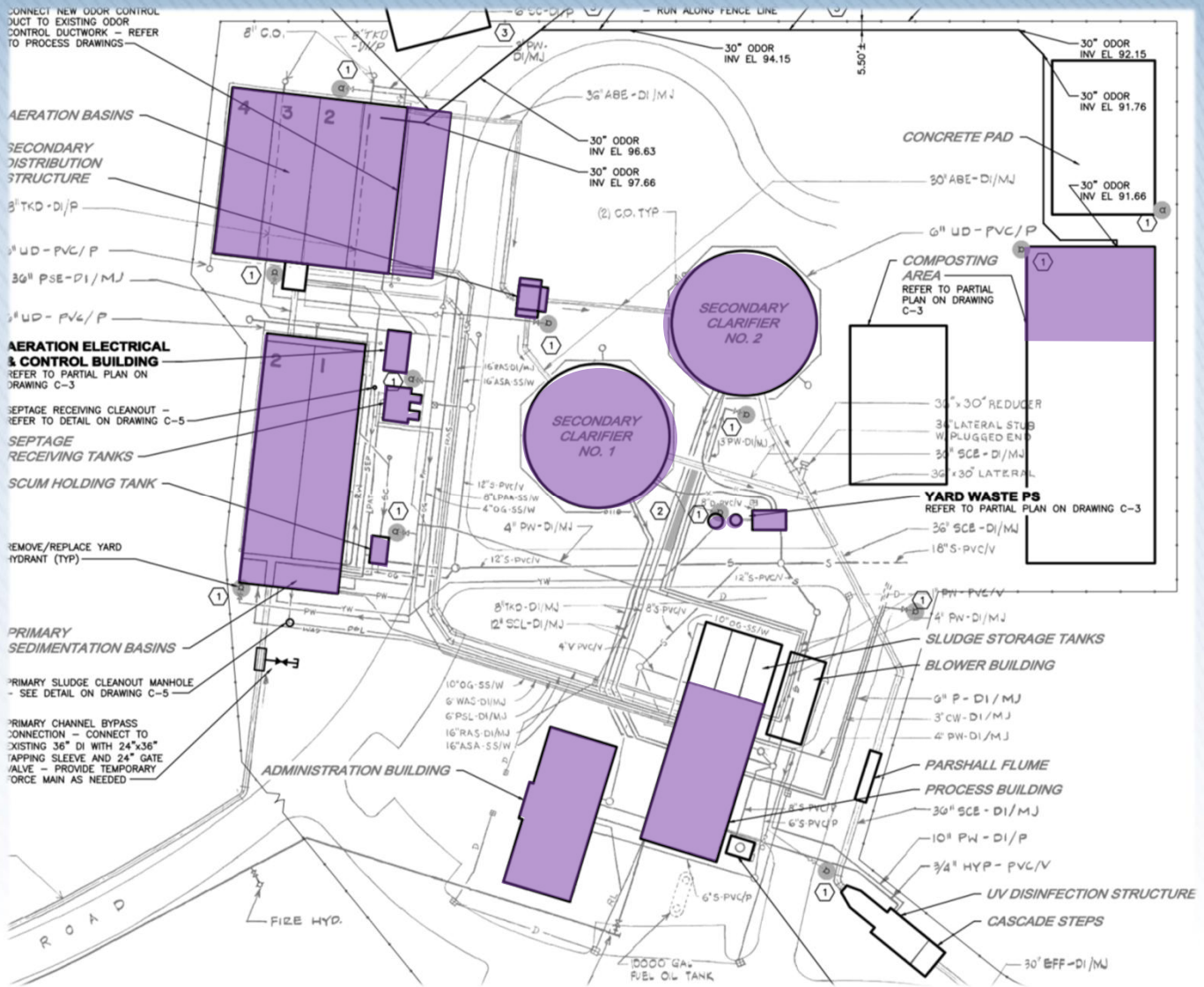


# Project Overview

## Aeration Basins/ Aeration, Electrical, and Control Building


# Project Overview

## Secondary Distribution Structure

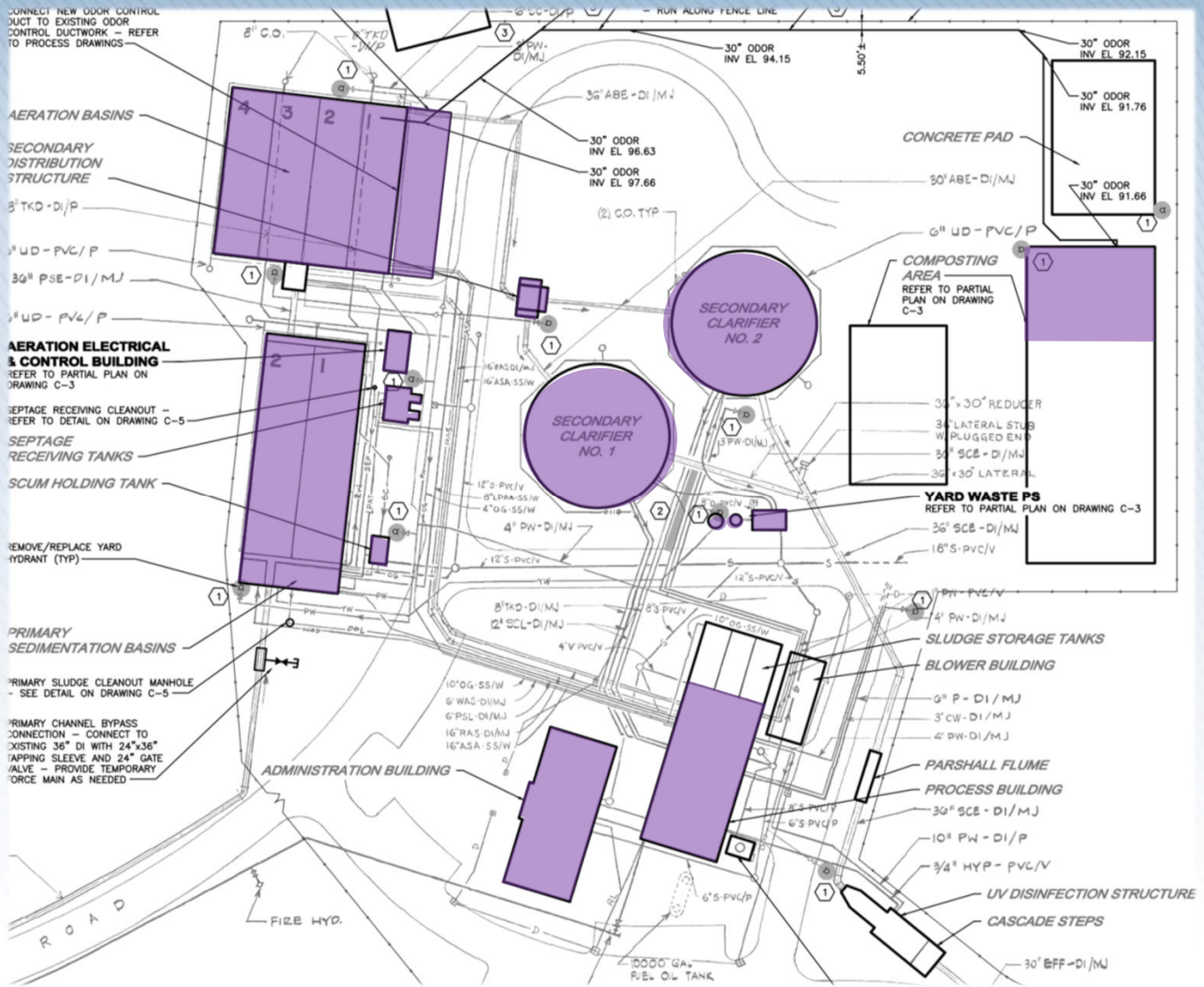


# Project Overview

## Secondary Distribution Structure

# Project Overview

## Secondary Clarifiers



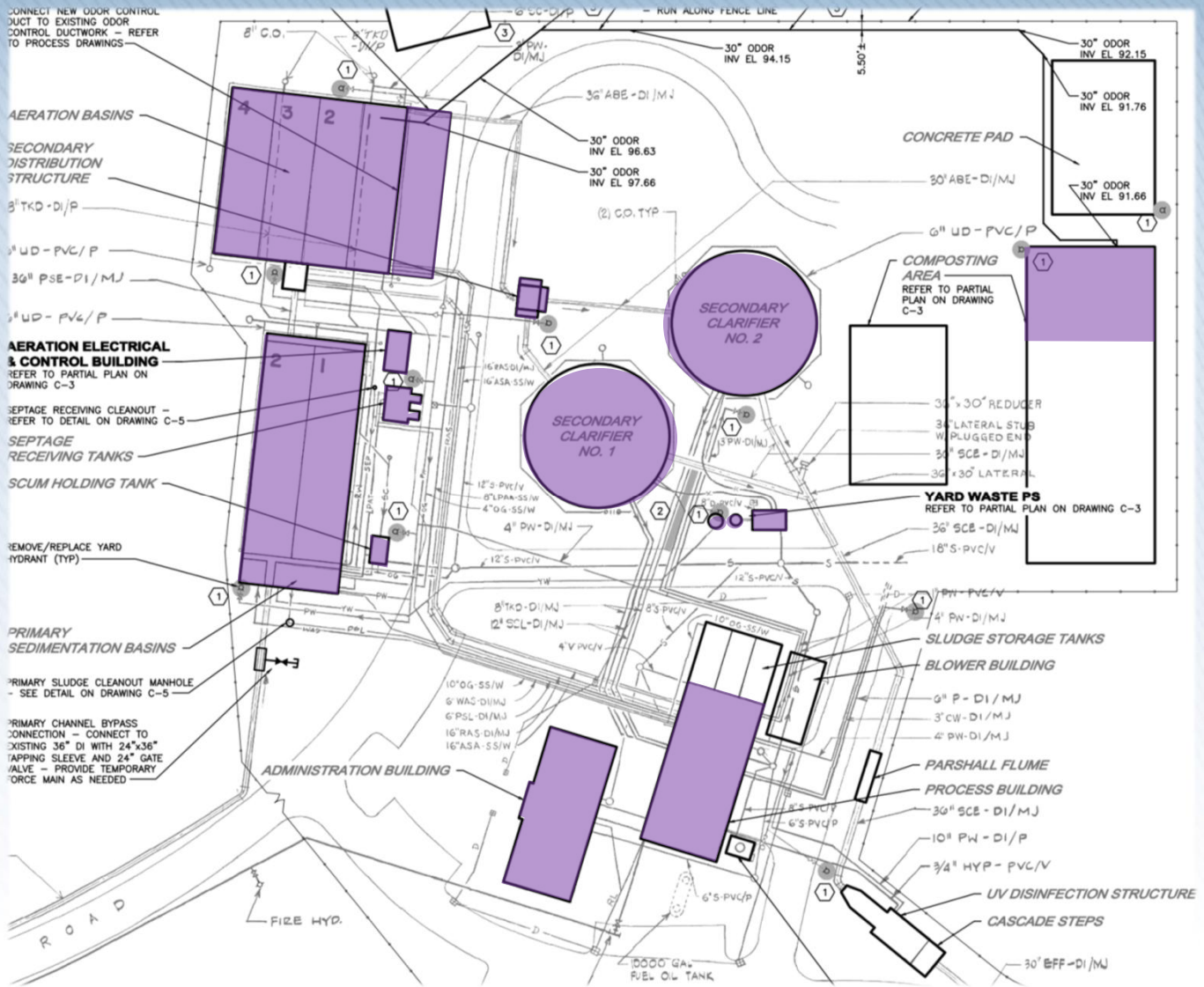
# Project Overview

## Secondary Clarifiers

- SS suction header mechanisms
- Full radius skimmer arm
- Walkway, platform
- Algae sweeps
- Density current baffles
- Concrete coating of launders

# Project Overview

## Process Building



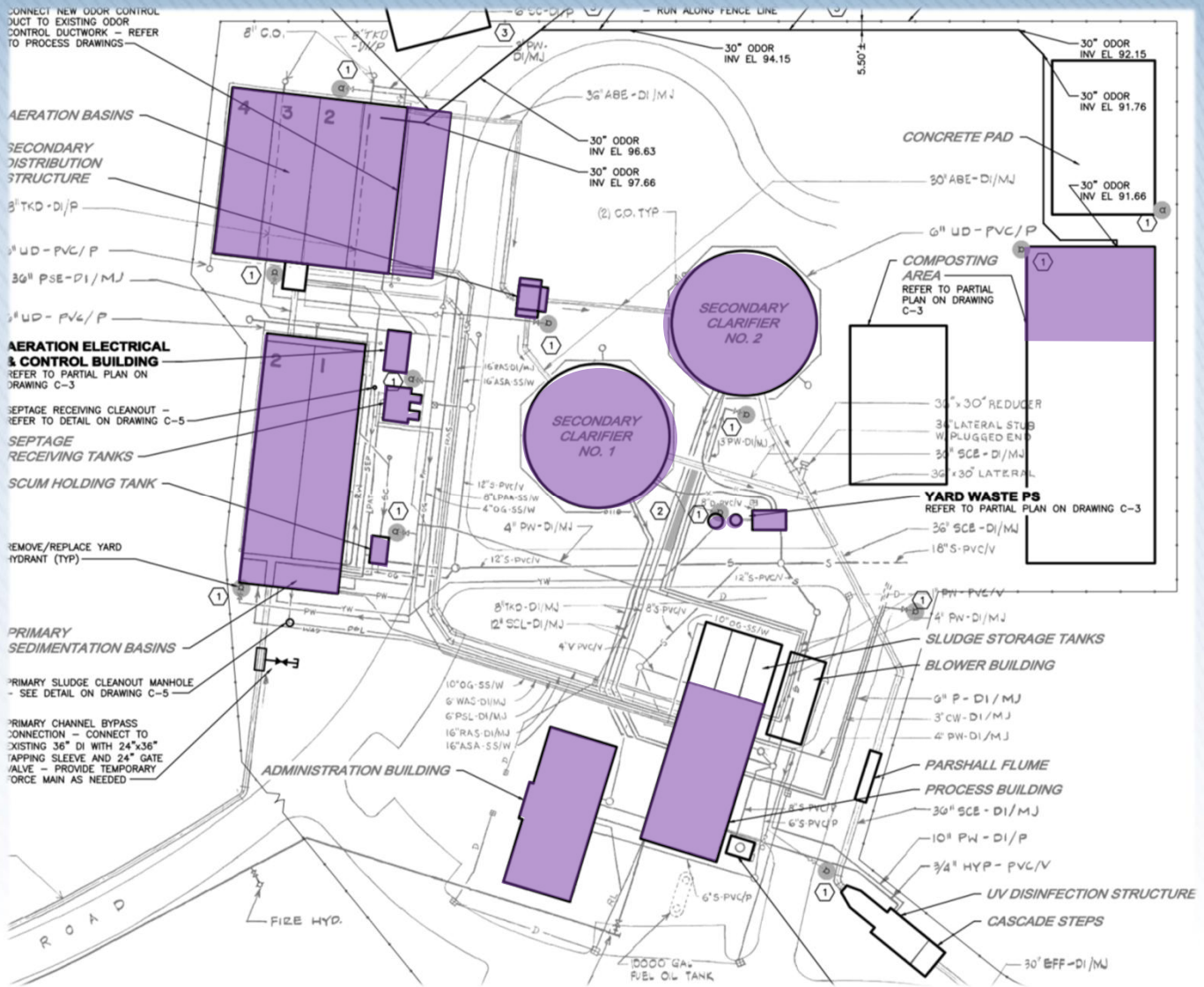
# Project Overview

## Process Building

- RAS pumps
- WAS pumps
- Valves, flow meters
- Polymer system
- Hypochlorite system
- Potassium permanganate pumps

# Project Overview

## Odor Control Systems

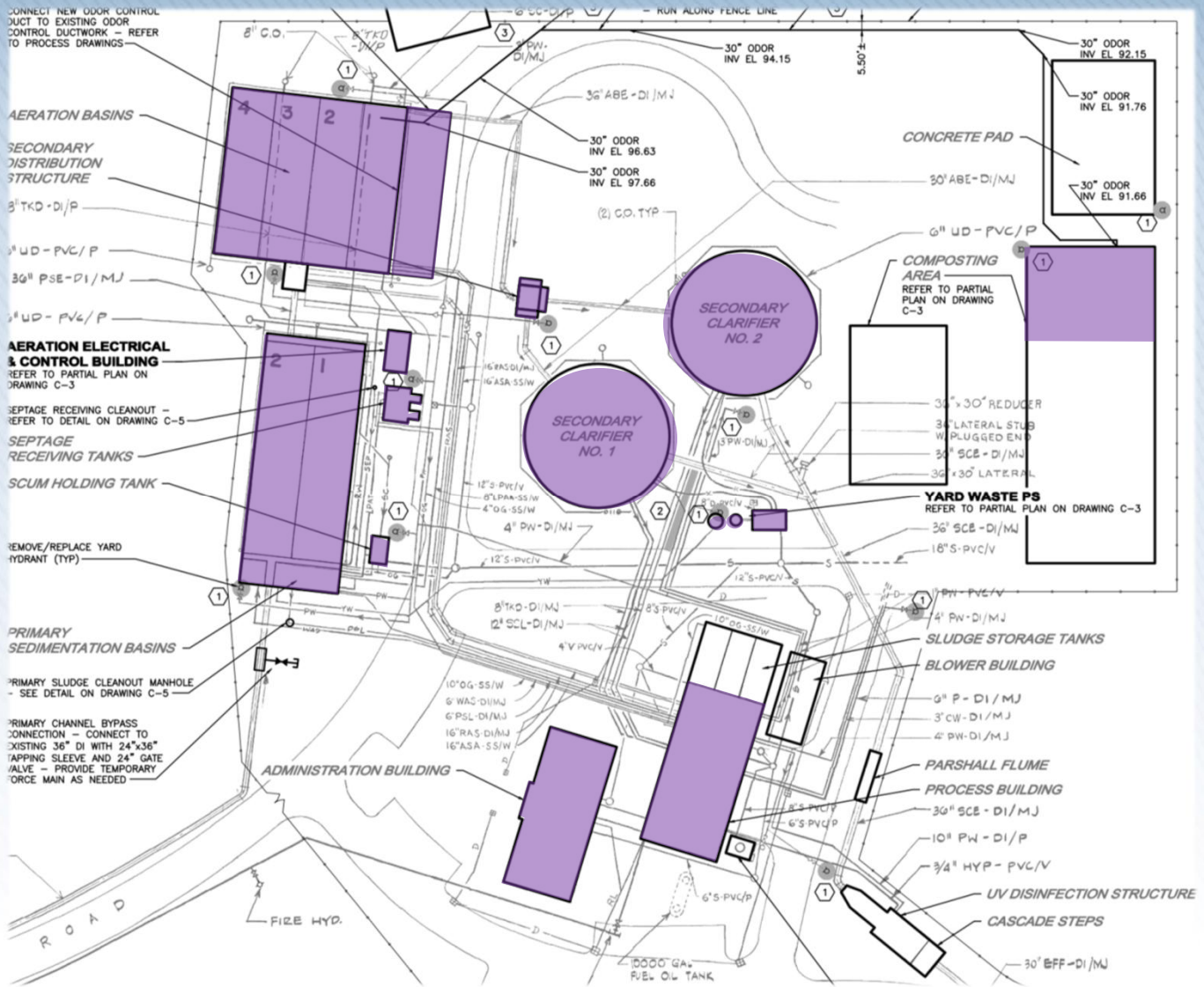


# Project Overview

## Odor Control Systems

# Project Overview

## Yard Waste Pump Station

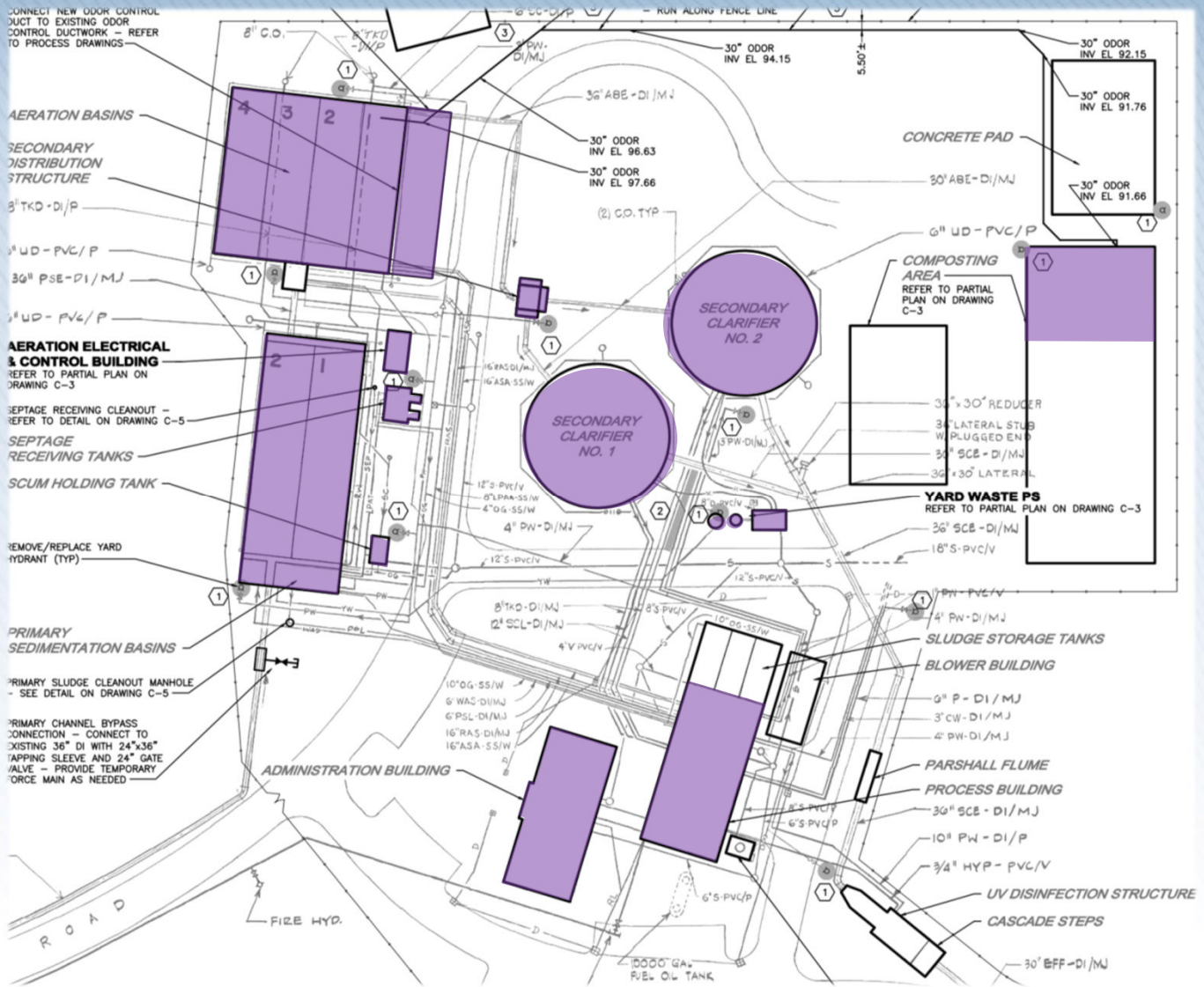


# Project Overview

## Yard Waste Pump Station

# Project Overview

## Administration Building



# Project Overview

## Administration Building

- Boilers
- HVAC
- Roofs
- Floors
- Ceilings
- Laboratory
- SCADA

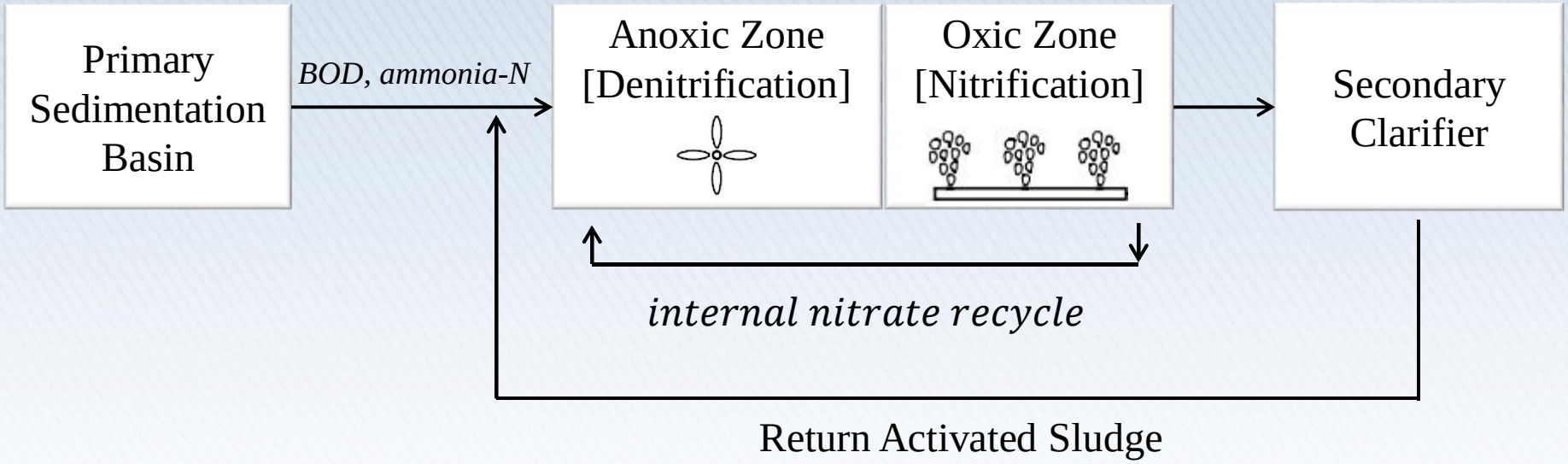
# Modified Ludzack-Ettinger Pilot Program Background

- Pending effluent total nitrogen limits
- Influent sampling program and Biowin modeling
- Reviewed / analyzed BNR processes and technologies
- Selected Modified Ludzack-Ettinger process
- Goal: seasonal average effluent Total Nitrogen < 8 mg/L

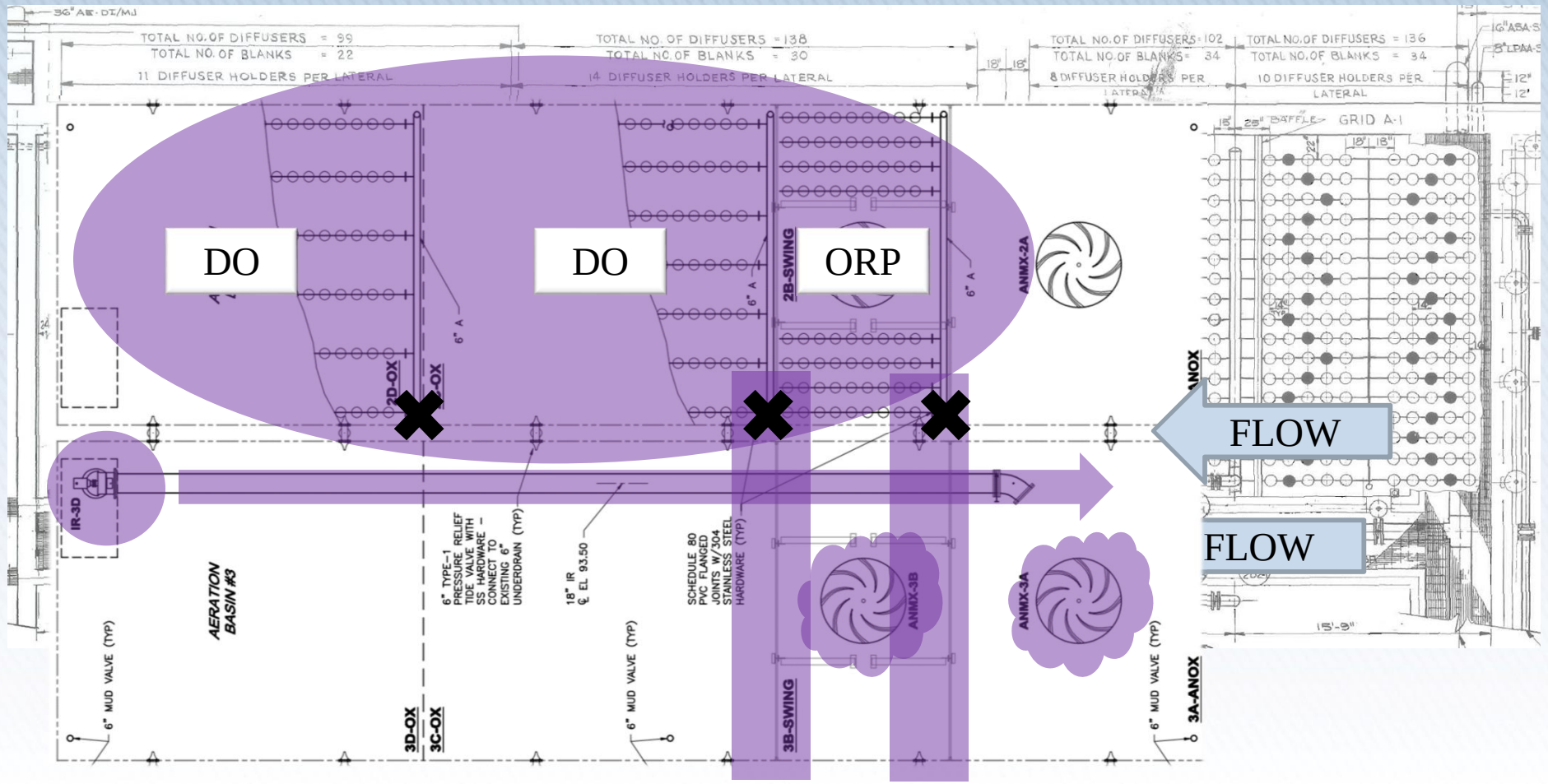
# Modified Ludzack-Ettinger Nitrogen Removal

$$ammonia\text{-}N + O_2 \rightarrow (nitrifiers) \rightarrow H^+ + H_2O + NO_2 + energy$$

$$BOD + NO_3 \rightarrow (denitrifiers) \rightarrow N_2 + CO_2 + energy$$



# Modified Ludzack-Ettinger Construction

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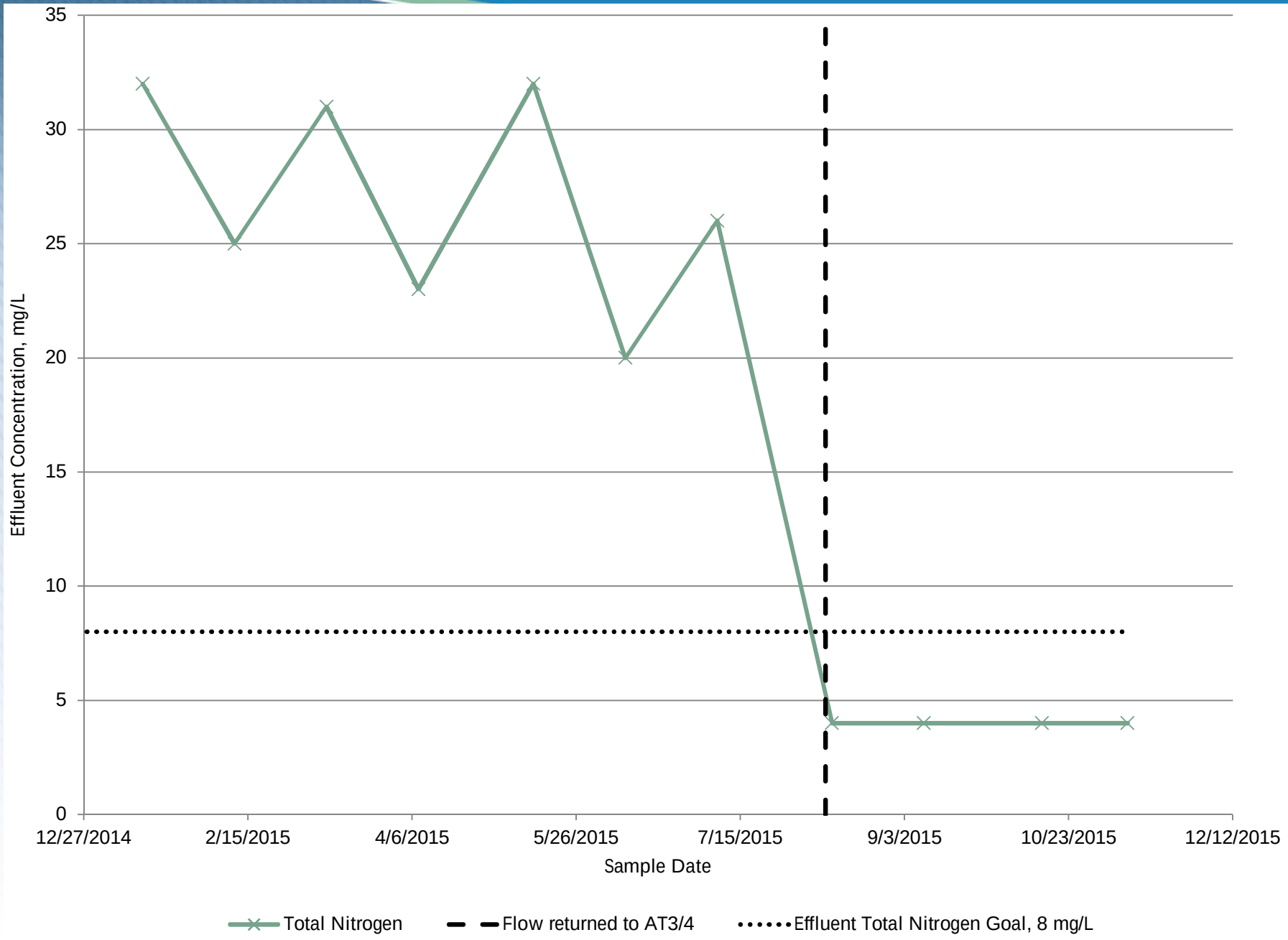
35
30
25
20
15
10
5
0
Effluent Concentration, mg/L
12/27/2014
2/15/2015
4/6/2015
5/26/2015
7/15/2015
9/3/2015
10/23/2015
12/12/2015
Sample Date
Total Nitrogen
Flow returned to AT3/4
Effluent Total Nitrogen Goal, 8 mg/L

# Modified Ludzack-Ettinger Nitrogen Removal – Preliminary Results

- Goal: effluent Total Nitrogen < 8 mg/L

| Conventional | | MLE Process | |
|---|---|---|---|
| Sample Date | Total Nitrogen (mg/L) | Sample Date | Total Nitrogen (mg/L) |
| August 13, 2014 | 25 | August 12, 2015 | < 4.0* |
| September 10, 2014 | 26 | September 9, 2015 | < 4.0* |
| October 8, 2014 | 27 | October 15, 2015 | < 4.0* |
| November 12, 2014 | 27 | November 10, 2015 | < 4.0* |

* Result below reporting limit

# Questions

Thank you!