Operation and Control of Multiple BNR Processes in One WWTP

CENTRAL PLANT

Williamsport Sanitary Authority's Chesapeake Bay and CSO Compliance Program

Presented by: Phil Anderson

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Purpose of Presentation

- Understand the operation and control of multiple the Biological Nutrient Removal (BNR) Systems.
- Review the Components of the Systems
  - Design criteria
  - Operation and process control
  - Target parameters
- Process Optimization

Agenda

- Overview of Central Plant
- Flow Pattern
- Biological Nutrient Removal
  - Design Criteria
    - Total Phosphorus Removal
    - Total Nitrogen Removal
- Operation & Monitoring
- Optimization

Where is Williamsport?

Agenda

- **Overview of Central Plant**
- Flow Pattern
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    - Total Nitrogen Removal
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Central Plant Overview of Existing

Central Plant Overview of Existing

The Central Plant:

- Initially constructed in 1955
- Upgraded to secondary treatment in 1974.
- Fine bubble air diffusers were installed in 1994 to provide improved air distribution and mixing in the activated sludge system.
- WSA is a CSO community serving 63,000.

Central Plant Overview of Existing

Since 2004 WSA was in negotiations with USEPA and PADEP:

- Final effluent discharges to the West Branch of the Susquehanna River (Chesapeake Bay Watershed).

- In addition to NPDES permit requirements, the Chesapeake Bay Nutrient Reduction program requires the removal of nitrogen and phosphorus

Central Plant Overview

Central Plant

Nutrient Credit Trading:

- **DEP Requires Evaluation**: Credit purchase to be considered for PENNVEST funding.
- **DEP Favors Trading:** Encourages POTWs to fund non-point BMPs if more cost-effective
- **Premise:** Buying credits may be less expensive than building and operating new infrastructure.
- **“Truing-up”:** Defer upgrades, use for permit year shortfalls.

Central Plant Nutrient Credit Trading

Nutrient Credit Trading (cont):

- **Credit Program**: Rules and policies not settled
- **Credit Supply/Price:** Availability uncertain; price subject to market variation.
- **Cost Comparison:** Current credit price is close to the cost of building some increments of treatment facilities.

Central Plant

In the end WSA:

- Evaluated the Nutrient Trading Program
- Determined the plant upgrades and expansion served the community better.
- Construction in addition to meeting the nutrient goals also provided capacity to reduce CSOs
- CP design started in 2005
- CP upgraded in 2009-2014

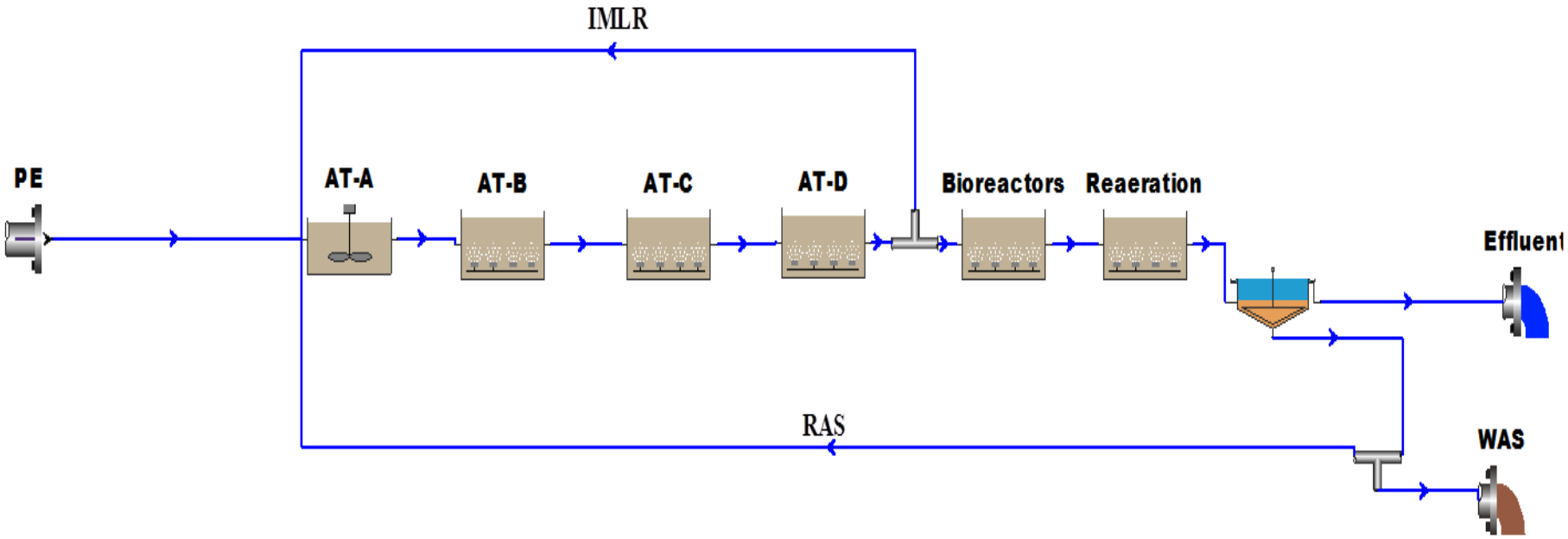
Central Plant Overview NPDES Permit

Parameter	Daily Average (mg/l)	Daily Average (ppd)	Annual (Pounds)
Flow (8.4 MGD)	na	na	na
CBOD	25	1,750	na
Nitrate	2.0	140	na
TKN	4.0	280	na
TN	6.0 (4.5)	420	**153,423**
Phosphorous	0.8 (0.5)	56	**20,456**

Central Plant Overview Process Modeling

Influent Parameters (Including Recycle Streams)	Annual Average - Average Flows, Average Loads	Annual Average - Average Flows, Max. Month Loads	Max Day
Flow	8.4	8.4	21
cBOD5 (mg/L)	112	162	77
cBOD5 (lb/d)	7,860	11,374	13,485
TSS (mg/L)	101	179	89
TSS (lb/d)	7,098	12,509	15,646
TKN (mg/L)	24	34	13
TKN (lb/d)	1,660	2,358	2,358
TP (mg/L)	3.8	7	2.6
TP (lb/d)	267	457	457[1]

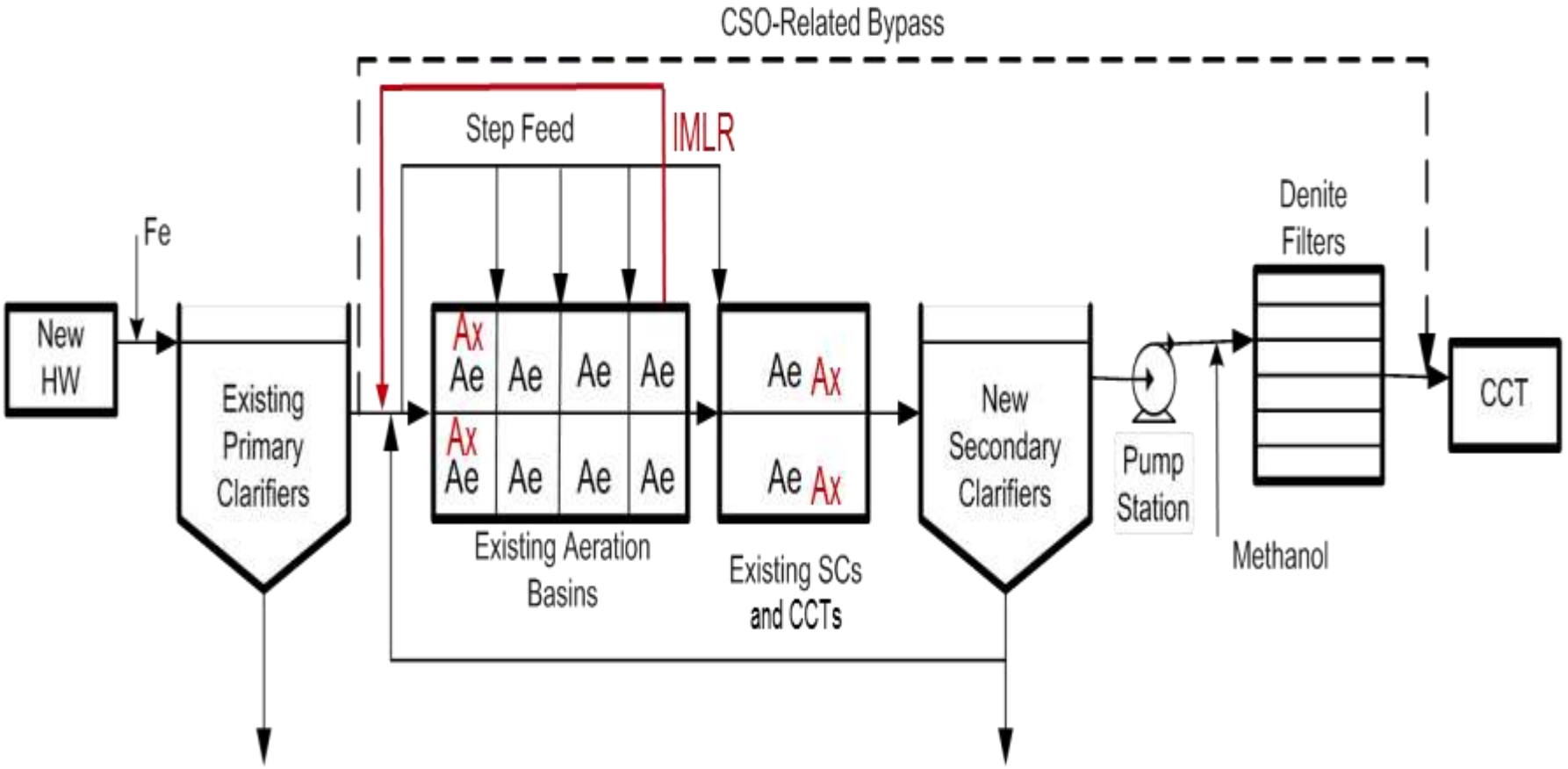
Central Plant Overview Process Modeling



Modeled 3 Different Conditions:

1. Average flows and average loads (to assess year-round performance)
2. Maximum month loads at average flow
3. Maximum month flows at max month loads (design condition to meet nutrient requirements)

Central Plant Overview Improvements



Central Plant Overview Improvements to Existing

- Activated Sludge
  - Improved Air Flow and DO Control (Aerobic)
  - Changed AS to Modifed Ludzak-Ettinger (MLE) Process for the removal of Nitrate.
  - Added IMLR Pumps – Return Nitrates to Influent Zones (Anoxic)
  - Anoxic Zones – Mixing only
  - Swing Zones – Mixing for Anoxic/Anaerobic and Air Diffusers for Aerobic
  - Anaerobic Zone for phosphorus removal
- Secondary Clarifiers converted to Bioreactors
- CCT converted to Reaeration Tanks

Central Plant Overview

New Facilities:

- CSO Tank
- Headworks
- Secondary Clarifiers
- Chemical Feed – Polymer, FeCl2 & NaOH
- Denitrification Filters – Carbon Feed
- Chlorine Contact Tank
- Sidestream Treatment – for recycle loading
- Gravity Belt Thickener
- SCADA

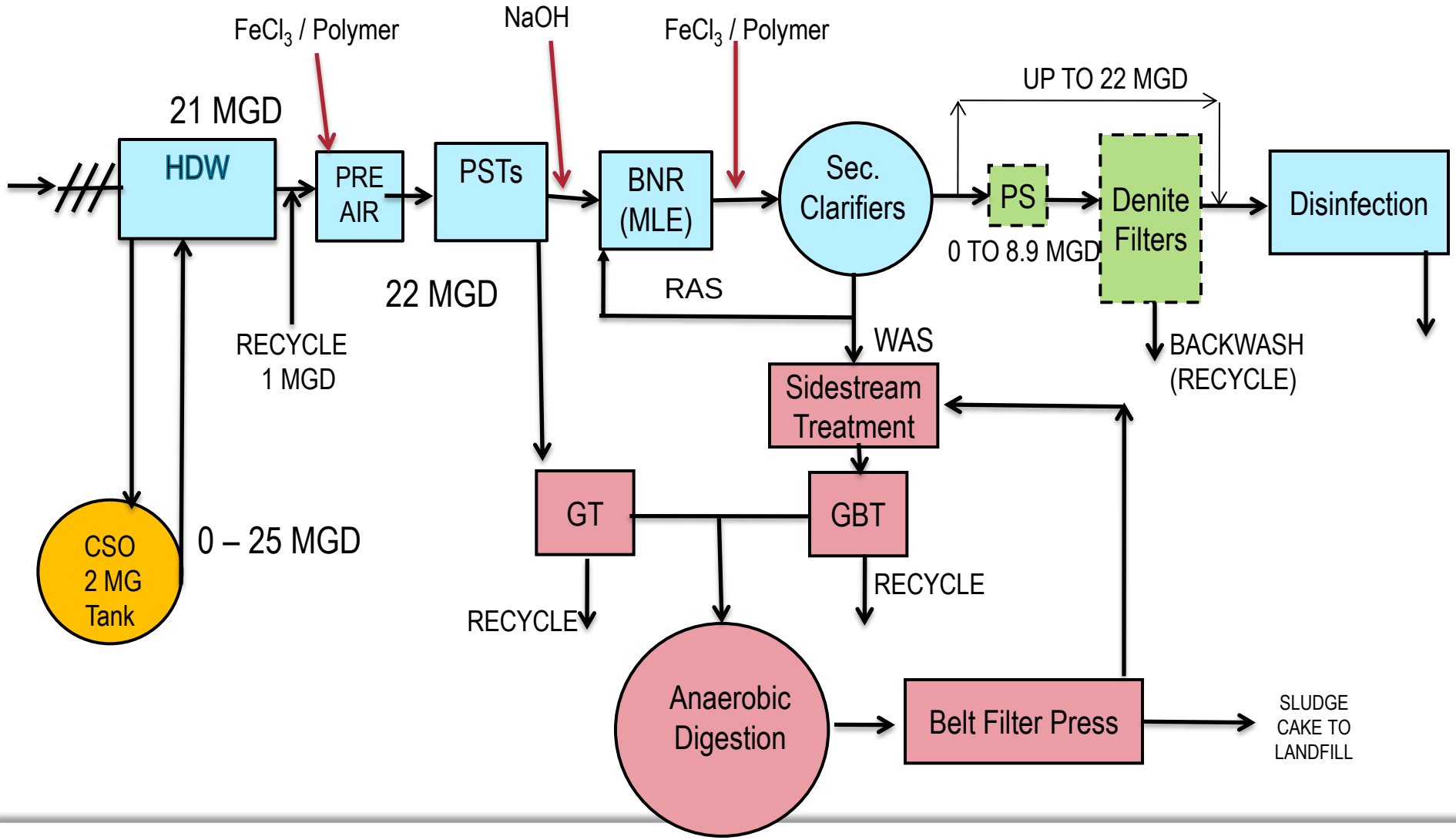
Central Plant Overview of Existing

Central Plant Overview

Agenda

- Overview of Central Plant
- **Flow Pattern**
- Biological Nutrient Removal
  - Design Criteria
    - Total Phosphorus Removal
    - Total Nitrogen Removal
- Operation & Monitoring
- Optimization

Flow Pattern



Flow Pattern

Agenda

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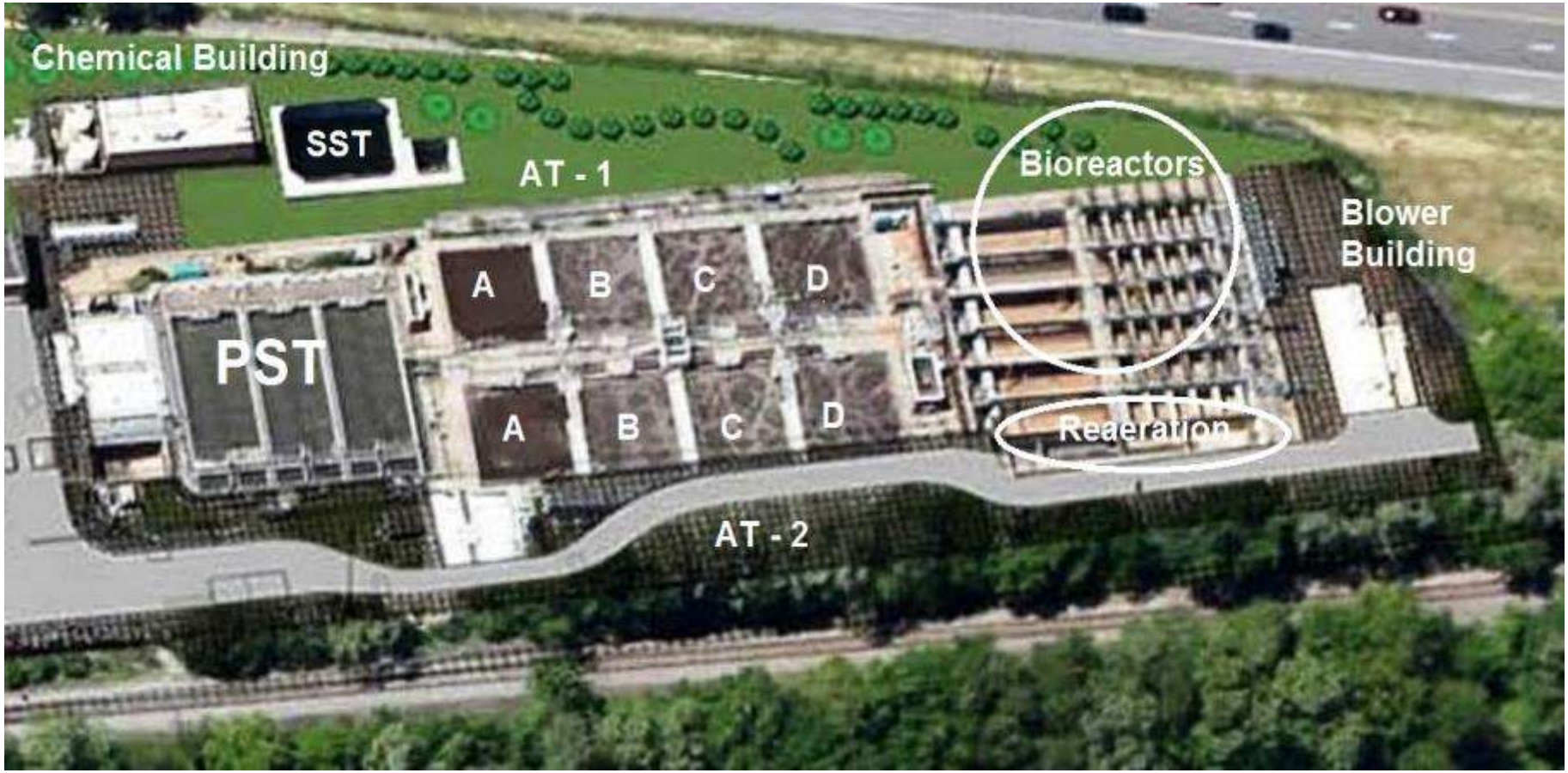
Biological Nutrient Removal Overview


Chemical Building
SST
AT - 1
Bioreactors
Blower Building
A
B
C
D
PST
A
B
C
D
Reaeration
AT - 2

Biological Nutrient Removal Overview

BNR by Activated Sludge using three zones (aerobic, anoxic & anaerobic):

- Aerobic to remove:
  - ✓ CBOD and Ammonia - Nitrification (produces nitrates)
- Anoxic to remove:
  - ✓ Nitrates using Denitrification
- Anaerobic to remove:
  - ✓ Phosphorus
- Permit Goal
  - ✓ Total Nitrogen (Nitrate Plus TKN)
  - ✓ Total Phosporus

Agenda

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Operation & Monitoring - MOPO

Schedule	System Startup
August 2012	Headworks; Influent and CSO Pumping, Screening and Grit Removal
September 2012	Primary Sludge Pumping
October 2012	Aeration Tanks (MLE)
January 2013	Secondary Clarifiers, RAS, Disinfection and CCT, Final Scum Pumping
March 2013	Denitrification Filters and Methanol System
	BFP Sludge Cake Conveyor and Cake Pumps
May 2013	Chemical Feed Systems (Ferric Chloride & Sodium Hydroxide)
August 2013	Side Stream Treatment (SST)
September 2013	Gravity Belt Thickener (GBT)
October 2013	Bio-reactors and Re-aeration Tanks

Operation & Monitoring - MOPO

- WWTP Staff - Who are they? What is their experience?
- Formed the WSA Process Control Team (PCT)
  - WSA Operations Manager
  - WSA WW Operations Manager
  - WSA CP Superintendent
  - WSA CP Assistant Superintendent
  - ARCADIS RPR (Resident Engineer)
  - ARCADIS Operations Specialist
  - ARCADIS Liaison Engineer
  - Gannett Fleming Construction Manager

Operation & Monitoring - MOPO

Operational Goals:

- Meet the limits of the NPDES
  - TN
  - TP
- Manage peak flows
  - Flow Controls
  - Maintain Bio Mass
- Well established operating procedures
- SCADA and process control

Operation & Monitoring

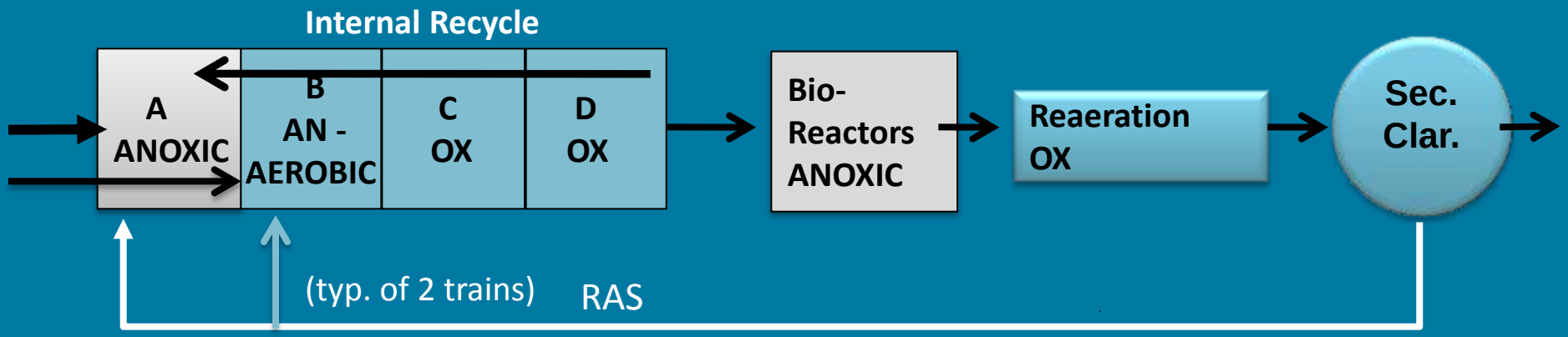
- **The BNR Process has three types of zones:**
- Selector anoxic zones (A) for selection against filamentous microorganisms and for denitrification (nitrate removal).
- Swing zones anoxic/anaerobic/aerobic (B) and (Bioreactors – anoxic/aerobic).
- Aerobic zones (C & D) for CBOD/COD removal and nitrification and reaeration (Reaeration Tanks).

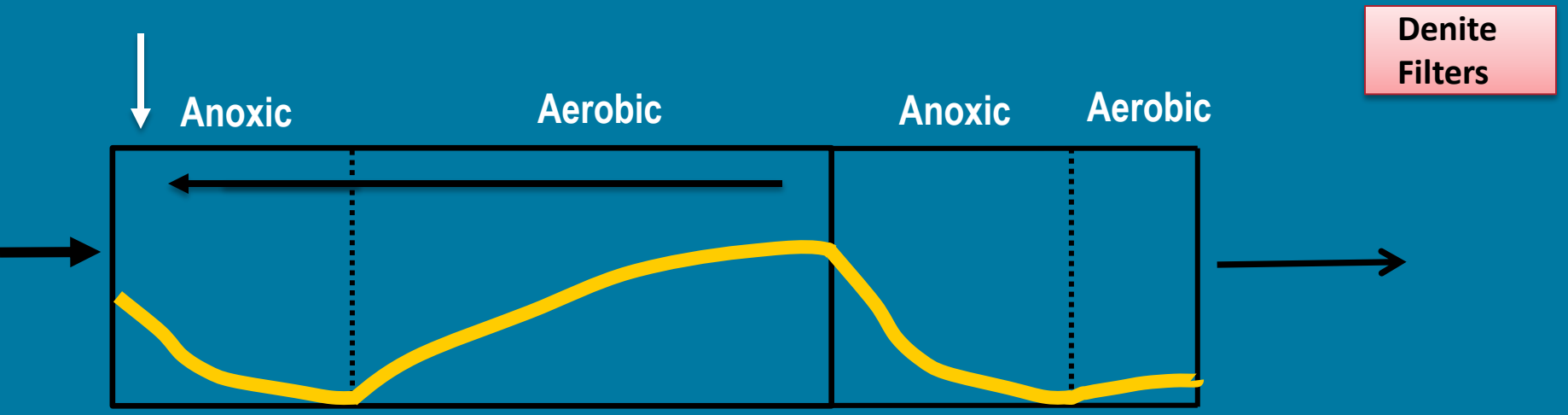
Operation & Monitoring

Warm weather operation:

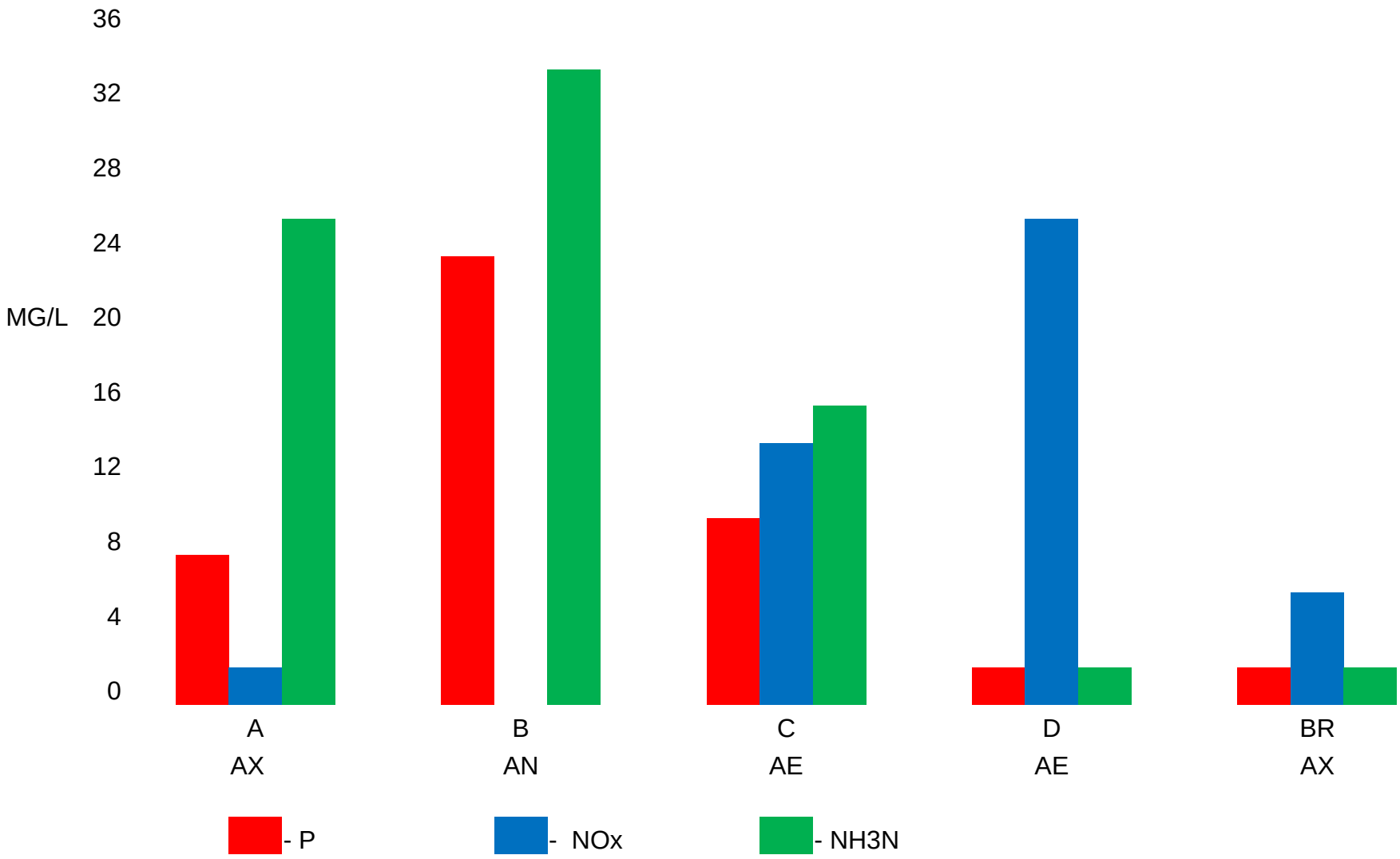
- Zone A and the bioreactors are operated in anoxic mode
- Zone B anaerobic for P removal
  - Plus RAS and Primary Effluent
- Zones C and D, and the reaeration tanks in aerobic mode.

Operation & Monitoring





Operation & Monitoring

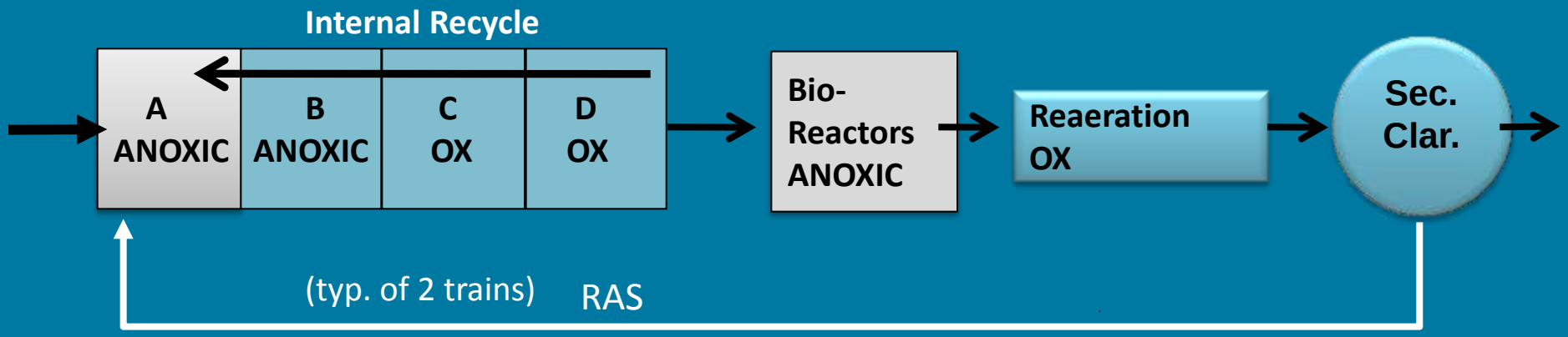


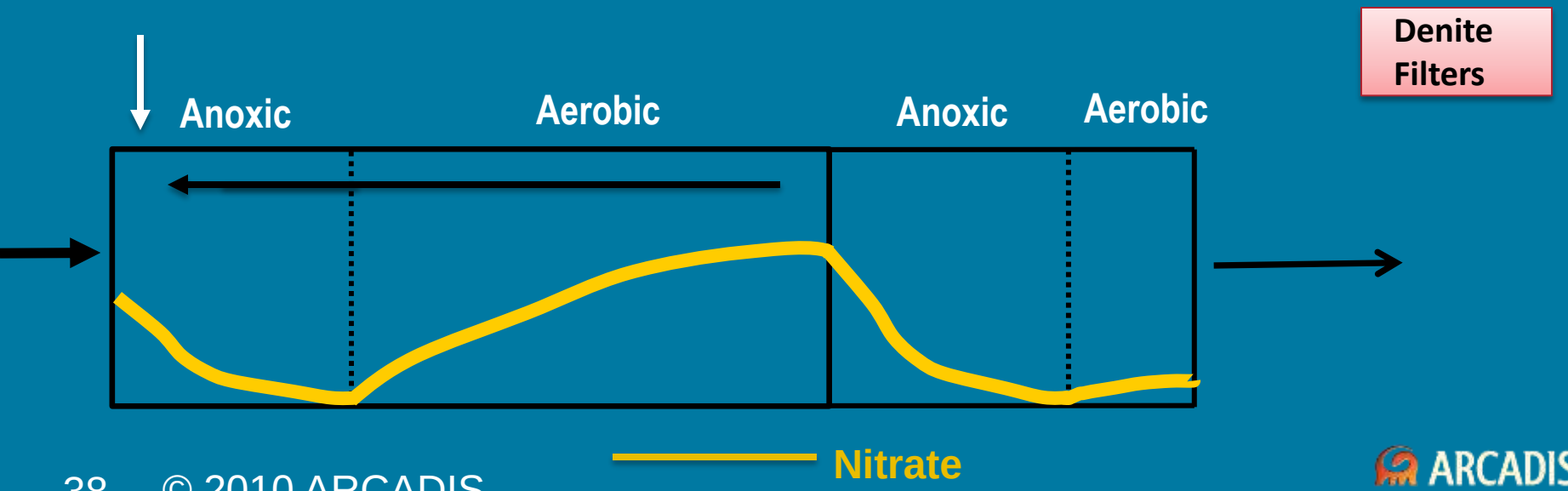
Operation & Monitoring

Fall & Spring Conditions:

- Maintain warm weather operation as long as possible to maintain P removal
- Zone B and the Bio-Reactors are operated in anoxic or aerobic modes in the transition seasons of fall and spring as necessary to achieve nitrification and denitrification.
- Any remaining nitrate removal is achieved in the denitrification filters.

Operation & Monitoring





Operation & Monitoring

Cold weather conditions:

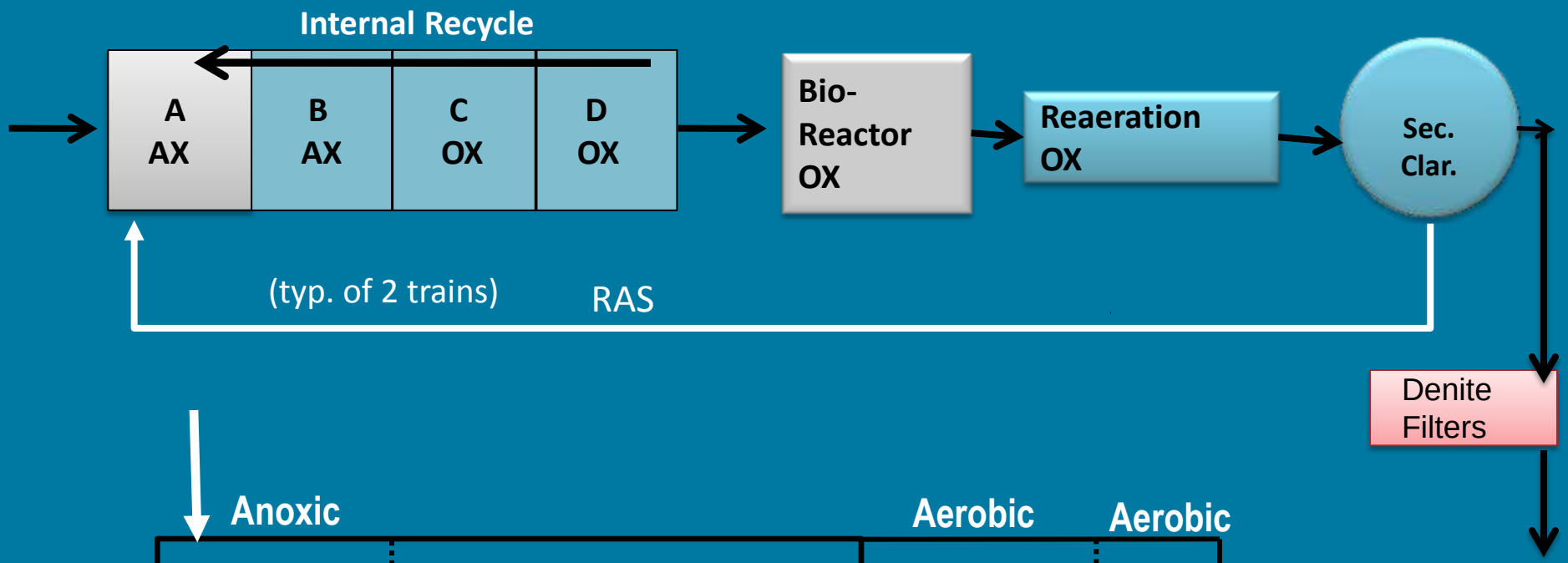
- Low wastewater temperatures (< 12˚ C) slow microbial activity.
- Zones A and B operated in anoxic mode
- Any phosphorus is passed on to the denitrification filters.
- Zones C and D, and bioreactors are operated in aerobic mode.

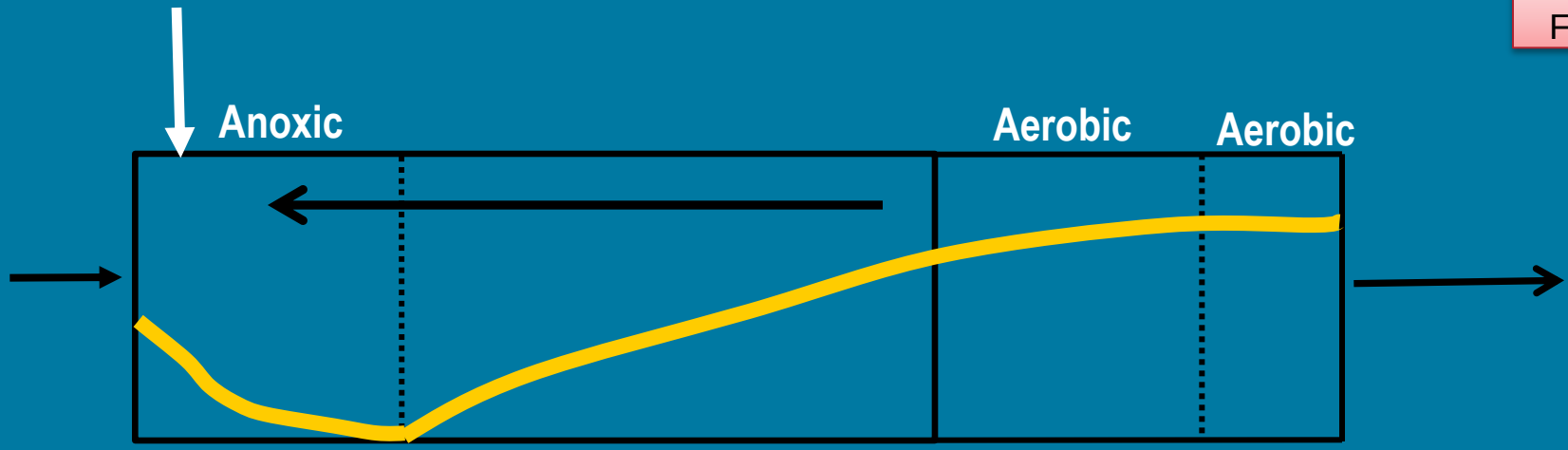
Operation & Monitoring

Cold weather conditions (continued):

- This maximizes the volume available for nitrification, while still achieving partial denitrification in Zone A and B.
- Any remaining nitrate and phosphorus removal is achieved in the denitrification filters.

Operation & Monitoring
Cold Weather





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Operation & Monitoring

Analytical Probes and Transmitters:

- Dissolved Oxygen (Zones B, C & D and Reaeration Tanks)
  - Improved Air Flow and DO Control Loop
- ORP (Zones A & B, Bioreactor effluent)
- Nitrate (Zones A, B & D)
- Ammonia (D)
- Phosphorus (Plant Influent Denite Filter Influent & Plant Effluent)

Operation & Monitoring

DO and Air Flow Control

Target Parameters

Parameter	Zone A	Zone B P - Removal	Zone B Winter	Zone C
ORP	- 50 to -450	-300 to -450	-50 to +100	--
DO	0 to 0.2 mg/l	0 to 0.2 mg/l	2 to 3 mg/l	3 mg/l
Nitrate	0 to 10 mg/l	0 to 2 mg/l	0 to 10	5 to 20 mg/l
Ammonia	>20 mg/l	>25 mg/l	>20	0 to 10 mg/l

Operation & Monitoring

DO and Air Flow Control

Target Parameters			
Parameter	**Zone D**	**Bioreactor**	**Reaeration Tank**
ORP	--	-50 to +100	--
DO	2 mg/l	0 to 3 mg/l	2 to 3 mg/l
Nitrate	0 to 4 mg/l	0 to 4 mg/l	0 to 4 mg/l
Ammonia	<5 mg/l	<5 mg/l	<5 mg/l

Operation & Monitoring IMLR Control

Parameter	Value	Comment
IMLR Pumps Return Rate	100 to 300%	Influent Flow < 9.0 MGD
% Return Rate of Plant Influent Flow	0% to 100%	Influent Flow 9.0 to 12.5 MGD
	Pumps Off	Influent Flow >12.5 MGD


IMLR Pump

Operation & Monitoring
Aeration Tank Flow Control

Imagine the result

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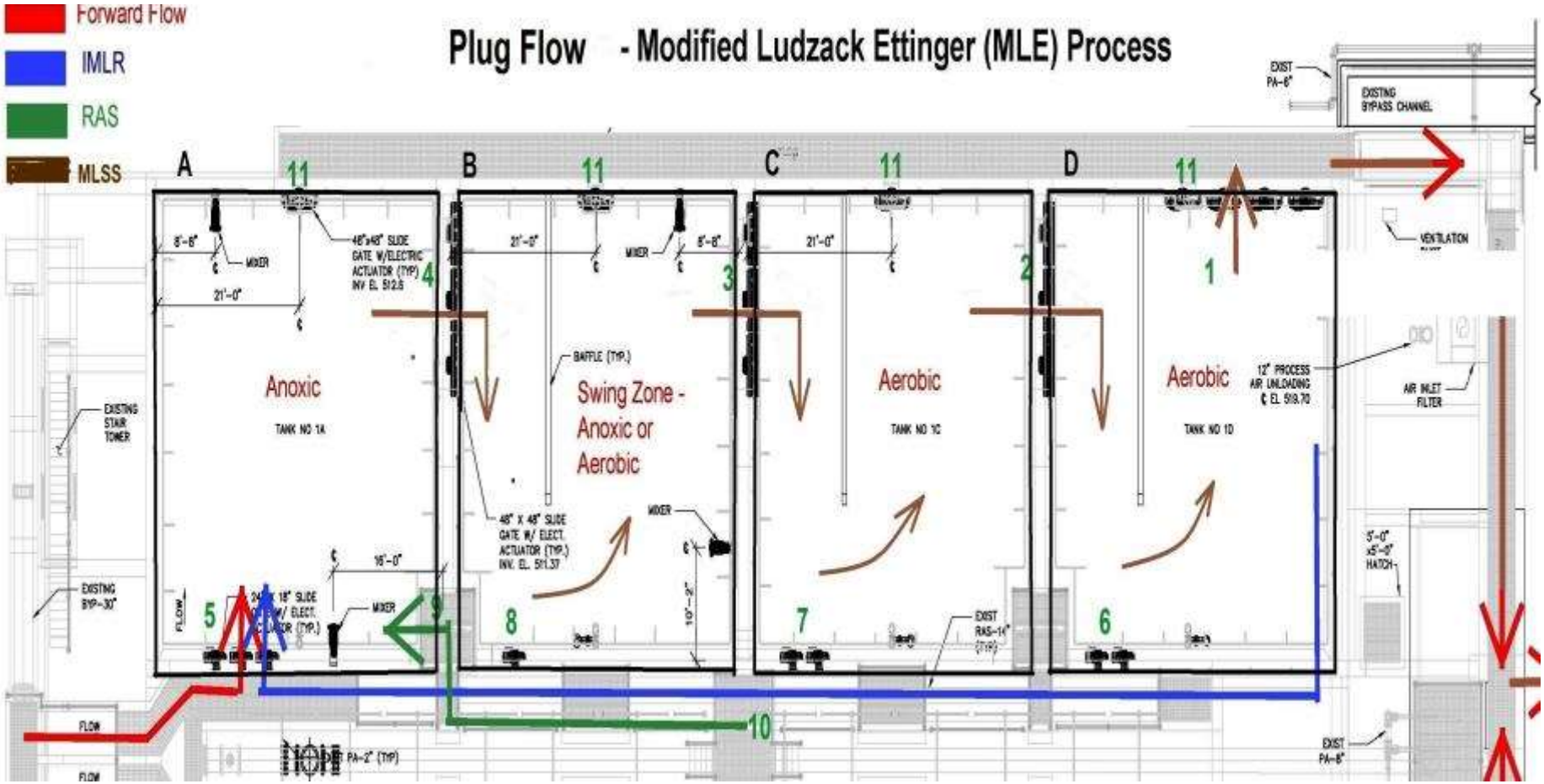
Operation & Monitoring
Aeration Tank Gates & Flow Control

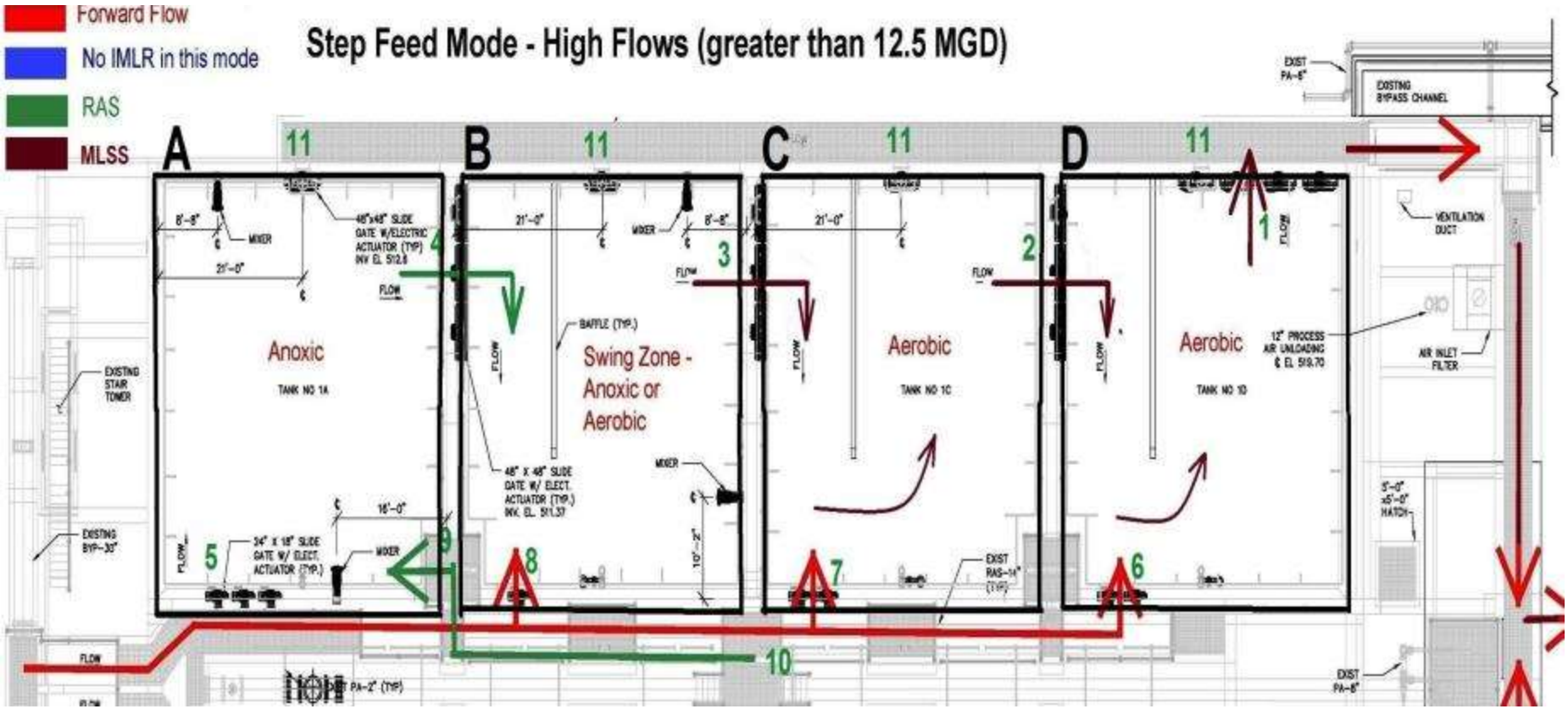
Normal Operation – Remote Auto

- All Influent gates operate in Remote Auto and can be controlled from the OPC or WS.
- Gate position is automatically changed to the flow modes below based on maximum flow setpoint adjustable by the Operator:
  - Plug Flow <14.0 MGD
  - Step Feed 14.0 to 18.0 MGD
  - Contact Stabilization >18.0 MGD

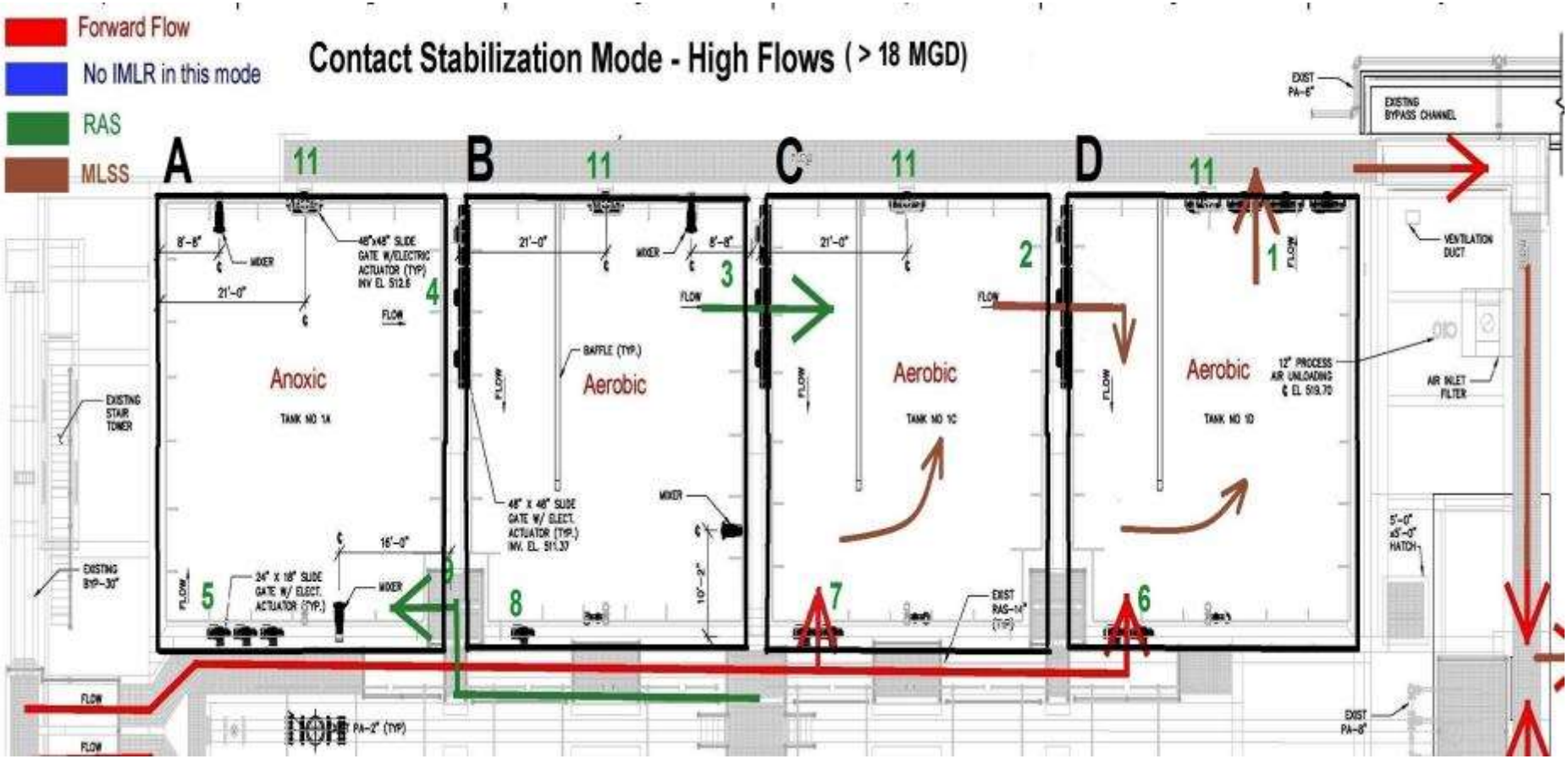
Operation & Monitoring

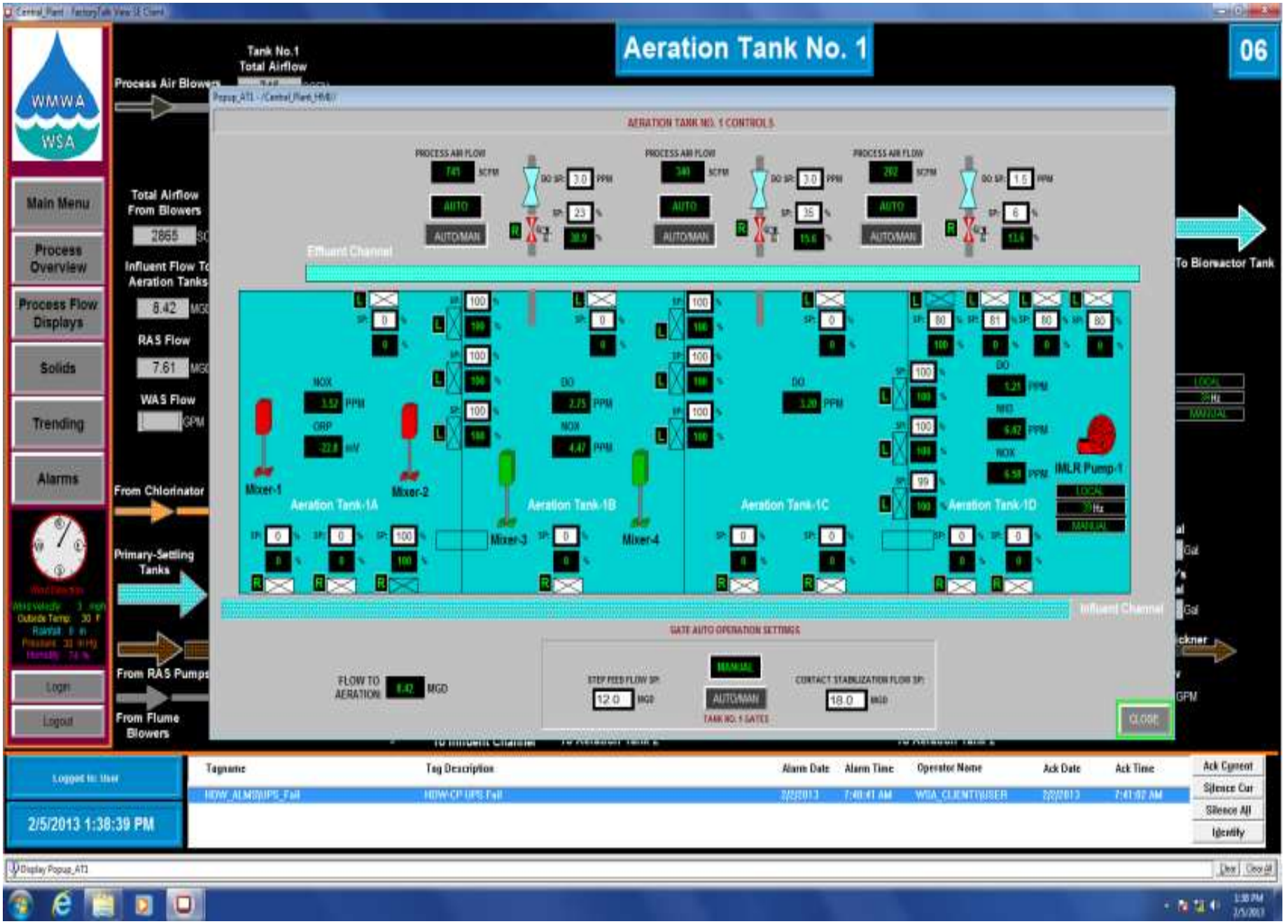


Operation & Monitoring



Operation & Monitoring




Aeration Tank No. 1
06
Tank No.1
Total Airflow
Process Air Blowers
Main Menu
Process Overview
Process Flow Displays
Solids
Trending
Alarms
Login
Logout
Total Airflow From Blowers
2865
Influent Flow To Aeration Tanks
8.42
RAS Flow
7.61
WAS Flow
From Chlorinator
Primary-Settling Tanks
From RAS Pumps
From Flume Blowers
To Bioreactor Tank
AERATION TANK NO. 1 CONTROLS
PROCESS AIR FLOW
Effluent Channel
Influent Channel
Mixer-1
Mixer-2
Mixer-3
Mixer-4
Aeration Tank-1A
Aeration Tank-1B
Aeration Tank-1C
Aeration Tank-1D
IMLR Pump-1
GATE AUTO OPERATION SETTINGS
FLOW TO AERATION
MGD
STEP FEED FLOW SP:
12.0
CONTACT STABILIZATION FLOW SP:
18.0
CLOSE
2/5/2013 1:38:39 PM
Tagname
Tag Description
Alarm Date
Alarm Time
Operator Name
Ack Date
Ack Time
Ack Current
Silence Cur
Silence All
Identify

Process Monitoring & Control System

OPC OWS

Agenda

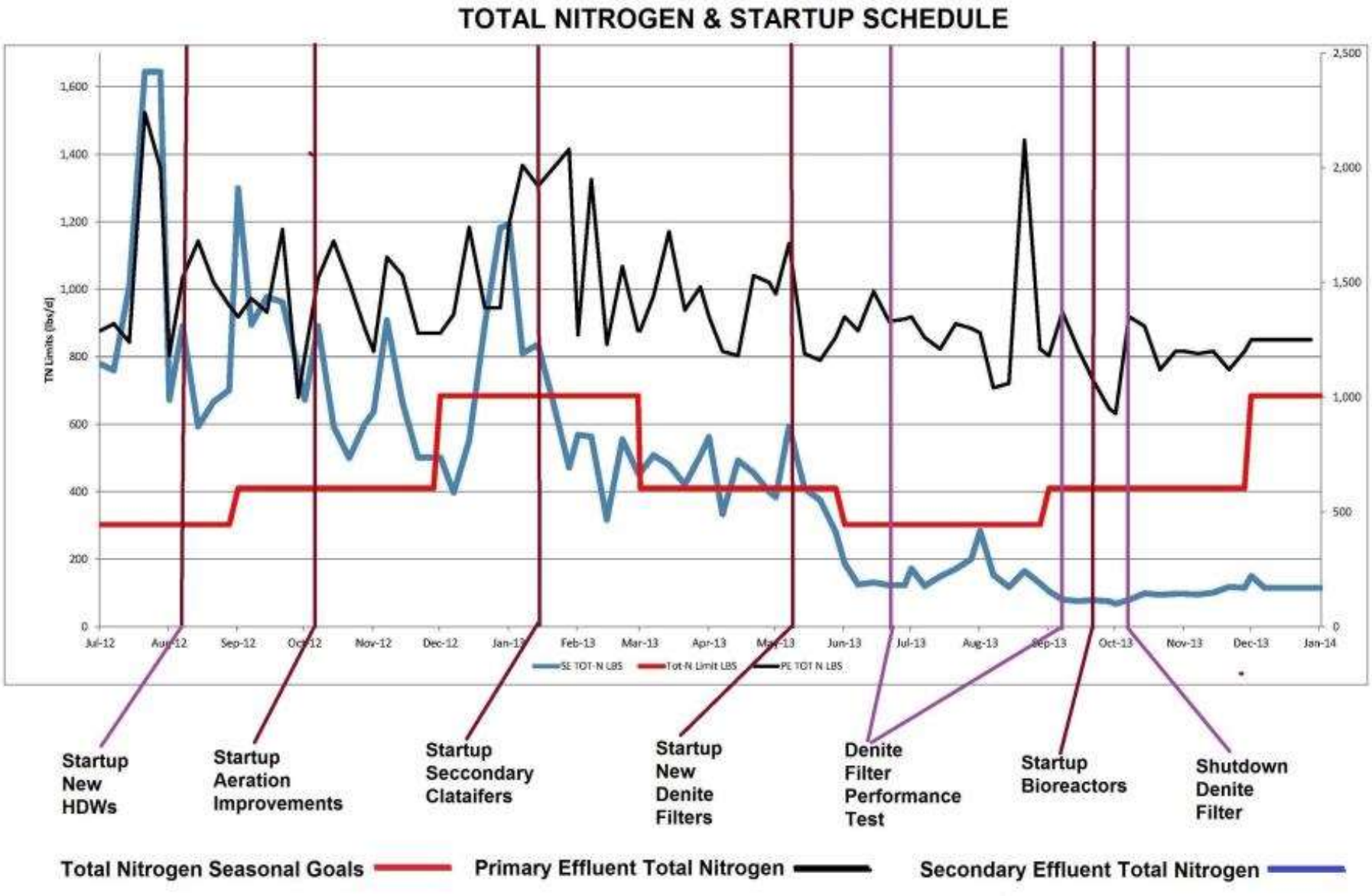
- Overview of Central Plant
- Flow Pattern
- Biological Nutrient Removal
  - Design Criteria
- Startup Planning
- Operation & Monitoring
- **Optimization**

Optimization

On Going:

- Created a tiered TN loading target
- Assist with BNR operation
  - Aeration tanks and bioreactors
  - Denitrification filters
- Continue to confirm the Bio Win Model
- Update Normal and Wet Weather BNR Operation and Denitrification SOPs
- Assist WSA in fine-tuning operations and SCADA control schemes

Optimization



Questions?