Managing Nutrient Removal at a 4 - Sludge BNR Facility

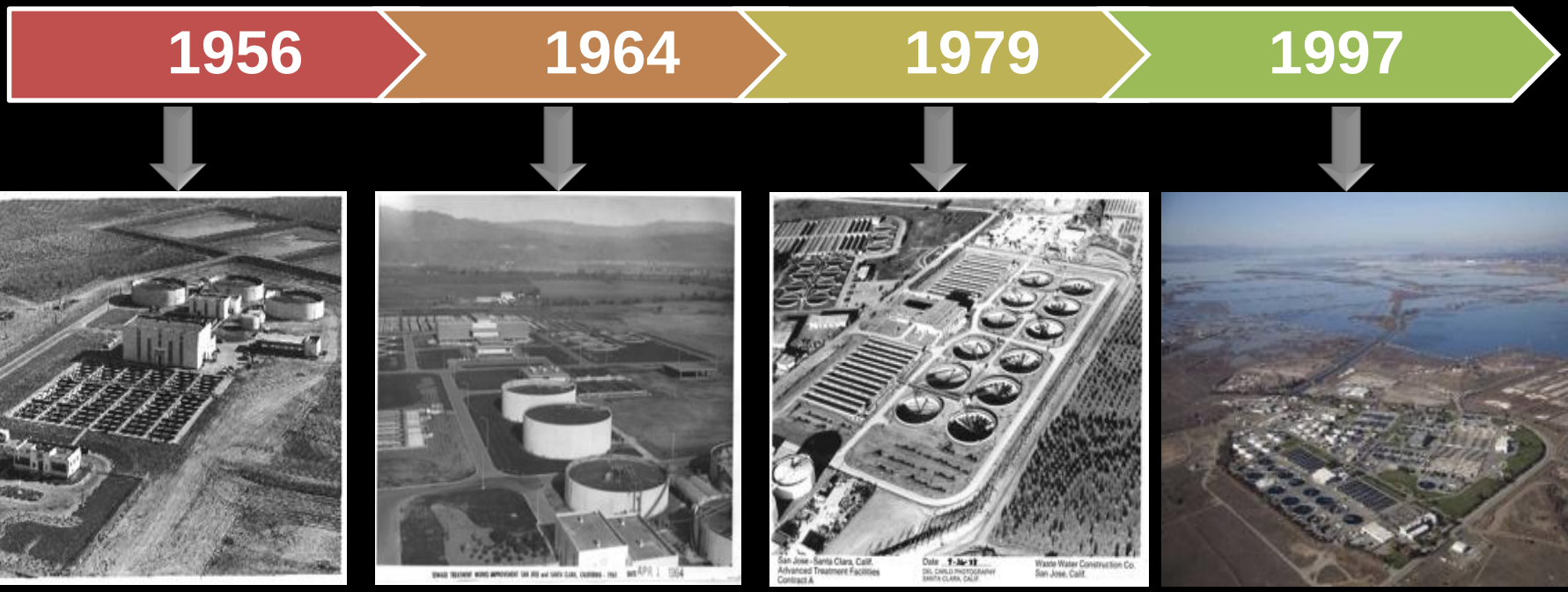
San José-Santa Clara Regional Wastewater Facility


Serving 1.4 million residents
+ 17,000 commercial & industrial facilities in Silicon Valley
Wastewater from San Jose
From Milpitas
From Santa Clara, Cupertino, & West Valley
Treated Effluent

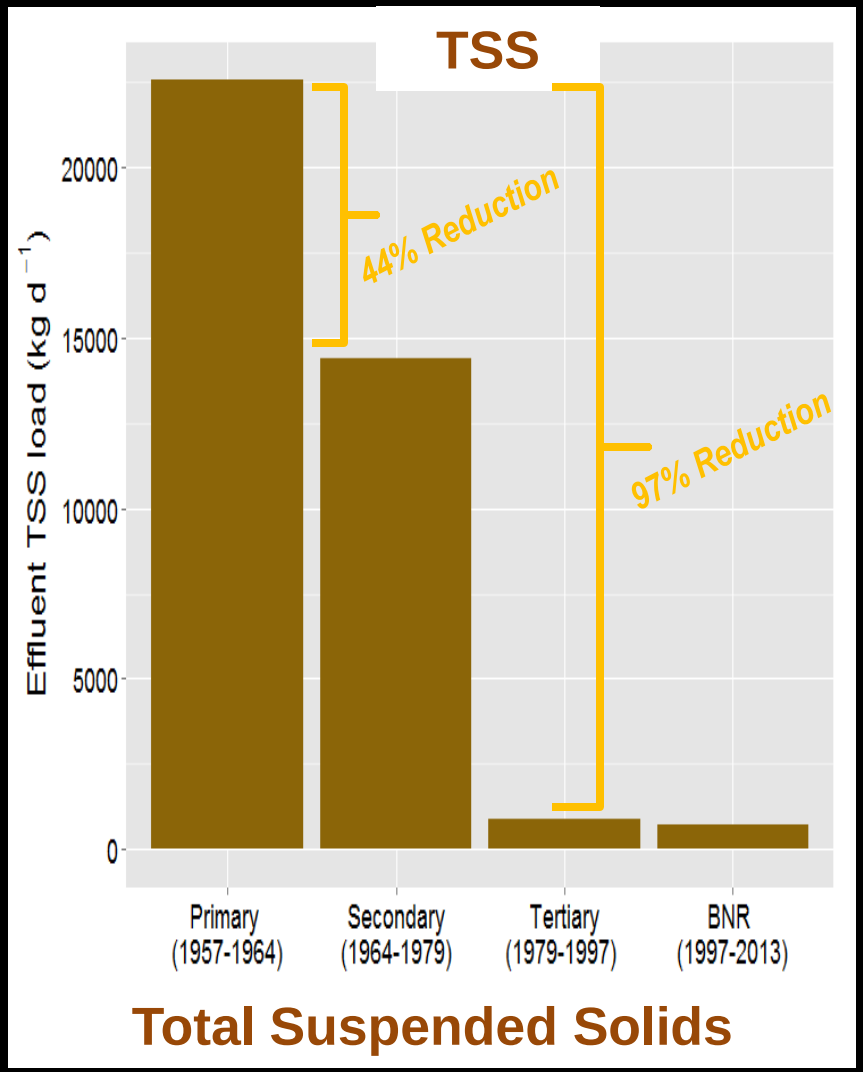

San Francisco Bay
Coyote Creek
Artesian Slough
San Jose-Santa Clara
Regional Wastewater Facility

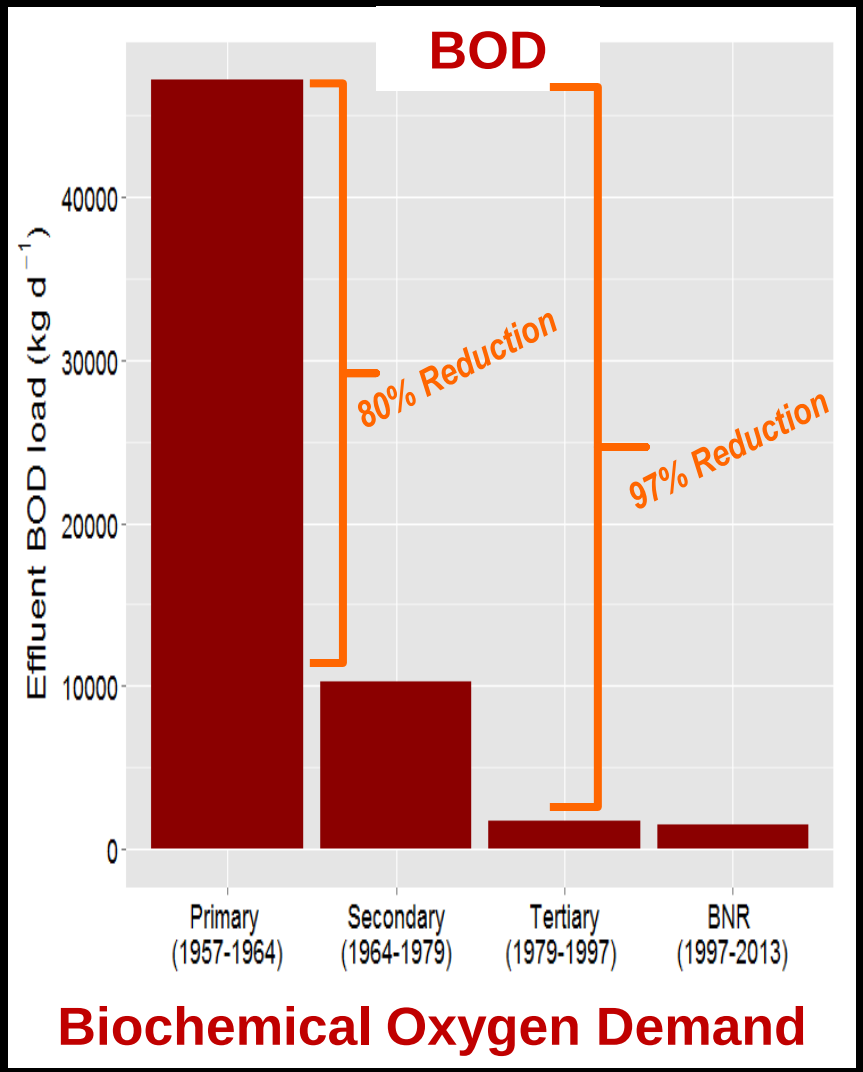
Treatment Eras

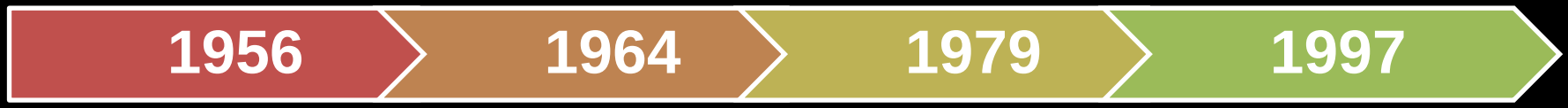
- **1957-1964**: primary treatment
- **1964-1979**: secondary treatment
- **1979-1997**: tertiary/advanced treatment
- **1997-2013**: Biological Nutrient Removal (BNR)



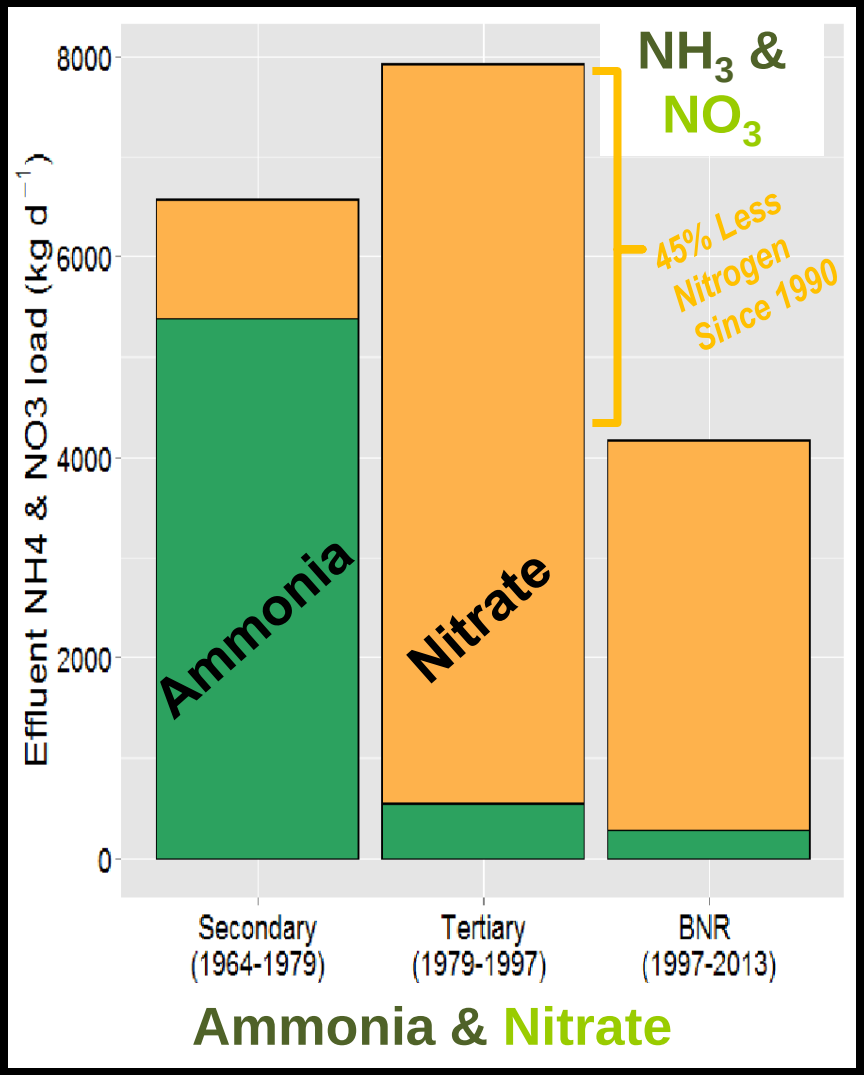
Facility Improvement = better effluent

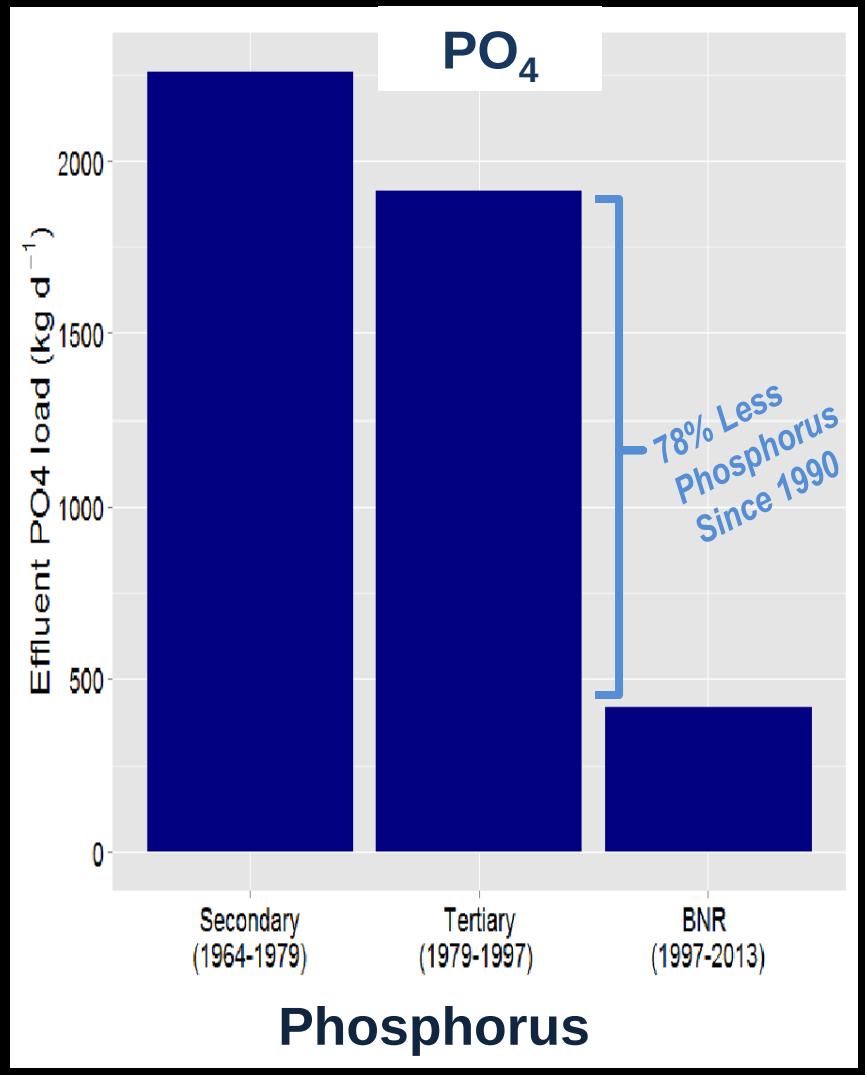






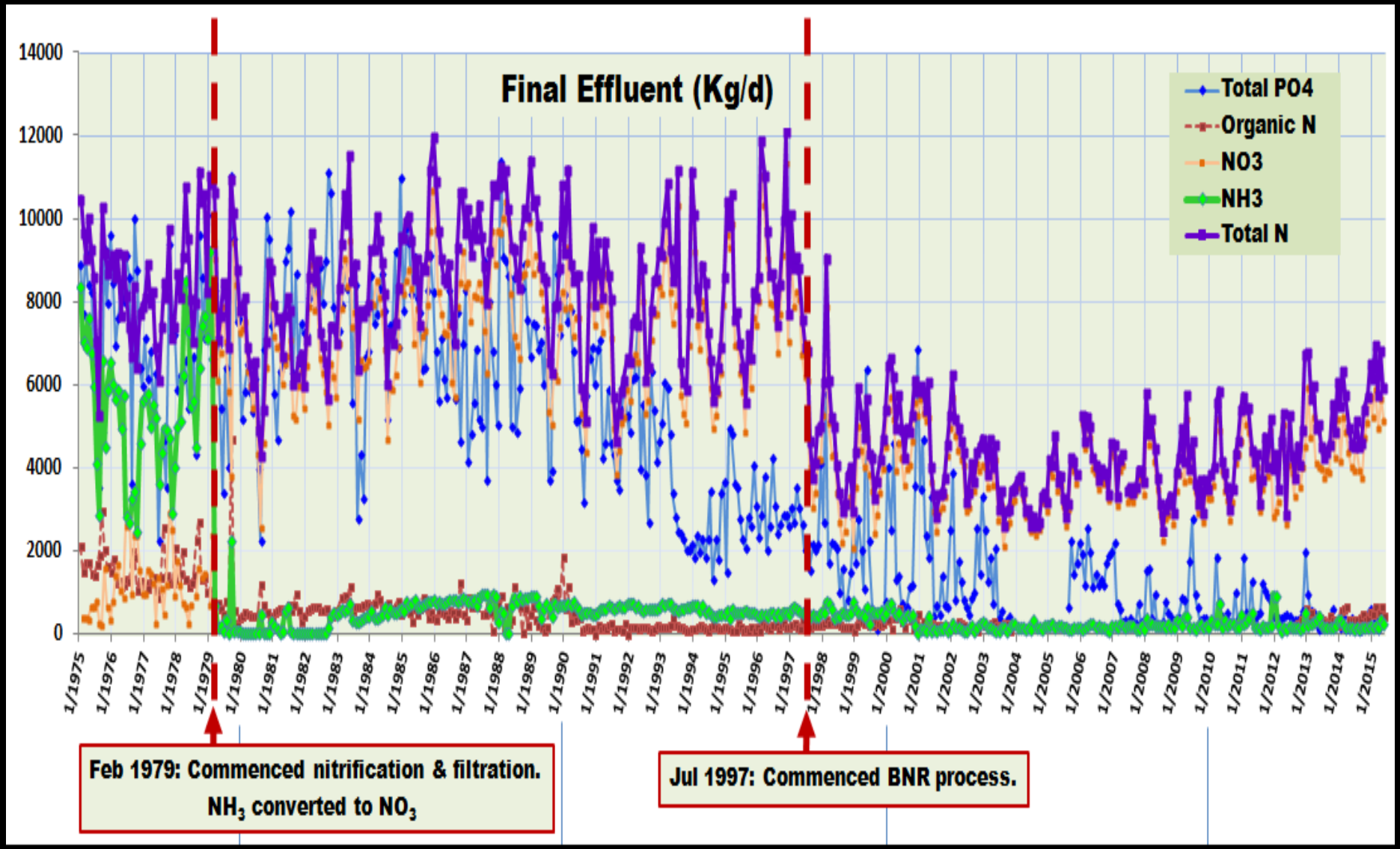
San Jose Nutrient Loads (Kg/d)





1956	1964	1979	1997
Primary	Secondary	Tertiary/ Advanced	BNR

San Jose Nutrient Loads (Kg/d)



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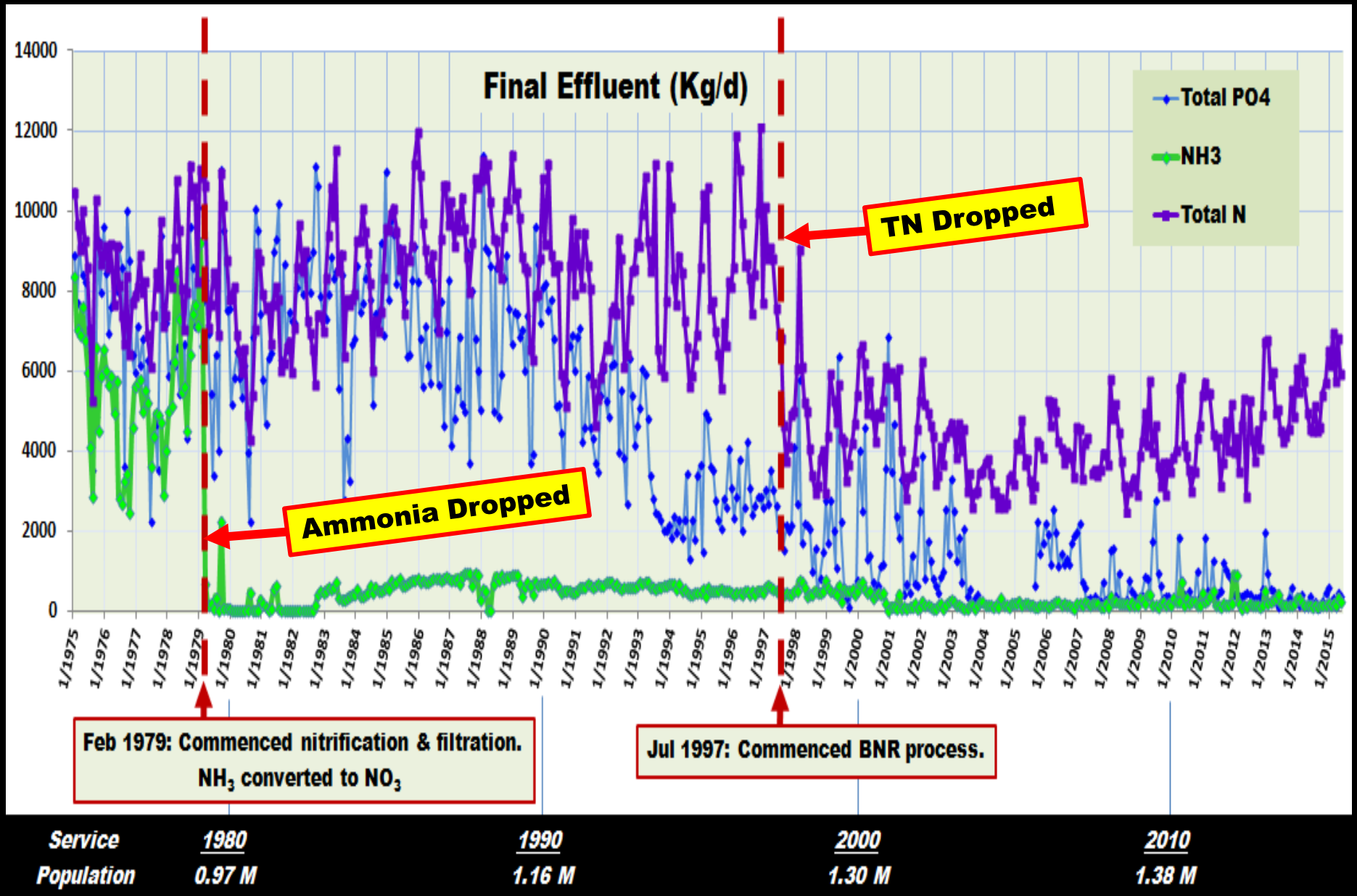
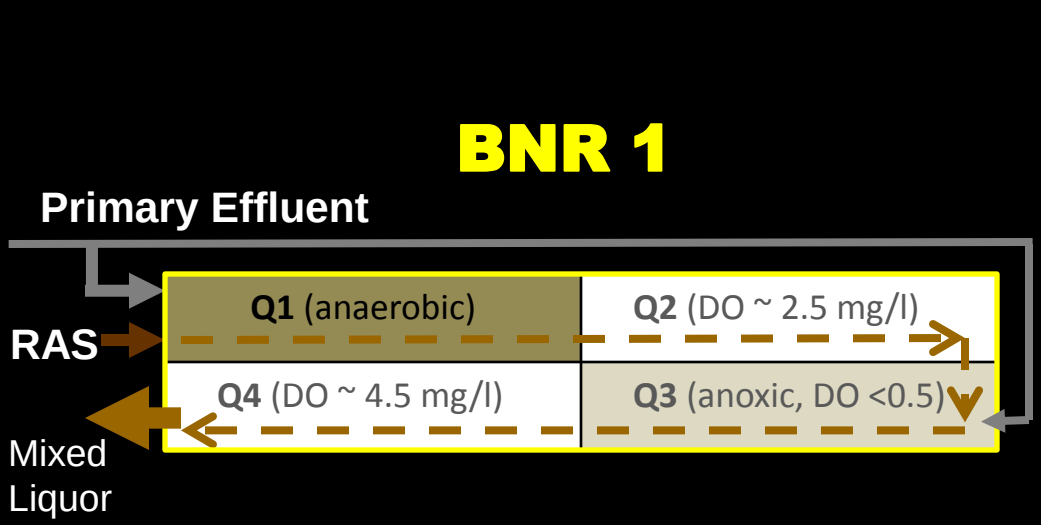
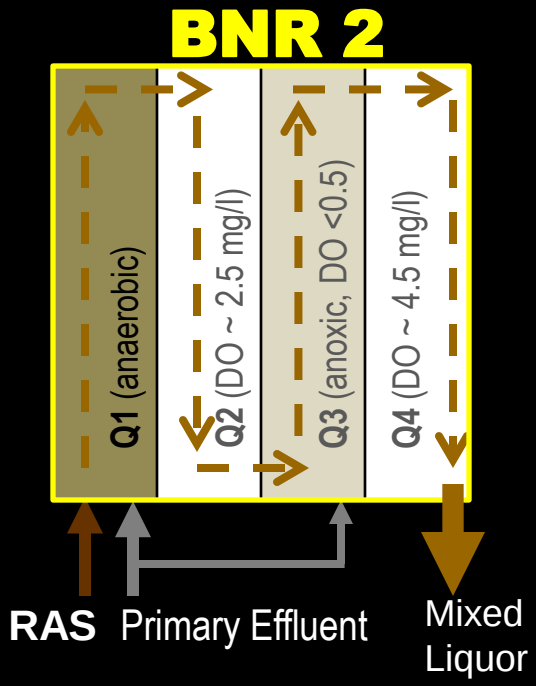


BNR 1 versus BNR 2

	BNR 1 ("Secondary")	BNR 2 ("Nitrification")
Year constructed	1964	1979
# of Batteries (A & B)	2	2
# of Basins (4-quad @)	16	8
Blowers	6 Gas – 1.62 KSCF/lb BOD	5 Electric – 1.41 KSCF/lb BOD
Volume per Basin	2.75 MG	3.0 MG
Total Aerator Volume	44 MG	24 MG





BNR 1

(Formerly known as “Secondary”)

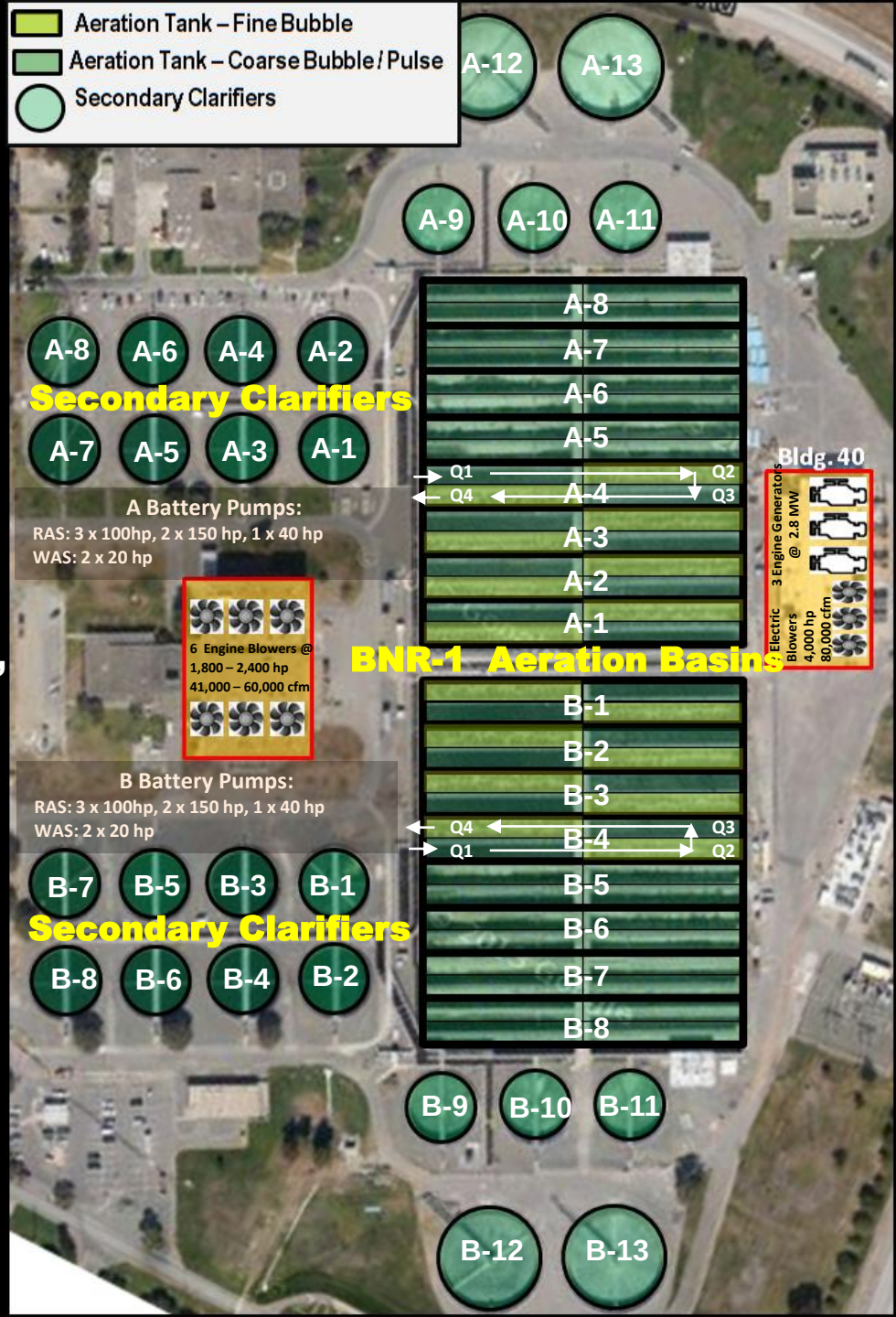
4-Stage, Step Feed Process

2 Batteries of aeration tanks: “A” & “B”

Each Battery has 8 Basins @ 2.75 MG

2.75 X 8 = 22 MG per battery

44 MG total volume



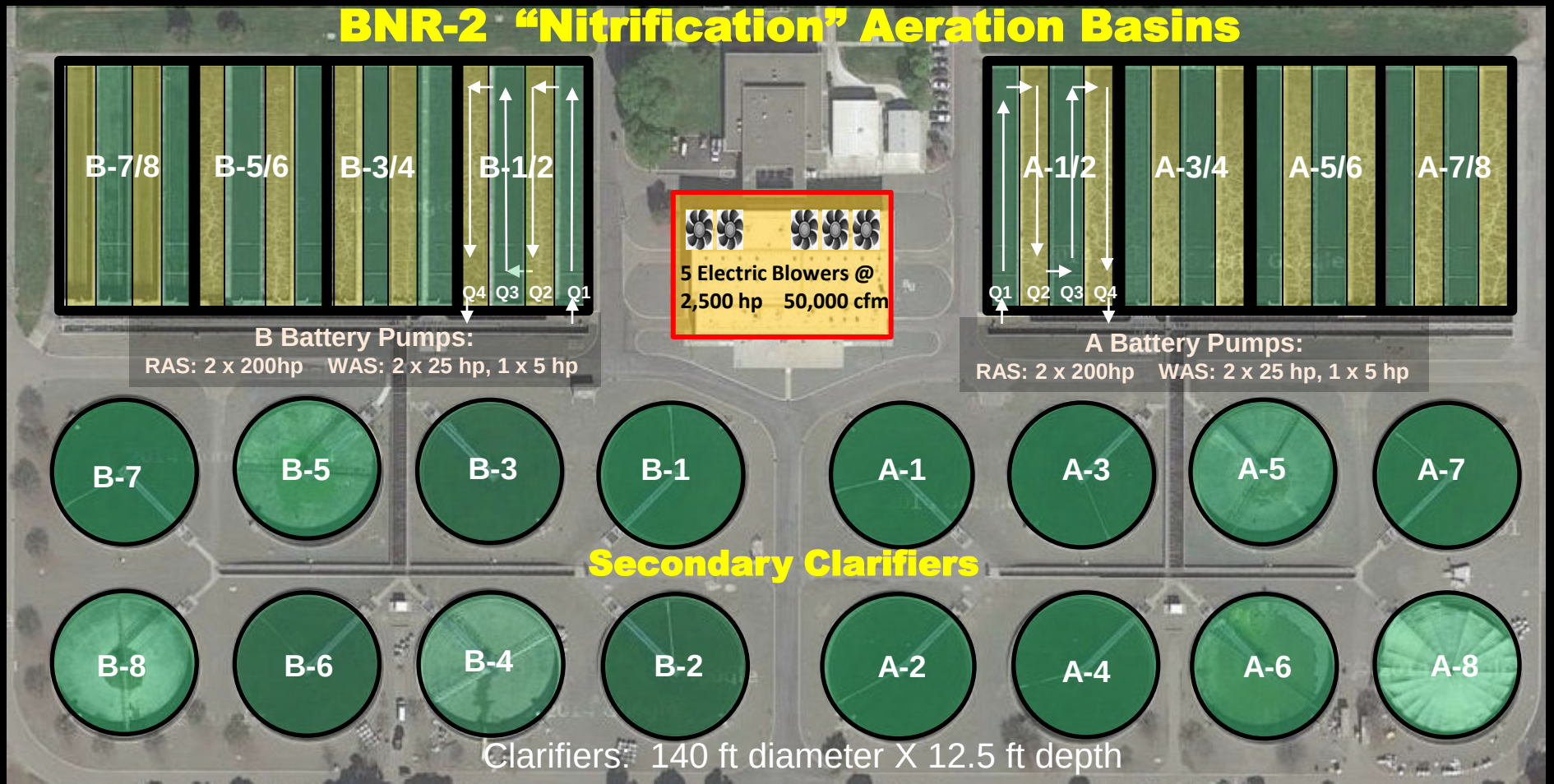
BNR 2

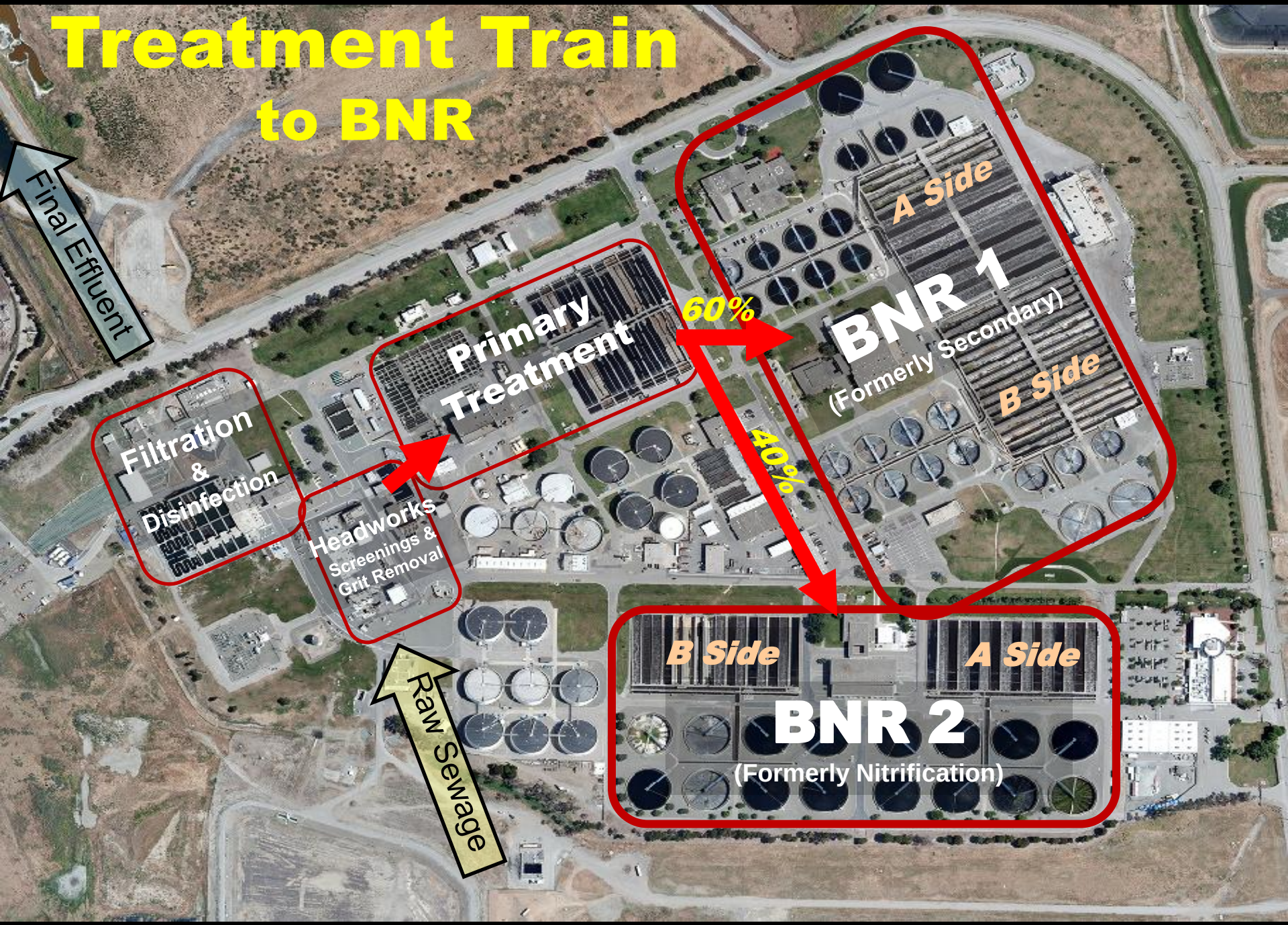
(Formerly known as “Nitrification”)

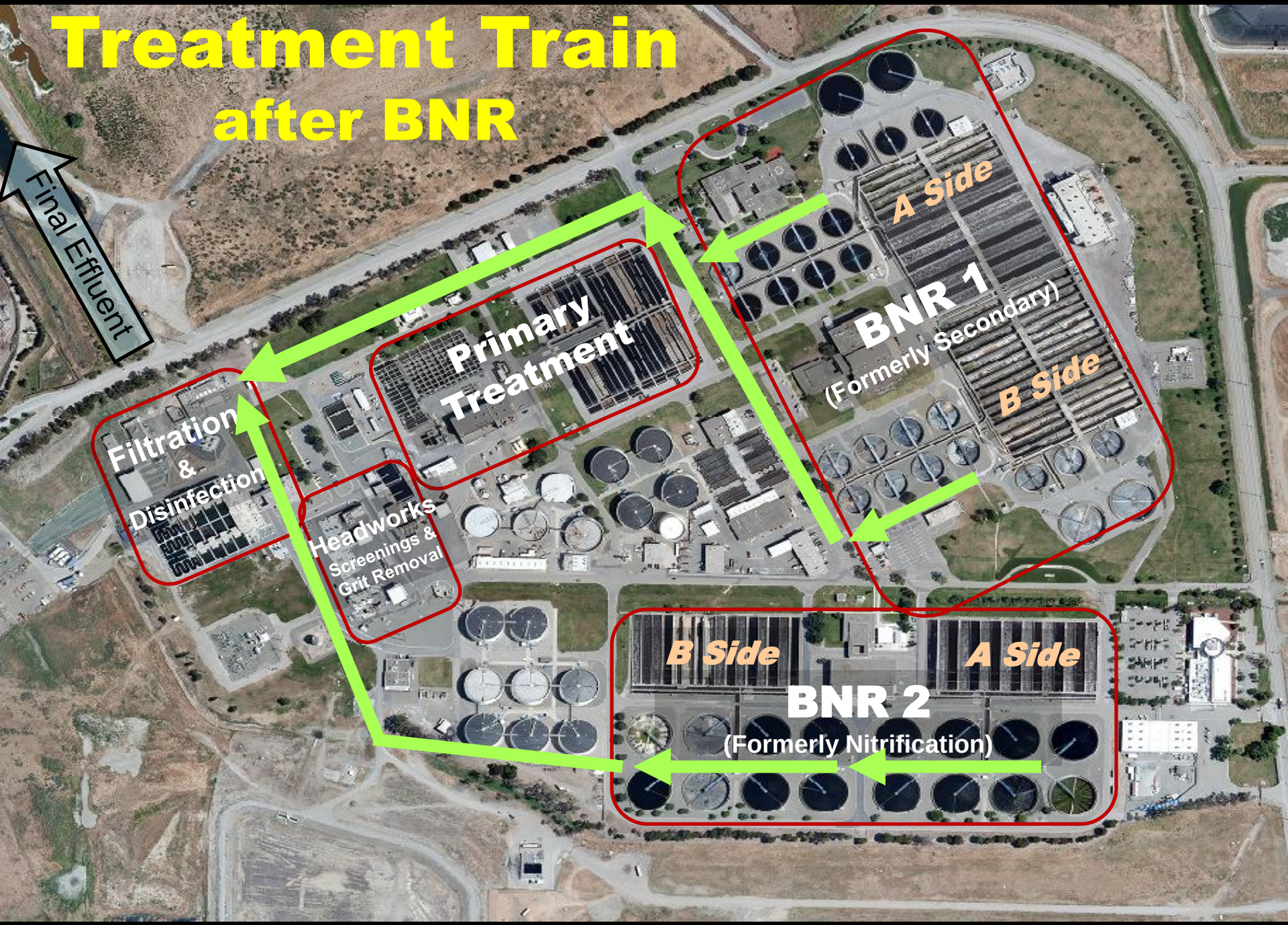
Two Batteries of aeration tanks: “A” & “B” - 4 basins each

Each Basin = 3.0 MG

3 X 4 = 12 MG per battery … 24 MG total volume




Treatment Train
to BNR
Final Effluent
Filtration
&
Disinfection
Primary
Treatment
Headworks
Screenings &
Grit Removal
Raw Sewage
60%
40%
A Side
BNR 1
(Formerly Secondary)
B Side
B Side
A Side
BNR 2
(Formerly Nitrification)


Treatment Train
after BNR
Final Effluent
Filtration
&
Disinfection
Primary
Treatment
Headworks
Screenings &
Grit Removal
A Side
BNR 1
(Formerly Secondary)
B Side
B Side
A Side
BNR 2
(Formerly Nitrification)

Key concept: Microbes like stability

(Applies to any process, except that microbes die and take a while to grow back)

- **Food/Mass (Technically SRT)**
- **Flow & Detention Time**
- **Air**
- **Temperature**

Basic Control Factor – SRT & Wasting

$$SRT = \frac{\text{Total tank capacity} \times \underset{\text{12-hr avg}}{\text{MLSS}}}{((\underset{\text{6-hr avg}}{\text{WAS Flow}} / 694) \times \underset{\text{2-hr avg}}{\text{RAS SS}}) + (\text{Eff TSS} \times \text{Inf Flow})}$$

Effluent TSS Target

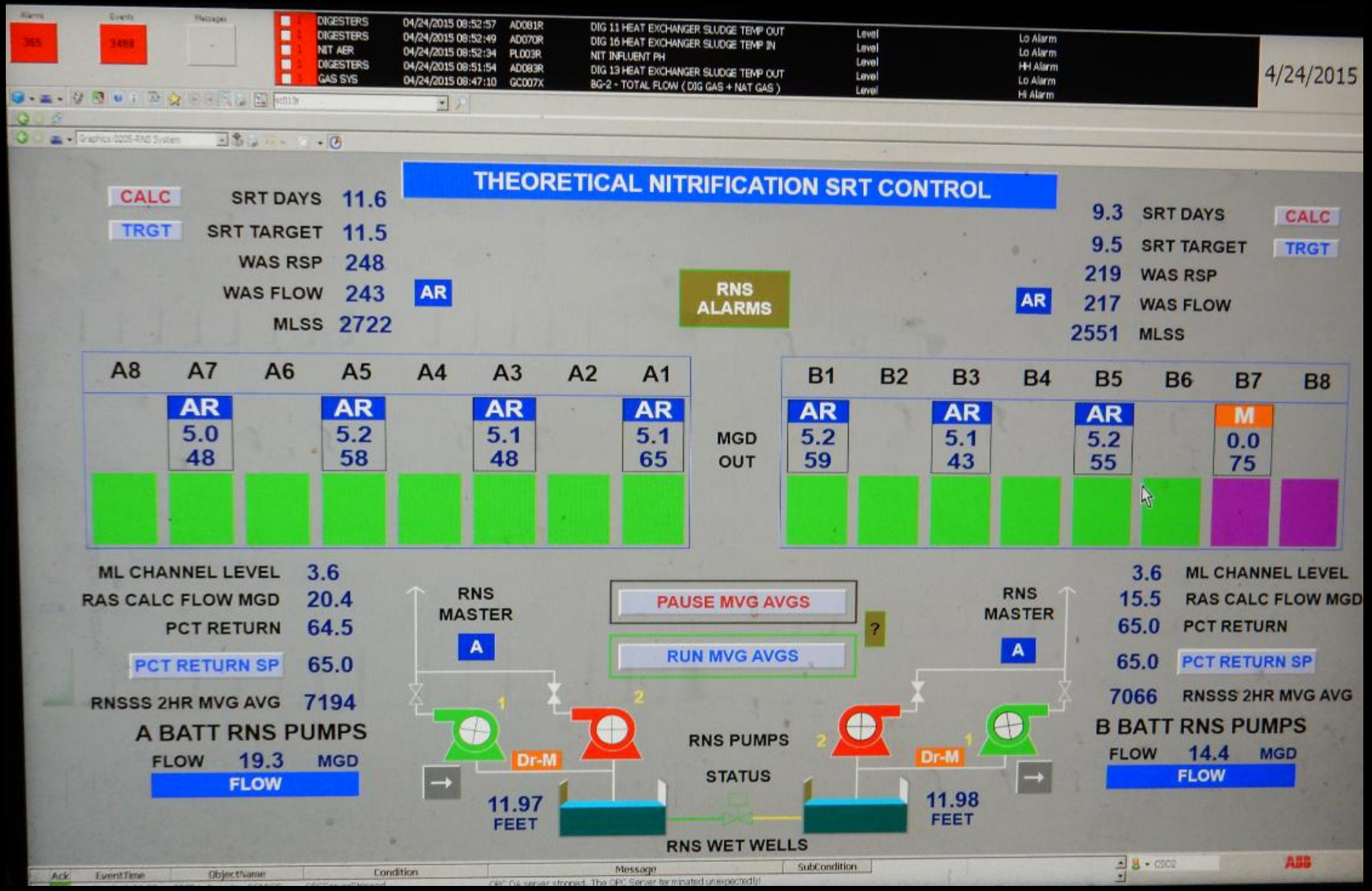
$$\underset{\text{Days}}{\mathbf{9.53}} = \frac{(\mathbf{3}\ \text{Tanks} \times 3.0\ \text{MG/tank} \times \mathbf{3121}\ \text{mg/l})}{((\mathbf{231.3}\ \text{gal/min} / \underset{\text{Gal/min/MGD}}{694}) \times \mathbf{8360}\ \text{mg/l}) + (\mathbf{8\ mg/l} \times \mathbf{20.90}\ \text{MGD})}$$

$$\text{WAS}_{\text{Remote Set Point}} = \left(\frac{\text{Total tank capacity} \times \underset{\text{12-hr avg}}{\text{MLSS}}}{\text{SRT Target} \times \underset{\text{2-hr avg}}{\text{RAS SS}}} - \frac{\text{Eff TSS} \times \text{Inf Flow}}{\underset{\text{2-hr avg}}{\text{RAS SS}}} \right) \times 694$$

$$\underset{\text{Gal/Min}}{\mathbf{231.8}} = \left(\frac{\mathbf{3}\ \text{Tanks} \times 3.0\ \text{MG/tank} \times \mathbf{3121}\ \text{mg/l}}{(\mathbf{9.50}\ \text{days} \times \mathbf{8360}\ \text{mg/l})} - \frac{\mathbf{8}\ \text{mg/l} \times \mathbf{20.90}\ \text{MGD}}{\mathbf{8360}} \right) \times 694$$

Black Font – Fixed Values **RED Font – Measured Values**

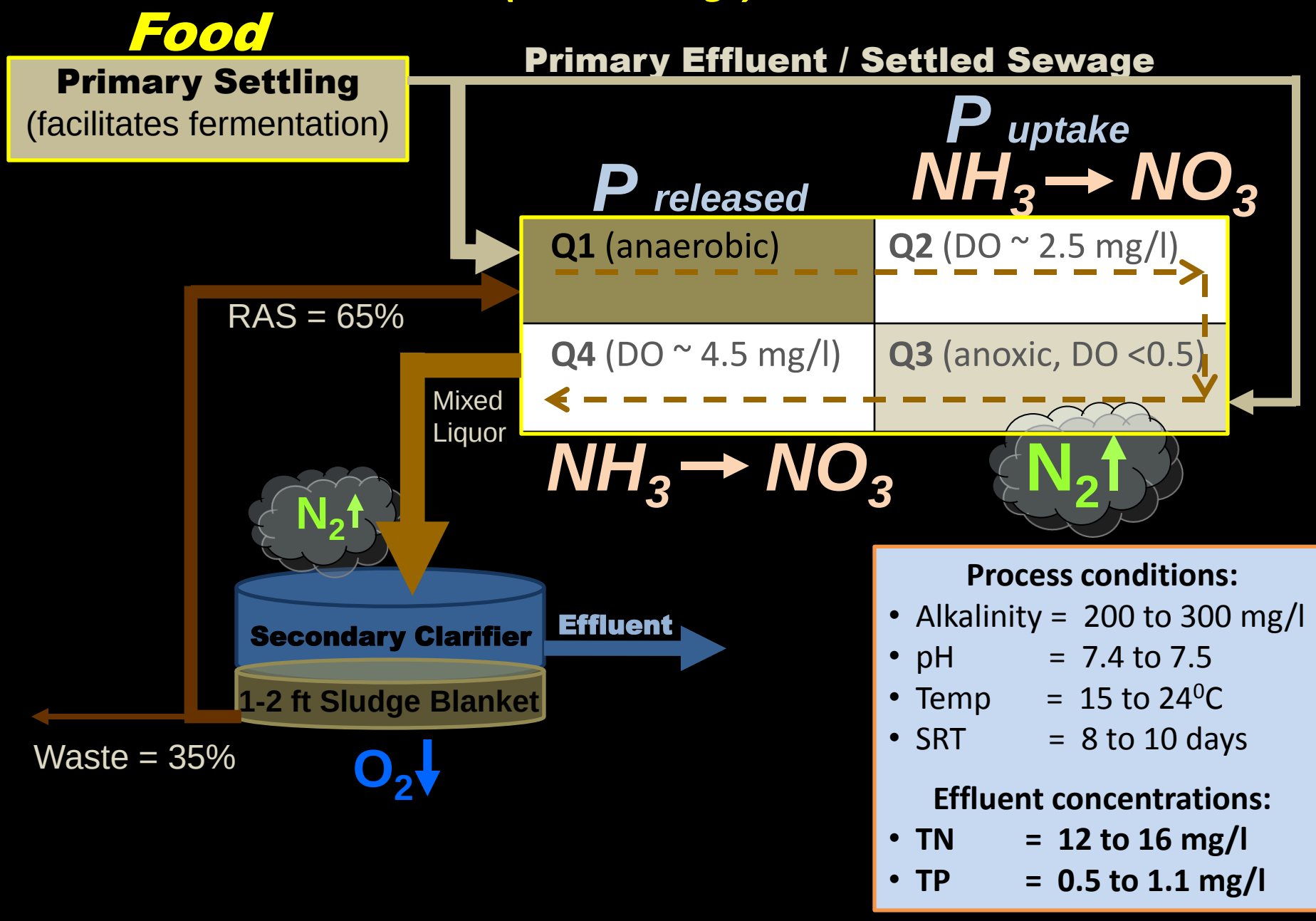
SRT & Wasting


DIGESTERS 04/24/2015 08:52:57 AD081R DIG 11 HEAT EXCHANGER SLUDGE TEMP OUT Level Lo Alarm
DIGESTERS 04/24/2015 08:52:49 AD070R DIG 16 HEAT EXCHANGER SLUDGE TEMP IN Level Lo Alarm
NIT AER 04/24/2015 08:52:34 PL003R NIT INFLUENT PH Level HH Alarm
DIGESTERS 04/24/2015 08:51:54 AD083R DIG 13 HEAT EXCHANGER SLUDGE TEMP OUT Level Lo Alarm
GAS SYS 04/24/2015 08:47:10 GC007X BG-2 - TOTAL FLOW (DIG GAS + NAT GAS) Level Hi Alarm
4/24/2015
THEORETICAL NITRIFICATION SRT CONTROL
CALC
SRT DAYS 11.6
TRGT
SRT TARGET 11.5
WAS RSP 248
WAS FLOW 243
MLSS 2722
AR
RNS ALARMS
AR
9.3 SRT DAYS
CALC
9.5 SRT TARGET
TRGT
219 WAS RSP
217 WAS FLOW
2551 MLSS
A8 A7 A6 A5 A4 A3 A2 A1
AR 5.0 48
AR 5.2 58
AR 5.1 48
AR 5.1 65
MGD OUT
B1 B2 B3 B4 B5 B6 B7 B8
AR 5.2 59
AR 5.1 43
AR 5.2 55
M 0.0 75
ML CHANNEL LEVEL 3.6
RAS CALC FLOW MGD 20.4
PCT RETURN 64.5
PCT RETURN SP 65.0
RNSSS 2HR MVG AVG 7194
A BATT RNS PUMPS
FLOW 19.3 MGD
FLOW
RNS MASTER
A
PAUSE MVG AVGS
?
RUN MVG AVGS
RNS MASTER
A
Dr-M
RNS PUMPS
STATUS
Dr-M
11.97 FEET
11.98 FEET
RNS WET WELLS
3.6 ML CHANNEL LEVEL
15.5 RAS CALC FLOW MGD
65.0 PCT RETURN
65.0 PCT RETURN SP
7066 RNSSS 2HR MVG AVG
B BATT RNS PUMPS
FLOW 14.4 MGD
FLOW
Ack EventTime ObjectName Condition Message SubCondition
ABB

Food for Bugs & Flow Equalization

Four-Stage Step-Feed BNR Process

(Food for Bugs)



Process conditions:

- Alkalinity = 200 to 300 mg/l
- pH = 7.4 to 7.5
- Temp = 15 to 24^{0}C
- SRT = 8 to 10 days

Effluent concentrations:

- **TN = 12 to 16 mg/l**
- **TP = 0.5 to 1.1 mg/l**

Air for Bugs

(Theoretical 10 MGD Scenario)

Primary Settling
(facilitates fermentation)

Primary Effluent / Settled Sewage

~ 6 MGD

Air

500 – 1500 SCFM

4000 – 5500 SCFM

DO Meter

Q1 (anaerobic)

Q2 (DO ~ 2.5 mg/l)

Q4 (DO ~ 4.5 mg/l)

Q3 (anoxic, DO <0.5)

~ 4 MGD

RAS = 65%

Mixed Liquor
15.5 MGD

DO Meter

1800 – 2100 SCFM

500 – 1500 SCFM

Air

Secondary Clarifier

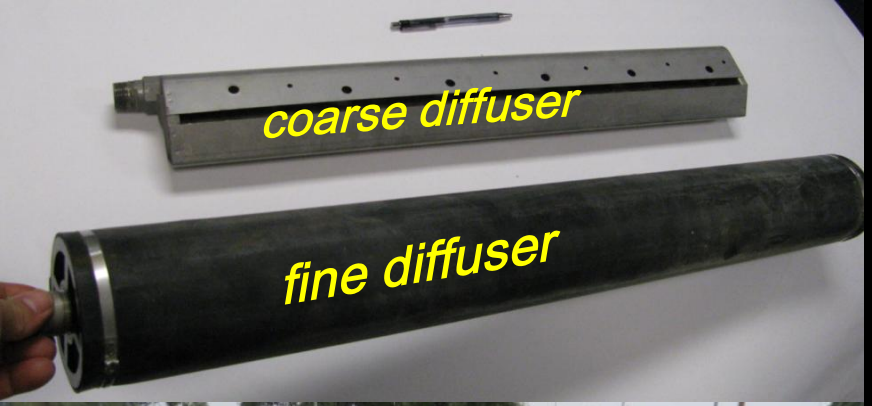
Effluent

9.5 MGD

1-2 ft Sludge Blanket

Waste = 35%

Air for Bugs



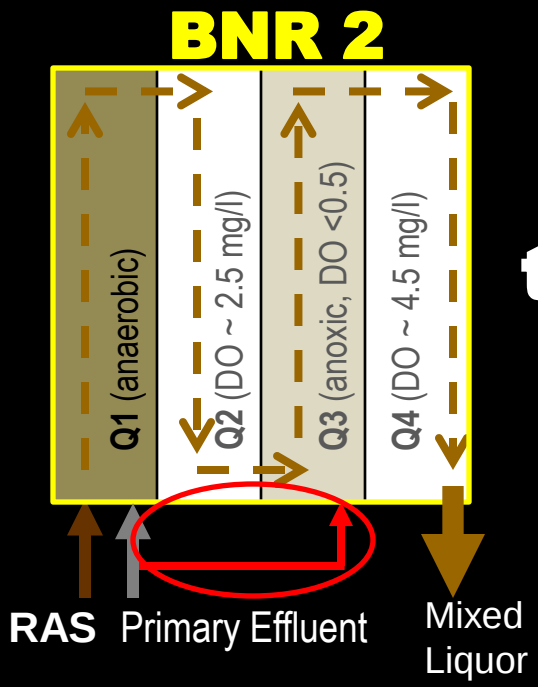
- ☑ Efficient
- ☒ But, last only 3 to 5 years
- ☒ Performance declines w/age

- ☑ These last forever
- ☒ But, not efficient

BNR 2 Basin in Operation

BNR 2 Basin in Operation

Step feed
what we need?



Plug flow
the way to go?

- **Biologically important sludge is in the 1st pass.**

☑ **Step Feed prevents washout**

☑ **Protects from toxic shock**

☑ **Provides denitrification**

☑ **Saves energy**

- **SRT drops from 10 to 7 days**

- **MLSS drops from 3000 to 2500 & Clarifier loading drops**

☑ **Accommodates more flow**

☒ **Must increase aeration to nitrify**

Parameters Monitored

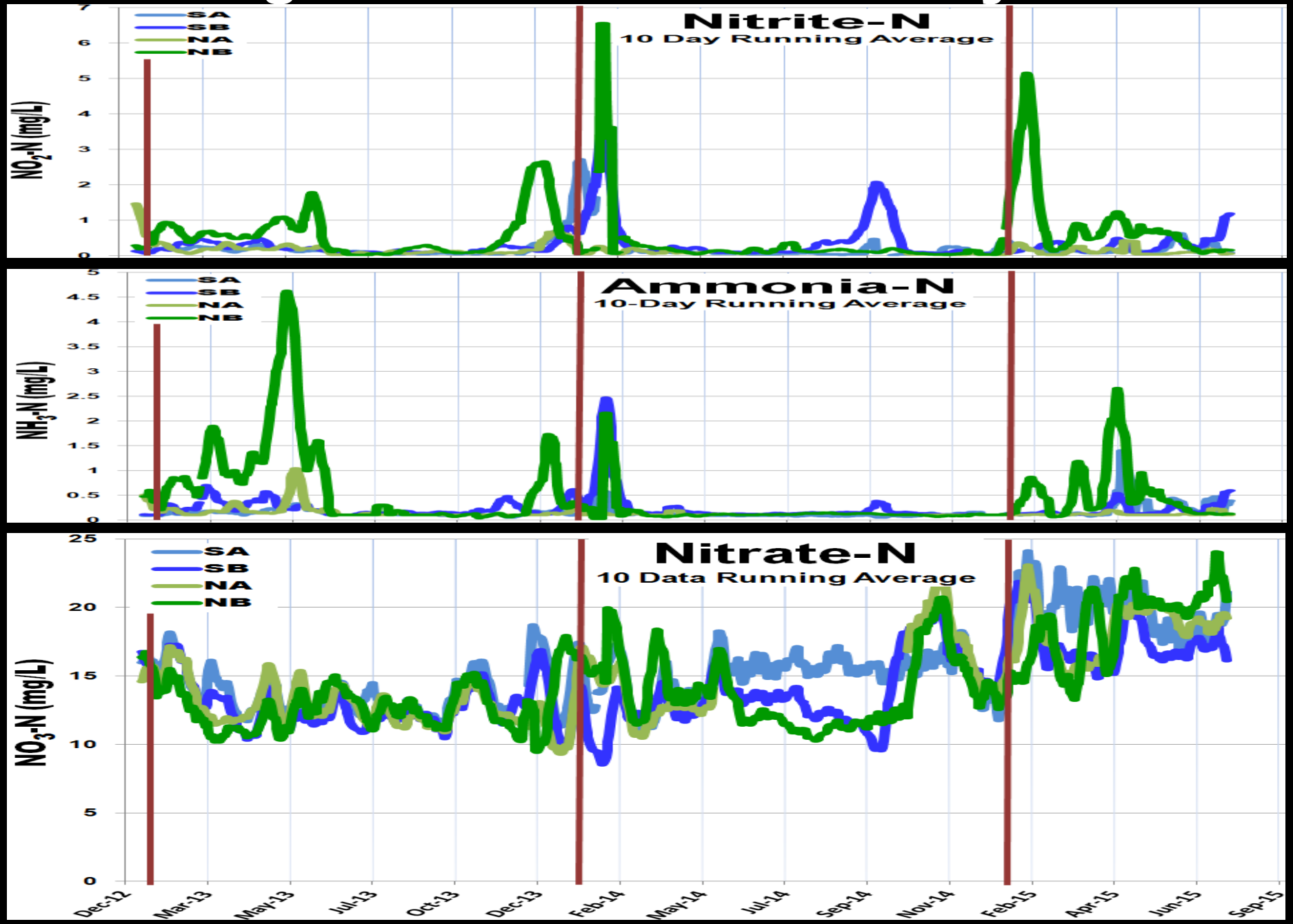
- DO monitored continuously
- MLSS monitored continuously + 2X daily by hand
- MLSS & VS lab tested 2X per week
- Depth of Secondary clarifier sludge - daily
- Filament counts - 2X per week
- SVI Calculated - 3X per day
- Influent + Effluent 24-hr composite: Cl-, NH_3, NO_2, NO_3, SO_4, TSS, Turbidity

- Flow output compared to individual valve readings

Control Options

- **SRT**
- **Increase aeration – take 3rd pass off pulse**
- **Cut feed – possibly go to plug flow** (no feed to 3rd pass)
- **Check sludge age:**
  - **Old sludge – increase wasting**
  - **Young sludge – decrease wasting**
- **Add or remove tanks from service**

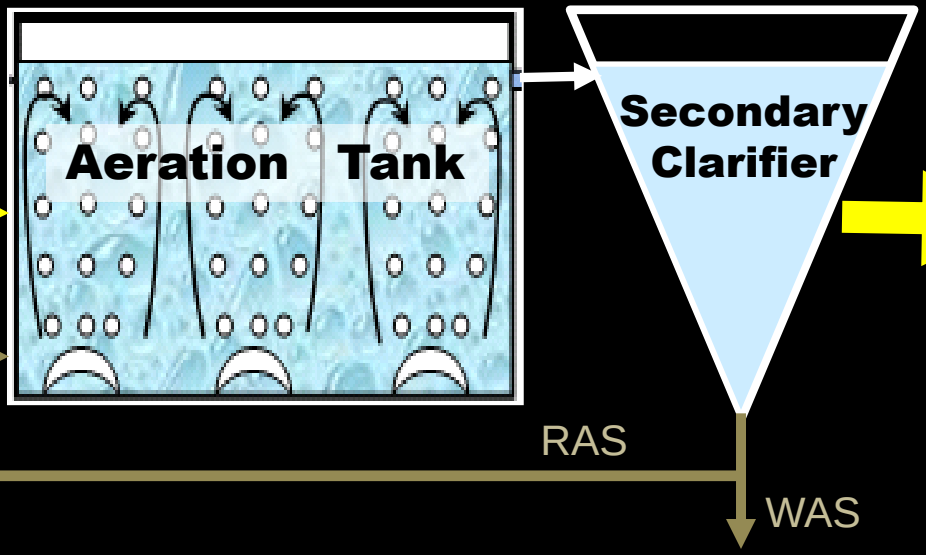
Nitrogen Trend after Secondary/BNR



Actual BNR Performance

(mg/l)

BOD	187
COD	334
NH_3	32
PO_4	14
TSS	120



BOD	18
COD	30*
NH_3	0.5*
PO_4	4
TSS	8*

Parameter	Removal (%)	Literature % Removal
BOD	90	85-95
COD	90	
PO_4	70	
TSS	93	

*/From FI grab analysis of 4/10/13

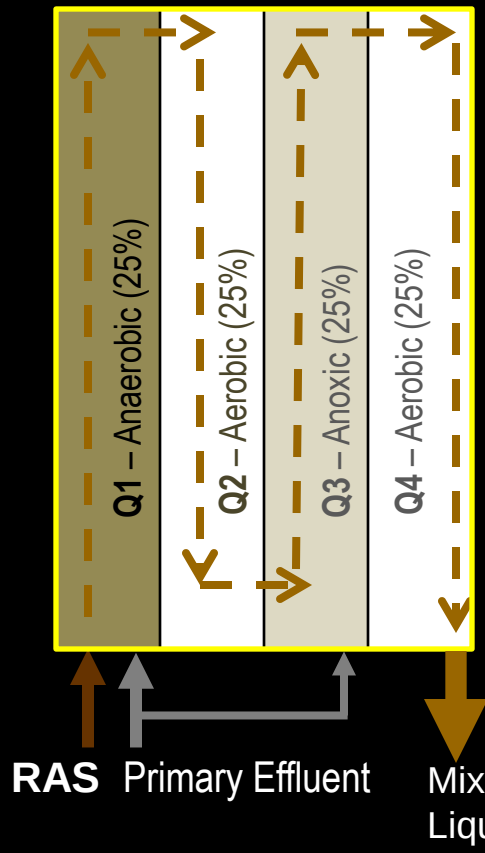
Control Room

Weekly Ops Meeting

Future Aeration Alternatives

from Process Modeling Study

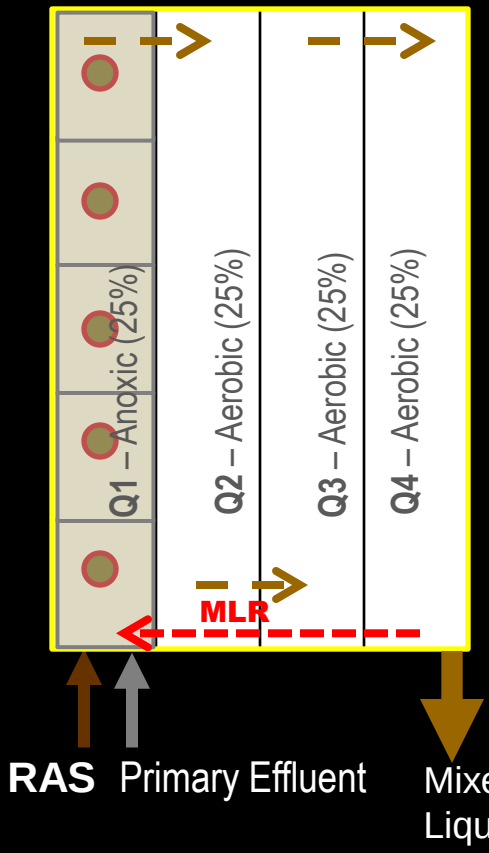
#1 Status Quo



Little bit of everything

#2 MLE

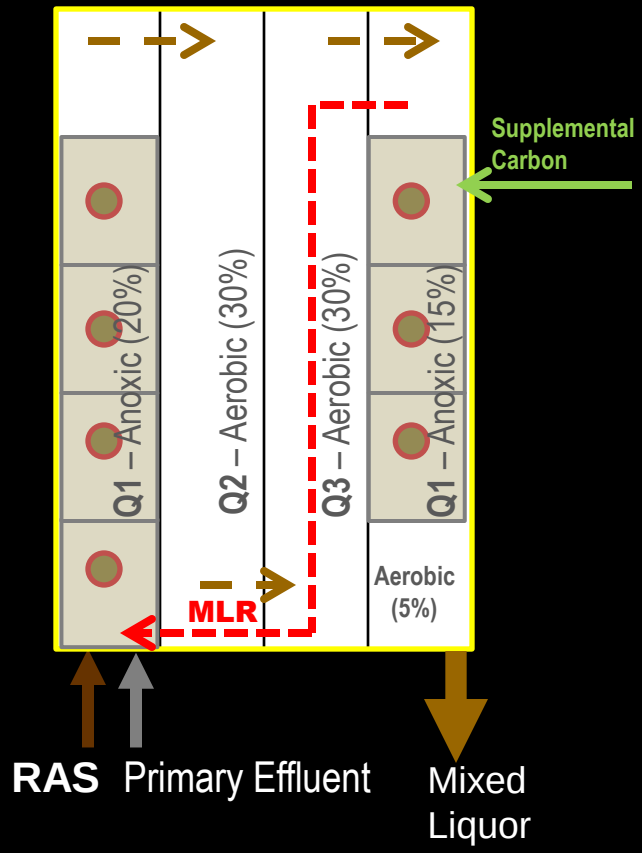
Baffle walls & mech. mixing in Q1
+ Mixed Liq. Recycle



Optimized for nitrogen

#3 Bardenpho

Baffles & mech. mixing in Q1/Q3
+ Mixed Liq. Recycle
+ carbon



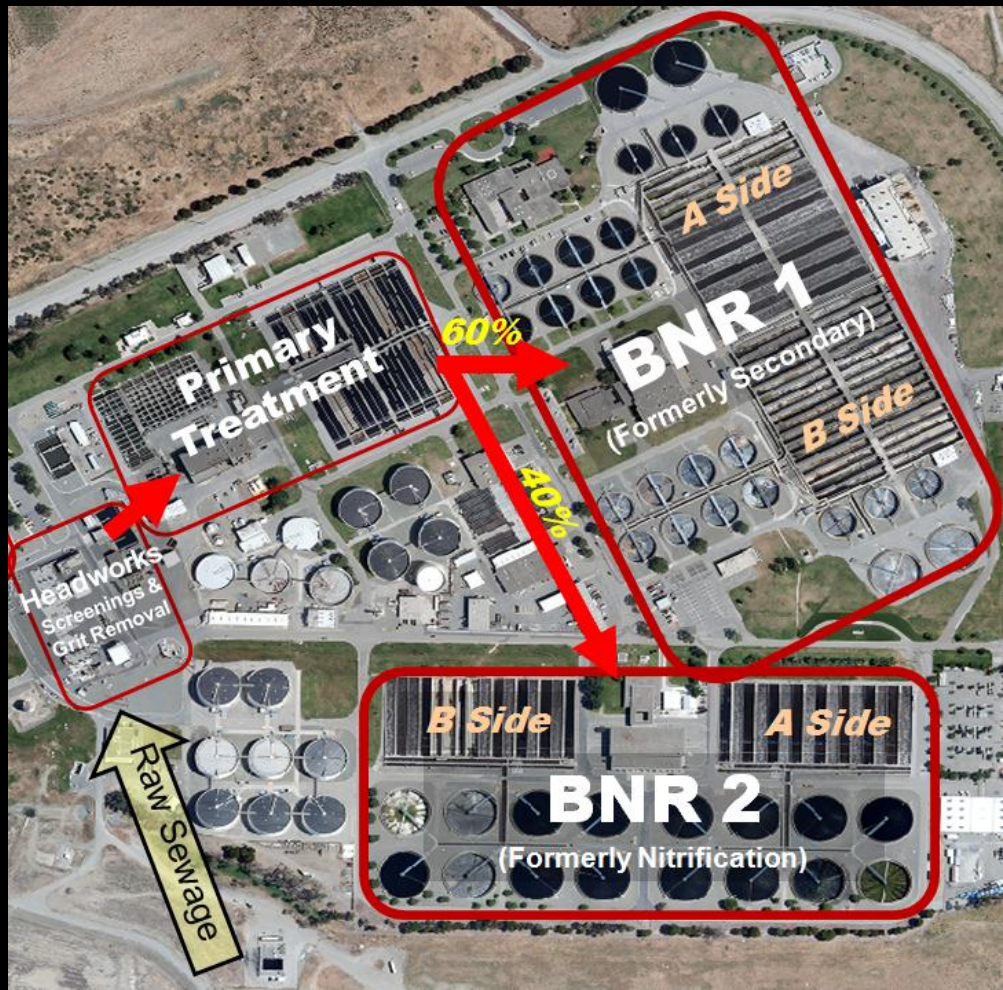
Enhanced nitrogen removal – at higher cost

Conclusion

Current 4-Sludge BNR system was adapted from existing infrastructure.

- **Flexible**
- **Effective**

Is it good enough???



Results at Outfall Weir