# Pilot Scale Membrane Bioreactor Study at King County

Amanda McInnis
Bob Bucher
Susan Anderson
J.B. Neethling

# King County Water Reuse Pilot Facilities
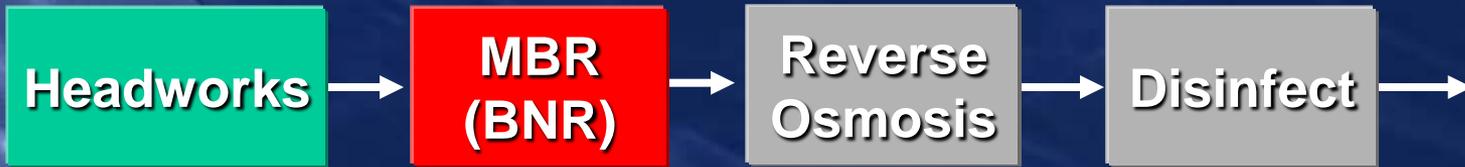
# MBR Trains

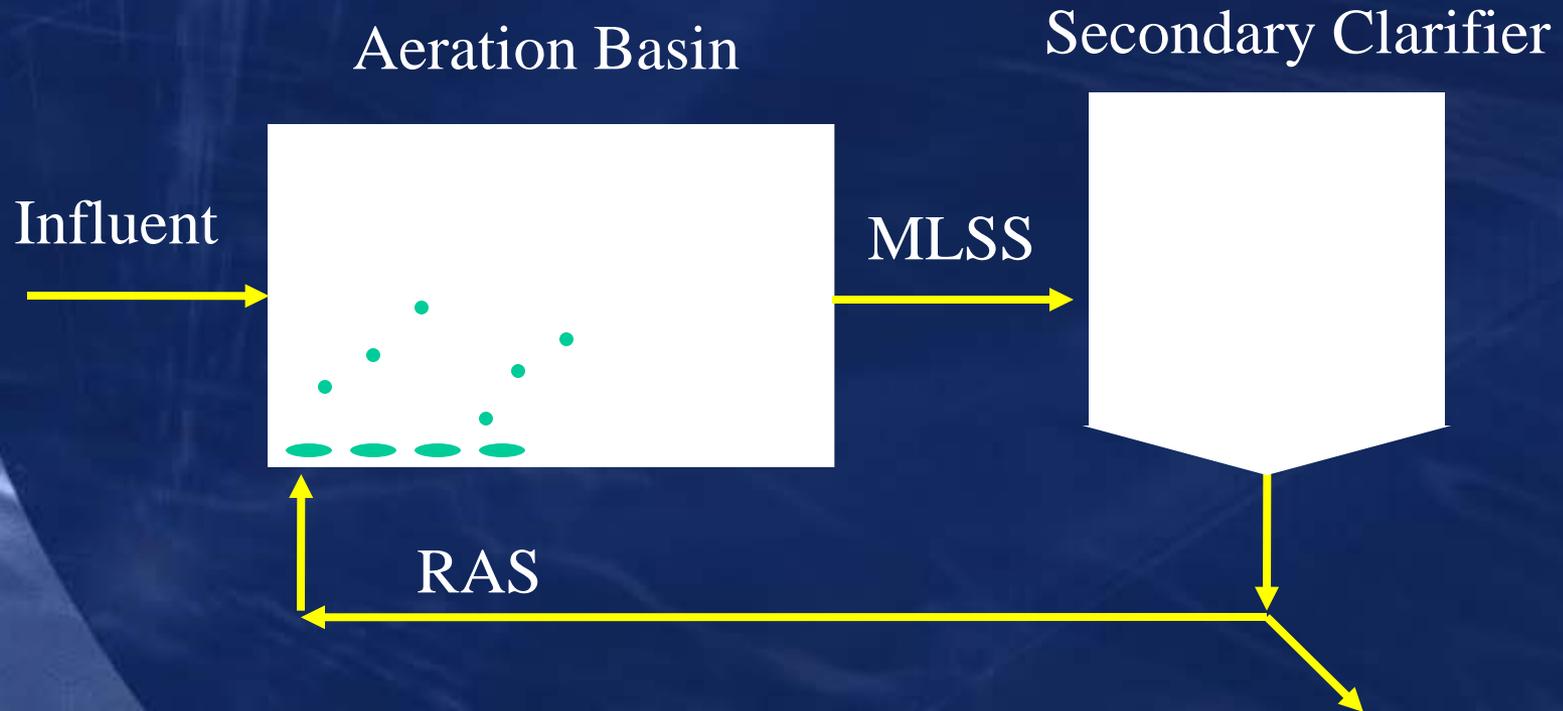Headworks → **Membrane BioReactor (nitrification only)** → Disinfect →
- *Class A*
- *All streams*

Headworks → **Membrane BioReactor (BNR)** → Disinfect →
- *Class A*
- *All streams*
- *All groundwater*

# MBR Trains

Headworks → MBR (nitrification) → Reverse Osmosis → Disinfect →

- *Class A*
- *Wetlands*
- *All streams*
- *All groundwater*
- *All lakes*

Headworks → MBR (BNR) → Reverse Osmosis → Disinfect →

- *Class A*
- *Wetlands*
- *All streams*
- *All groundwater*
- *All lakes*

# Conventional Treatment

Aeration Basin

Secondary Clarifier

Influent

MLSS

RAS

# What Is a Membrane Bioreactor (MBR)?

Aeration Basin
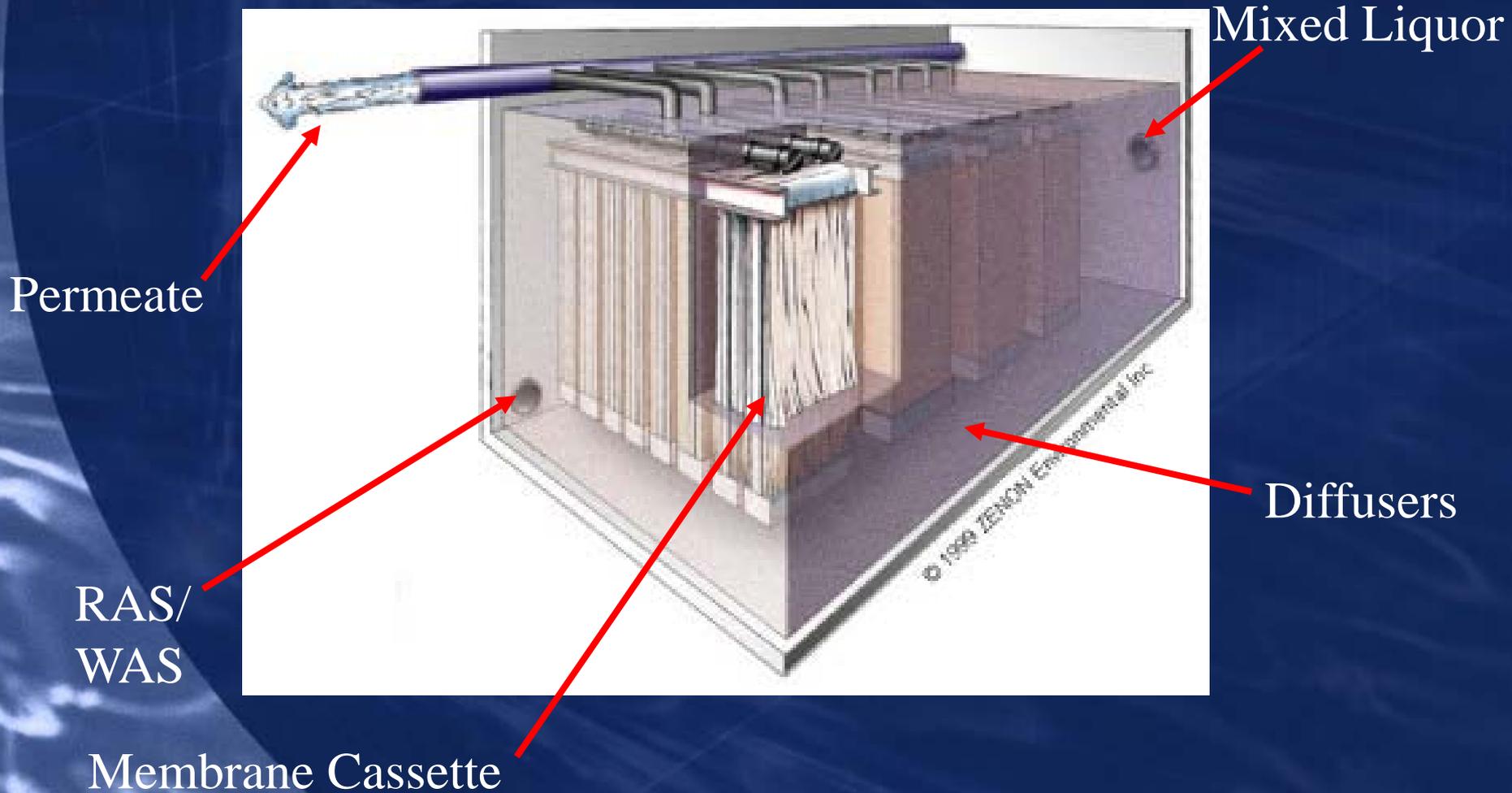
Membrane Tank

Influent

Vacuum Pump

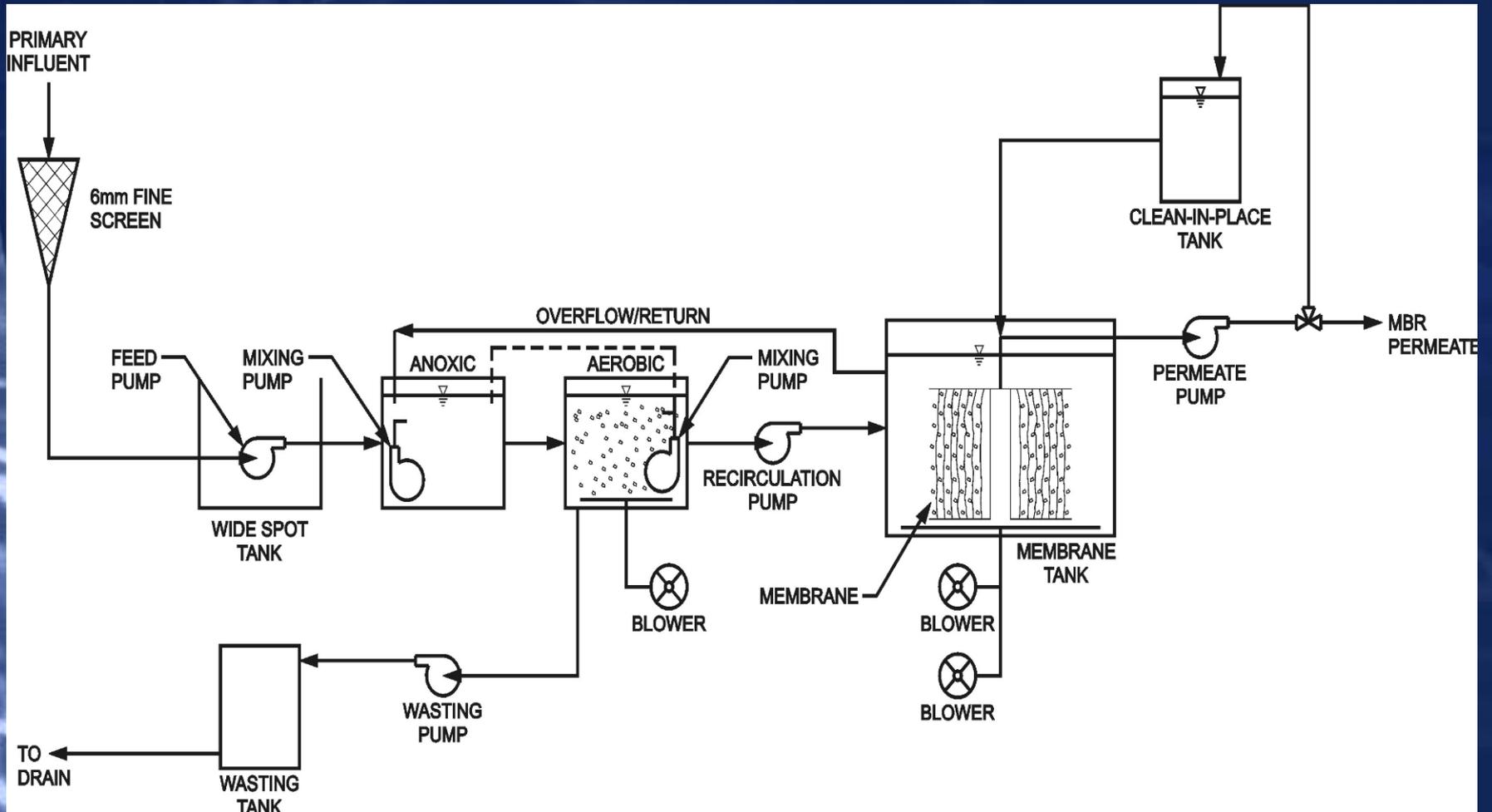RAS=MLSS
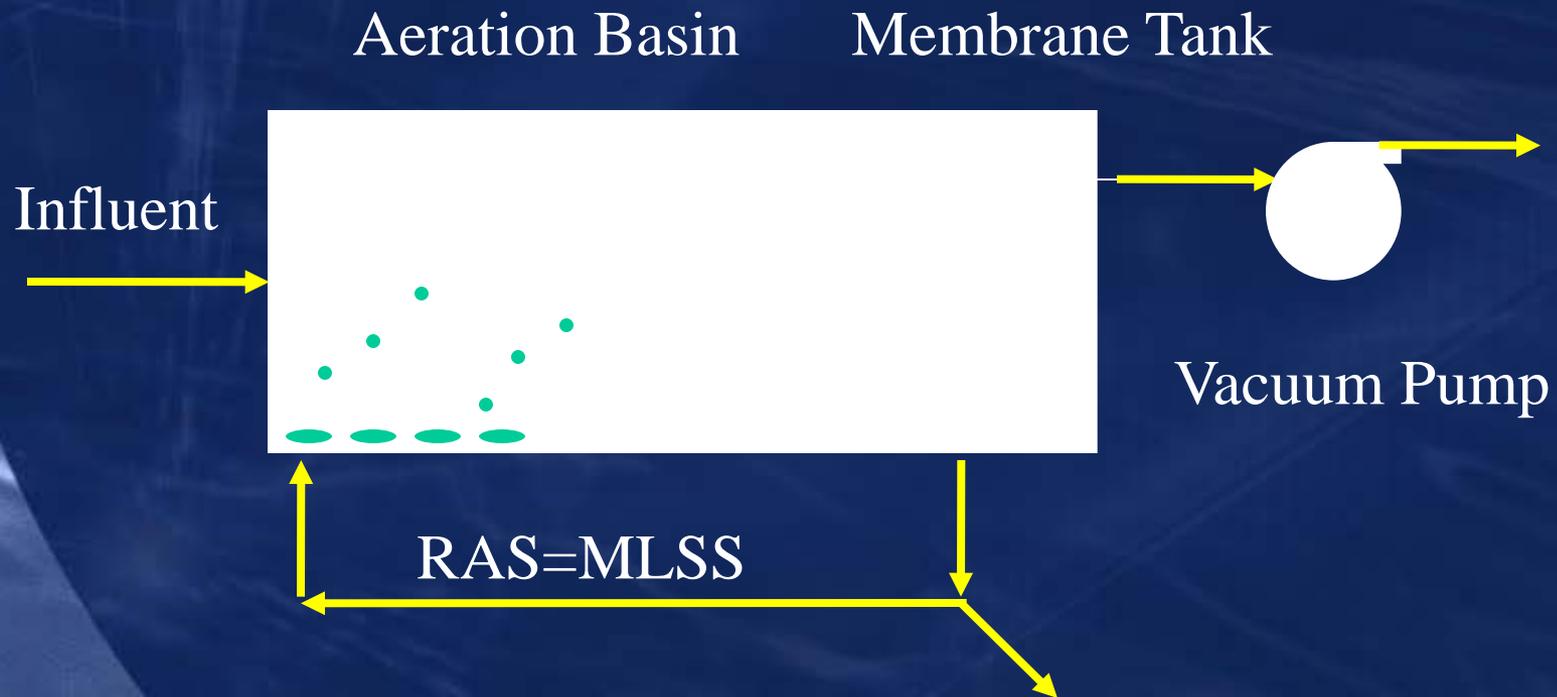
# Presentation Overview



- Study overview
- Turbidity removal
- Peaking performance
- Membrane Cleaning
- Nitrogen Removal
- Phosphorous Removal
- Coliform removal
- Operation at Low SRT

# MBR 3D View



Mixed Liquor

Permeate

Diffusers

RAS/
WAS

Membrane Cassette

© 1999 ZENON Environmental Inc.

# System Schematic

# Pilot Study Overview

| Process Goal | Actual Aerobic TSA (days) | Actual Total TSA (days) | Average Flow (gpm) | Average Flux * (gfd) | Relax mode or Backpulse mode |
|---|---|---|---|---|---|
| N/dN | -- | -- | 5.4 | 11.7 | Relax 8/29-9-13 Backpulse 9/14 |
| N/dN | 10.0 | -- | 5.3 | 11.5 | Backpulse |
| N/dN | 10.0 | 15.0 | 7.4 | 16.1 | Backpulse 11/16-12/2 Relax 12/3 |
| N/dN | -- | -- | 5.5 | 12.0 | Relax |
| N/dN | 5.6 | 8.5 | 5.5 | 12.0 | Relax |
| N/dN | -- | -- | 5.5 | 12.0 | Relax |
| Bio-P | -- | -- | 5.5 | 12.0 | Relax |
| Bio-P | 6.1 | 7.4 | 7.8 | 16.9 | Relax |

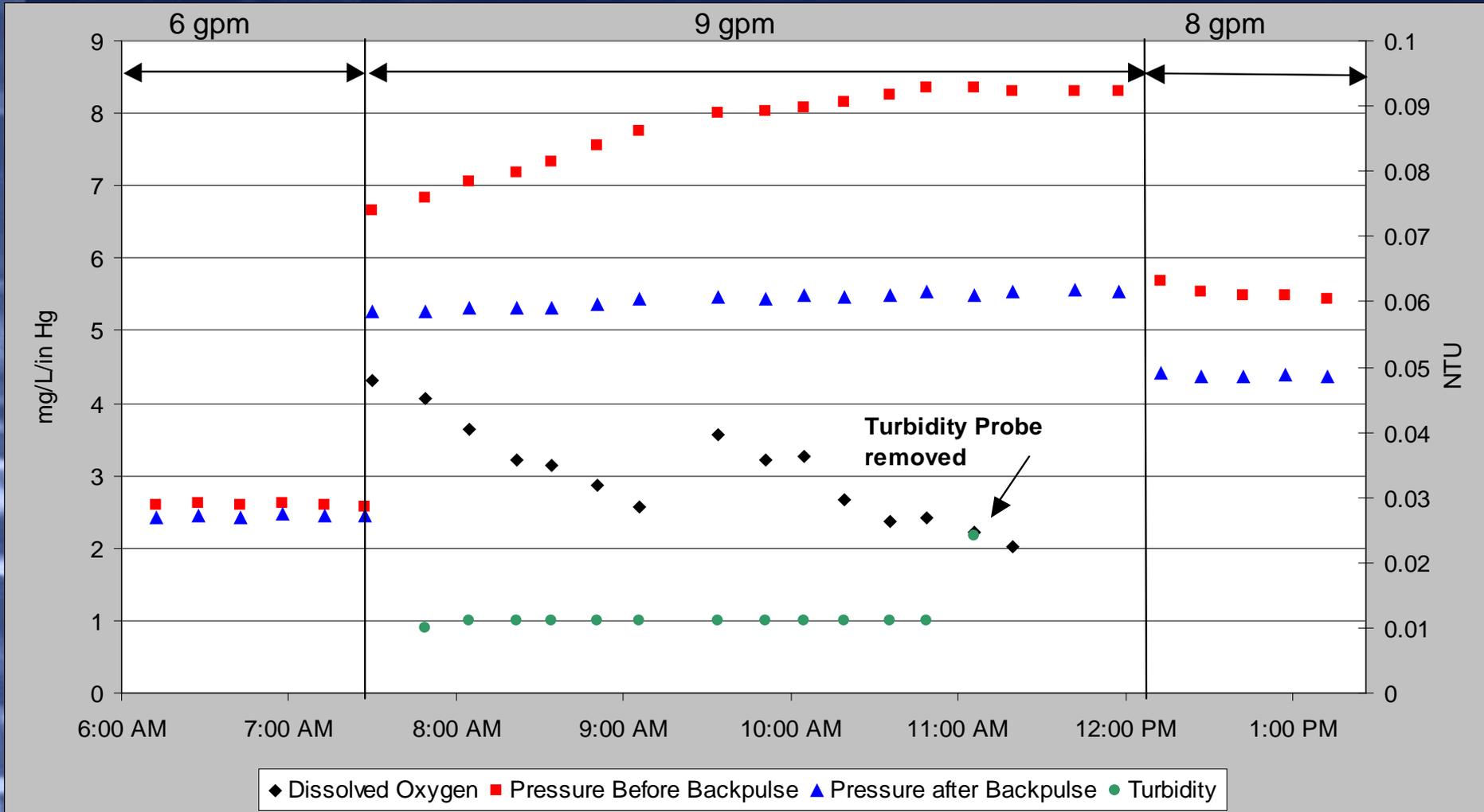# Process Overview
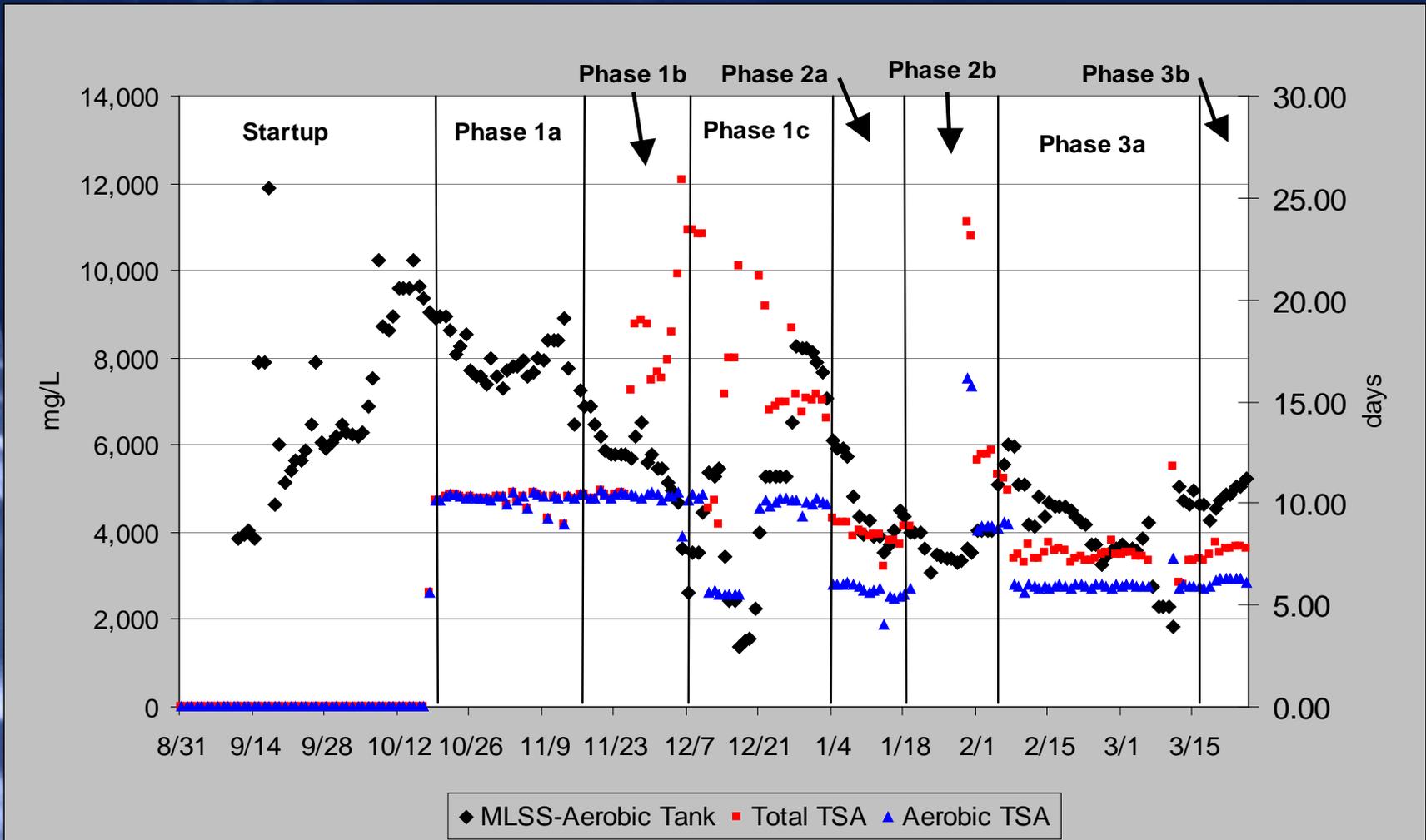
# Turbidity Performance
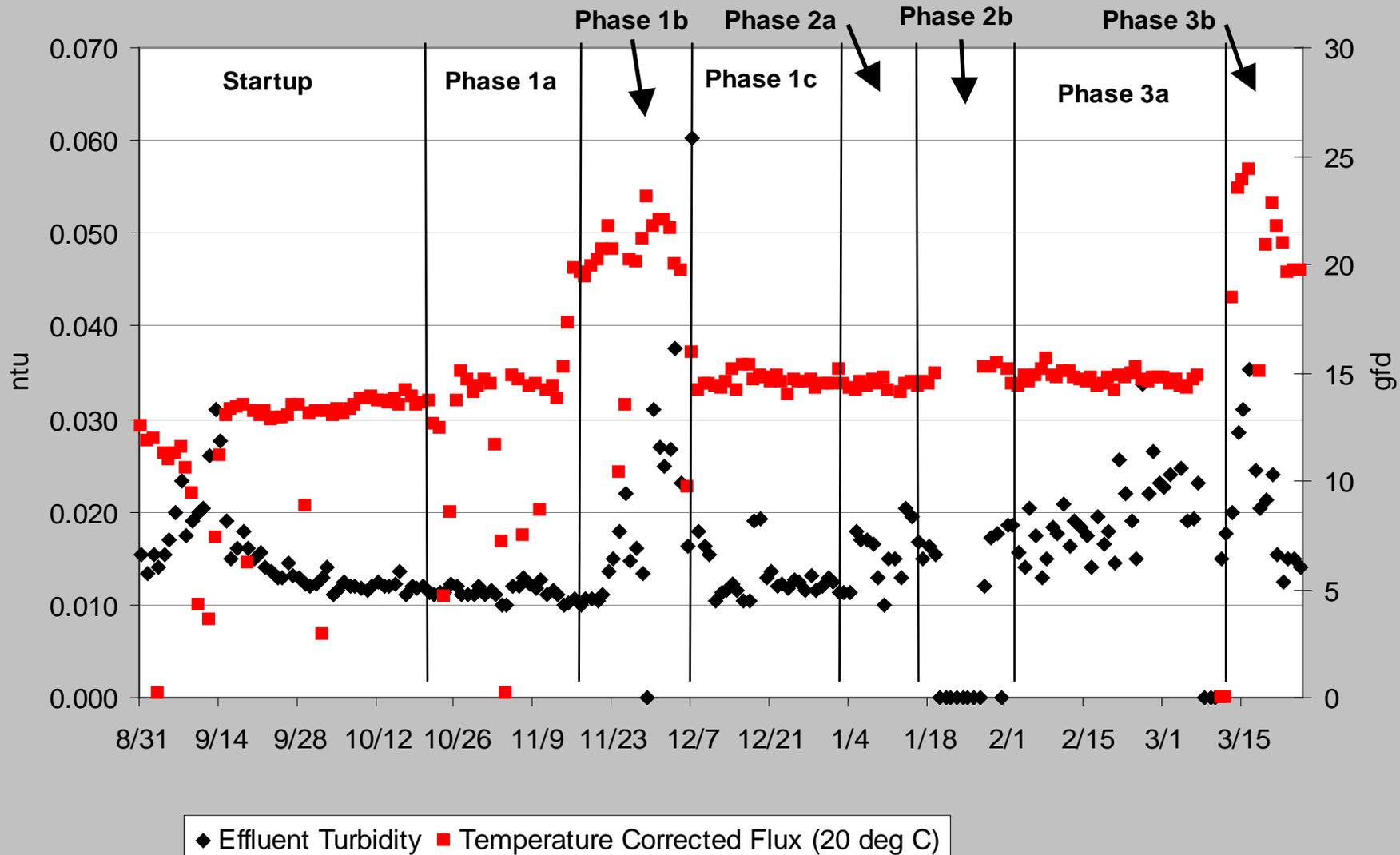
# Turbidity Performance

- Produced consistently low (<0.02 NTU) effluent turbidities, even under peak flow conditions.
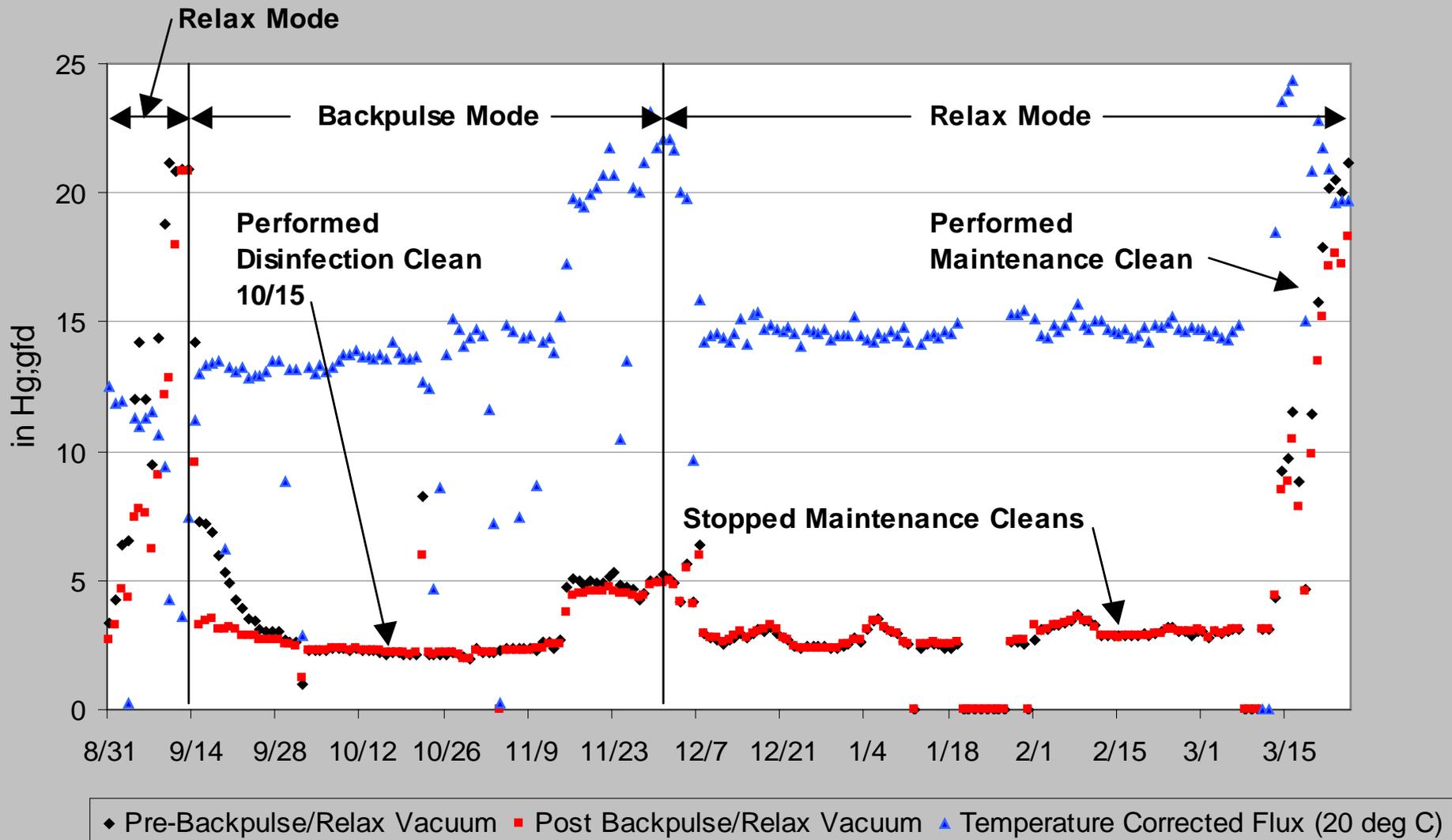
# 4-hour Peaking Test

# Peaking Performance

- System operated for 22 days at an avg flux of 20 gfd with effluent turbidity avg 0.02 NTU.

- The system responded well to (3) 4-hour peaking tests where flux was increased to >20 gfd.

- Effluent turbidities remained constant in the peaking tests with effluent turbidities 0.01 to 0.03 NTU.

# Membrane Cleaning

# Nitrogen Removal

| Process Goal | Actual Total TSA (days) | Average Flux (gfd) | Effluent NH4 (mg/L) | Effluent NO3 (mg/L) |
|---|---|---|---|---|
|  | -- | 11.7 | 0.04 | 6.93 |
| N/dN | -- | 11.5 | 0.03 | 7.90 |
| N/dN | 15.0 | 16.1 | 0.31 | 5.23 |
| N/dN | -- | 12.0 | 0.40 | 5.88 |
| N/dN | 8.5 | 12.0 | 0.02 | 7.42 |
| N/dN | -- | 12.0 | 0.02 | 9.37 |
| Bio-P | -- | 12.0 | 0.02 | 8.52 |
| Bio-P | 7.4 | 16.9 | 0.34 | 9.53 |

# Phosphorous Removal

| Process Goal | Actual Total TSA (days) | Average Flux (gfd) | Effluent TP (mg/L) | Effluent Ortho-P (mg/L) |
|---|---|---|---|---|
|  | -- | 11.7 | 3.64 | 2.90 |
| N/dN | -- | 11.5 | 1.62 | 1.39 |
| N/dN | 15.0 | 16.1 | 0.52 | 0.97 |
| N/dN | -- | 12.0 | 0.62 | 0.52 |
| N/dN | 8.5 | 12.0 | 0.73 | 0.72 |
| N/dN | -- | 12.0 | 1.09 | 1.00 |
| Bio-P | -- | 12.0 | 0.95 | 0.92 |
| Bio-P | 7.4 | 16.9 | 0.97 | 0.92 |

# Phosphorous Removal

- Unit was <u>not designed</u> for biological P removal.

- Did not meet removal goals

- No improvement in removal when process was modified for bio-P
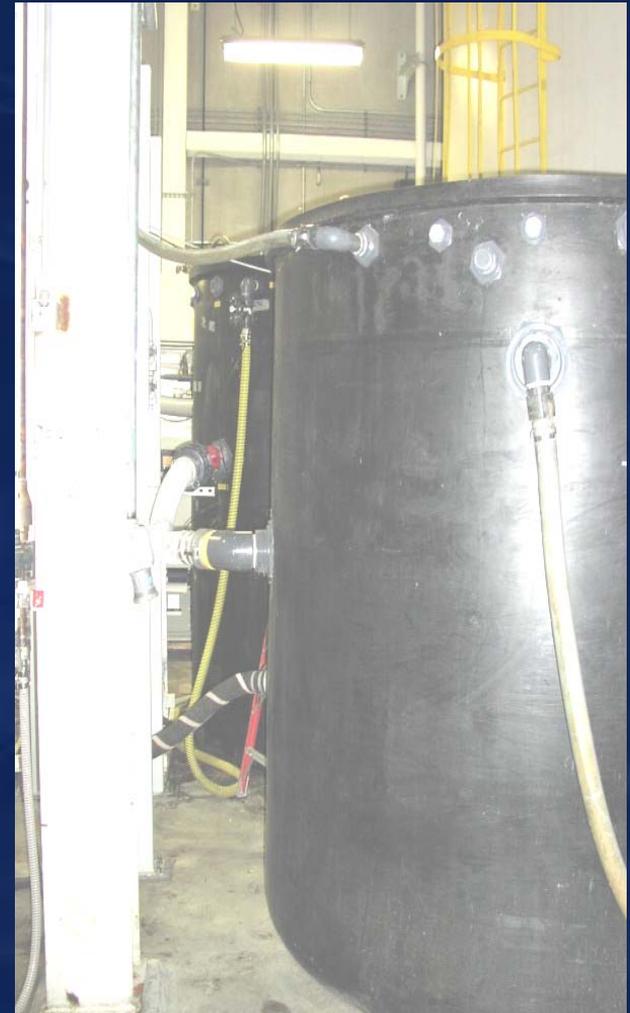
# Coliform Removal

- During Start-up, effluent total Coliform concentrations were as high as $1.7 \times 10^3$ CFU/100 mL.

- Effluent Coliform levels dropped in later phases and no Coliform was detected for the remainder of the study.

# Operation at Low SRT

- The system operated successfully at a total SRT of 8 days and an aerobic SRT of 6 days for >3 months.

- The system did not have operation difficulties with high vacuum pressures

# Operation at Low SRT

- Complete ammonia removal (<0.02 mg/L)was achieved

- Low effluent turbidities (0.02 NTU average) were achieved during the low SRT period.

# Reverse Osmosis (RO)



- Four months of operation

- Feed trials

# Reverse Osmosis (RO)

| Issue | Pilot Experience |
|---|---|
| Performance | TDS < 120 mg/L (>92%)<br>TOC < 1.6 mg/L (83%)<br>NH4-N < 0.02 mg/L (>90%)<br>NO3-N < 0.2 mg/L (>97.5%)<br>TP < 0.02 mg/L (>99%)<br>Metals < MDL |
| | |
| Startup | Immediate |
| | |
| Flux | 9 gfd |
| | |

# Acknowledgement

- King County Technology Assessment Program
- West Point Treatment Plant Process Group
- West Point Treatment Plant Process Laboratory
- King County Environmental Laboratory
- West Point Treatment Plant O & M Staff
- King County Construction Management Staff
- HDR (Bruce Willey, JB Neethling, Michael Norton)
- B&V (Cindy Wallis-Lage)
- Zenon Environmental, Inc.

**King County**