# Pilot testing enhanced biological phosphorus removal at Chicago WRPs using existing infrastructure

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# Overview

- In an effort to examine the effectiveness of enhanced biological phosphorus removal, demonstration projects were initiated at two plants with a goal to reach 1 mg/L TP in effluent using current infrastructure
  - Stickney WRP
    - Started in October 2011
    - Restarted in May 2012
  - Calumet WRP
    - Started in April 2012

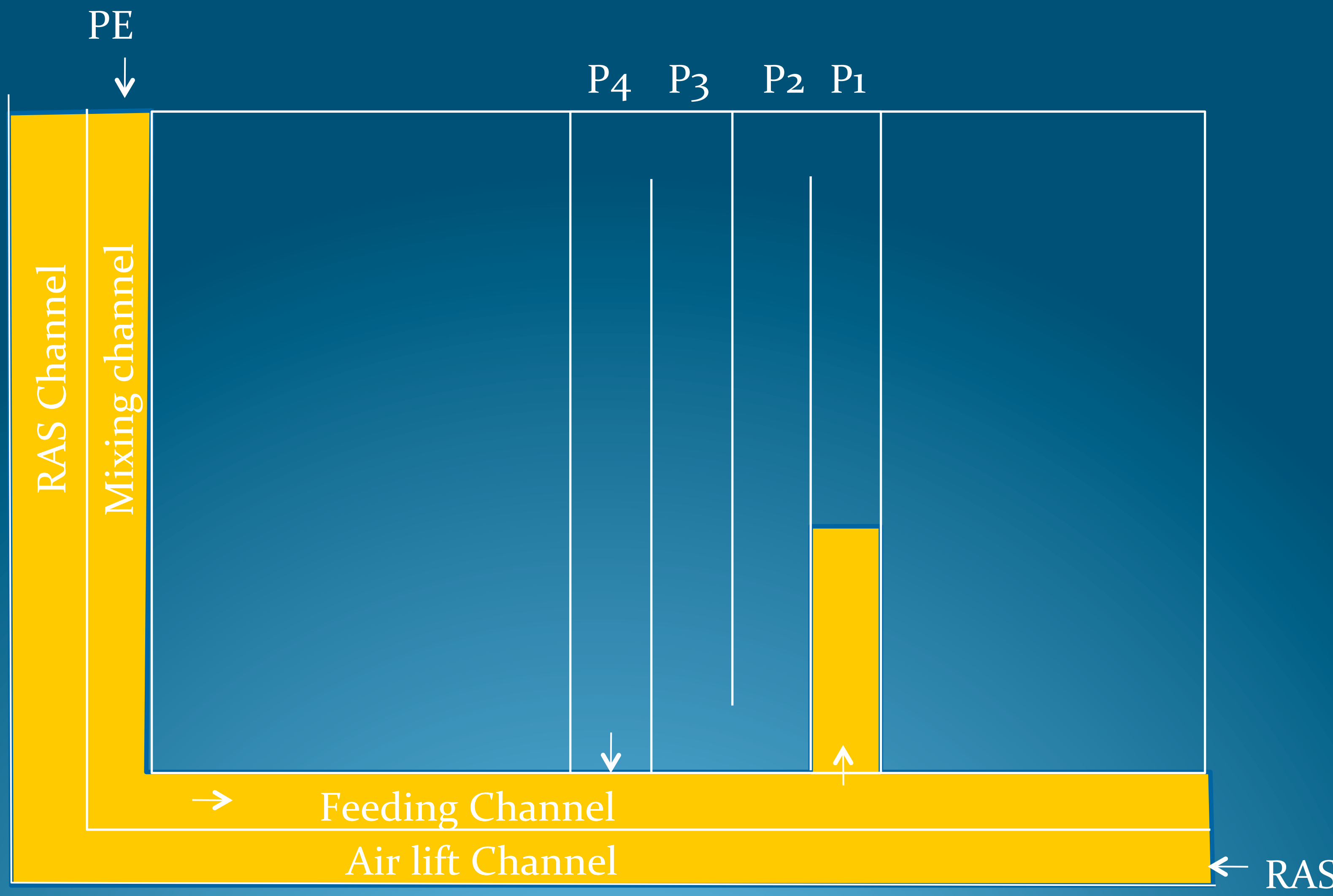
# Stickney Background

- Serves 2.3 million people
- Single stage nitrification activated sludge plant
- Design avg flow of 1,200 MGD and design max of 1,400 MGD
  - 2011 avg: 608 MGD
  - 2011 max: 1,250 MGD
- Primary effluent is mixture of Imhoff and preliminary settling tanks
- Converted Battery (Battery D)
  - 8 tanks, 4 pass plug flow
    - 50.7 MG (6.3 MG per tank)
    - 2011 avg HRT: 8.7 hrs
  - 415 ft per pass
  - 400 foot RAS channel
  - 1,600 foot mixing and feed channel
  - Aeration basins are of similar size
- Coarse bubblers in RAS/mixing/feed channel and spiral roll fine bubble diffusers in aeration tanks

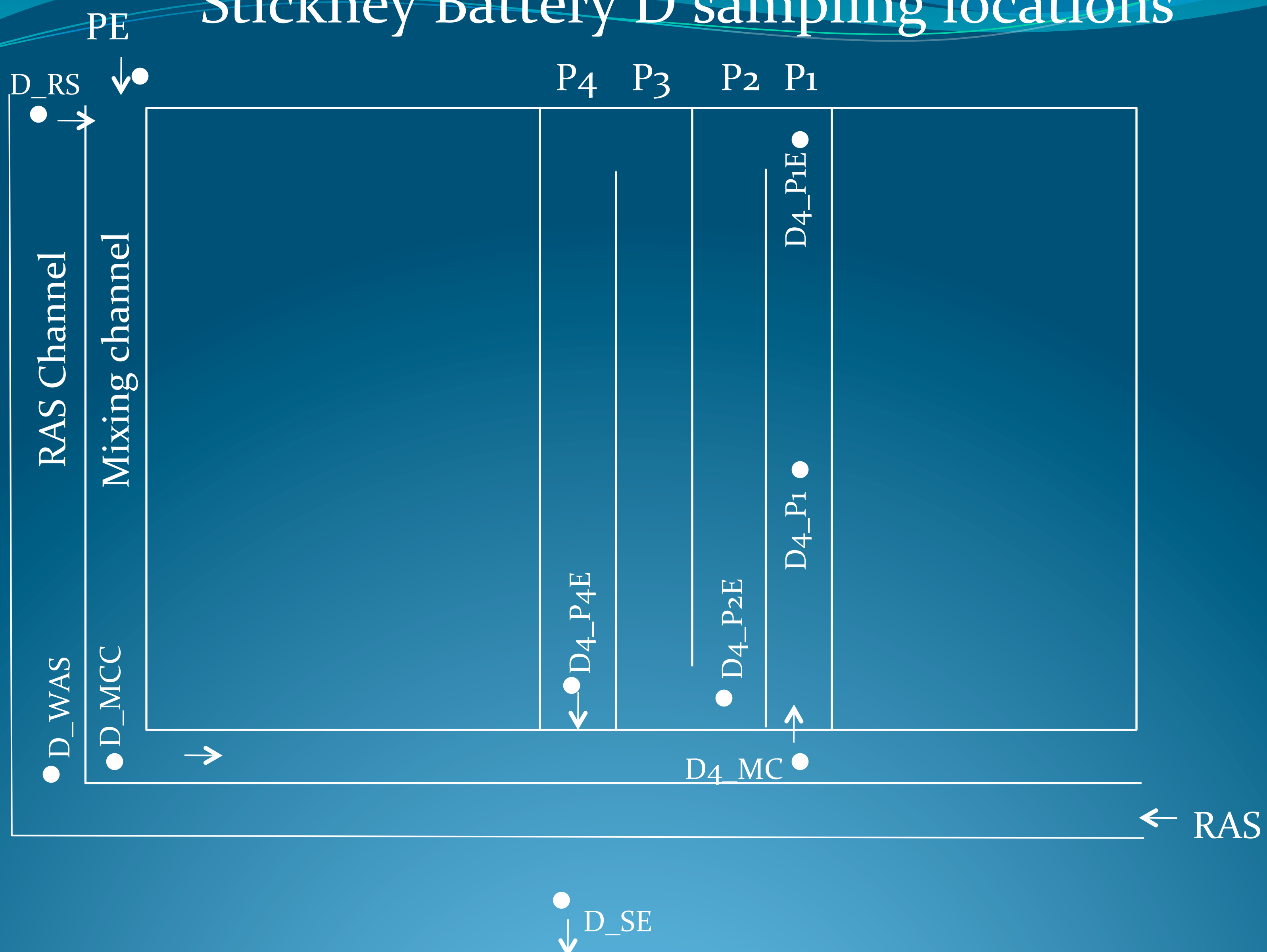
# Stickney Objectives for 2012

- Phase I
  - Compare control Battery A to EBPR convert Battery D
- Phase II
  - Look at EBPR Battery efficiency under different stress conditions
    - low flow, high flow, low P loads, and high P loads
  - Look at diurnal variation of bio P removal in Battery D
- Phase III
  - Modify length of anaerobic zone
  - Modify RAS return
- Phase IV (incorporated)
  - Use past and Phase I-III data to evaluate the effect of EBPR on nitrification
  - Run nitrification rate tests on EBPR mixed liquor and control mixed liquor
  - Install $NH_3$ probe at end of Battery D tank to get real time and continuous information on nitrification in tank

# Stickney Battery D sampling locations



# Stickney Battery D sampling locations



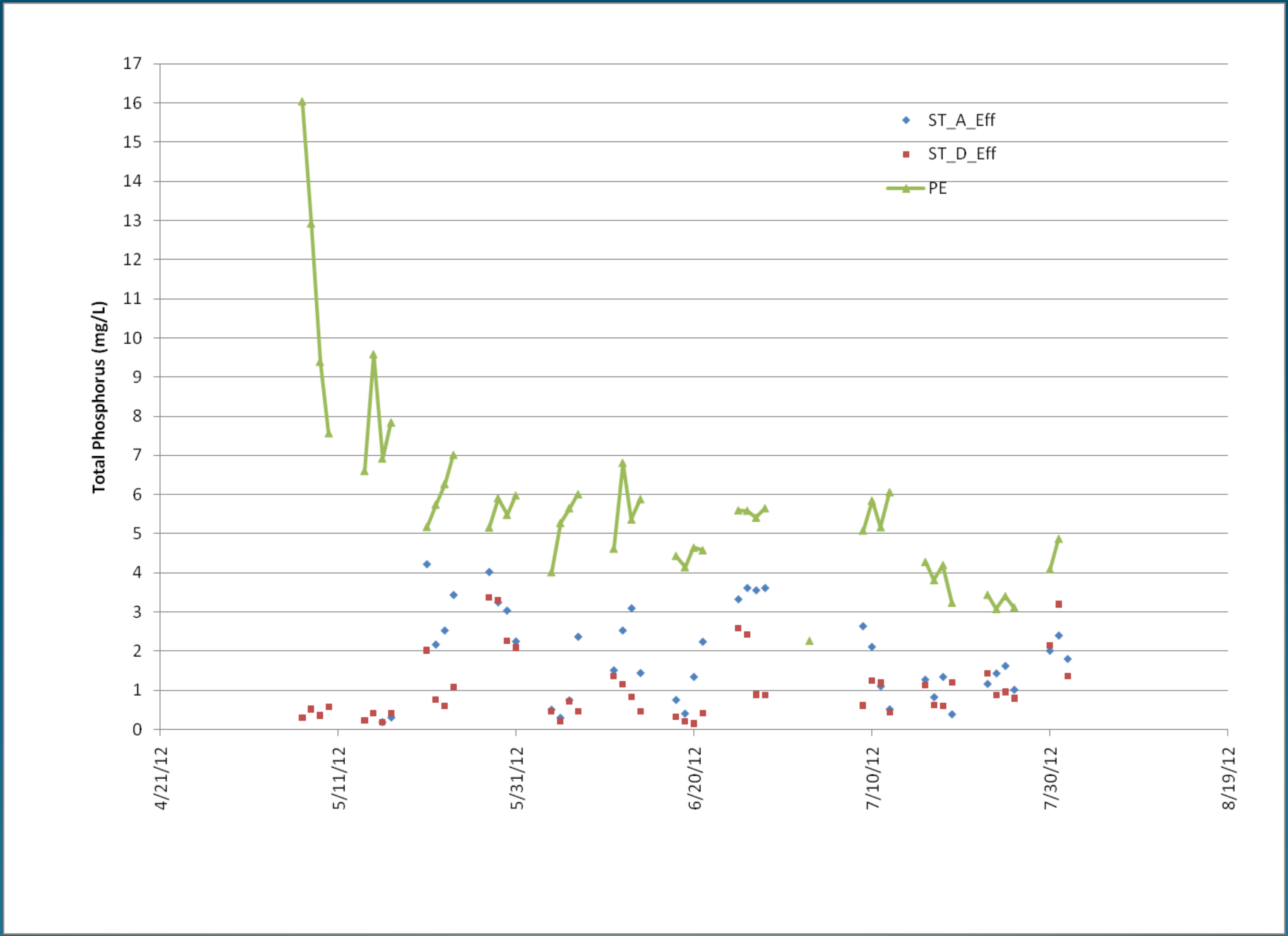

Also collecting daily composites of Imhoff and Preliminary effluents, RAS, and effluents from each battery

# Parameters

| Parameter | Container Type | Extent of Filtration | Volume (mL) |
|---|---|---|---|
| TSS and VSS | Plastic | Unfiltered | 250 |
| $NH_3$-N | Plastic | Coarse | 250 |
| $NO_3$-N and $NO_2$-N | Plastic | Coarse | 250 |
| TKN and TP | Plastic | Unfiltered | 250 |
| Mg and K | Plastic | Unfiltered | 250 |
| Soluble Mg and K | Plastic | 0.45-micron | 250 |
| COD | Plastic | Unfiltered | 250 |
| Soluble COD | Plastic | 0.45-micron | 250 |
| Ortho-P and sol P | Plastic | 0.45 micron | 250 |
| Nitrification rate | Plastic | Unfiltered | 3,000 |

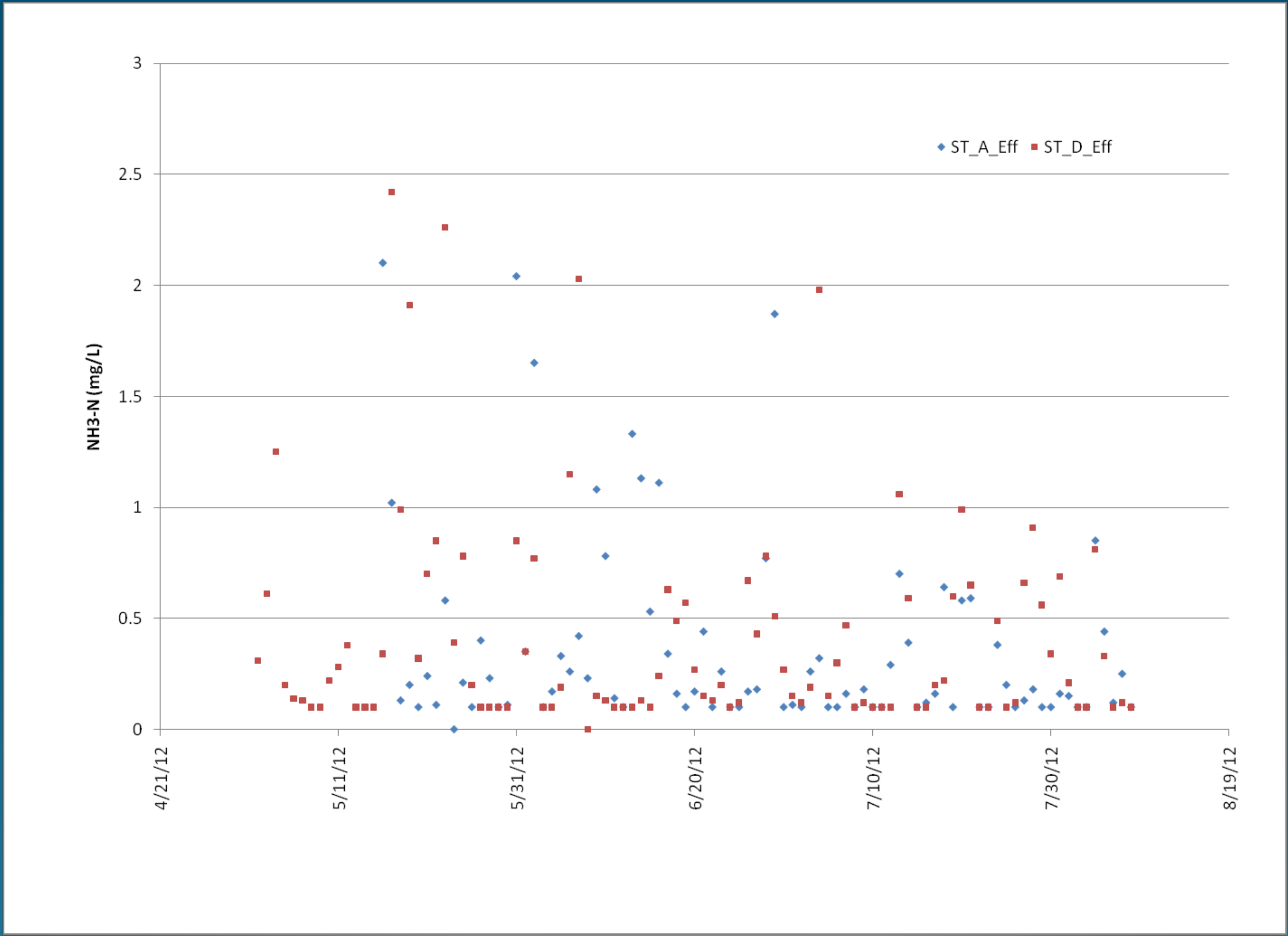
Also operational data such as battery flows, SRTs, RAS flows, F:M, and HRTs

# Findings



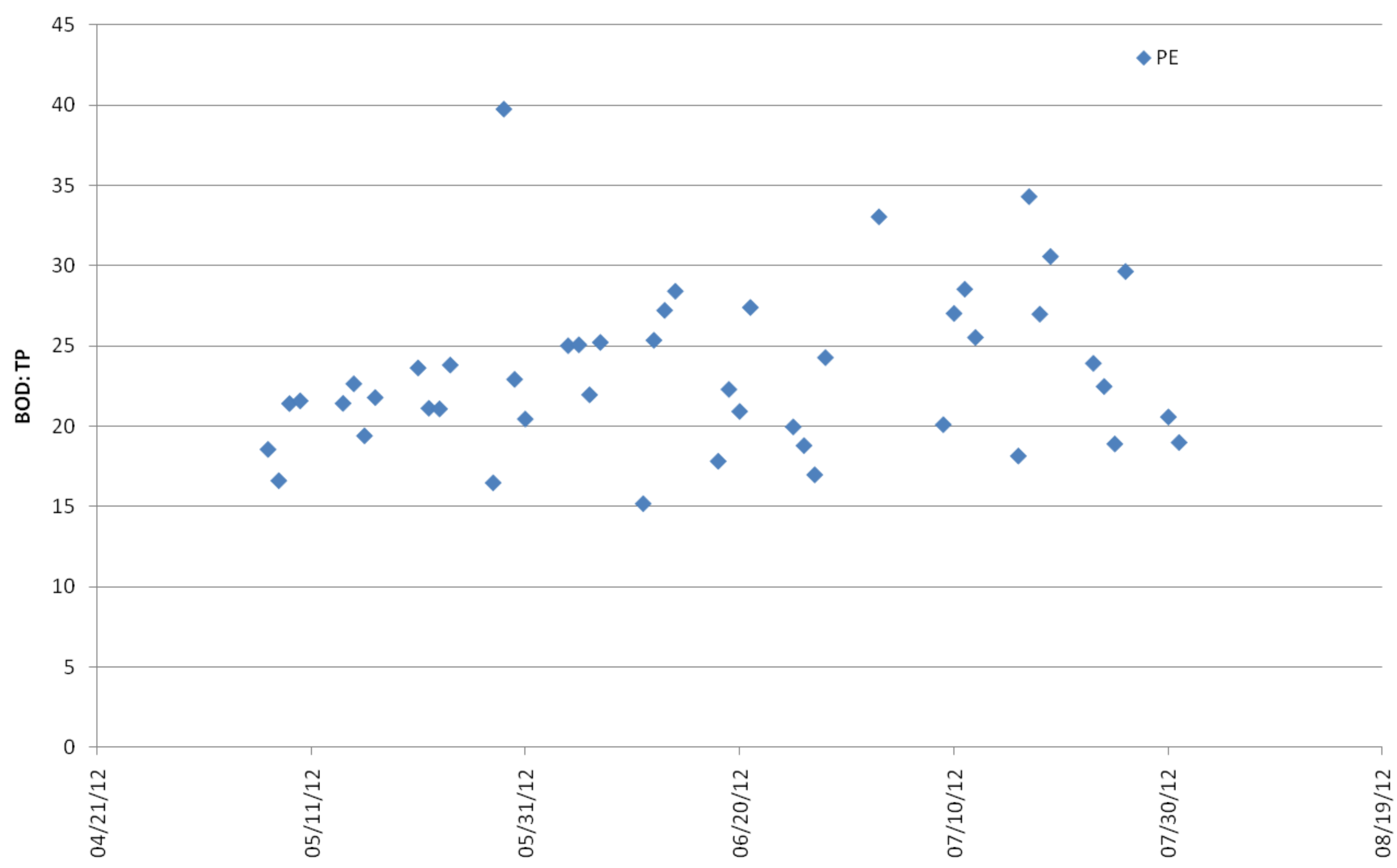
Total Phosphorus (mg/L)
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
4/21/12
5/11/12
5/31/12
6/20/12
7/10/12
7/30/12
8/19/12
ST_A_Eff
ST_D_Eff
PE

# Findings



NH3-N (mg/L)
3
2.5
2
1.5
1
0.5
0
ST_A_Eff
ST_D_Eff
4/21/12
5/11/12
5/31/12
6/20/12
7/10/12
7/30/12
8/19/12

# Findings



45
40
35
30
25
20
15
10
5
0
BOD: TP
PE
04/21/12
05/11/12
05/31/12
06/20/12
07/10/12
07/30/12
08/19/12

# Findings

- Seeing P reduction in converted battery relative to control
- Nitrification not inhibited
- BOD:TP>20 most of the time
- $NO_3$-N and DO still a little too high in entering anaerobic zone→want both close to zero
- Did see sharp increase in DO in aerobic zone after transition (~ 2 mg/L) much but not all of the time
- See relatively higher abundance of PAOs in converted battery based on limited data

# Stickney future investigation for 2012

- Investigating different mixing technologies to achieve complete denitification and near-zero DOs
- Examining VFAs and rbCOD in PE and mixed liquor entering anaerobic zone
- Sol P in WAS➔ensure no secondary release
- Install continuous DO and NO3 monitors in RAS/mixing/feed channel and anaerobic zone

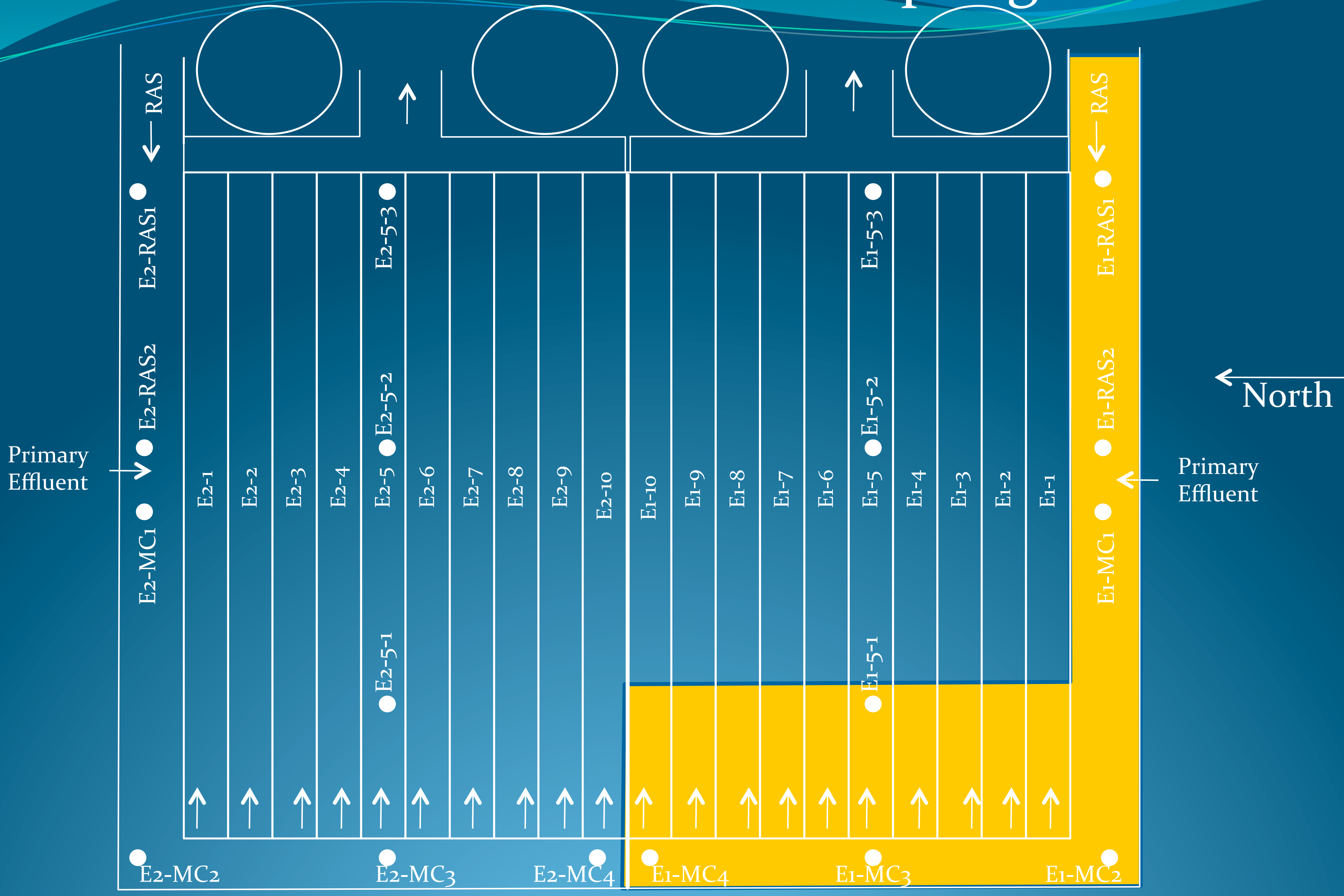
# Calumet Background

- Serves 1.1 million people
- Single stage nitrification activated sludge plant
- Design avg flow of 354 MGD and design max of 430 MGD
  - 2011 avg: 263 MGD
  - 2011 max: 488 MGD
- Converted Battery (Battery E1)
  - 10 tanks, single pass plug flow
    - 16.2 MG (2 MG per tank)
    - 2011 avg HRT: 7.1 hrs
  - 425 ft per pass
  - 254 foot RAS channel
  - 580 foot mixing and feed channel
  - All batteries are of different size except the control battery E2
- Coarse bubblers in RAS/mixing/feed channel and spiral roll final bubble diffusers in aeration tanks

# Objectives

- Phase I
  - Review plant and battery operational and influent data/ information
- Phase II
  - Background characterization in RAS and mixing channel of Battery E1
- Phase III
  - Compare control Battery E2 to EBPR converted Battery E1

# Calumet Batteries E1 and E2 sampling locations




Also collecting daily composites of primary, RAS, and effluents from each battery

# Findings

| Year | Flow | Influent TP | Primary effluent TP | Secondary Effluent TP | %TP rem | Primary effluent BOD5:TP |
|---|---|---|---|---|---|---|
| | mgd | mg/L | mg/L | mg/L | % | unitless |
| 2005 | 224 | 6.44 | 6.12 | 3.78 | 41.4 | 16.3 |
| 2006 | 283 | 4.85 | 4.58 | 2.46 | 49.3 | 19.4 |
| 2007 | 273 | 4.29 | 3.88 | 2.16 | 49.6 | 21.9 |
| 2008 | 286 | 5.21 | 4.44 | 2.65 | 49.1 | 19.0 |
| 2009 | 291 | 5.19 | 4.77 | 3.17 | 39.0 | 19.2 |
| 2010 | 238 | 6.14 | 5.71 | 3.75 | 38.9 | 16.8 |
| 2011 | 263 | 5.76 | 4.91 | 2.90 | 49.7 | 17.8 |

# Findings

- RAS and mixing channel DOs and $NO_3$-N too high and air needed turn down (Phase I)
- Not seeing the same P removal as Stickney
- Nitrification not inhibited
- BOD:TP<20
- $NO_3$-N and DO still too high in entering anaerobic zone→want both close to zero
- Did not see sharp increase in DO in aerobic zone after transition
- PAO abundance is inconclusive

# Calumet future investigations in 2012

- Investigating different mixing technologies to achieve complete denitification and near-zero DOs
- Examining VFAs in PE and mixed liquor entering anaerobic zone
- Initiate examination of the affect of fermentation and rbCOD addition to anaerobic phase of EBPR process through lab tests

# Questions?

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