REINHOLD ENVIRONMENTAL Ltd.

# 2015 APC Round Table & Expo Presentation

July 13 & 14, 2015, in Atlanta, GA / Hosted by Southern Company

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# Complying With The Steam Electric Power ELGs

## Case Study From A Pilot Trial At A Coal-Fired Power Plant Treating FGD WW

Nelson Fonseca – Product Manager

**Imagination at work.**

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# Today's Agenda

- Technology Options
- Polymeric Organosulfide (MetClear*)
- Biological  Treatment (ABMet*)
- FGD Optimized ZLD Treatment
- CASE STUDY: Phys/Chem + ABMet Pilot Treating FGD WW at Coal-Fired Power Plant


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# Technology Options









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# A Complete Solution Requires a Combination of Technologies

| Proposed FGD ELGs | | | |
|---|---|---|---|
| **Constituent** | **units** | **30-day avg.** | **1-day max** |
| Arsenic (total) | µg/L | 6 | 8 |
| Mercury (total) | ng/L | 119 | 242 |
| Selenium (total) | µg/L | 10 | 16 |
| Nitrate + nitrite as N | mg/L | 0.13 | 0.17 |

## Local Regulations

- Lower limits on Hg, $NO_3$, Se, As
- Limits on other constituents such as chlorides, TDS, or boron


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# Utilities Need Viable, Practical, and Proven Technologies

| | |
|---|---|
| Treat and Discharge | **Biological**<br>**Chemical precipitation**<br>Advanced chemical<br>Filtration<br>Adsorption<br>Ion exchange |
| Zero Liquid Discharge (ZLD) | Evaporation Ponds<br>Deep-well injection<br>Thermal evaporation<br>Thermal evap. & crystallization<br>Solidification |


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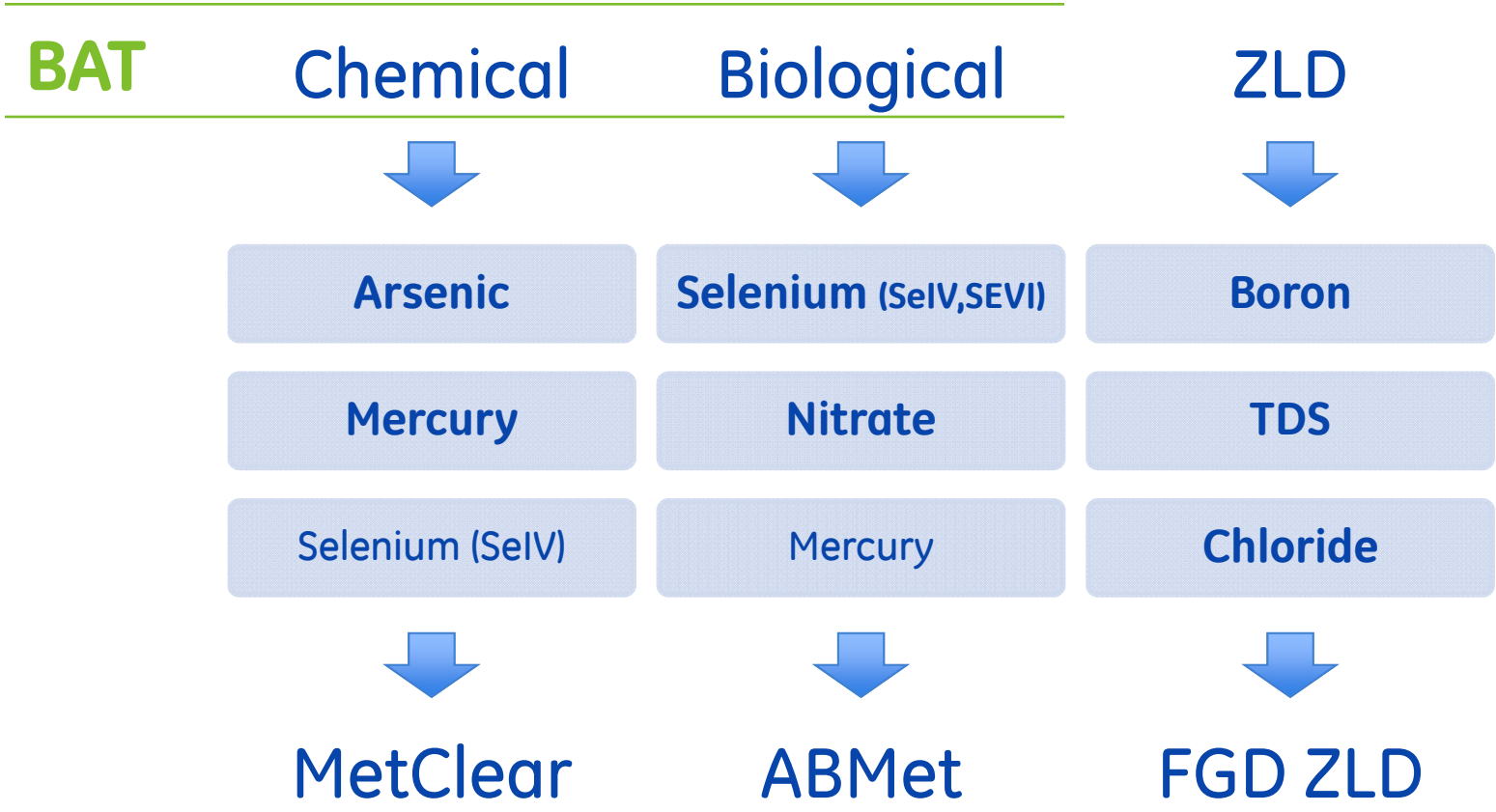
# Three Core Technologies to Address the Challenge of FGD WW Treatment





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# Polymeric Organosulfide (MetClear )









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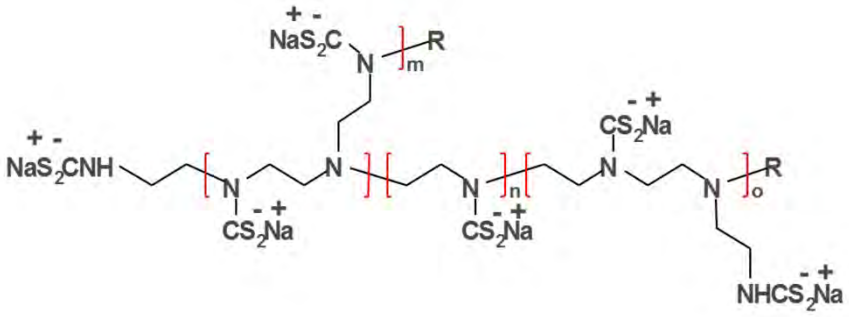
# Advanced Hg Removal

- Low toxicity:  100- 1000x less toxic than Carbamates and 10x less than thioCarbonates
- Integrated into Phys/Chem system
- High molecular weight molecule produces a dense sludge that passes TCLP
- Effective on many complexed metals
- Removal of metals to ppb levels (Hg to ppt)
- Lower dose rates (More Active Groups- polymer) than other organosulfide products (polymer)
- Metals Affinity: Hg > Ag > Cd > Cu > Pb > Zn > Co > Ni > $Fe^{2+}$ > Mn





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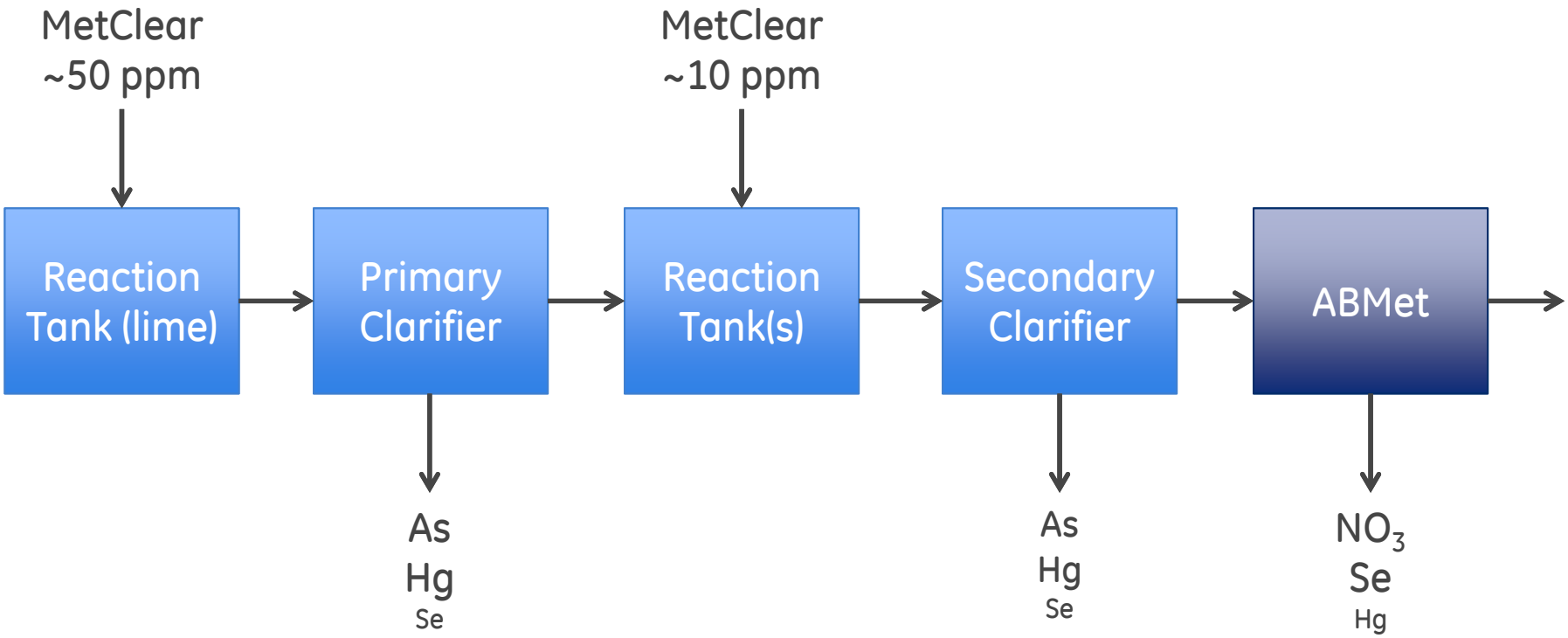
# Integrated Chemical Precipitation + Biological Solution





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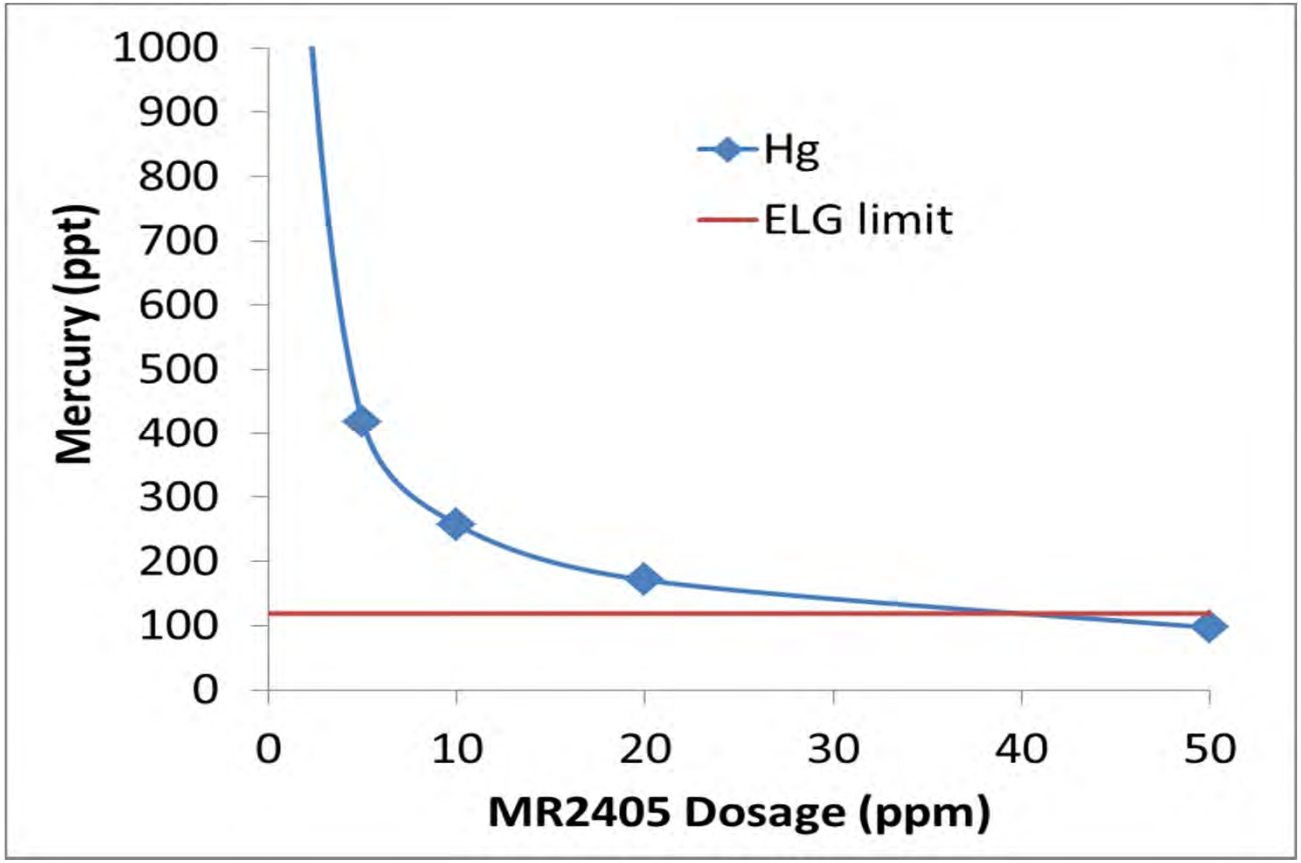
# Effective Removal with Coagulation, Flocculation and Gravity Settling





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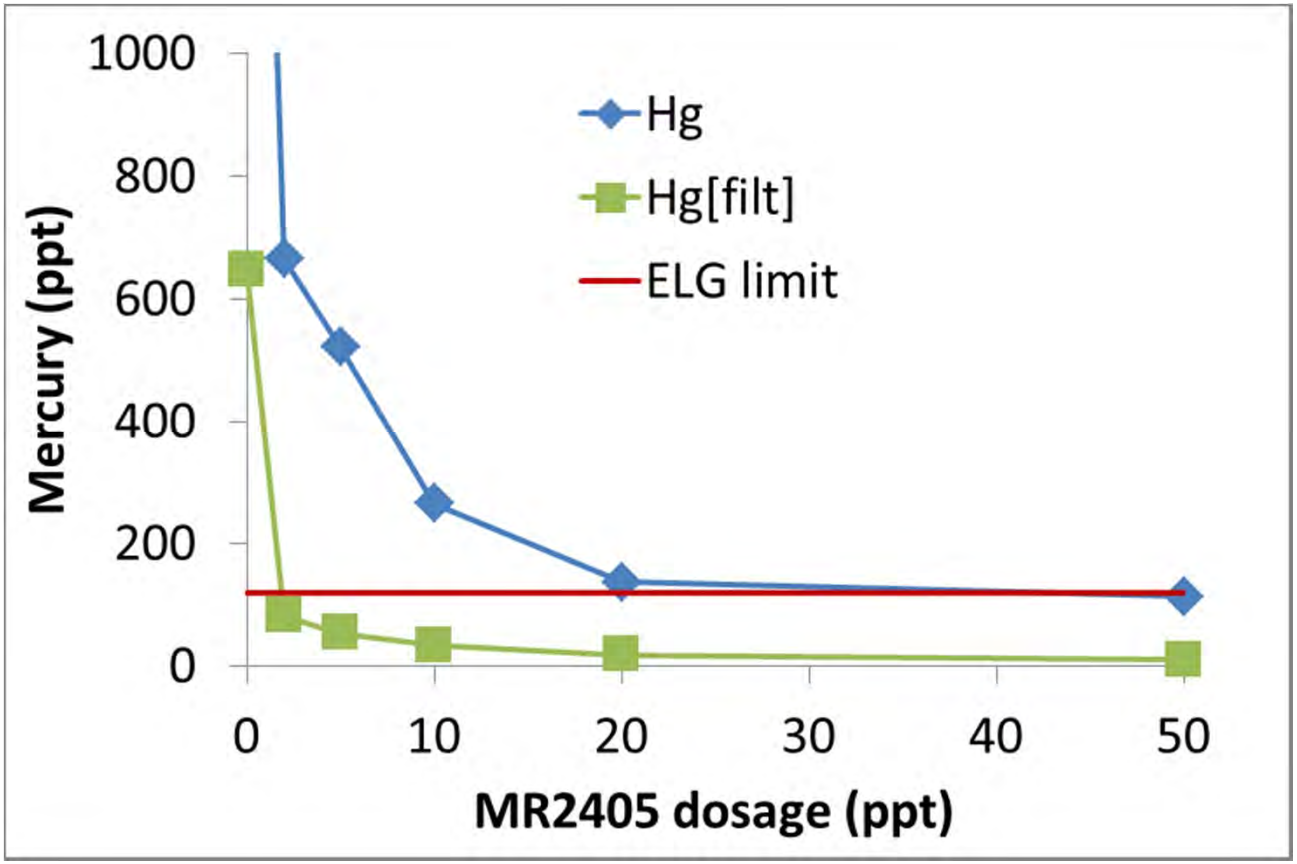
# Filtration Enhances Removal to Low Double Digit ppt Concentrations





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# Biological Treatment (ABMet)


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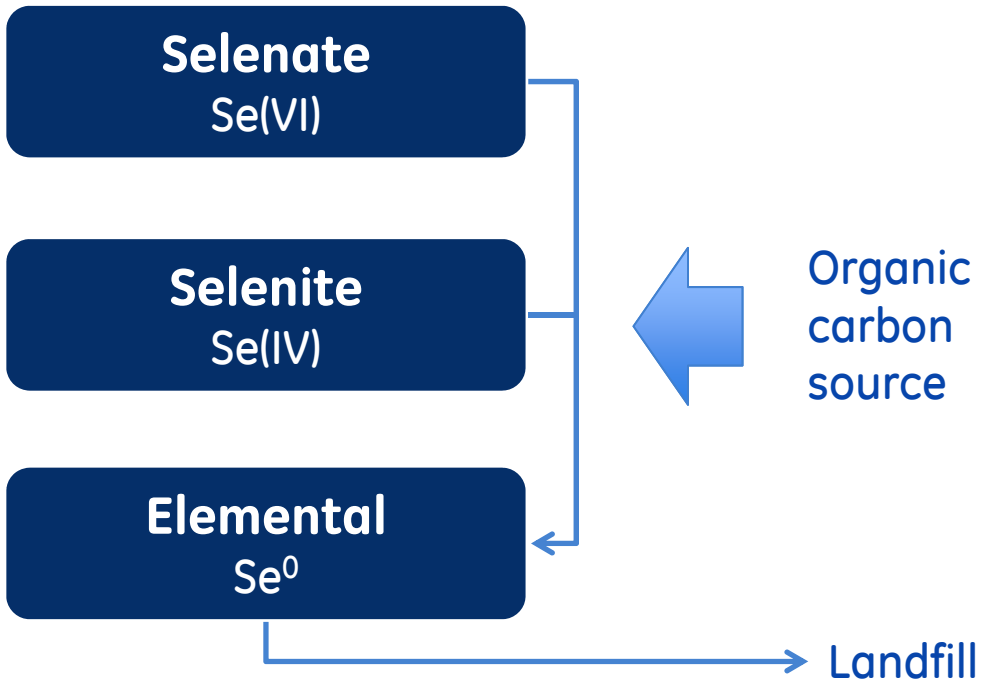
# Elemental Selenium is the Stable By-Product of a Biological Process





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# Biological Reduction of Major Constituents Occurs in a Sequence

## 1. Nitrate Reduction to Nitrogen Gas

$$5CH_3COO^- + 8NO_3^- + 3H^+ \rightarrow 4N_2 + 4H_2O + 10HCO_3^-, \Delta G = -479 \, {}^{kJ}/_{mol}$$

## 2. Selenate/Selenite Reduction to Elemental Selenium

$$0.75CH_3COO^- + SeO_4^{2-} + 1.25H^+ \rightarrow Se^0 + H_2O + 1.25HCO_3^-, \Delta G = -396 \, {}^{kJ}/_{mol}$$

## 3. Sulfate Reduction to hydrogen bisulfide ions and $H_2S$

$$CH_3COO^- + SO_4^{2-} \rightarrow HS^- + 2HCO_3^-, \Delta G = -48 \, {}^{kJ}/_{mol}$$


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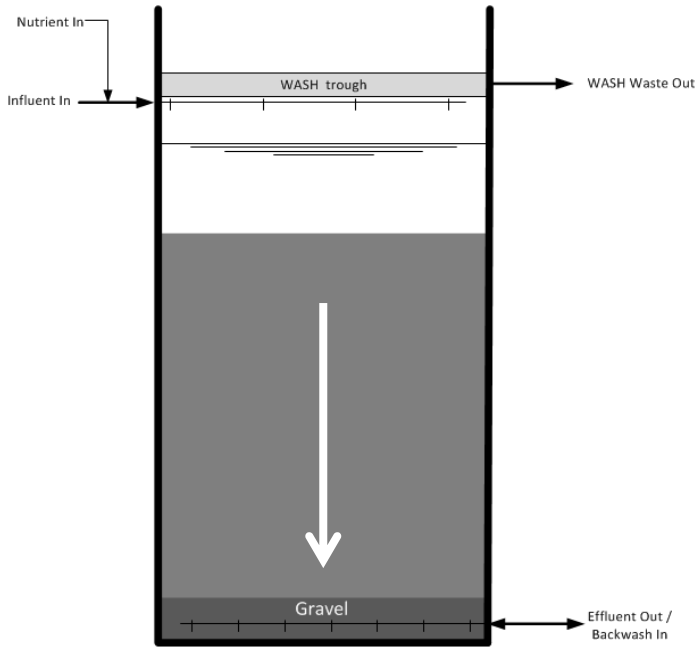
# Process is Controlled to Maximize Selenium Removal via ORP Feedback




| Electron Acceptor | Approximate ORP |
|---|---|
| Oxygen | >0 mV |
| Nitrate | < 0 mV |
| Nitrite | < -50 mV |
| Selenate | < -100 mV |
| Selenite | < -150 mV |
| Sulfate | < -200 mV |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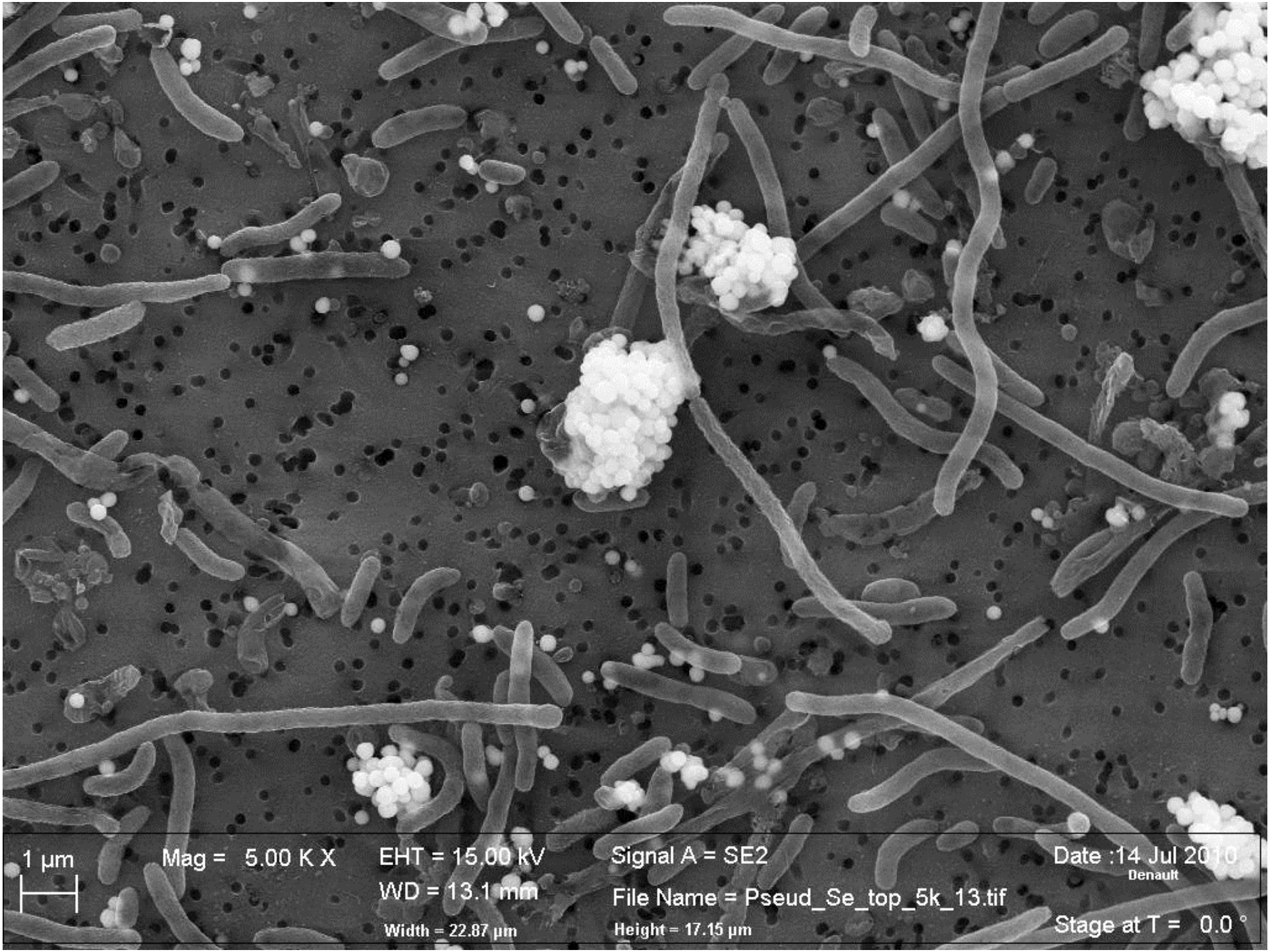
1 µm
Mag = 5.00 K X
EHT = 15.00 kV
WD = 13.1 mm
Width = 22.87 µm
Signal A = SE2
File Name = Pseud_Se_top_5k_13.tif
Height = 17.15 µm
Date :14 Jul 2010
Denault
Stage at T = 0.0 °

# FGD Optimized ZLD Treatment (Solidification/Stabilization Process)


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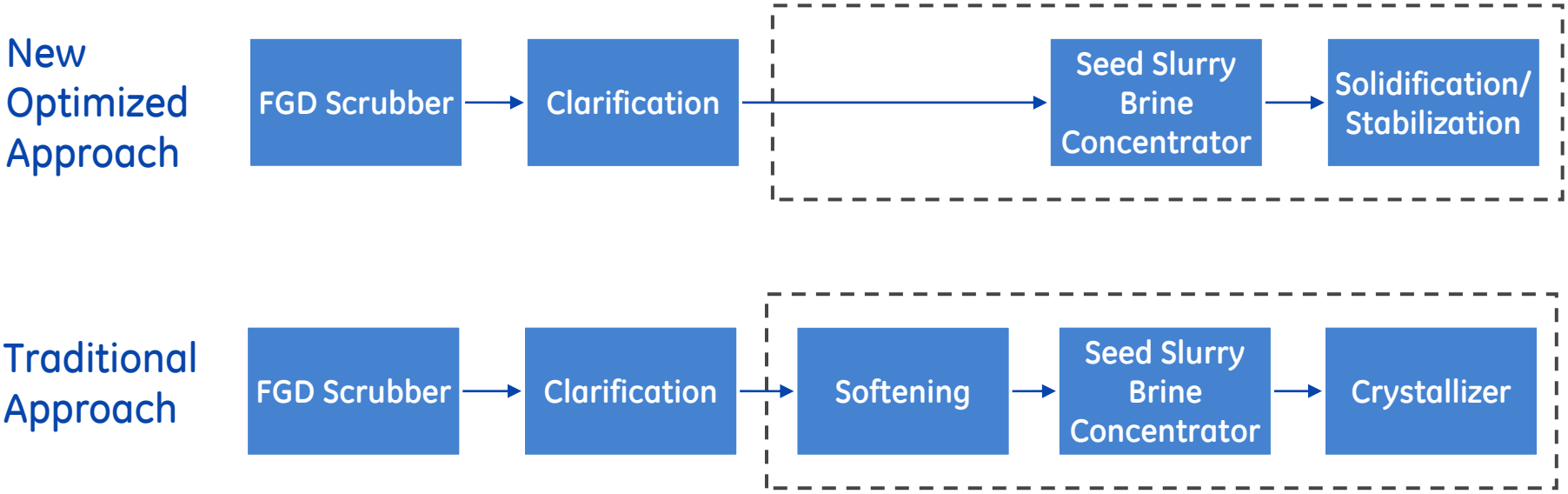
# New Process Removes Softening Step and Replaces Crystallization Step




- 45% to 55% CAPEX reduction and 55% to 60% OPEX reduction over traditional ZLD
- No NPDES permit
- Minimized landfill concerns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# CASE STUDY

## Phys/Chem + ABMet Pilot Treating FGD WW at Coal-Fired Power Plant









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# FGD Pilot Study at a Coal-Fired Power Plant

**Challenge:** Meet the proposed ELG discharge limits for Arsenic, Mercury, Selenium, and Nitrate

**Solution:** Phys/Chem treatment with poly-organosulfide (MetClear) addition followed by biological (ABMet) treatment treating FGD WW form a pond


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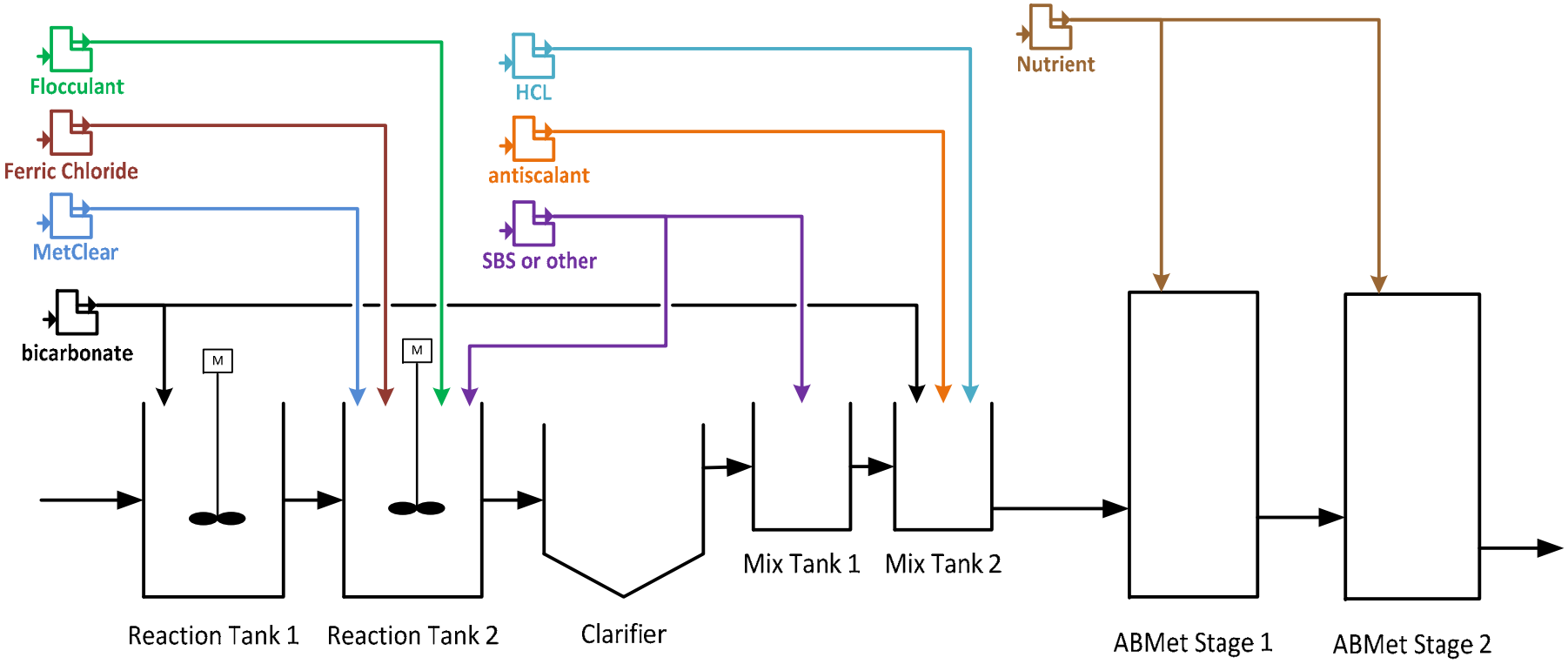
# Phys/Chem + ABMet Pilot Flow Sheet



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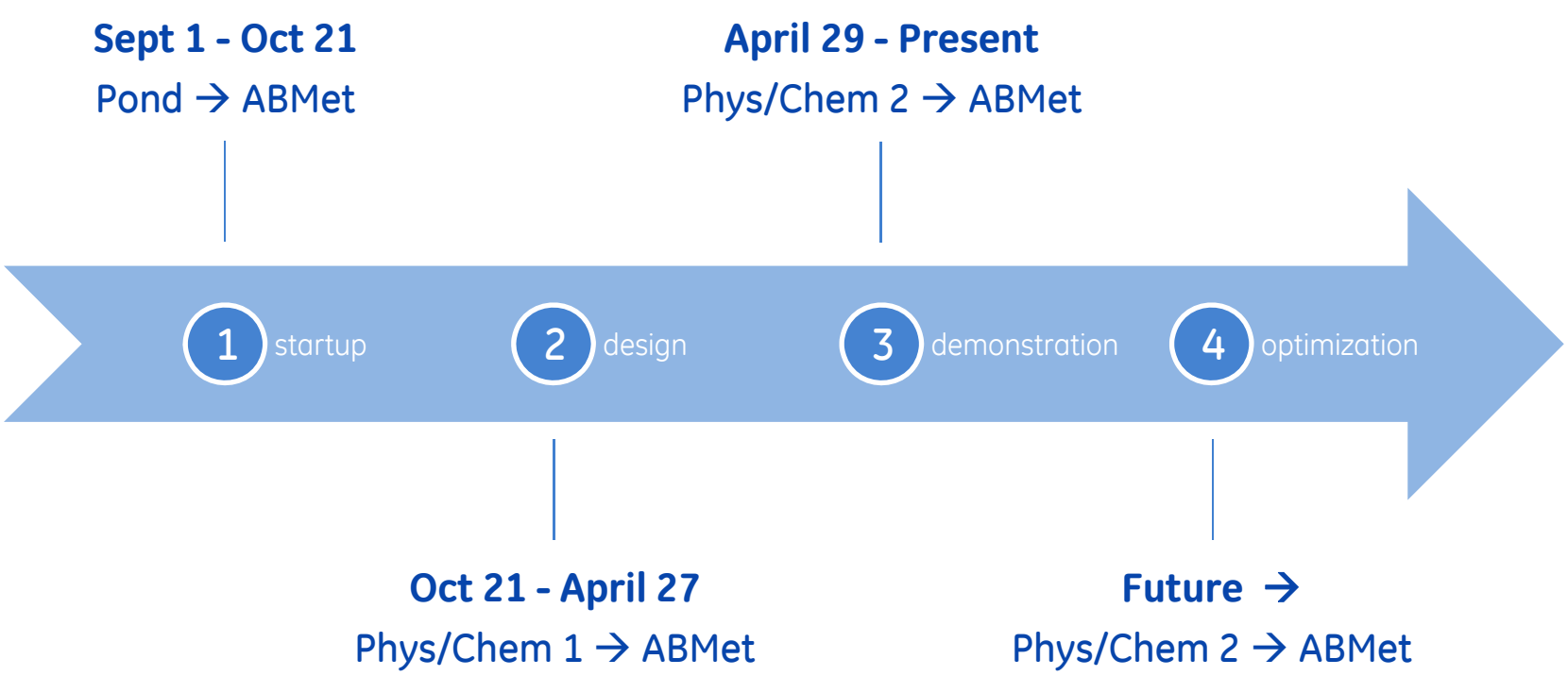
# Project Timeline




- From no pre-treatment to integrated phys/chem + ABMet process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# Selenium Speciation in Pond (ppm)


- Percent of total selenium as selenate >95% during full load operation



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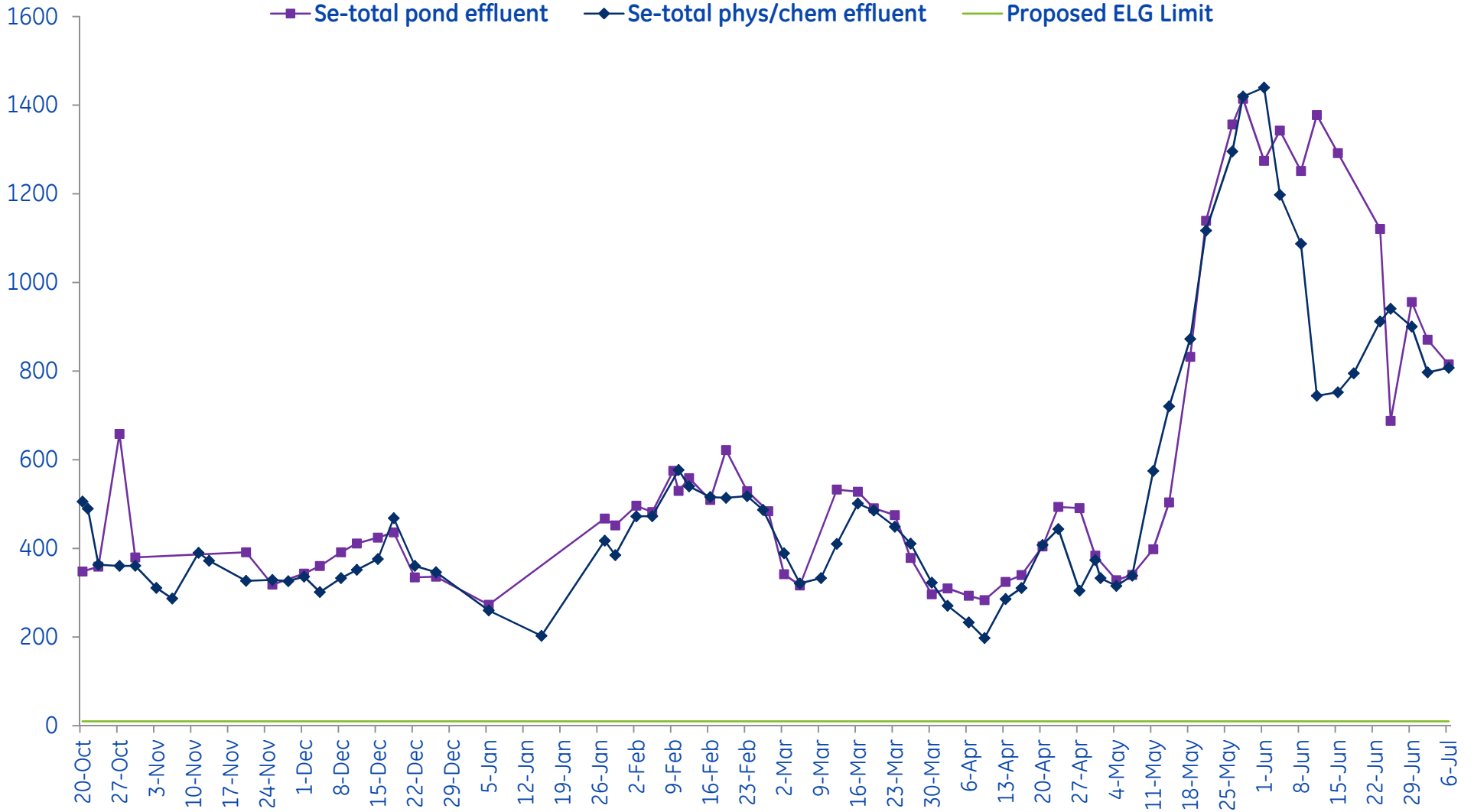
# Selenium Removal in Phys/Chem (ppb)




- Insignificant selenium removal in phys/chem system



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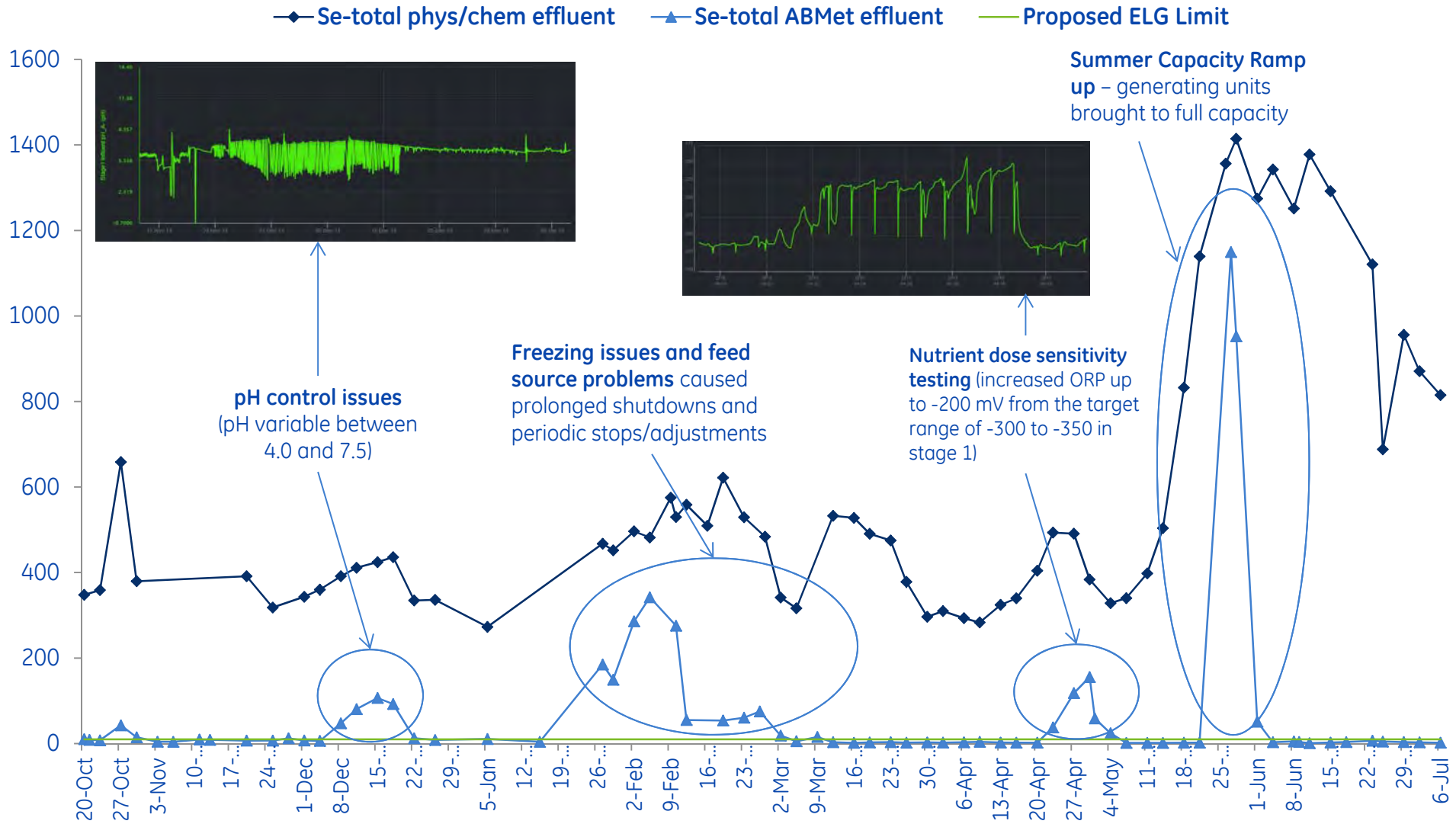
# Selenium Removal in ABMet (ppb)




- Consistent total selenium removal in ABMet system with decreasing HRT
- Strategies to handle sudden load increases are required



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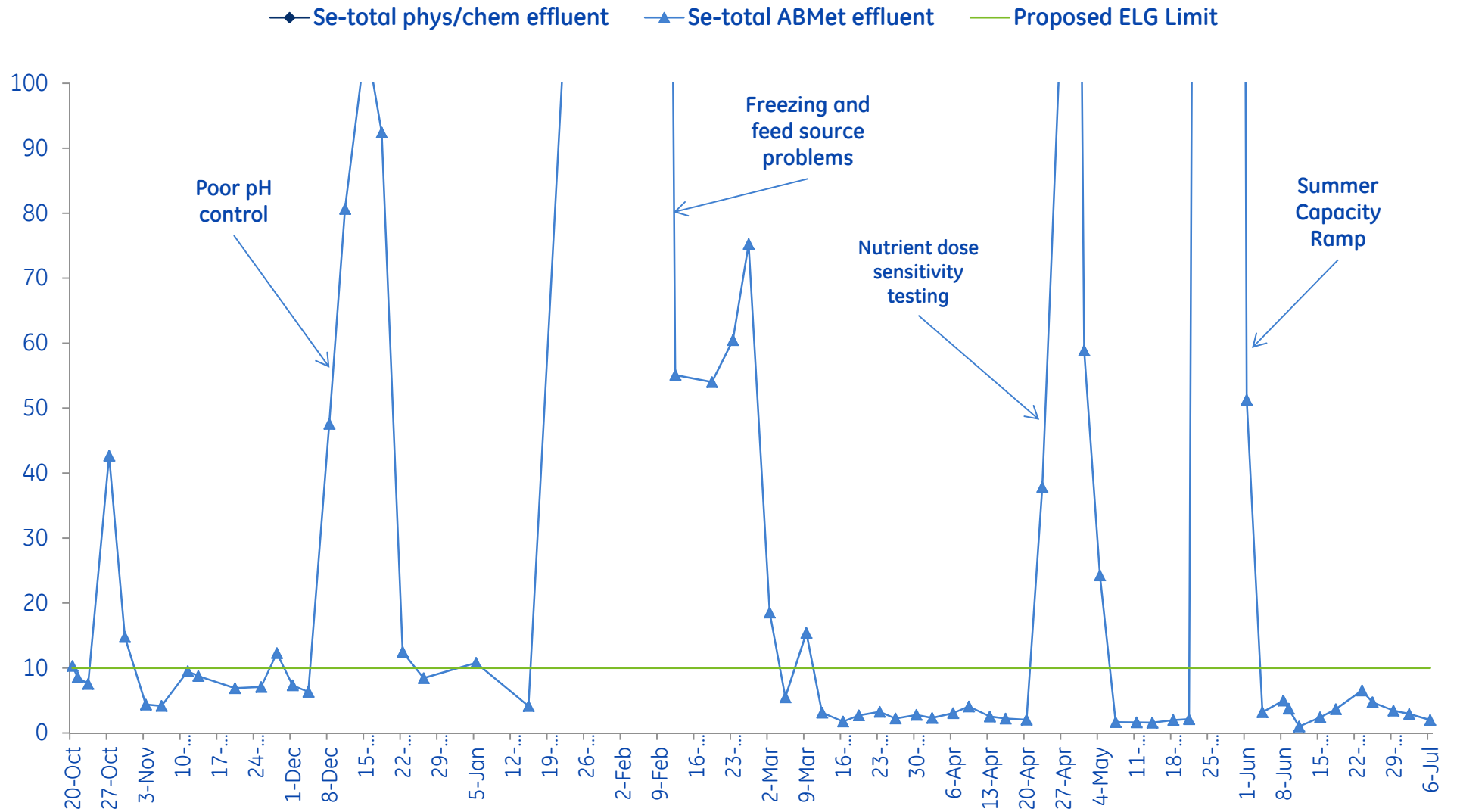
# Selenium Removal in ABMet (ppb)



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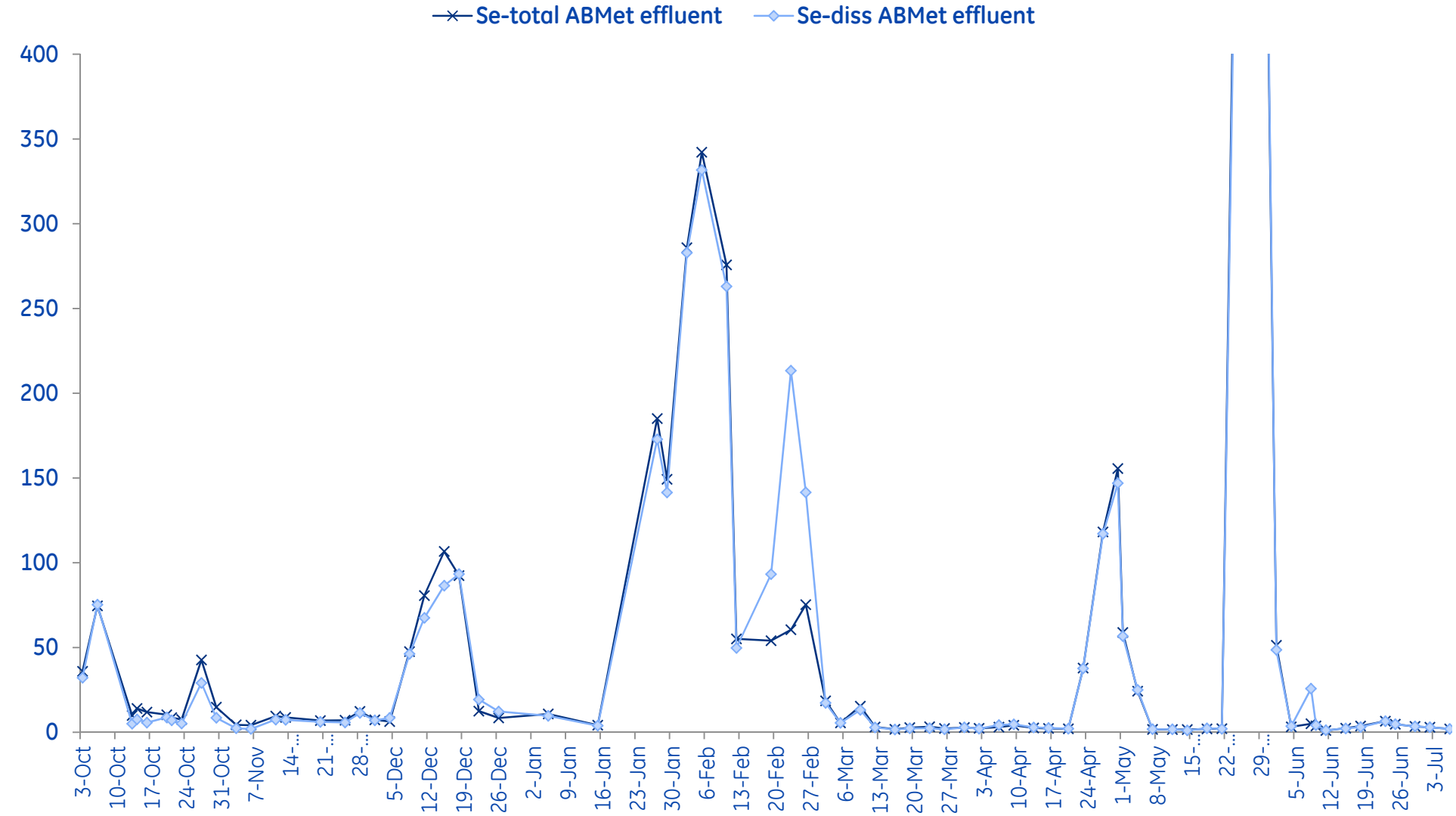
# Total vs. Diss. - ABMet Effluent Se (ppb)




- Elemental selenium retained within the biofilter – no need for post-treatment



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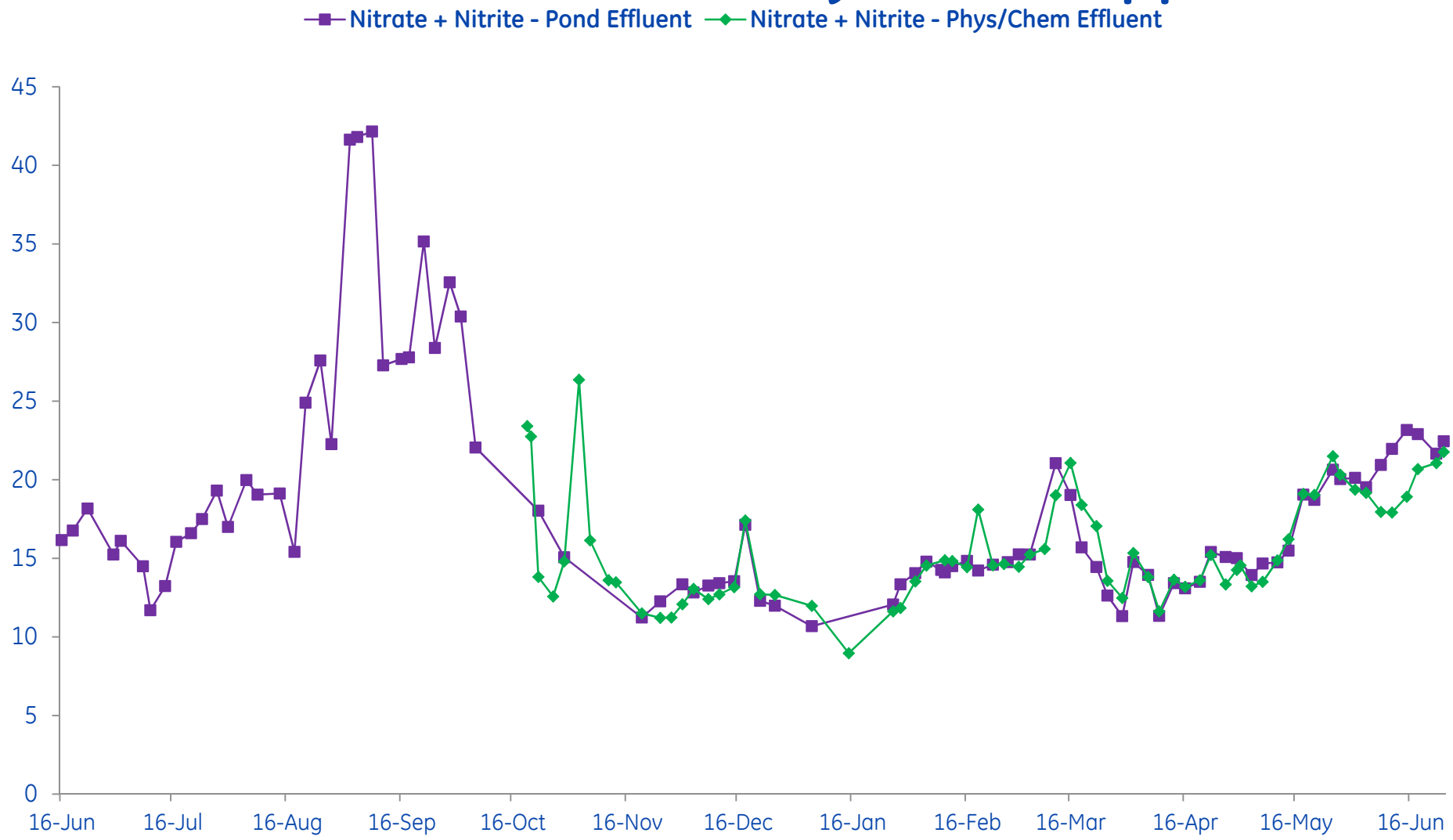
# Nitrate Removal in Phys/Chem (ppm)




- No removal of nitrate in phys/chem



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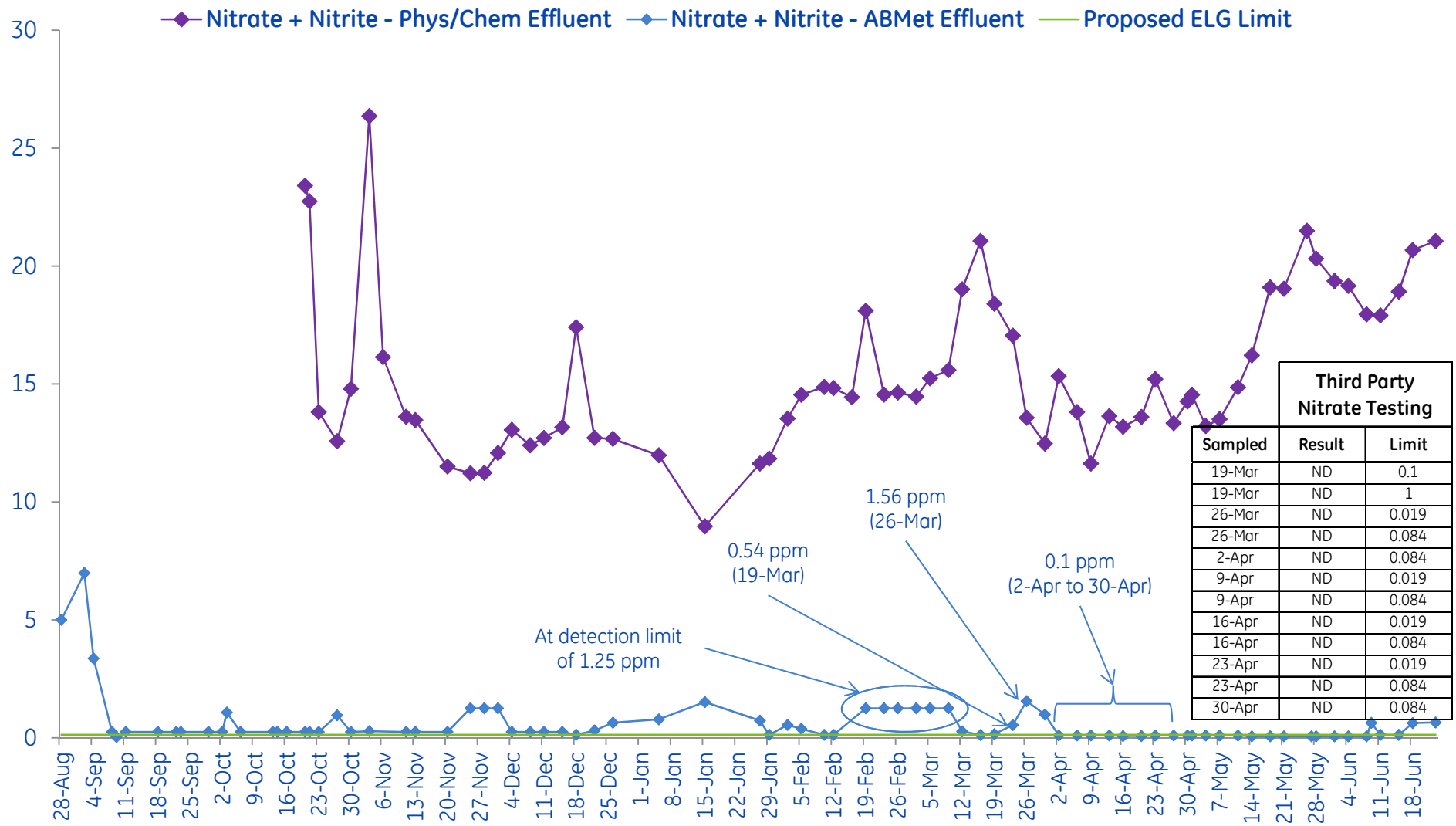
# Nitrate+Nitrite Removal in ABMet (ppm)




**Third Party Nitrate Testing**

| Sampled | Result | Limit |
|---|---|---|
| 19-Mar | ND | 0.1 |
| 19-Mar | ND | 1 |
| 26-Mar | ND | 0.019 |
| 26-Mar | ND | 0.084 |
| 2-Apr | ND | 0.084 |
| 9-Apr | ND | 0.019 |
| 9-Apr | ND | 0.084 |
| 16-Apr | ND | 0.019 |
| 16-Apr | ND | 0.084 |
| 23-Apr | ND | 0.019 |
| 23-Apr | ND | 0.084 |
| 30-Apr | ND | 0.084 |

- Consistent denitrification to non-detect levels
- Analytical accuracy can be a challenge – interferences with Cl and Br and the ICP



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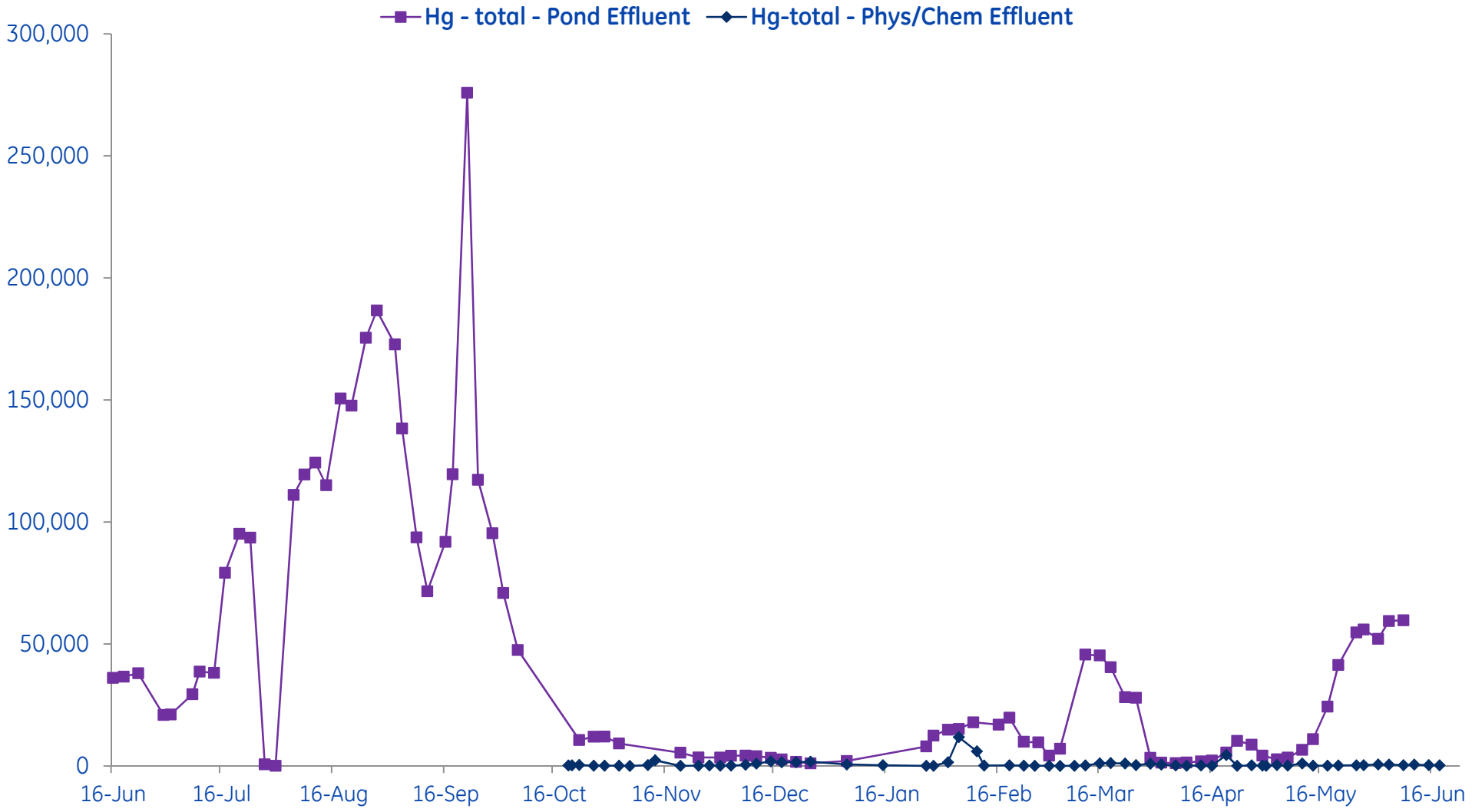
# Mercury Removal in Phys/Chem (ppt)



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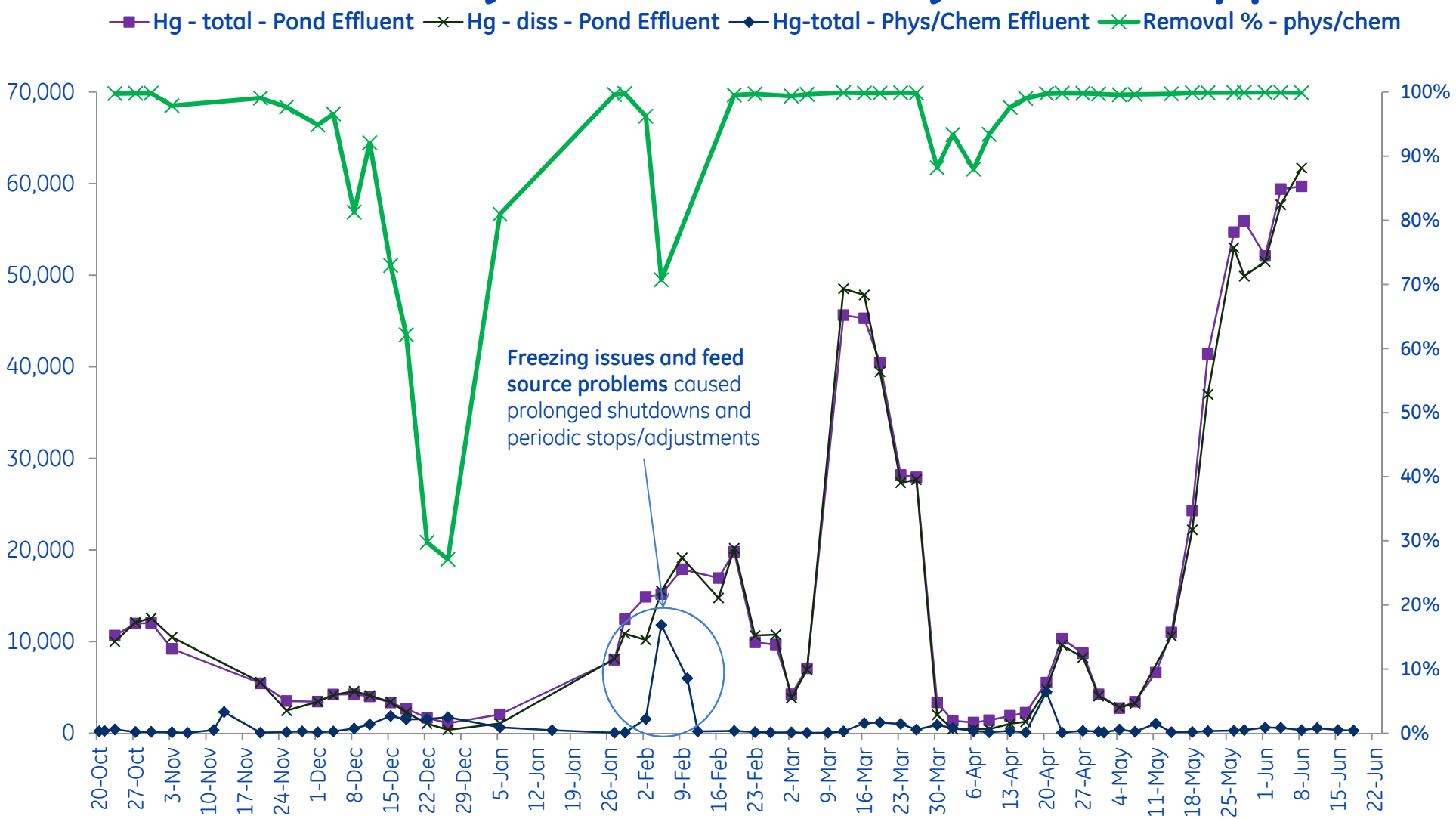
# Mercury Removal in Phys/Chem (ppt)




- Greater than 99.5% removal of dissolved mercury since April 16 in Phys/Chem



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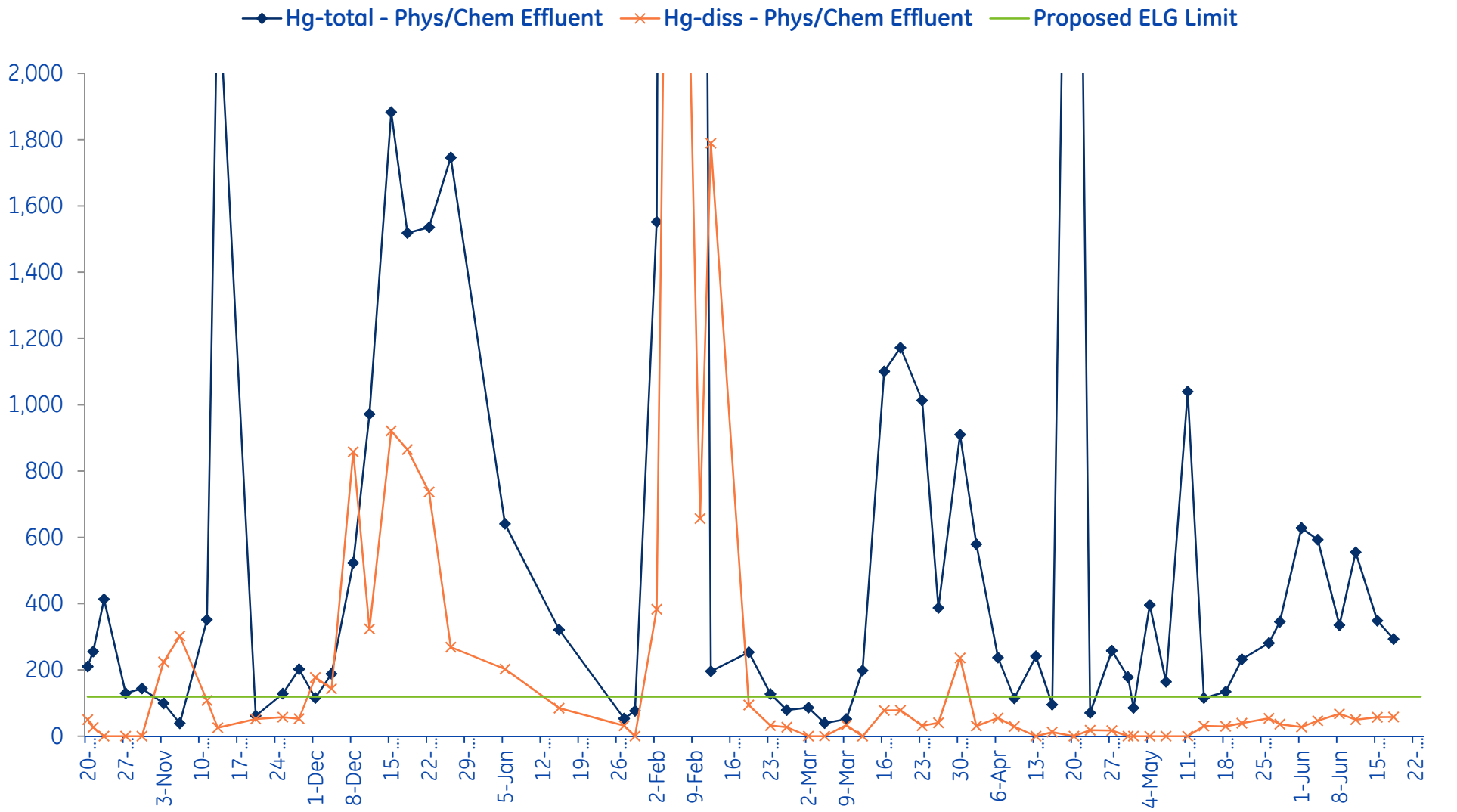
# Mercury Removal in Phys/Chem (ppt)




- MetClear reduces dissolved mercury to below the proposed ELG limits
- Ferric chloride dose optimization underway to improve particulate Hg removal



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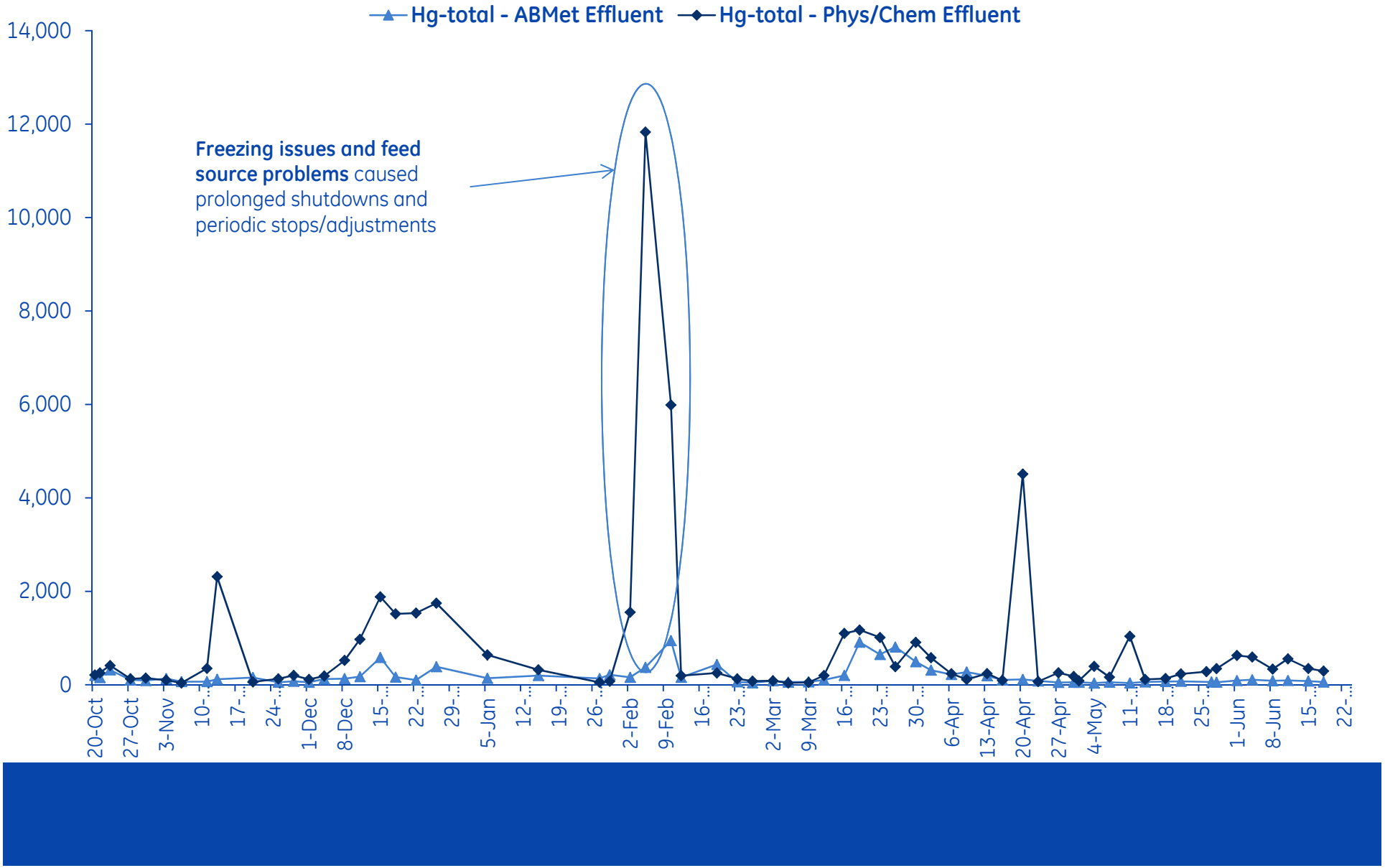
# Mercury Removal in ABMet (ppt)



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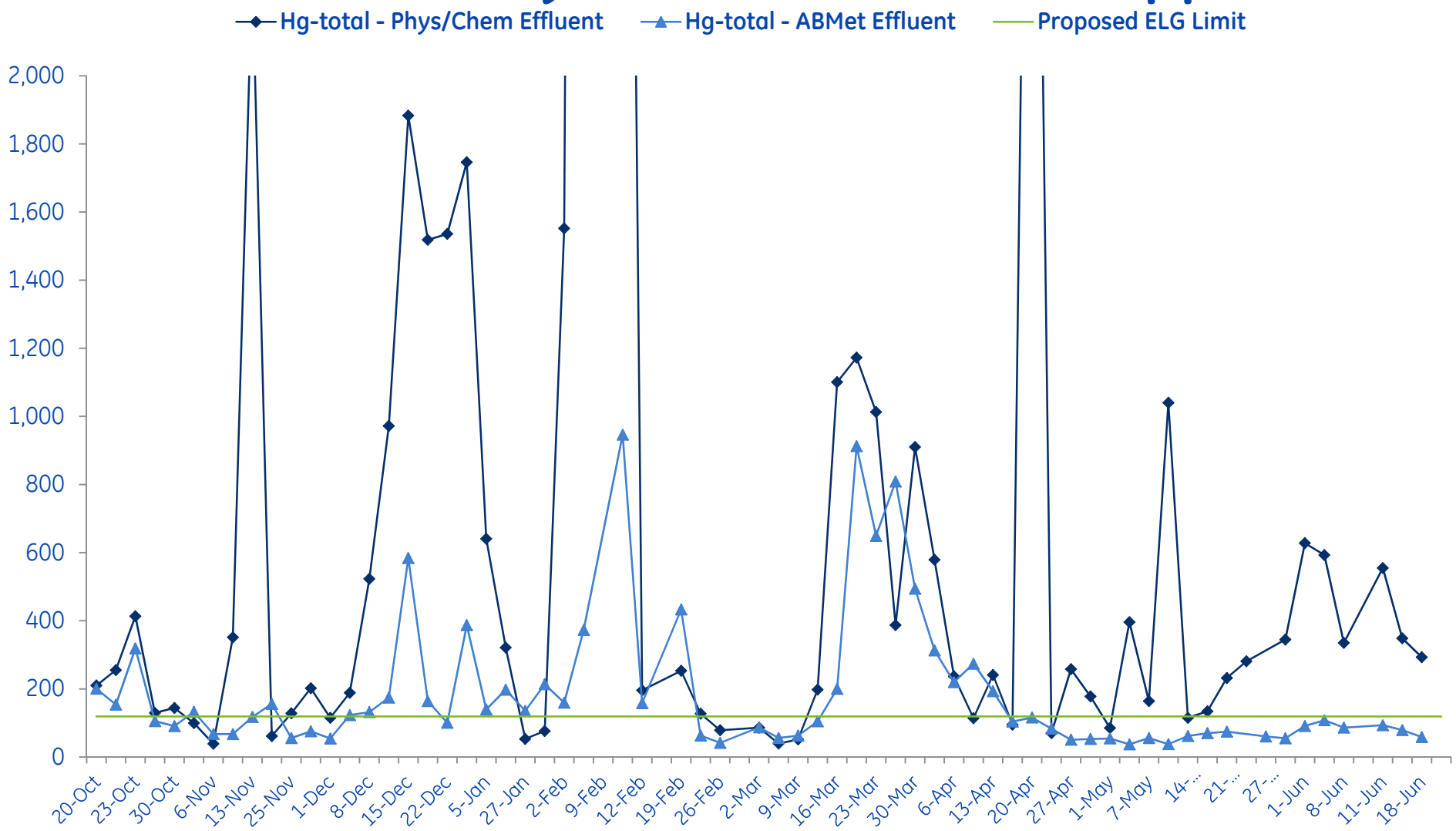
# Mercury Removal in ABMet (ppt)




- ABMet reduces dissolved mercury and filters out particulate mercury



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# Key Process Parameters to Optimize Biological Process

| | |
|---|---|
| ORP | • Reduce oxidant load in the feed → auto. feed ORP control loop with reducing chemical addition<br>• Optimize biological process for selenium reduction → auto. ORP control loop of bioreactor effluent ORP and nutrient addition |
| Oxidant | • Reduce oxidant load in the feed → manual titration and dosing adjustment of reducing chemical dosing and feed ORP control |
| pH | • optimize biological activity → auto. feed pH control loop with acid addition<br>• eliminate scaling potential → auto. feed pH control loop with acid addition |
| Alkalinity | • Maintain pH buffer through biological reactors → manual alkalinity measurement and alkali chemical addition |


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# Thank you

**Imagination at work.**