Continuous Improvement at Teck's West Line Creek Water Treatment Plant

MEND 2019 Presentation
December 5, 2019

Teck

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- West Line Creek
- Continuous Improvement
- Example: Minimize Selenite
- What is Next?
- Questions

Elk Valley Water Quality Plan

- The goal of the Elk Valley Water Quality Plan (EVWQP) is to protect the aquatic environment and human health by reducing selenium, nitrate, sulphate and calcite formation.

- The West Line Creek Water Treatment Plant is part of Teck's implementation plan to achieve water quality targets and permit limits.

West Line Creek
Water Treatment Plant

- Biological based treatment facility using Envirogen Fluid Bed Reactor Technology

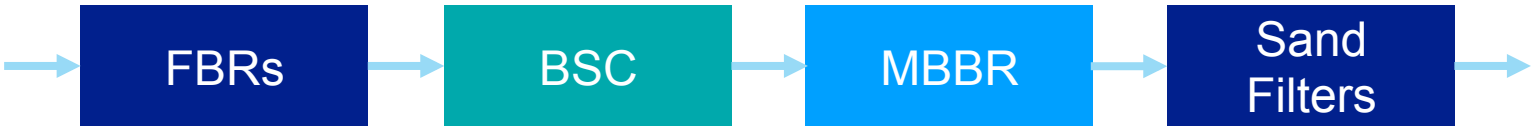
Designed for:

- 7500 m^3/d water treatment
- Nitrate Removal
- Selenium removal

Discharge Permit Requirements:

- Max discharge 8300 m^3/d
- Nitrate < 3 mg/L
- Selenium < 20 µg/L

Simplified Flowchart of Key Unit Operations (Initial Configuration)



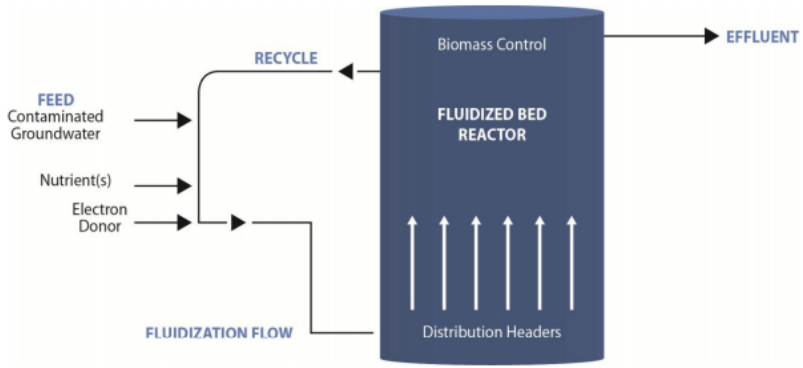
Initial Simplified West Line Creek Primary Flow Path

FBR = Fluid Bed Reactor

BSC = Ballasted Sand Clarifier

MBBR = Moving Bed Bioreactor

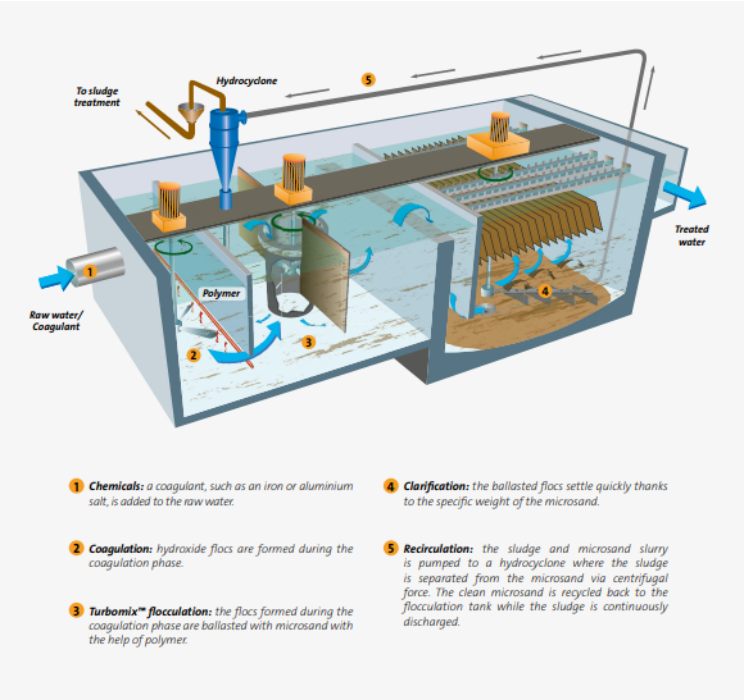
What is an FBR?



Taken from: Envirogen Technologies, 2011. Treatment of Selenium Containing Coal Mining Wastewater with Fluidized Bed Reactor Technology. An Envirogen Technologies Whitepaper: August 2011.

- West Line Creek uses Envirogen's Fluidized Bed Reactor technology
- A carbon source (electron donor) and nutrients are added to the feed water to promote biological reduction of nitrate and selenium
- The FBR contains media to provide growth sites for biology to attach to
- This media is fluidized by recycling a portion of treated water to maintain a target upflow velocity through the reactor

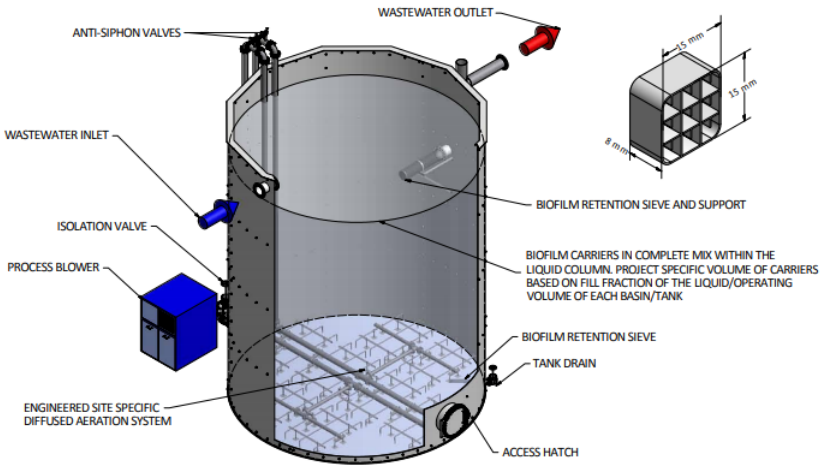
What is a BSC?



Taken from: Veolia Water Technologies, 2014. Actiflo: the Ultimate Clarifier, Veolia Actiflo Brochure: November 2014.

- A Ballasted Sand Clarifier (BSC) is used as the primary solid-liquid separation step at West Line Creek
- A BSC uses sand to help encourage flocs to settle quickly

What is an MBBR?



Taken from: H2Flow Product Brochure: H2Flow MBBR –Bioreactor Treatment of Coummunities and Industries. No date.

- A Moving Bed Bio Reactor (MBBR) is used to re-oxygenate the water and to remove excess BOD and/or ammonia
- MBBR uses plastic media carriers to provide a surface for biology to attach to

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- **Continuous Improvement**
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How is Continuous Improvement Different from Research and Development?

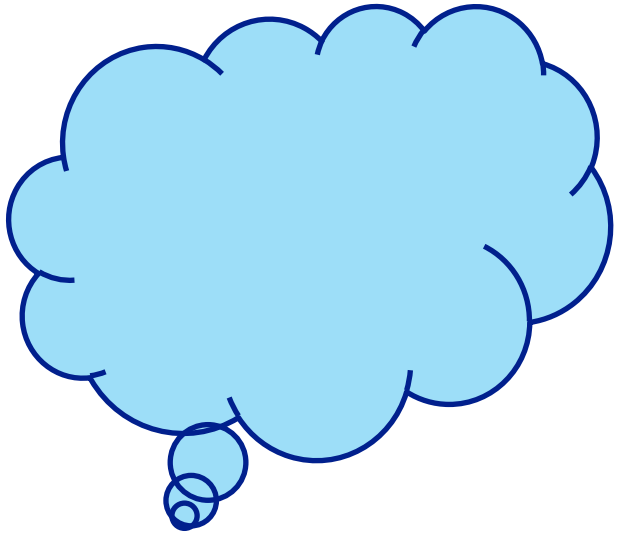
- **Continuous Improvement** projects in water operations focus on understanding and improving existing operations. They typically result in making a series of incremental changes to move towards a long term goal
  - Changes usually involve no change or minor change to existing operation manual
  - To lower risk, often prudent to test hypotheses at a smaller scale than main plant

- **Research and Development** projects focus on step changes in technology that have the potential to be a game changer:
  - Addition of advanced oxidation circuit to West Line Creek
  - Use of saturated rock fills for selenium and nitrate removal

Idea Generation

Ideas generated and selected from discussions with:

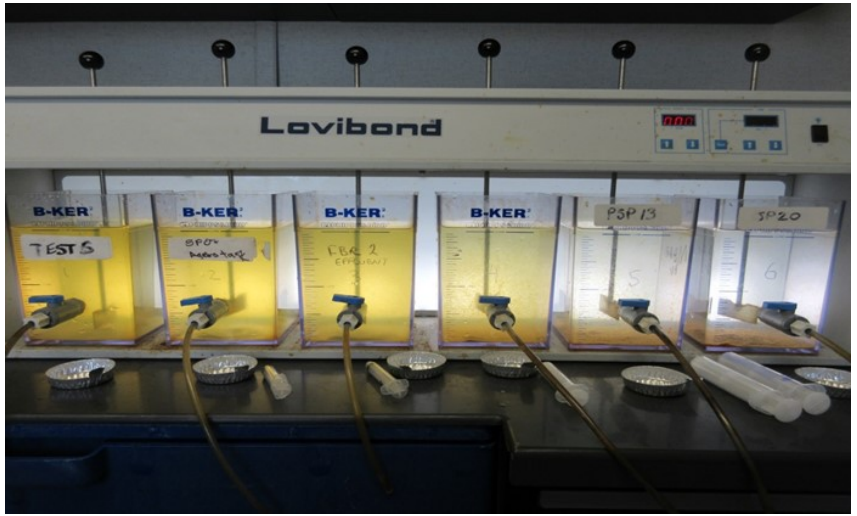
- Operating technicians
- Vendors
- Subject Matter Experts
- Water Operations leadership



Batch Bench Scale Provides Proof of Concept

Promising ideas are typically first tested in a batch mode on the bench

For every good idea, several ideas are ruled out at this stage



Mini Continuous Scale Minimizes Implementation Risk

Performed at low flowrates (typically on the order of ~1 L/min)

Only performed if risks identified that warrant further study prior to implementation full scale; can be particularly useful for biological unit operations which take a long time to reach steady state

Full Scale Plant Trial

Develop test plan and evaluate incrementally when possible

Successful changes incorporated into routine operations

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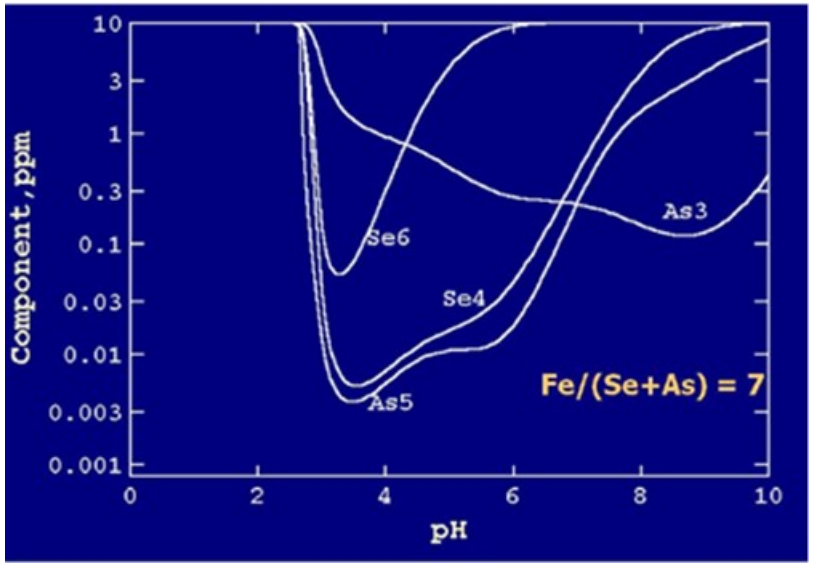
Opportunity to Lower Final Total Selenium: Removal of Selenite

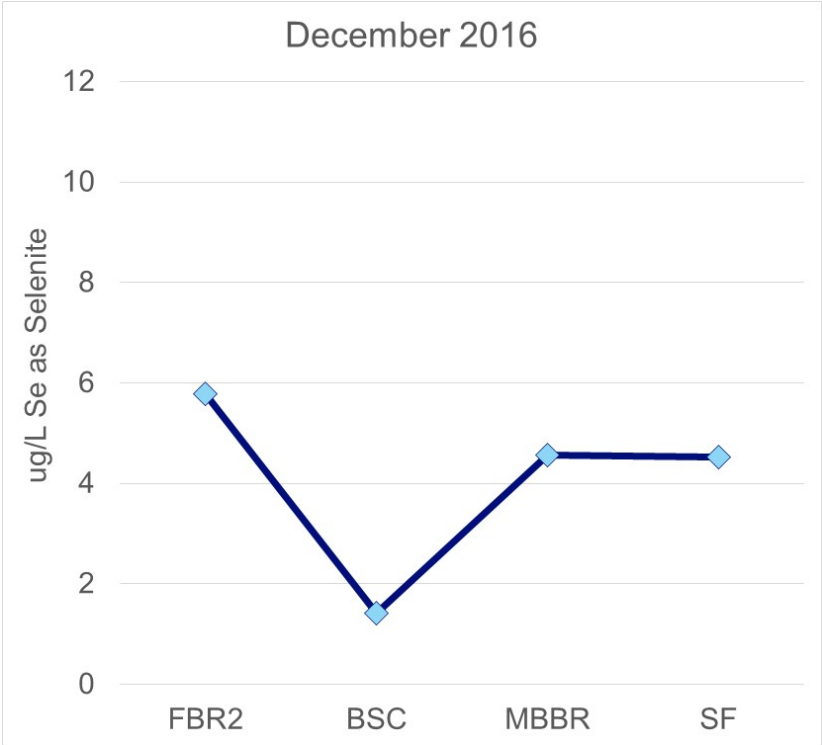
- Selenium Speciation surveys began at West Line Creek in October 2016
- Selenite (SeO_3^{-2}) identified in effluent
- Removal of selenite using iron oxy-hydroxides is well known
- Opportunity identified to lower final selenium by using ferric chloride to remove selenite



Twidwell, L.G., 2011. The Removal of Arsenic, Selenium and Metals from Aqueous Solution by Iron Precipitation and Reduction Techniques.

Selenite Distribution Across Unit Operations 2016: Identification of Opportunity

- BSC uses ferric chloride as coagulant
- Lowest selenite after BSC
- Selenite forms across MBBR
- Selenite stable in process post MBBR
- Opportunity to remove selenite after before sand filters?



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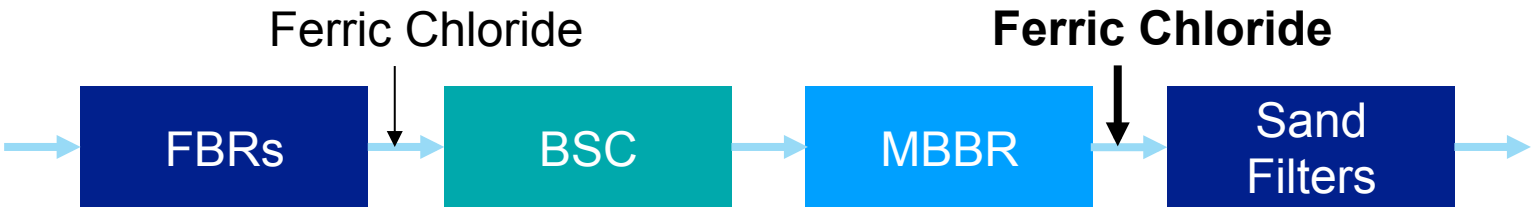
SF = Sand Filters

First Change: Add Ferric Chloride before Sand Filters



2017 Simplified West Line Creek Primary Flow Path

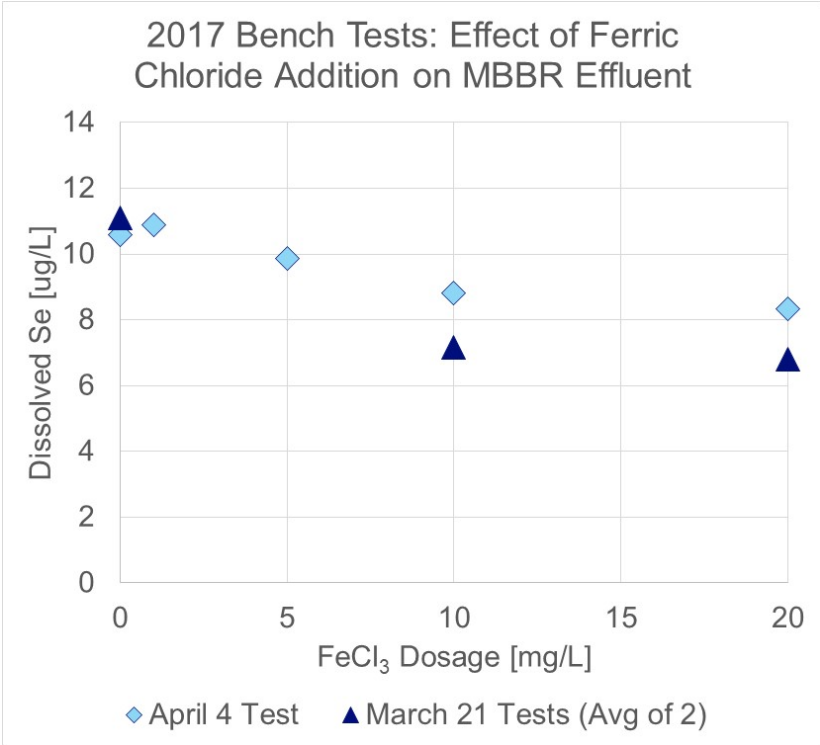
FBR = Fluid Bed Reactor

BSC = Ballasted Sand Clarifier

MBBR = Moving Bed Bioreactor

Batch Bench Work Provided Proof of Concept

- Jar tests performed on MBBR effluent showed ferric chloride addition could reduce dissolved selenium
- Speciation on second set of tests confirmed that this change was due to removal of selenite

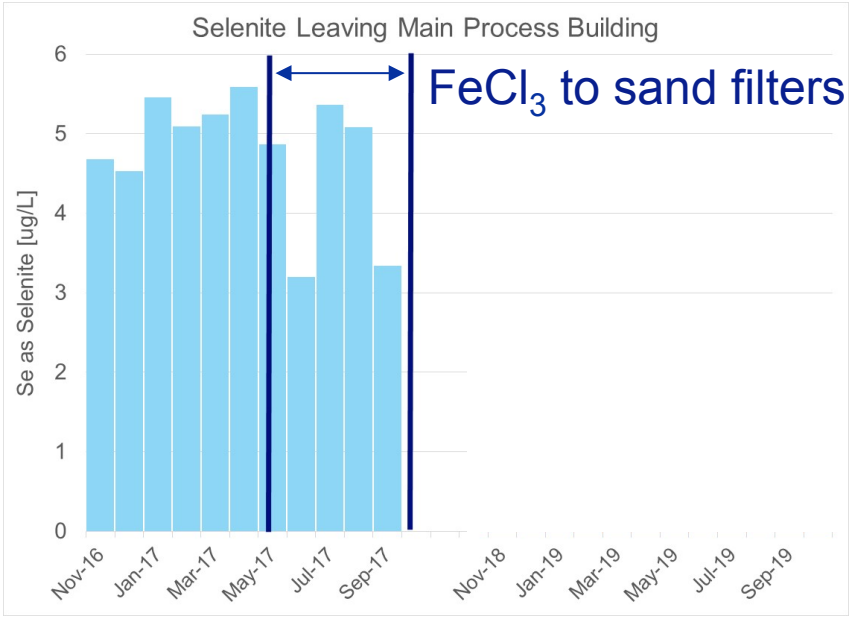


Monthly Average Selenite After Sand Filters Some Improvement with Ferric Addition

- Risk identified for full scale implementation was plugging of sand filter

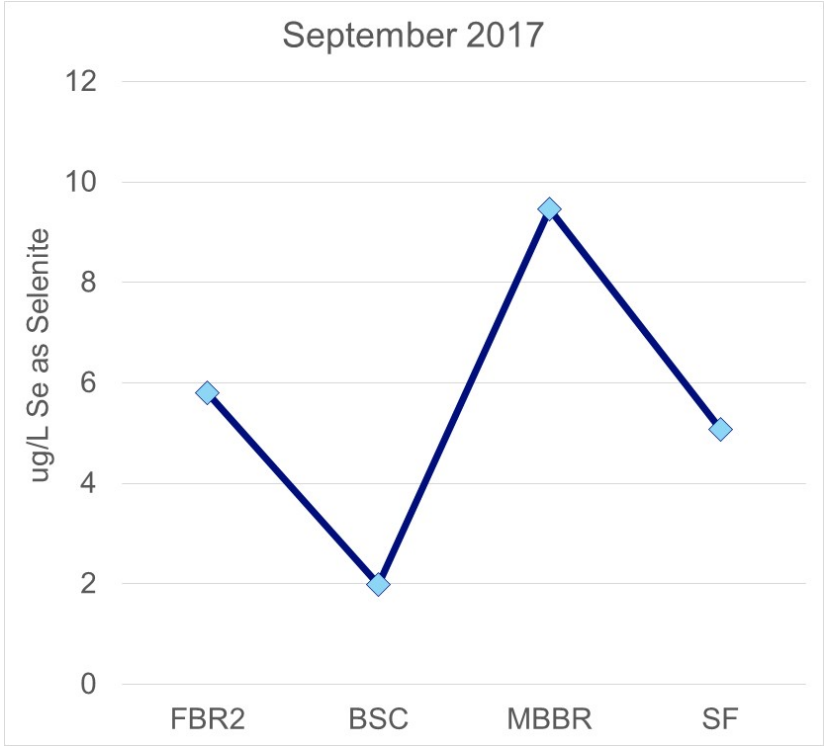
- Developed full scale testplan:

Gradual increases in ferric chloride from 1 mg/L to 15 mg/L to allow for monitoring of impact on pressure drop and sand movement in sand filters



Full Scale Implementation

- Results showed with ferric chloride addition before sand filters, selenite was removed, but final value not as low as after the BSC



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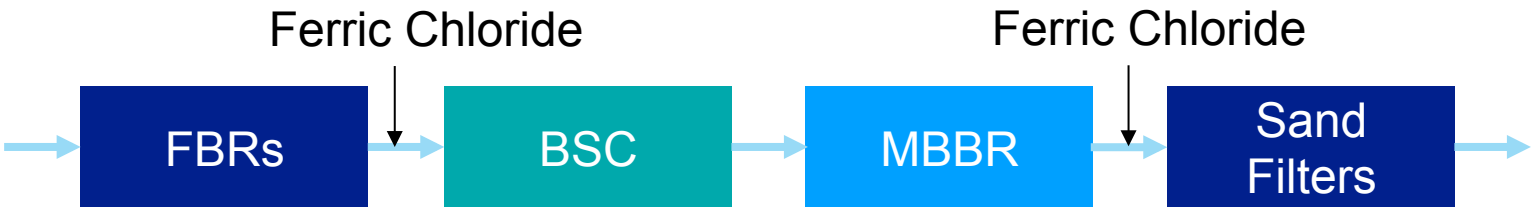

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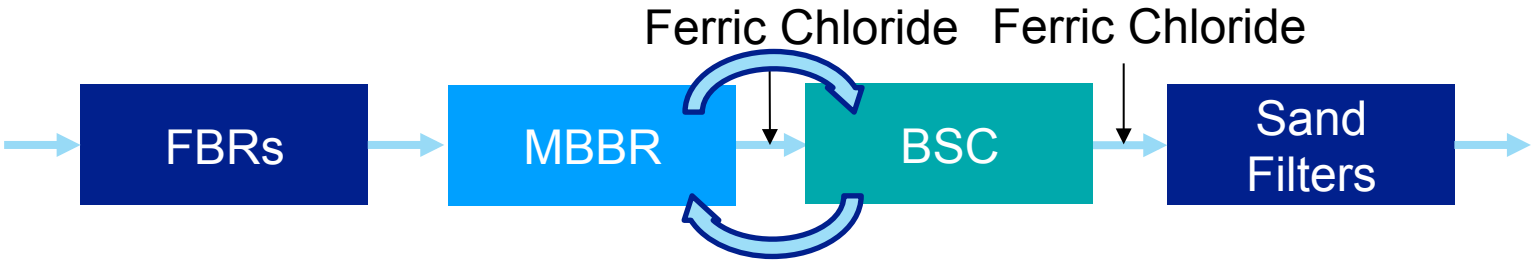
Second Change: Reverse MBBR and BSC



2018 Simplified West Line Creek Primary Flow Path

FBR = Fluid Bed Reactor

BSC = Ballasted Sand Clarifier

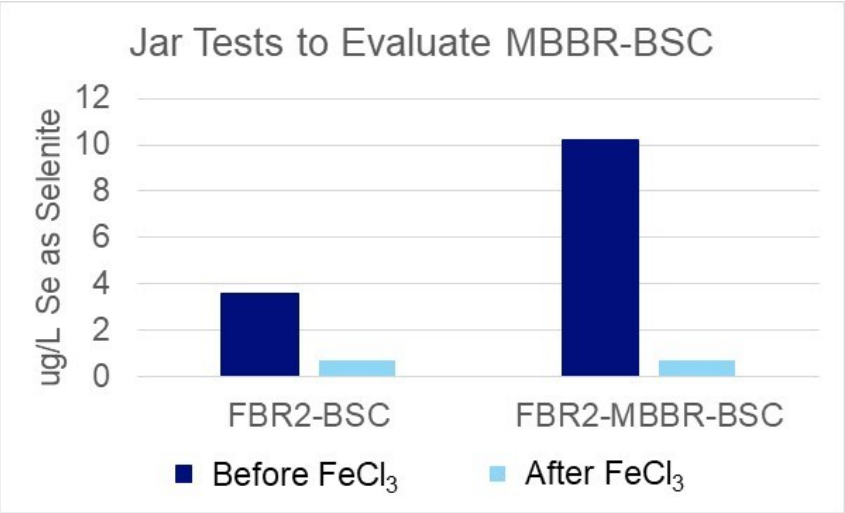
MBBR = Moving Bed Bioreactor

Batch Bench Work Provided Proof of Concept

- Under original configuration, most biomass is removed in BSC, prior to MBBR

Key Questions:

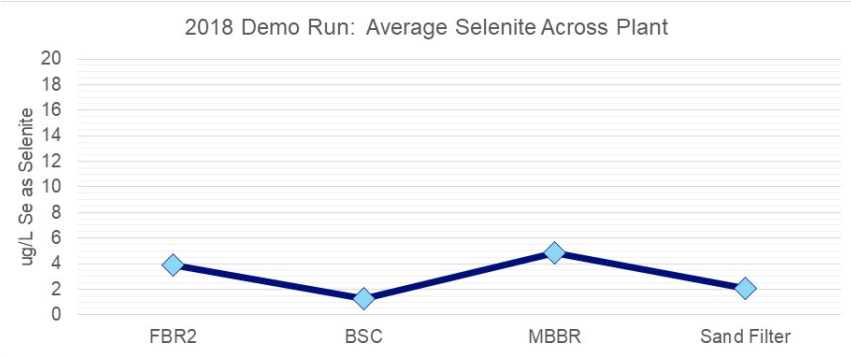
- Will increased biomass result in more selenite formation?
- If so, would 80 mg/L $FeCl_3$ be adequate to remove this additional biomass?

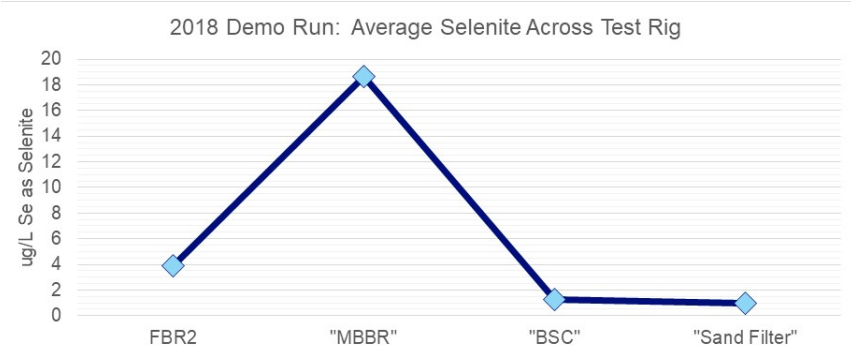


Mini Continuous Testing to Minimize Risk Associated with Increased Biomass to MBBR

- Six week demonstration trial to determine if increased biomass to test MBBR would result in higher final selenium at end of process

- Average results from demonstration run show slightly lower selenite at end of process, despite significant increase in selenite across test MBBR



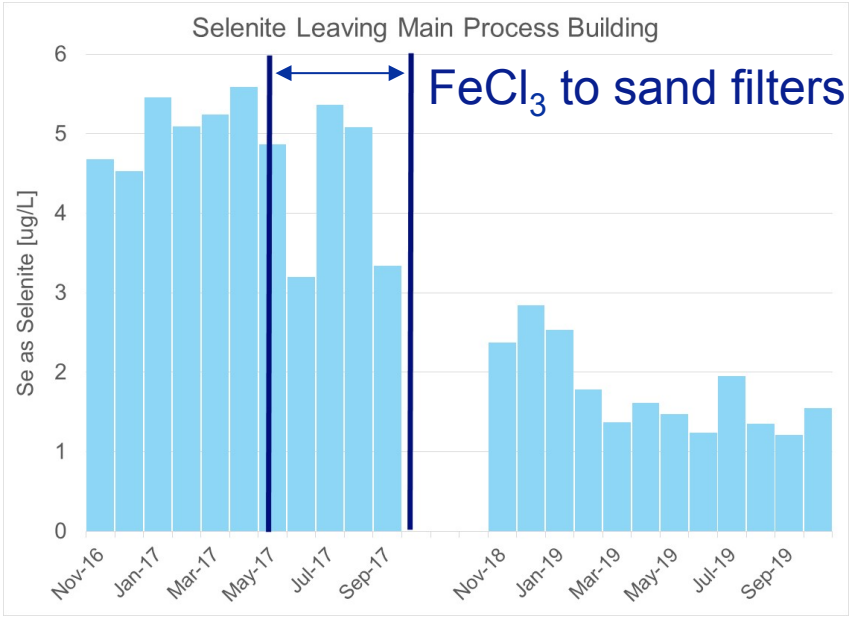


Full Scale Implementation Plan

- Full scale implementation required repiping between unit operations
- Unable to pipe with valves to switch between configurations: developed plan to allow for mechanical switch within 48 hours
- Implementation with 2018 plant restart with new AOP circuit

Results: Monthly Average Selenite After MBBR-BSC Flowsheet Modification

- Consistently lower selenite values leaving the main water treatment plant building since MBBR-BSC flowsheet modification
- Since modification, selenite leaving the main building are lower
- Lower selenite leaving main building results in lower selenium at outfall



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Current Continuous Improvement Initiative

Optimizing Fluid Bed Reactors to Maximize Selenium Removal

- Careful review of plant data trends to identify better operating modes
- Study underway with mini FBR skids to optimize carbon dosing strategy and evaluate impact of different carbon sources

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