



A Design & Build Active Treatment Plant for the Globe Mine High Strength Mine Drainage

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Globe Mine Location near Newell, WV

Globe (Clay) Mine Location
near Newell, WV



Globe Mine Site (Clay Mine)

Raw Water Characteristics

| Parameter | Units | Mine 1 | Mine 2 | Flow Weighted Average |
|------------------------|---------------------------|--------|--------|-----------------------|
| Flow, Average | gpm | 6.7 | 18.6 | 25.3 |
| pH | S.U | 4.5 | 3.5 | 3.6 |
| Acidity | mg/L as CaCO ₃ | 308 | 6,770 | 5,060 |
| Iron, Total | mg/L | 130 | 2,710 | 2,030 |
| Manganese, Total | mg/L | 5.0 | 45. | 34.4 |
| Aluminum, Total | mg/L | 7.0 | 245. | 162. |
| Sulfate | mg/L | 840 | 10,500 | 7,100 |
| Total Dissolved Solids | mg/L | 1,150 | 18,900 | 6,730 |
| Calcium, Total | mg/L | 83 | 218 | 163. |

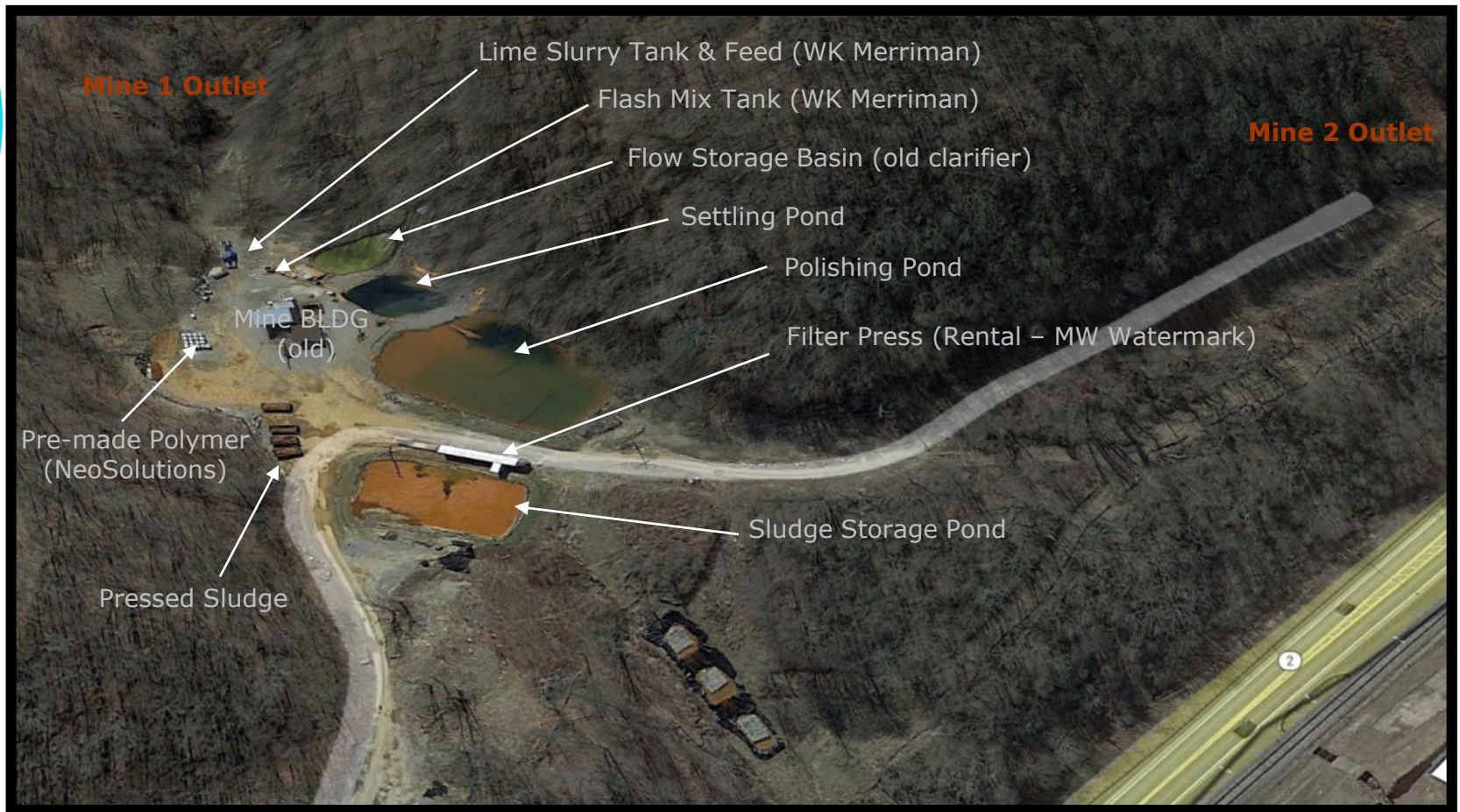
At Low Flow:

Acidity = 8,000 mg/L

Iron = 3,900 mg/L

Globe Mine Site

Temporary Treatment

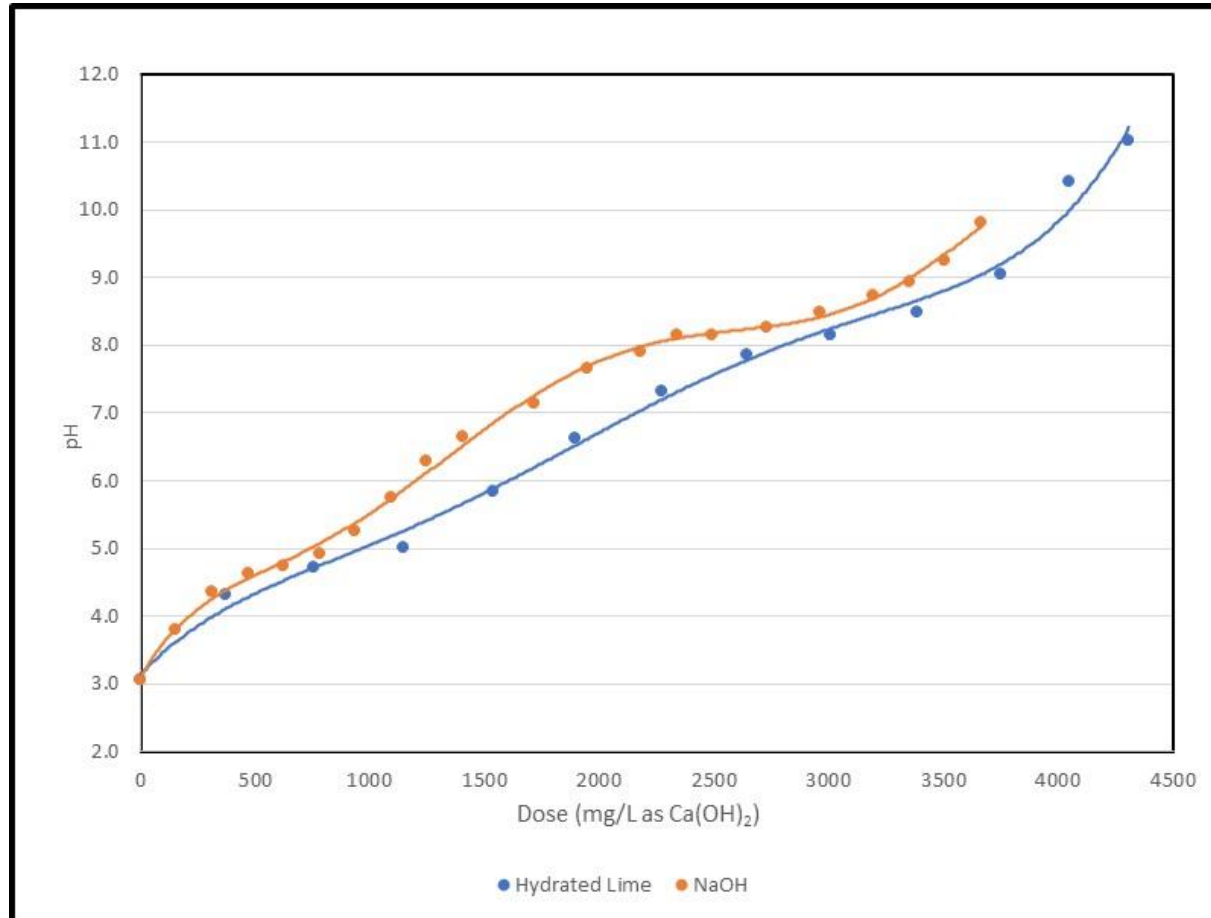




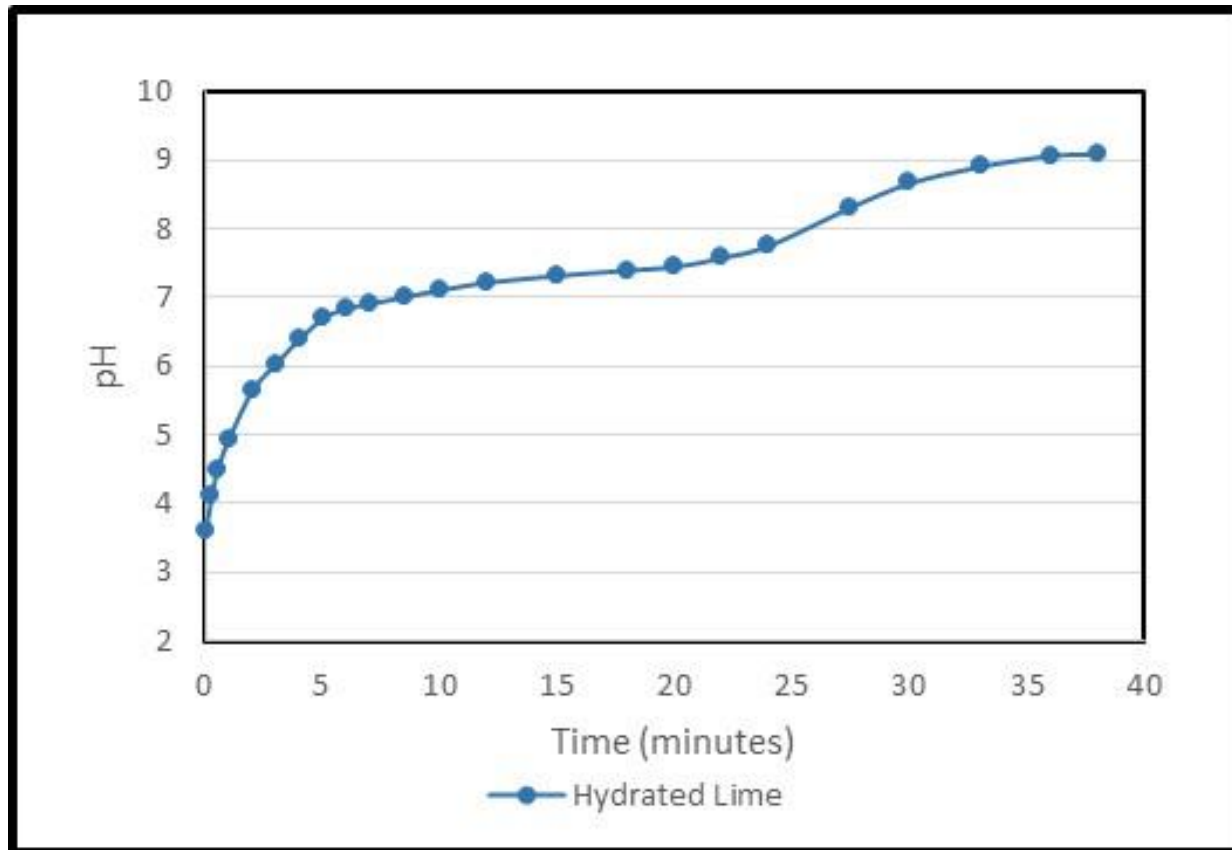
Globe Mine Site

Treatability Investigation

Neutralization Titration Evaluation

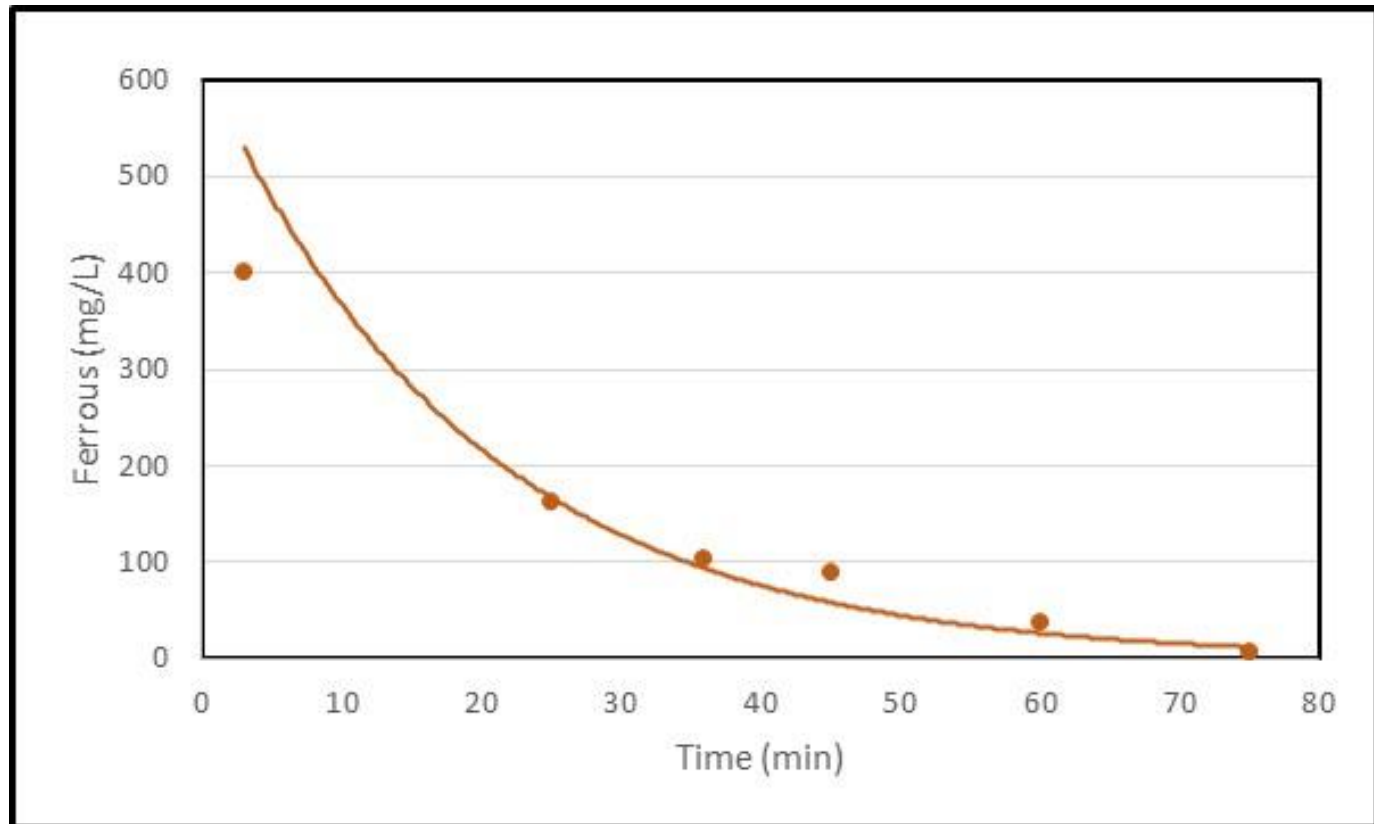


Lime Dissolution Kinetics



Ferrous Oxidation Kinetics

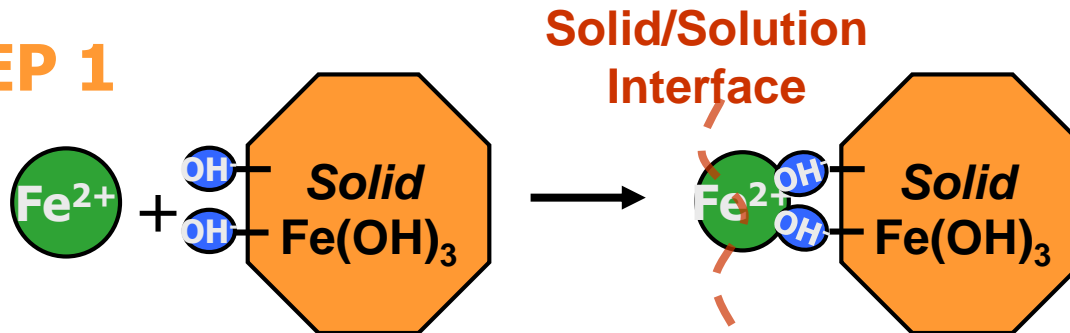
pH = 7.0 to 7.5



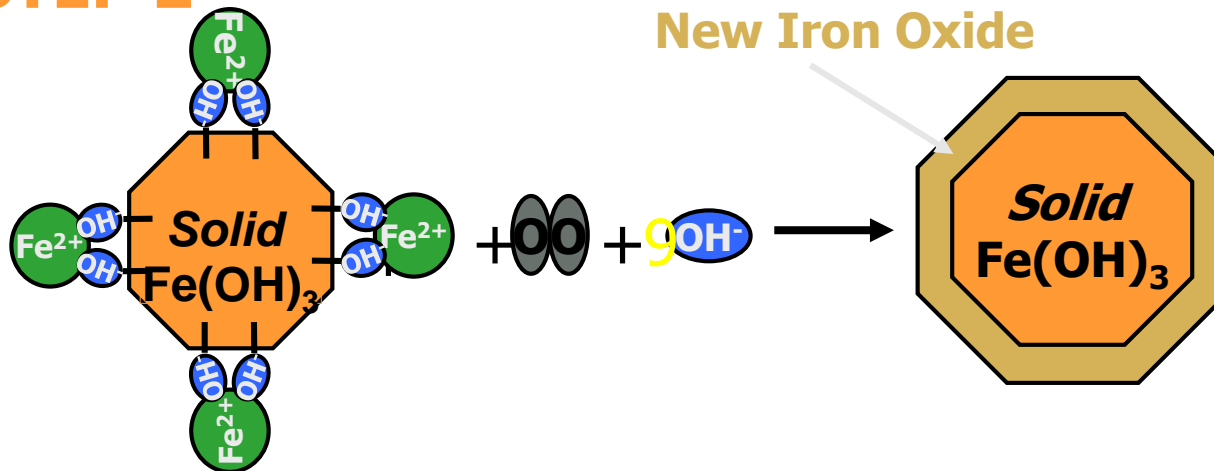
Heterogeneous Ferrous Iron Oxidation

Surface-based Oxidation & Precipitation

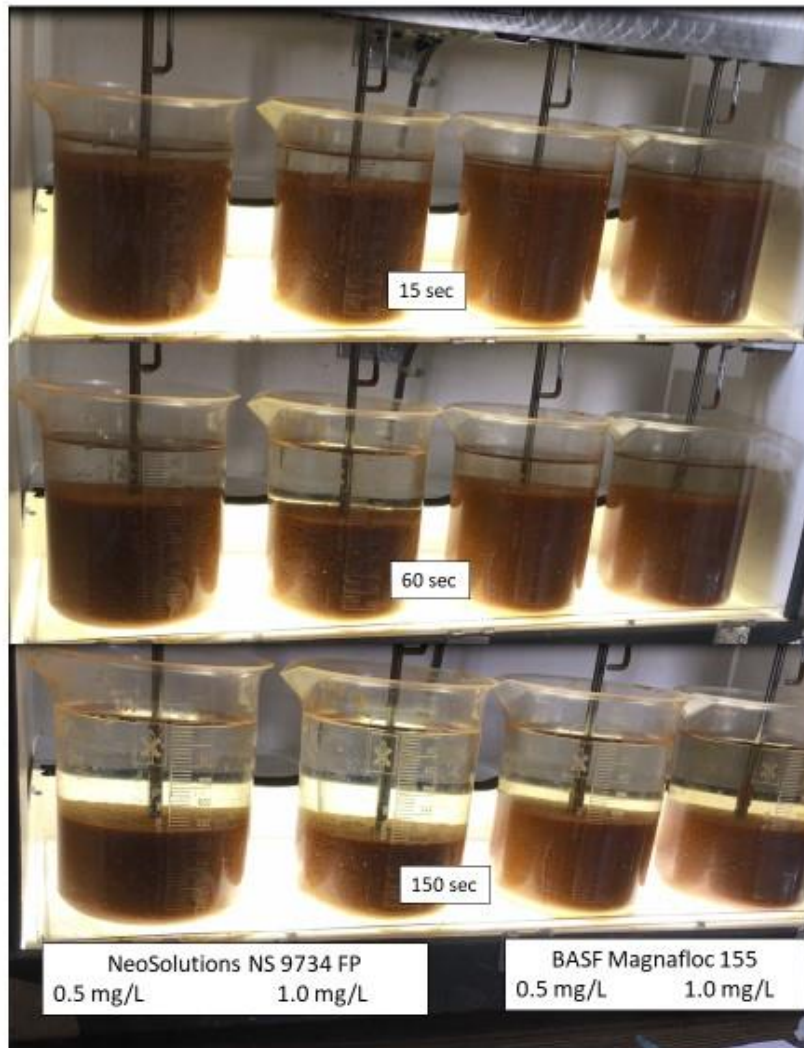
STEP 1



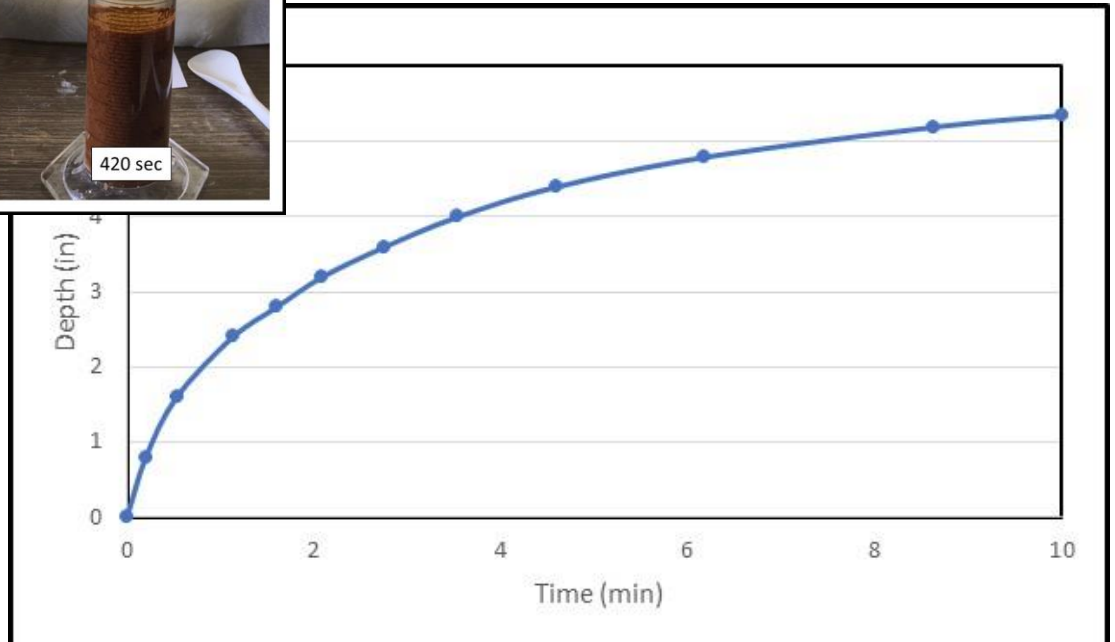
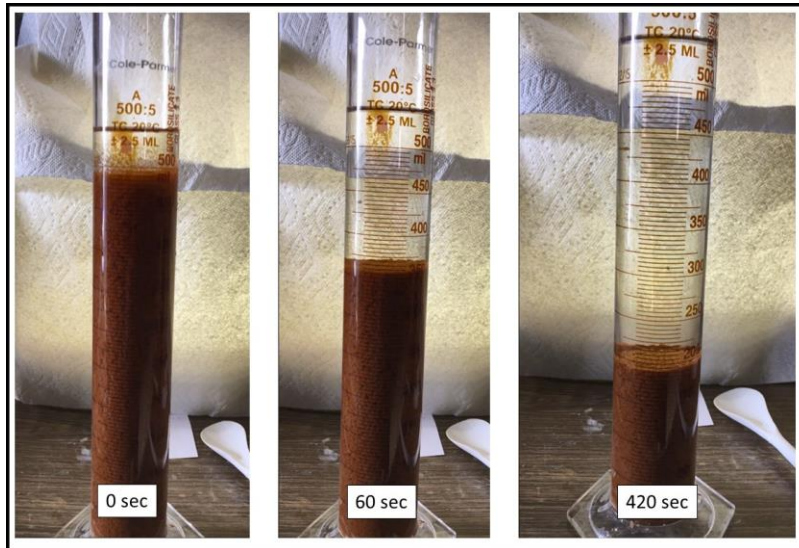
STEP 2



Polymer Testing



Solids Settling Tests



Solids Characteristics & Dewatering



NaOH Sludge
(No Oxidation)

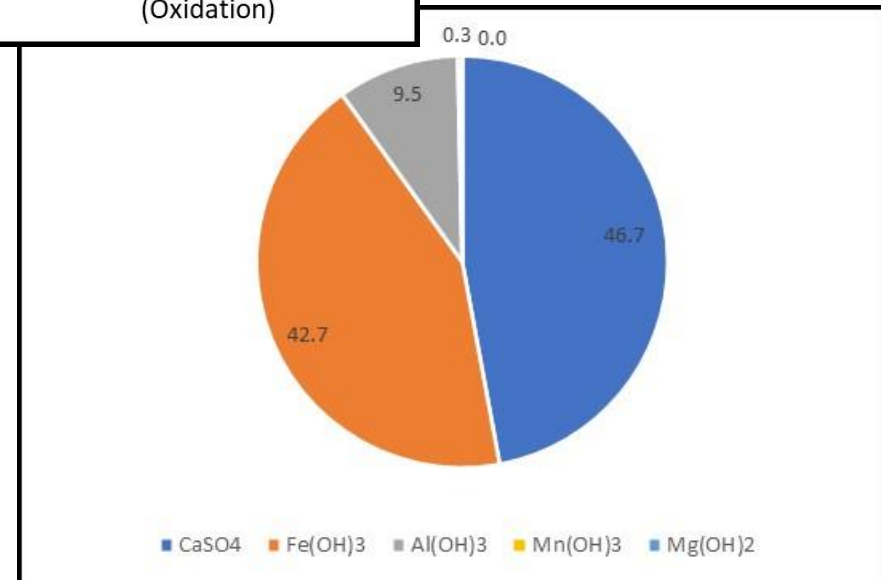


Lime Sludge
(No Oxidation)



Lime Sludge
(Oxidation)

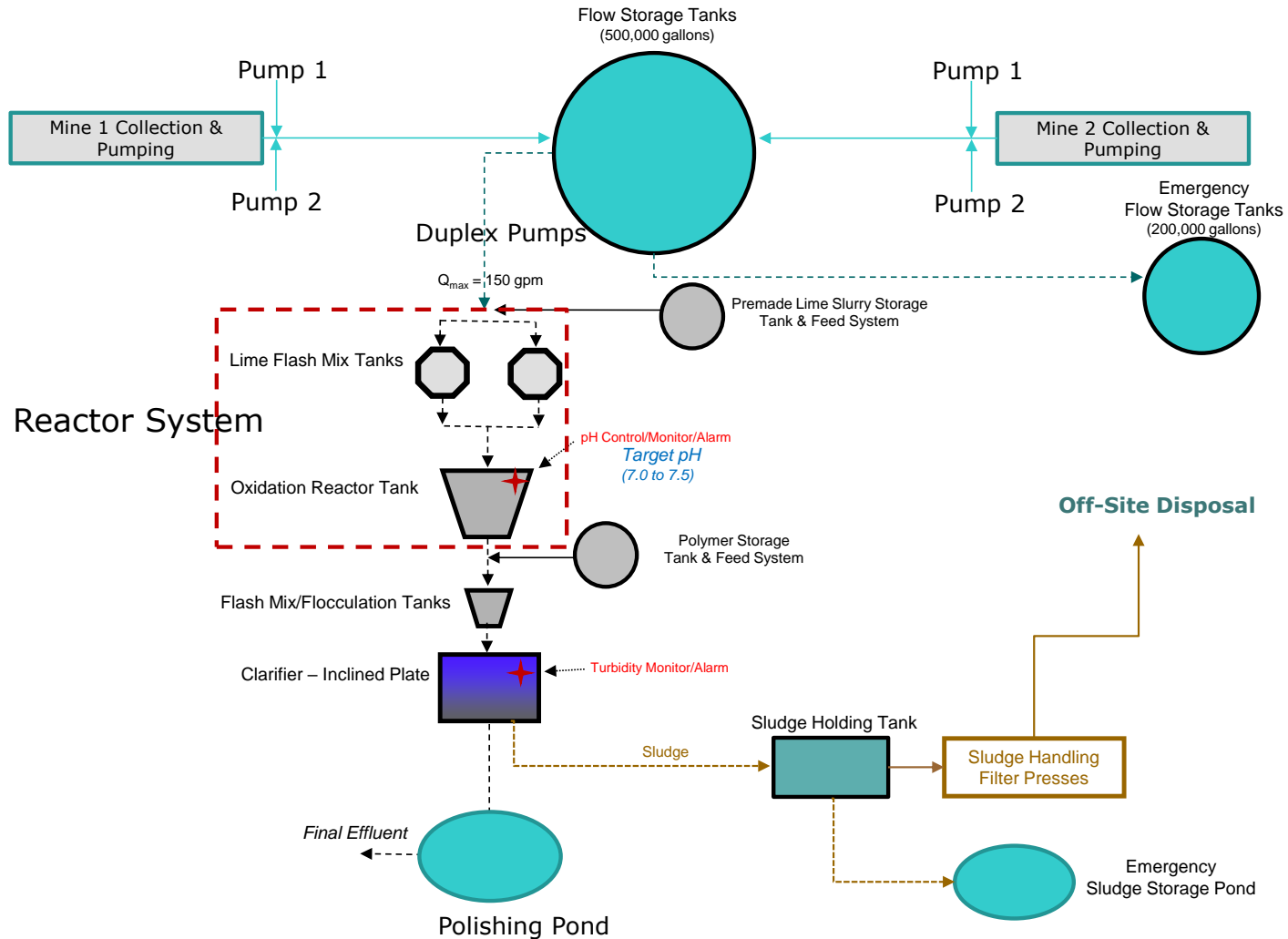
| Parameter | Units | Raw | TSS |
|-------------------|-------------|--------------|---------------|
| Iron | mg/L | 3,000 | 5,500 |
| Aluminum | mg/L | 250 | 750 |
| CaSO ₄ | mg/L | NA | 6,000 |
| TSS | mg/L | Total | 12,250 |



Globe Mine Site

New Treatment Plant

Globe Mine Site Process Flow Diagram



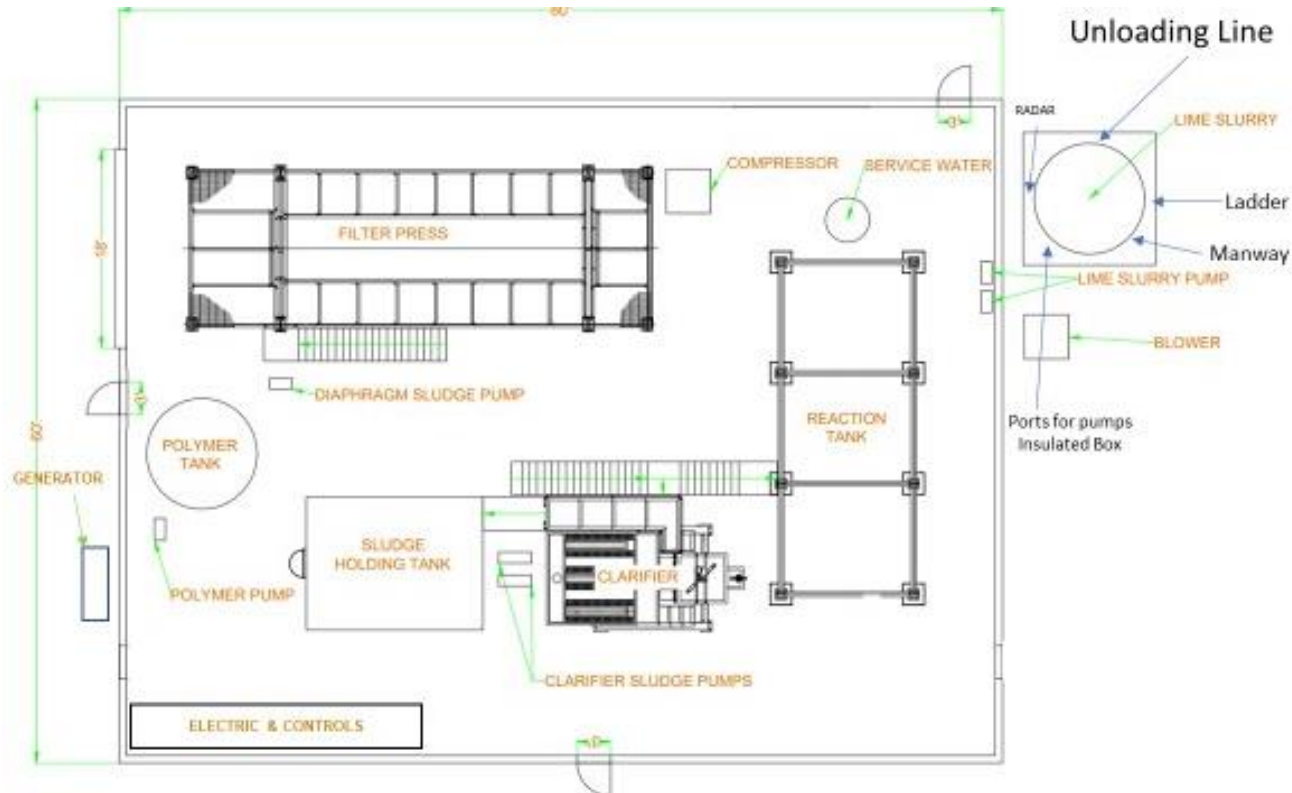
Globe Mine Site

Location & Plan View

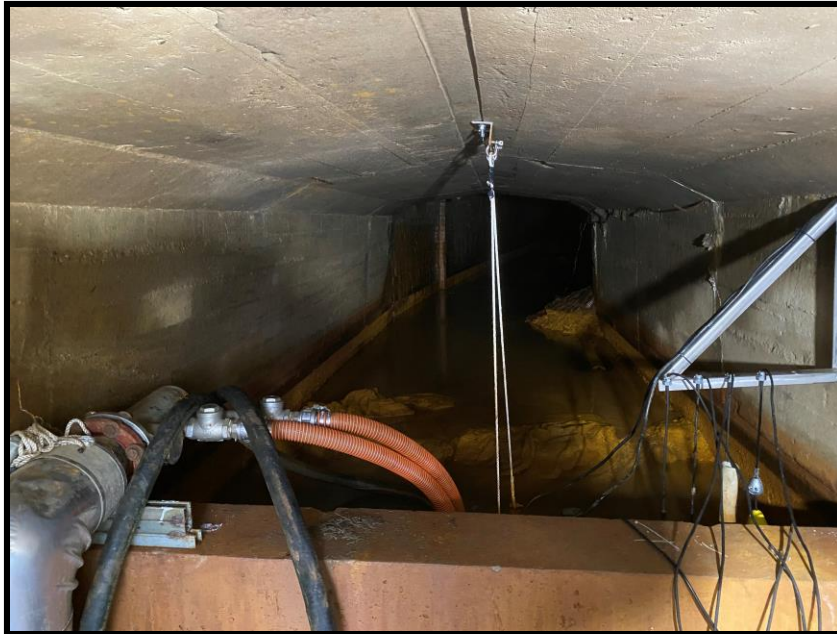


Globe Mine Site

Building & Treatment Plant Layout

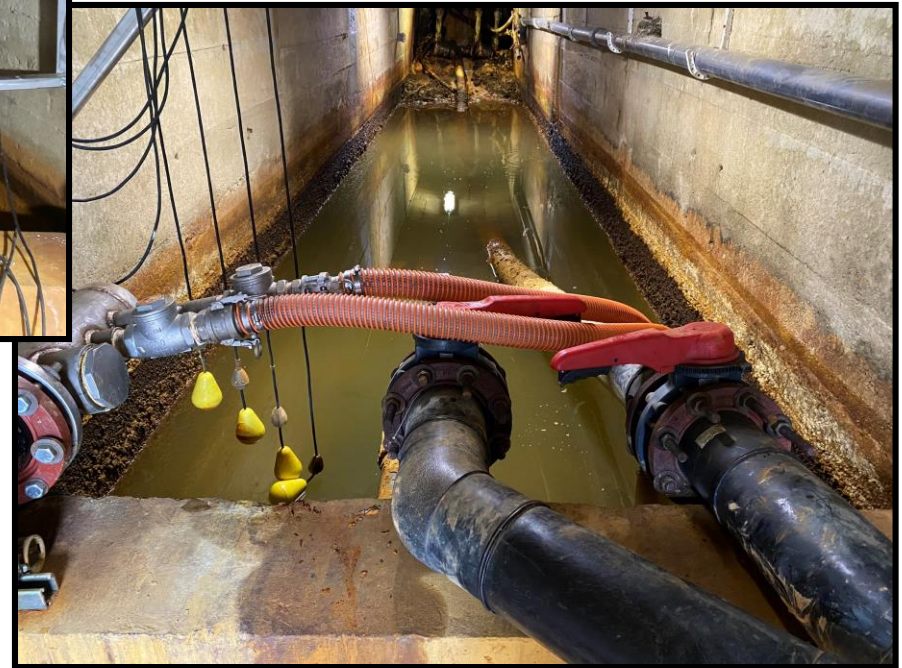


Mine Entry Pump Systems



Mines are gravity flow with water stored behind concrete walls near the entry

Duplex submersible SS pumps 1½ HP (~150 gpm) are operated by floats (also provide alarms)



Above Ground Storage Tank

Above Ground Storage Tank (500k gals)
stores pumped mine water to allow
flexibility of
operation & maintenance
(AST level monitored)



Duplex submersible SS 1½ & ¾
HP pumps (50-150 gpm) deliver
flow to treatment system

Lime Slurry Storage Tank & Feed System

WK Merriman, Inc.



Lime Slurry System Consists of:

1. Insulated & Heated Storage Tank
2. Level Monitoring
3. Mixer to Suspend Lime Slurry
4. Offloading Equipment
5. Duplex Hose Pumps (Manual or pH Controlled)



Reactor Tank System

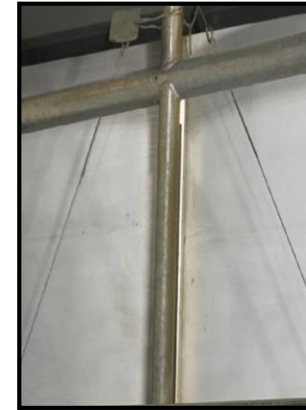
Purestream, Inc. (Kentucky)

Reactor Tank System Consists of:

1. SS Inlet Flow Control Box
2. Lime Flash Mix Tanks (2 – only one operating)
3. Oxidation Reactor with Mixers and Diffused Air
4. PD Blower to Deliver Air
5. Outlet Trough



pH Monitoring & Control



Blower Unit



Flocculation & Clarifier System

WESCO, Inc.

Clarifier System Consists of:

1. Polymer Flash Mix Tank
2. Flocculation Mix Tank
3. Inclined Plate (Lamella) Clarifier
4. SS Plates and Troughs

Turbidity
Monitoring



Polymer (Pre-Made) Storage & Feed System



Polymer System Consists of:

1. 6,000 gal Storage Tank
2. Watson Marlow Qdos Pump
(2 operating/backup)
1. Stores & Delivers Premade Polymer
 1. Neolutions 9734 Premade Polymer

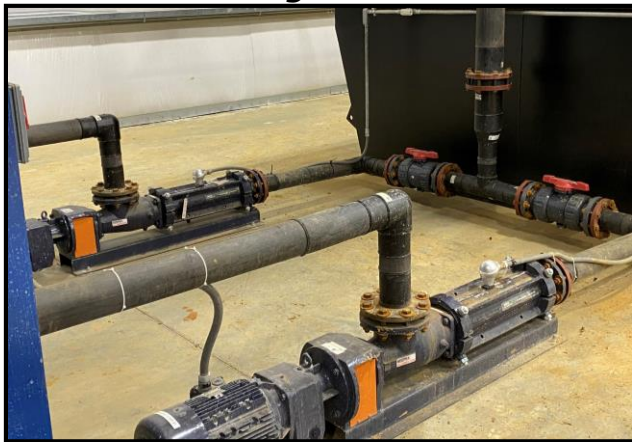
Sludge Pumps & Storage Tank

Sludge Storage Tank

Mixers provide Uniform Sludge

Progressive Cavity Sludge Pumps (2)

Pump Sludge from Clarifier to Storage Tanks



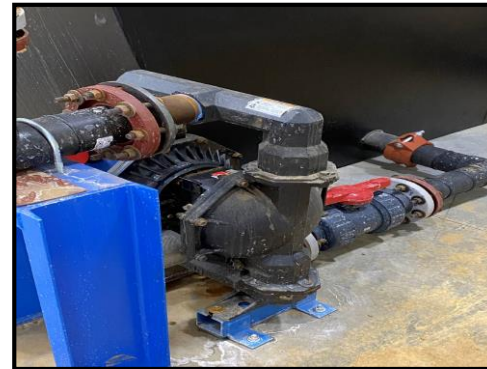
Sludge Filter Press System

M.W. Watermark, LLC

Plate & Frame
(65 CF) Filter Press



Diaphragm Pump



Screw Compressor
With Dryer

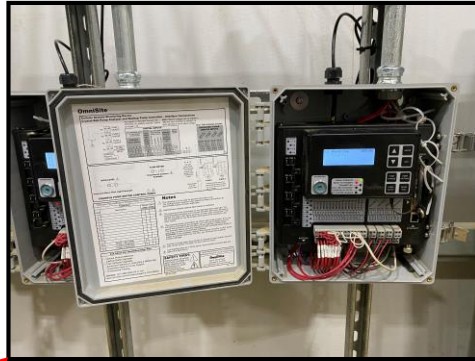


Control & Monitoring Systems

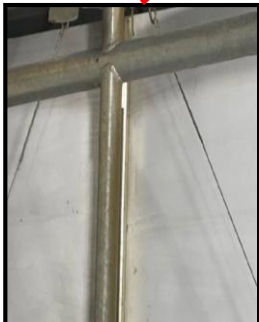
Cellular-Based Internet System

Omnisite(s)
for System Monitoring & Alarms

Control Panel
for System Components



pH & Turbidity



Tank Levels

1. AST
2. Lime
3. Sludge



GuardDog NEW OmniAdvantage Plan Jonathan Dietz Sat - 5/7/22 5:00 AM EDT

Device Status **Globe Levels (37521)**

Auto Refresh Normal Alarm Unacknowledged Alarm

| Input | Description | Condition | State Changes | Last Change | Options |
|-------|---------------------|-----------|---------------|-----------------------|---------|
| 1 | Blower | In Alarm | 18 | Thu - 5/12/22 3:07 PM | ⌵ |
| 2 | Sludge Tank Mixer 1 | In Alarm | 21 | Thu - 5/12/22 3:07 PM | ⌵ |
| 3 | Sludge Tank Mixer 2 | In Alarm | 21 | Thu - 5/12/22 3:07 PM | ⌵ |
| 4 | Reactor Flash Mixer | In Alarm | 19 | Thu - 5/12/22 3:07 PM | ⌵ |
| 5 | Reactor Flox Mixer | In Alarm | 19 | Thu - 5/12/22 3:07 PM | ⌵ |
| 6 | Sludge Pump 1 | In Alarm | 19 | Thu - 5/12/22 3:07 PM | ⌵ |
| 7 | Sludge Pump 2 | In Alarm | 19 | Thu - 5/12/22 3:07 PM | ⌵ |
| 8 | Reactor Feed Pump | In Alarm | 17 | Thu - 5/12/22 3:07 PM | ⌵ |

| Input | Description | Pump Failure | State Changes | Last Change | Excursion Routine | State Changes | Last Change | Insufficient Routine | State Changes | Last Change | Options |
|-------|--------------------|--------------|---------------|-------------|-------------------|---------------|-------------|----------------------|---------------|-------------|---------|
| 12 | Mixer 1 Pump 1 | Normal | 0 | NA | Unused | 0 | NA | Unused | 0 | NA | ⌵ |
| 13 | Mixer 2 Pump 2 | Normal | 0 | NA | Unused | 0 | NA | Unused | 0 | NA | ⌵ |
| 14 | Mixer 2 High Alarm | Normal | 0 | NA | Unused | 0 | NA | Unused | 0 | NA | ⌵ |

| Description | Value | Condition | State Changes | Last Change | Options |
|---------------------|------------------------------|-----------|---------------|------------------------|---------|
| Pressure Sensor | Present | Normal | 4 | Wed - 5/12/22 4:39 PM | ⌵ |
| Battery Status | 12.25 Volts | Normal | 1 | Mon - 4/26/22 11:13 AM | ⌵ |
| Signal Strength | -75 dB | Normal | 2 | Tue - 4/26/22 10:42 AM | ⌵ |
| Maintenance Key | Enabled | Normal | 2 | Tue - 4/26/22 6:07 PM | ⌵ |
| Communication Check | Last Report: 5/12/22 1:02 PM | Normal | 0 | NA | ⌵ |

| Input | Description | Value | Condition | State Changes | Last Change | Options |
|-------|-------------------|----------------|-----------|---------------|------------------------|---------|
| 1 | Sludge Level | 4,300.00 gal | Normal | 26 | Sat - 4/30/22 12:41 AM | ⌵ |
| 2 | Line Slurry Level | 8,471.75 gal | Normal | 8 | Fri - 5/12/22 1:10 PM | ⌵ |
| 3 | ADT Level | 275,000.00 gal | Normal | 4 | Thu - 5/12/22 1:28 PM | ⌵ |

| Output | Description | Control | State Changes | Last Change | Options |
|--------|-------------|---------------|---------------|-----------------------|---------|
| 1 | Output 1 | Automatic | 1 | Tue - 4/26/22 9:23 PM | ⌵ |
| 2 | Output 2 | Automatic | 27 | Wed - 4/26/22 4:58 PM | ⌵ |
| 3 | Output 3 | In Hand - OFF | 2 | Thu - 4/26/22 4:23 PM | ⌵ |
| 4 | Output 4 | In Hand - OFF | 1 | Tue - 4/26/22 9:23 PM | ⌵ |

GuardDog NEW OmniAdvantage Plan Jonathan Dietz Sat - 5/7/22 5:00 AM EDT

Device Status **Globe Treatment (37522)**

Auto Refresh Normal Alarm Unacknowledged Alarm

| Input | Description | Condition | State Changes | Last Change | Options |
|-------|--------------------------|-----------|---------------|------------------------|---------|
| 1 | Raw Feed Pump 1 | In Alarm | 9 | Thu - 5/12/22 3:18 AM | ⌵ |
| 2 | Raw Feed Pump 2 | In Alarm | 2 | Tue - 4/26/22 3:03 AM | ⌵ |
| 3 | Line Slurry Mixer | Normal | 2 | Fri - 4/26/22 10:27 AM | ⌵ |
| 4 | Line Pump 1 | In Alarm | 6 | Thu - 5/12/22 3:09 PM | ⌵ |
| 5 | Line Pump 2 | In Alarm | 27 | Wed - 4/26/22 10:27 AM | ⌵ |
| 6 | Reactor Flash Mixer 1 | In Alarm | 7 | Thu - 4/26/22 3:07 PM | ⌵ |
| 7 | Reactor Flash Mixer 2 | In Alarm | 3 | Thu - 5/12/22 11:26 AM | ⌵ |
| 8 | Reactor Aeration Mixer 1 | In Alarm | 7 | Thu - 5/12/22 3:07 PM | ⌵ |
| 9 | Reactor Flash Mixer 2 | In Alarm | 7 | Thu - 5/12/22 3:07 PM | ⌵ |

| Input | Description | Pump Failure | State Changes | Last Change | Excursion Routine | State Changes | Last Change | Insufficient Routine | State Changes | Last Change | Options |
|-------|--------------------|--------------|---------------|-------------|-------------------|---------------|-------------|----------------------|---------------|-------------|---------|
| 12 | Mixer 1 Pump 1 | Normal | 0 | NA | Unused | 0 | NA | Unused | 0 | NA | ⌵ |
| 13 | Mixer 1 Pump 2 | Normal | 0 | NA | Unused | 0 | NA | Unused | 0 | NA | ⌵ |
| 14 | Mixer 1 High Alarm | Normal | 0 | NA | Unused | 0 | NA | Unused | 0 | NA | ⌵ |

| Description | Value | Condition | State Changes | Last Change | Options |
|---------------------|------------------------------|-----------|---------------|-----------------------|---------|
| Pressure Sensor | Present | Normal | 1 | NA | ⌵ |
| Battery Status | 13.25 Volts | Normal | 1 | Tue - 4/26/22 3:03 AM | ⌵ |
| Signal Strength | -74 dB | Normal | 0 | NA | ⌵ |
| Maintenance Key | Enabled | Normal | 0 | NA | ⌵ |
| Communication Check | Last Report: 5/12/22 1:02 PM | Normal | 0 | NA | ⌵ |

| Input | Description | Value | Condition | State Changes | Last Change | Options |
|-------|---------------------|----------|------------|---------------|-----------------------|---------|
| 1 | Reactor pH | 5.99 pH | Normal | 0 | NA | ⌵ |
| 2 | Clarifier Turbidity | 1.68 NTU | Normal | 0 | NA | ⌵ |
| 3 | Line Pump 1 | 0.00 GPM | In Alarm | 7 | Thu - 5/12/22 3:07 PM | ⌵ |
| 4 | Line Pump 2 | NA | Line Alarm | 1 | Wed - 4/26/22 7:13 PM | ⌵ |

| Output | Description | Control | State Changes | Last Change | Options |
|--------|-------------|---------------|---------------|-----------------------|---------|
| 1 | Output 1 | Automatic | 1 | Tue - 4/26/22 9:23 PM | ⌵ |
| 2 | Output 2 | Automatic | 2 | Wed - 4/26/22 3:30 PM | ⌵ |
| 3 | Output 3 | In Hand - OFF | 1 | Tue - 4/26/22 9:23 PM | ⌵ |
| 4 | Output 4 | In Hand - OFF | 1 | Tue - 4/26/22 9:23 PM | ⌵ |

Backup Power Supply (Propane)

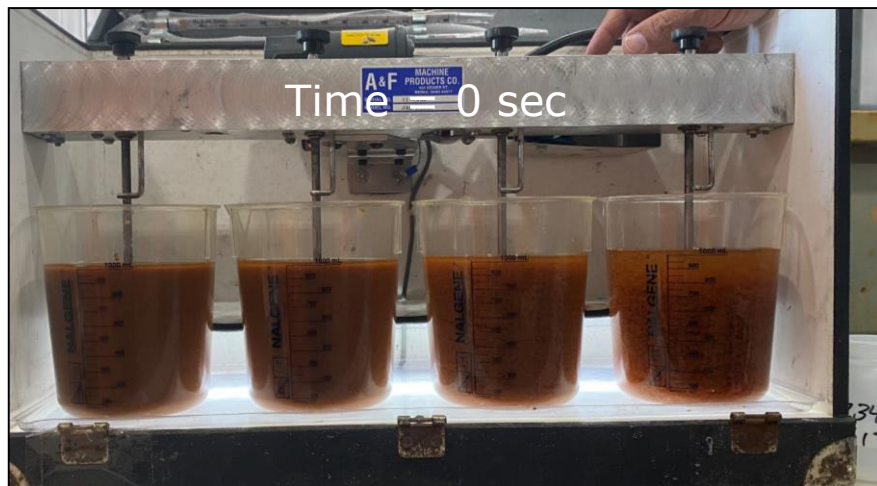


Globe Mine Plant Operation

1. Start-up April 2022
2. Initial operating pH of 9.0 (due to Mine 1 water in AST)
3. Decreased operating pH to 7.5
4. Expect to lower operating pH to ~7.0
5. Effluent Compliant with NPDES Effluent Limits Since Startup
6. Low flow operation has high solids (> 10,000 mg/L)
 - a. Causes Hindered Settling vs. Slow Zone Settling
 - b. Due to limited particle interaction



Planned Low Flow Operational Modification



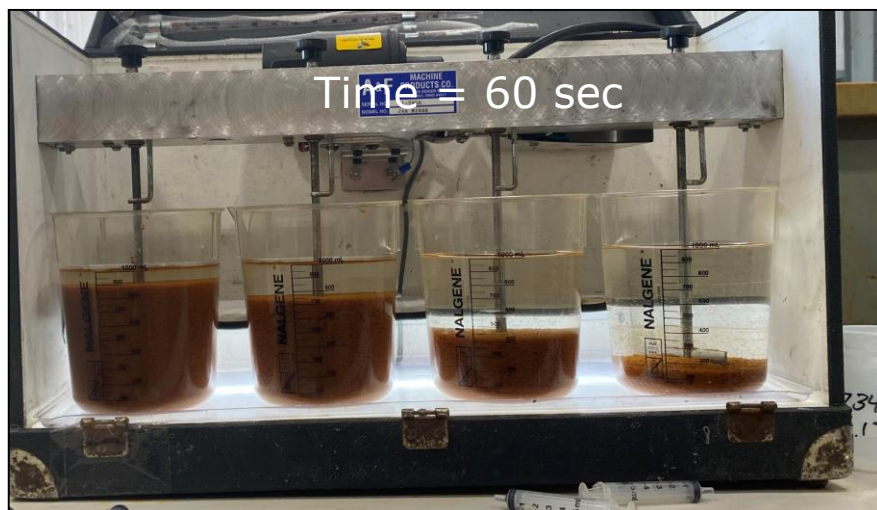
Based on IOT suggestions:

Dalton Derberry of Neosolutions conducted Jar Tests at various dilutions of neutralized/oxidized water containing solids (>15,000 mg/L) with clarified water (< 10 mg/L) using a 2 mg/L NS9734 pre-made polymer dose.

Jar Testing indicated that 1:1 dilution ratio yielded settling rates 8x faster than without dilution.

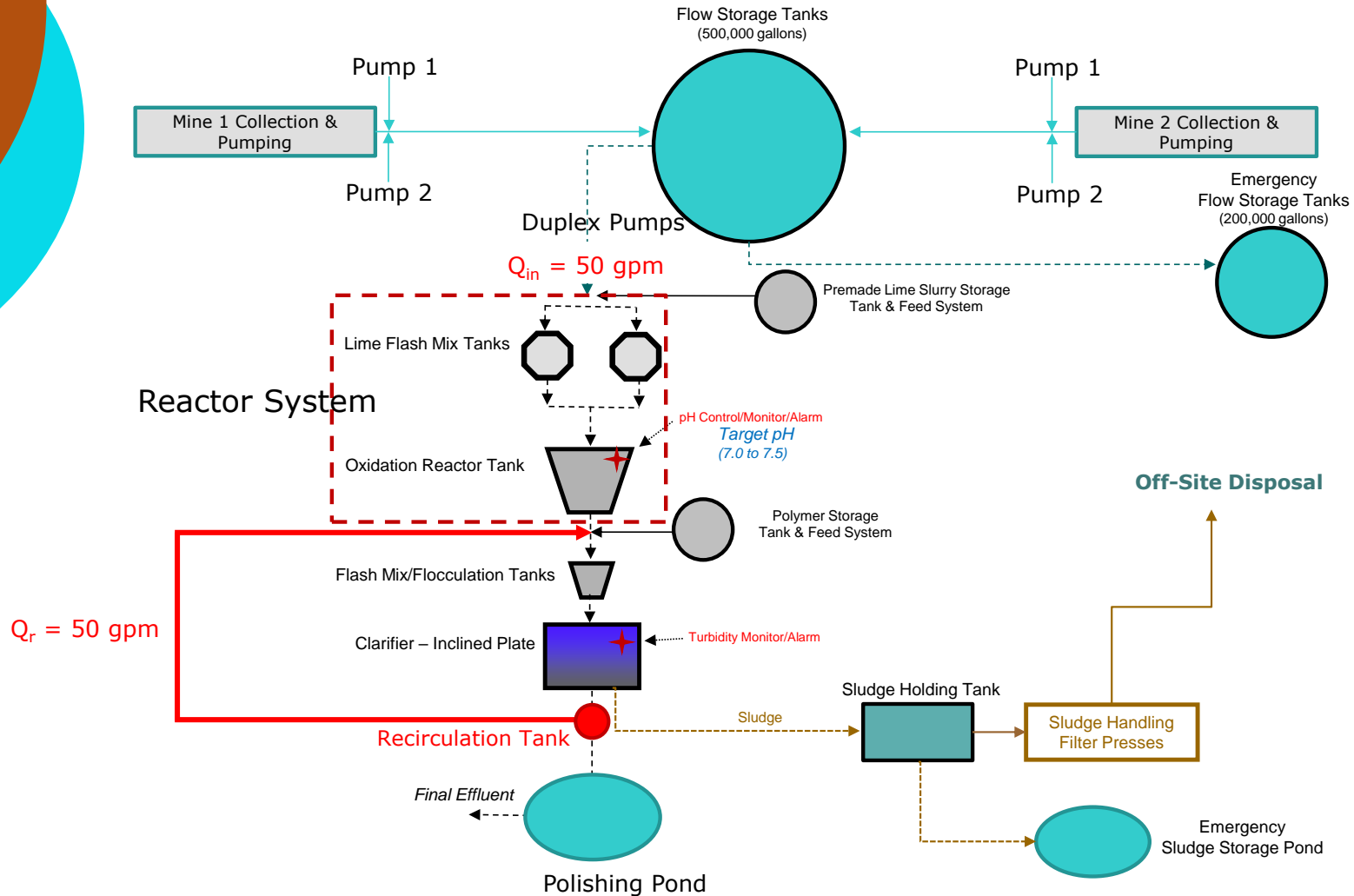
Dilution allowed for increased particle interaction (i.e., flocculation) forming larger particles that settled faster, and is consistent with Stoke's Law.

Dilution Ratio 0 3:1 1:1 1:3



Globe Mine Site

Modified Process Flow Diagram for Low Flow





A Design & Build Active Treatment Plant for the Globe Mine High Strength Mine Drainage

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