Off-Grid Active Treatment Using Siphons, Dosers, and Passive Mixing

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Presentation Outline

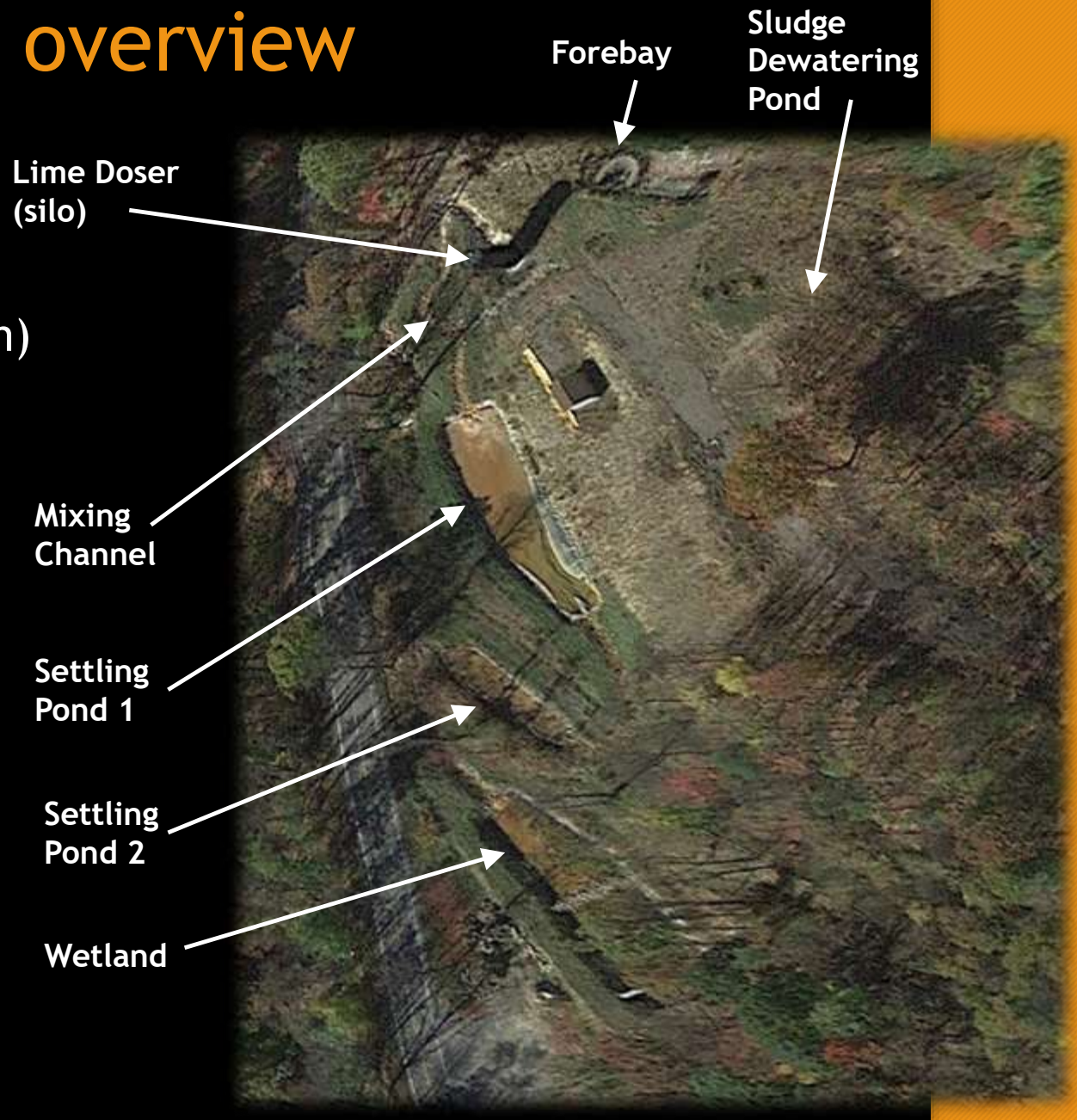
- Site location
- Existing treatment system overview
- Project goals & objectives
- Improved treatment design
- System operation
- System performance evaluation
- Operation & maintenance to date
- Crystal ball estimates

Site Location

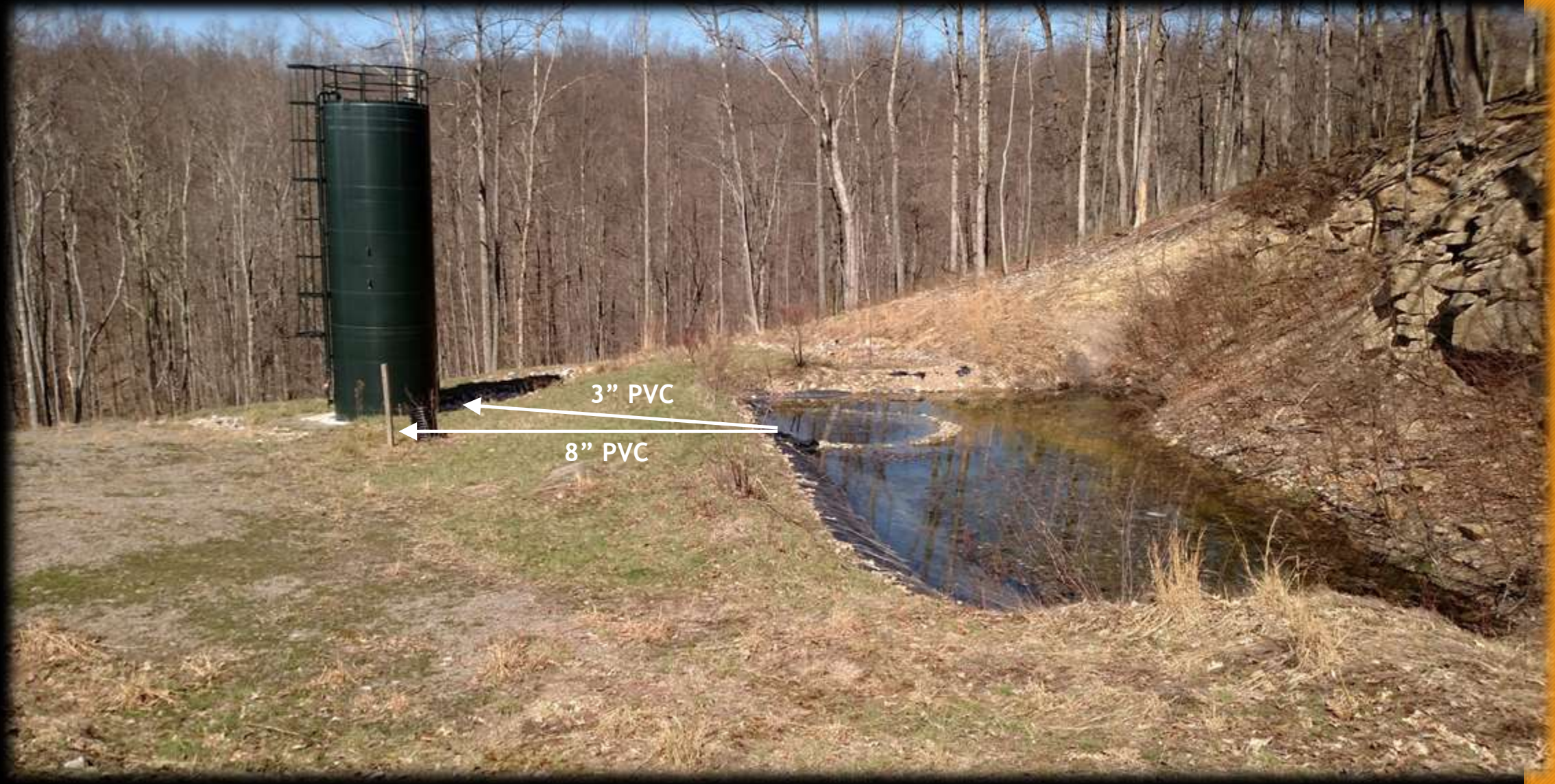
- Friends of the Cheat
  -Pase Site
  Active Treatment
  Improvement Project
- Preston County
  West Virginia
  Route 26
  2 miles north of
  Tunnelton
- 39.409235, -79.763516

Existing treatment system overview

- 2012 Reconstruction (replaced passive system)
- Forebay (collection pond)
- Lime doser with silo
- Mixing channel
- Settling pond 1
- Settling pond 2
- Wetland
- Sludge dewatering pond



Existing Forebay & Silo



Existing Lime Doser

Feed Rate Control

Existing Mixing Channel & Settling Pond 1

Raw Water Characteristics

- Flow (gpm): 0 – 288; 75 avg / 46 median
- Measured Acidity (mg/L) 145 – 545; 312 avg / 279 median
- Calculated* Acidity (mg/L) 103 – 453; 227 avg/ 194 median
- M. Acid Load (lb/d): 12 – 1845; 253 avg /151 median
- C. Acid Load (lb/d): 8 -1145; 169 avg / 106 median

*Acidity calculated assuming iron is half ferrous and half ferric

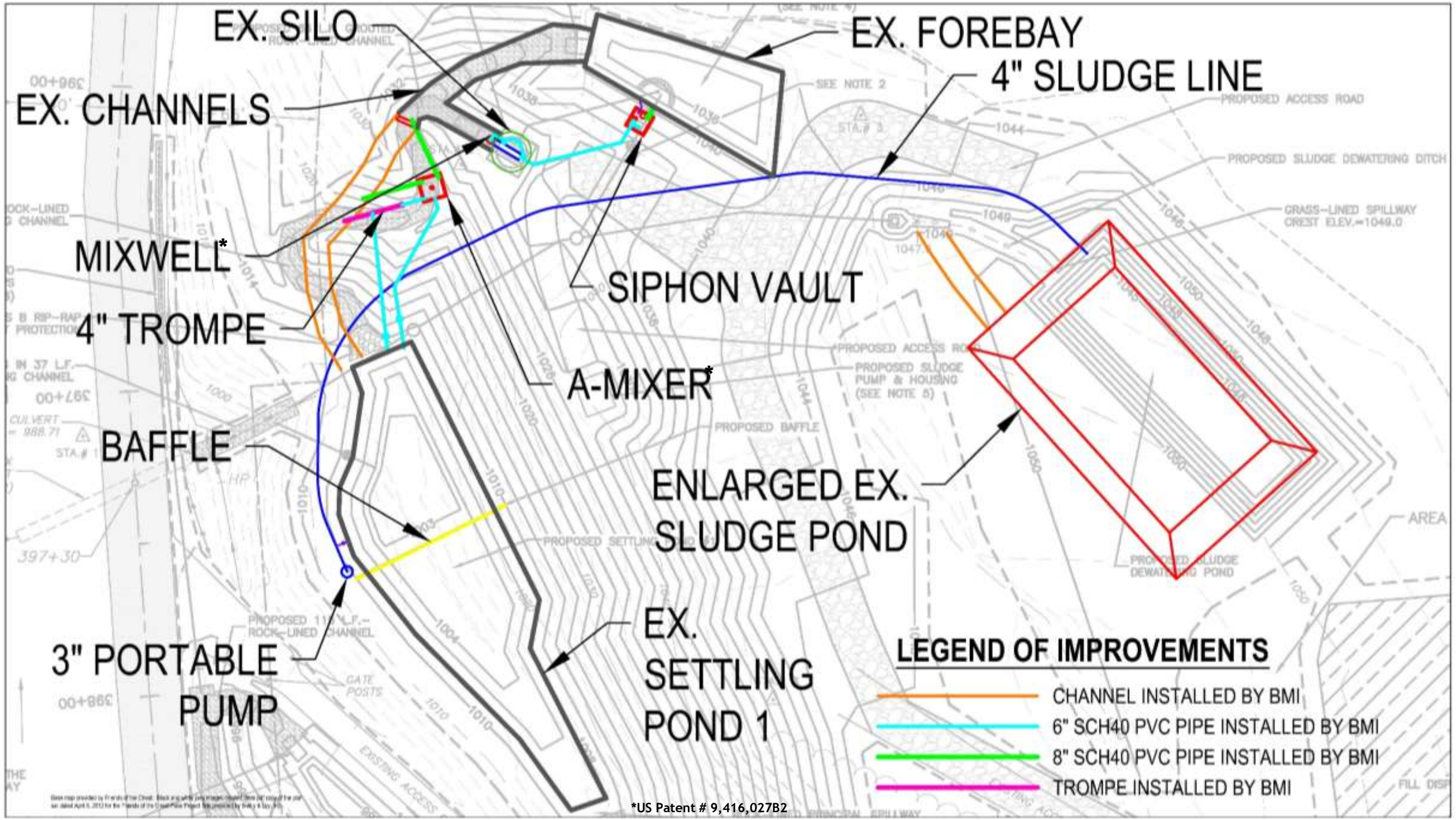
Improvement Project Goals & Objectives

- Goal: Improve treatment effectiveness
- Objectives:
  - 1) Reduce overtreatment/undertreatment (simplify operation)
  - 2) Improve lime utilization (increase efficiency)
  - 3) Reduce sludge generation
  - 4) Provide sludge removal system (rehab/clean SP1 & SP2)
  - 5) Improve existing settling ponds (including baffle & road)

Improved Treatment Design

- Forebay - Automatic dosing siphon (cycle on/off)
- “Constant Head” feed rate control
- MixWell*
- Use existing upper mixing channel (grouted)
- A-Mixer* (trompe-powered airlift mixer)
- Rebuild lower mixing channel
- Add baffle to Settling Pond 1
- Pump out Settling Ponds 1 & 2
- Permanent sludge line (with portable pump)
- Portable industrial power snake

*US Patent # 9,416,027


EX. SILO
EX. FOREBAY
4" SLUDGE LINE
EX. CHANNELS
MIXWELL*
4" TROMPE
SIPHON VAULT
A-MIXER*
BAFFLE
ENLARGED EX. SLUDGE POND
3" PORTABLE PUMP
EX. SETTLING POND 1
LEGEND OF IMPROVEMENTS
CHANNEL INSTALLED BY BMI
6" SCH40 PVC PIPE INSTALLED BY BMI
8" SCH40 PVC PIPE INSTALLED BY BMI
TROMPE INSTALLED BY BMI
*US Patent # 9,416,027B2

System Operation

- Siphon used as forebay outlet to provide periodic “constant” flow rate (cycle on/off)
- Model 523 Automatic Dosing Siphon (230 gpm minimum rated flow)
- 5” diameter
- 23” drawdown

System Operation

- Added 6” siphon bypass to facilitate calibration
- Includes 6” overflow
- Includes 1” trigger

System Operation

- Siphon outlets to silo
- Air vents at inlet and outlet of piping in silo
- Weep drain to prevent freezing

System Operation

- Small portion of water used to control tipping rate (2” PVC gate valve)
- Doser lime apertures set to maximum (limited to opening size at which lime will freely flow)

System Operation

- Majority of flow directed to 6” MixWell center pipe
- Lime is flushed into top of MixWell
- Baffle directs lime to bottom
- Center pipe nozzle outlet at bottom of MixWell restricts flow to about 140 GPM (to match trompe capacity)
- *More info on MixWells: Leavitt et al., 2012. WVMDTF*

System Operation

- Flows from MixWell via channel to A-Mixer
- Trompe is primary outlet of A-Mixer
- Trompe discharges back to channel to Settling Pond 1
- A-Mixer has 8” overflow
- *More info on A-Mixer: Leavitt et al., 2012. WVMDTF*

System Operation

- A-Mixer has central 12” lift pipe held above tank floor
- Air is released from 1” pipe just above bottom of 12” pipe
- Tank has 6” drain

System Operation

System Operation

- 4” Trompe (downpipe size)
- Dual 6” air chambers have common 1” air line to A-Mixer
- Includes drain extending from bottom of uppipe (outlet side)
- *More info on trompes: Leavitt 2011, WVMDTF*

System Operation

A-Mixer

2.5 CFM

~750 GPM

System Operation

- Permanent 4” PVC sludge line
- Riser to hookup 3” Gorman Rupp 10D1-GX270 pump (~300 gpm at 54’ TDH)
- 3” drain/chase water port

System Performance Evaluation

- Sampled: Raw, MixWell, and A-Mixer (at trompe)
- 1/24/18 – System cycling on/off (total inflow <140 gpm)
  - All flow during “on” cycle measured at trompe = 125 gpm (near end of cycle)
- 2/22/18 – System running constantly (total inflow >140 gpm)
  - Portion of water bypassing siphon and discharging via Forebay spillway
    - Mixing with treated water from MixWell before A-Mixer
  - Trompe 141 gpm + A-Mixer Overflow 55 gpm = 196 gpm
    - Confirmed flow at SP1 with 90° V-notch weir with staff gauge = 208 gpm
- System designed for ~85th percentile flow
  - When inflow >140 gpm, feed rate needs to be increased to account for Forebay overflow

System Performance Evaluation

- Captured lime at both spouts and counted “tips” (lb/tip)
- Evacuated & sealed bags and weighed within 24 hr
- Timed tips (tip/min)

System Performance Evaluation

- Bucket & stopwatch at trompe & overflow (if flowing)
- Sampled A-Mixer at Trompe outlet

System Performance Evaluation

Date	Point	Field pH s.u.	Lab pH s.u.	(Hot) Acidity mg/L$CaCO_3$	Sulfate mg/L	T.Fe mg/L	D.Fe mg/L	T.Mn mg/L	D.Mn mg/L	T.Al mg/L	D.Al mg/L	T.Ca mg/L	D.Ca mg/L	T.Mg mg/L	D.Mg mg/L	Acid Load lb/d $CaCO_3$	ΔAcid Load lb/d $CaCO_3$	Lime Feed lb/d $CaCO_3$	Lime Feed lb/d CaO
1/24/18	Raw	3.05	2.80	238	419	9.6	9.1	2.2	2.1	22.5	21.9	35.6	33.4	27.3	26.7	357	0	459	274
	MixWell	5.13	8.76	-78	390	9.7	0.0	2.2	1.7	24.2	2.6	204.1	121.9	28.3	26.9	-116	473		
	A-Mixer	10.15	8.56	-52	400	10.2	0.2	2.3	0.1	23.7	2.3	157.5	129.4	29.5	21.9	-78	435		
2/22/18	Raw	3.04	2.63	461	628	52.3	52.2	4.2	4.1	36.1	35.8	31.3	29.6	31.9	31.2	1086	0	1600	953
	MixWell	6.41	6.80	-1	616	52.3	1.2	4.2	3.3	38.7	15.3	220.9	146.0	31.5	30.2	-1	1087		
	A-Mixer	8.91	7.78	-22	640	53.4	0.0	4.2	1.9	37.9	0.0	190.1	176.7	31.4	28.2	-51	1137		

Lime Feed CaO = Actual measured lime material [pebble quicklime (potentially partially hydrated? – last load received 8/11/17)].
Lime feed CaCO3 = Adjusted for 94% purity and 0.56 conversion factor.
Note that the lime feed rate assumes constant flow. No lime is fed when cycle is off during Forebay refill (i.e. if actual flow was 75 gpm 1/24/18, actual feed would be 94 lb/day)
Flow measured at A-Mixer (trompe outlet & overflow): 1/24/18 125 gpm (cycling on/off) & 2/22/18 196 gpm (constant flow).

1/24/18 Estimated efficiency: 95% (Δ Acid load) or 79% (Δ D. Ca/T. Ca)

2/22/18 Estimated efficiency: 71% (Δ Acid load) or 93% (Δ D. Ca/T. Ca)

"Overall estimated efficiency" about 85%

Operation & Maintenance to Date

- Settling Pond 1 (SP1) & Settling Pond 2 (SP2) cleaned to about <0.5’ sludge before startup
- System placed on-line 4/5/17
- Pumped SP1: n=6 (5/19/17, 7/13/17, 8/16/17, 12/7/17, 2/13/18, 3/16/18)
  - 120,000 gallon total capacity
- Pumped SP2: n=2
  - 11,000 gallon total capacity
- Oxide Delivered as of March 2018: 28.5 ton (Mar ‘17 10 t, ~Jun ‘17 10 t, Aug ’17 8.5 t)
- Estimated hours spent on-site per week: 4 (plus about 5 hours for each pumping event)
- Pumped out MixWell once
- Drain A-Mixer during each sludge pumping event
- Other minor maintenance (brush cutting, clean MixWell nozzle, trompe inlet, etc.)

Crystal Ball Estimates

- Historic monitoring indicates average acid load: 46/31 t/year (meas/calc)
- If 85% efficiency, = 22 - 32 tons of lime per year needed (actual about 29 t delivered)
  - Included February 2018, historically wet month (>6 inches of precipitation)
  - Measured acid load varied by OVER 300% from January to February 2018

Thank you!

- Much thanks to the great folks a The Friends of the Cheat!
  - www.cheat.org; David Petry, Madison Ball, Amanda Pitzer
  - 2018 Cheat River Festival: May 4th & 5th www.cheatfest.org
- WV DEP (EPA 319 funding); WV DEP AML (lime supplier)
- OSM Watershed Cooperative Assistance Program
- Generosity of Charlie Pase (landowner)
- Thanks to Solid Rock Excavating, Inc., Albright WV (construction)
- In memory of Bruce Leavitt, Inventor & Trompemaster