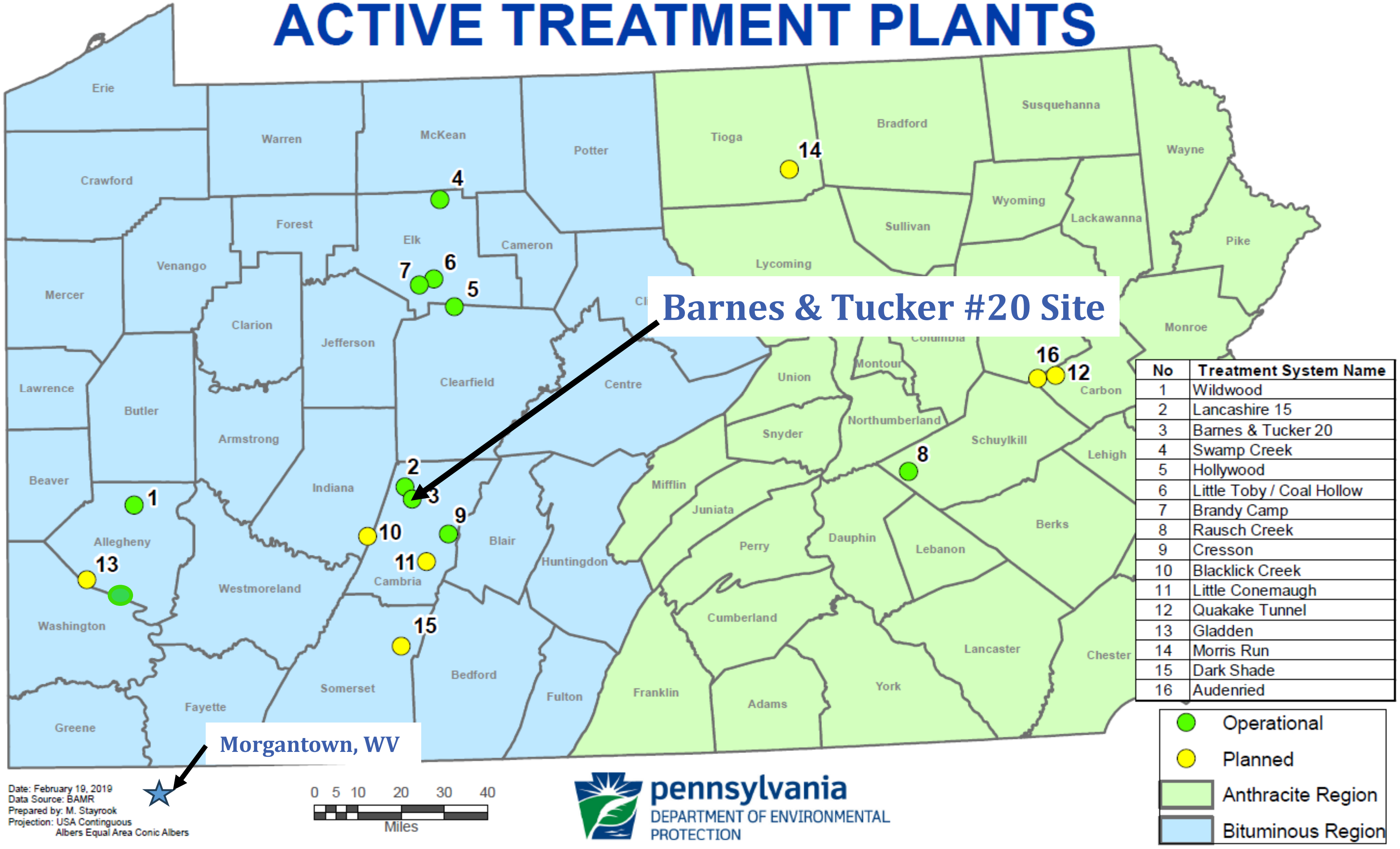
The Barnes & Tucker #20 Mine Drainage Treatment Facility: Optimization Case Study in Consideration of Variable Flow & Water Chemistry

Brad Shultz, P.E., Mining Engineer, OSMRE
Rich Beam, P.G., AML & Reg. Program Spec., OSMRE

Dean Baker, P.E., PADEP BAMR (ret.)
Roger Rummel, P.E., PADEP BAMR
Steve Fisanick III, P.E., PADEP BAMR (ret.)

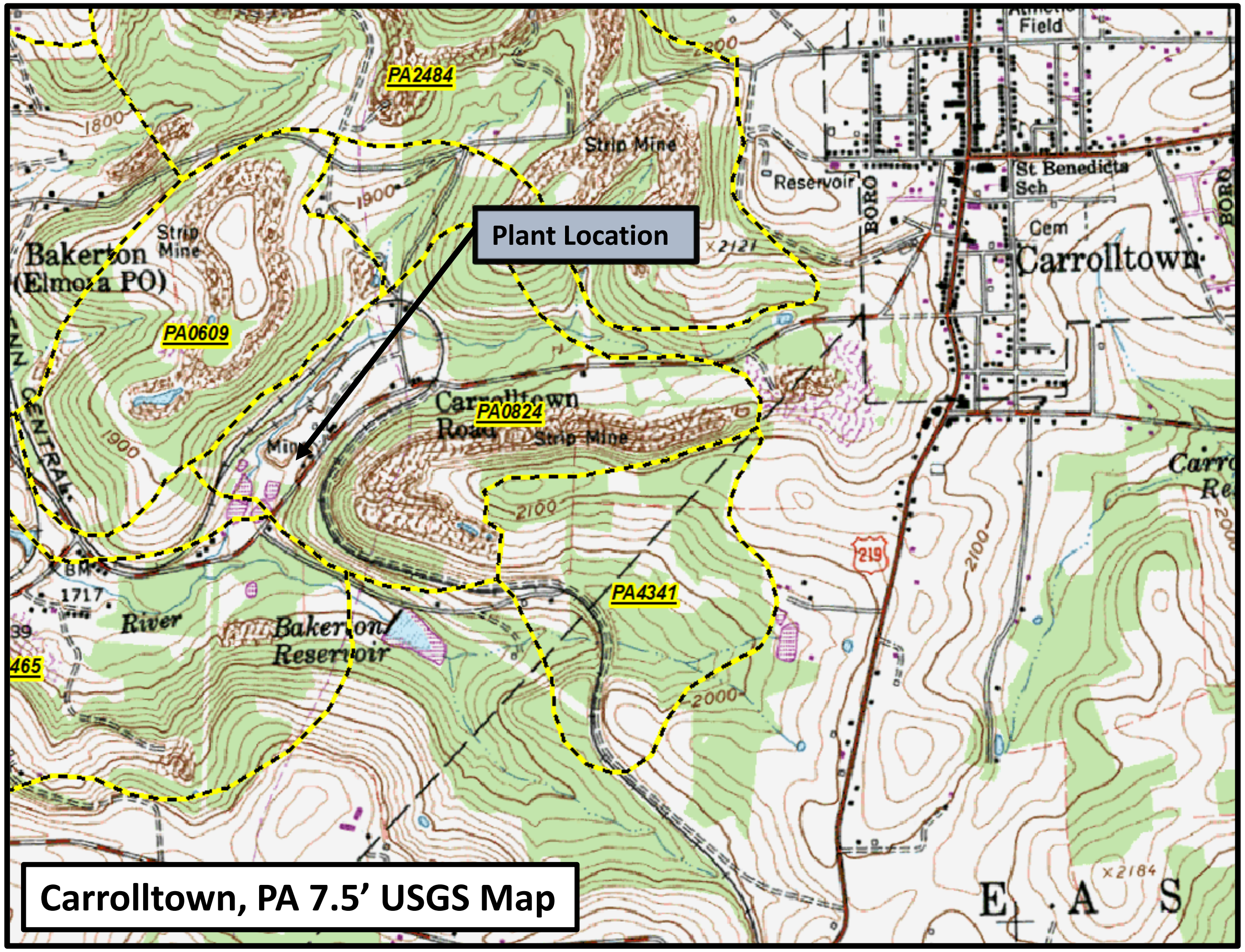
BUREAU OF ABANDONED MINE RECLAMATION ACTIVE TREATMENT PLANTS



No	Treatment System Name
1	Wildwood
2	Lancashire 15
3	Barnes & Tucker 20
4	Swamp Creek
5	Hollywood
6	Little Toby / Coal Hollow
7	Brandy Camp
8	Rausch Creek
9	Cresson
10	Blacklick Creek
11	Little Conemaugh
12	Quakake Tunnel
13	Gladden
14	Morris Run
15	Dark Shade
16	Audenried

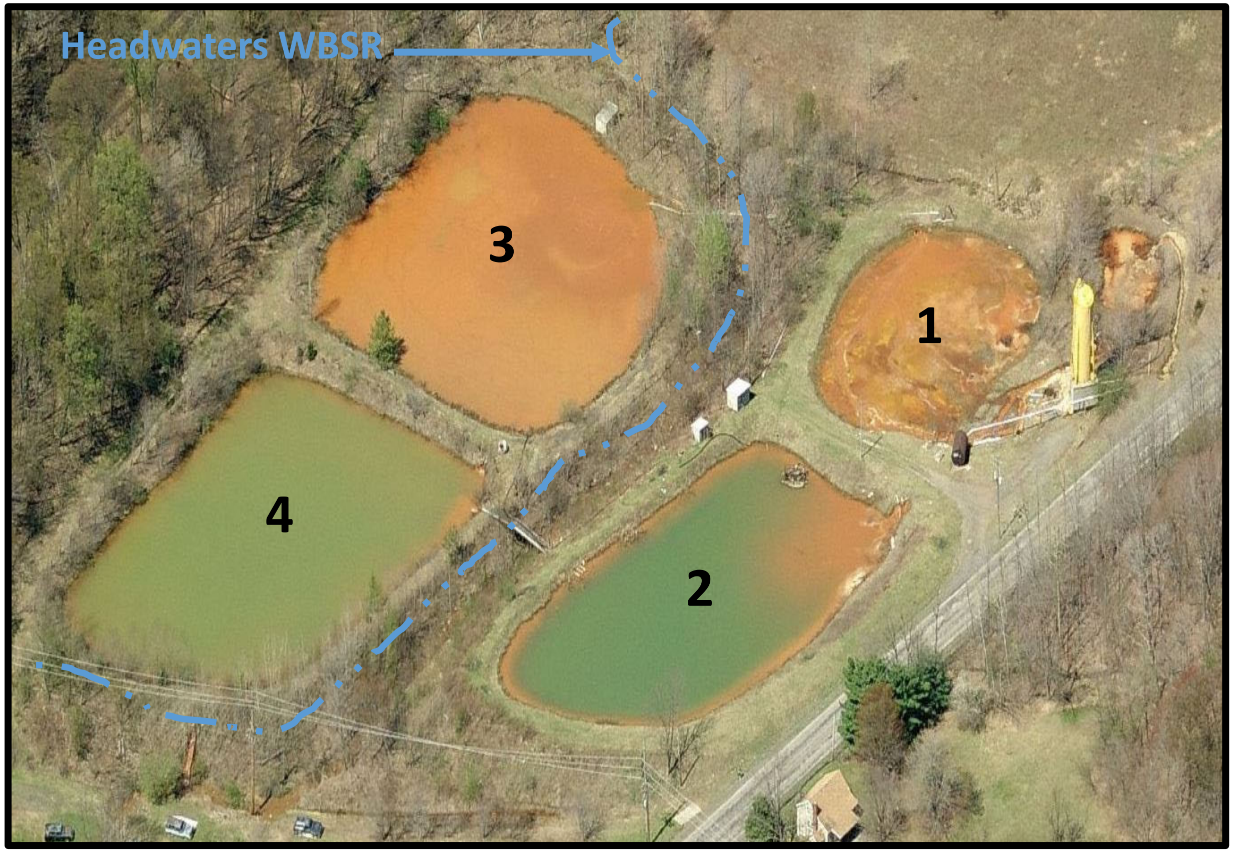
Barnes & Tucker #20 Treatment Facility

- Located in West Carroll Township, Cambria County, PA, USA (AML Problem Area, PA 0824)
- Facility constructed by Barnes & Tucker Coal Co. in 1966 in response to amendments to PA Clean Streams Law
- Receiving Stream Sequence:
  - Headwaters of West Branch Susquehanna River



Barnes & Tucker #20 Treatment Facility

- PADEP assumed treatment obligation as part of the Barnes & Tucker Coal Co. Bankruptcy (2001)
- Plant influent quantity and quality varies seasonally; 1.9 L/s (30 gpm) to >19 L/s (>300 gpm); Net acidic to net alkaline



2006 aerial photo showing original lime treatment configuration. Ponds 1&3 completely filled with solids at the time.

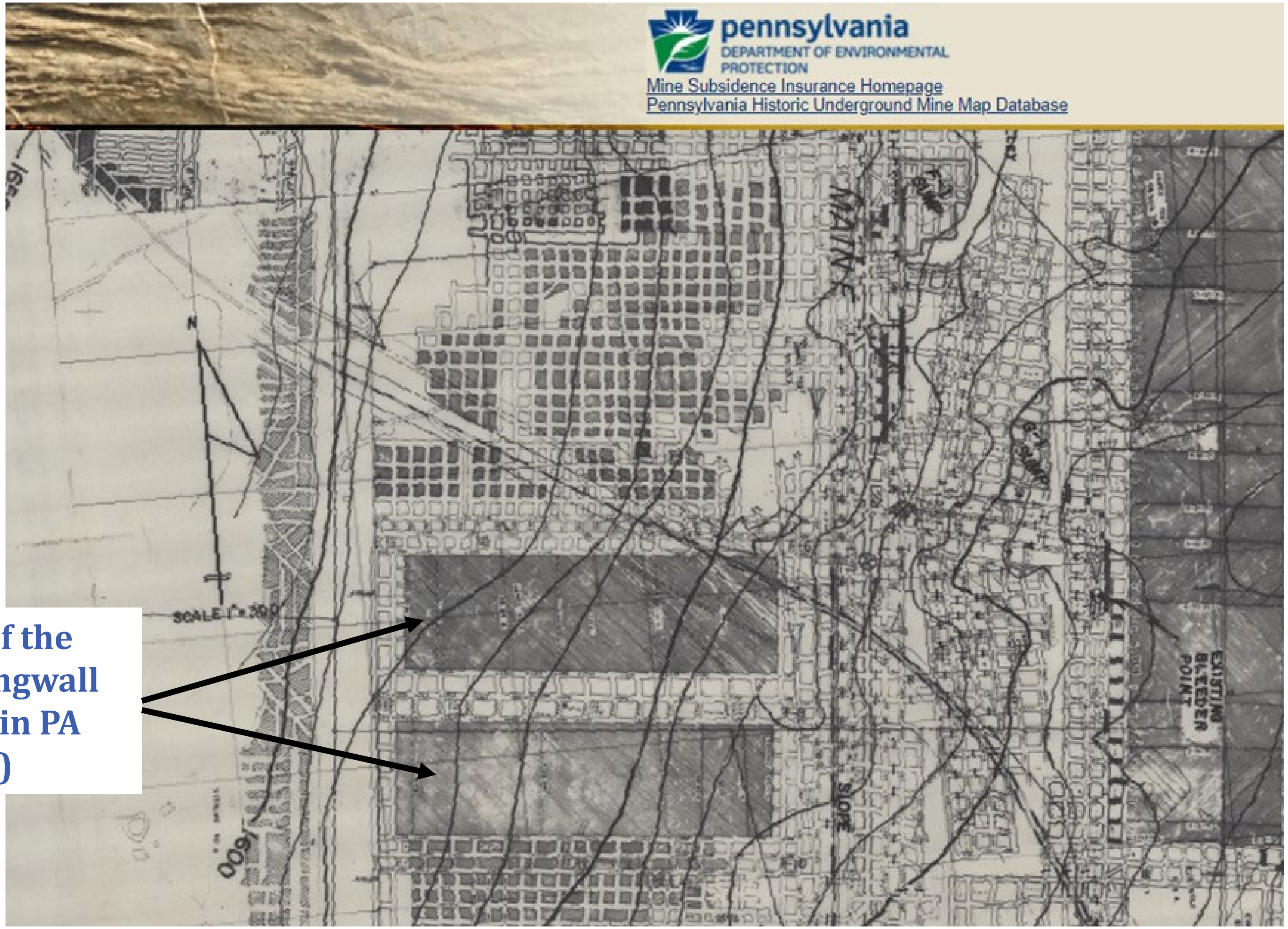
B&T #20 Pond 1 Sludge Removal (2014)

Background

- Lower Kittanning (B) seam underground mine originally opened in 1906 by the Logan Coal Co. as its #5 mine.
- The Navy Smokeless Coal Company assumed operations in the 1920's.
- Barnes & Tucker (B&T) acquired the mine in 1955, renaming it the #20 mine and operated until 1985.
- Current treatment site was a drift opening mine access, shop facilities, coal rail loadout, and processing/storage facilities.

Sept. 1967 Air Photo

B&T #20 Mine Map



Some of the first longwall panels in PA (1960s)

OSMRE

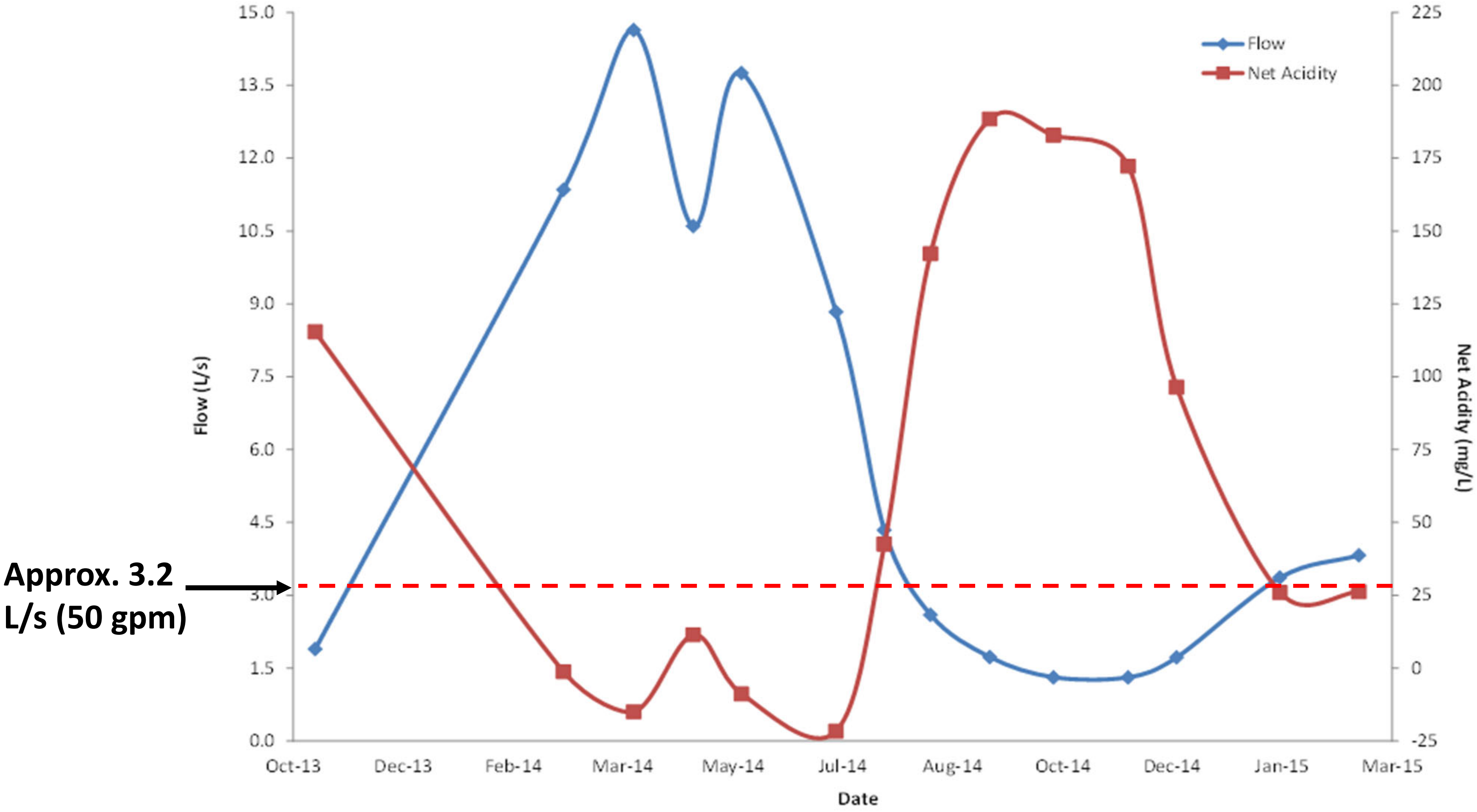
Mine Water Characterization

- Local structural geology affects mine water quantity and quality water
- An anticline within the mine workings separates a free-draining portion and a mine pool portion
  - Free-draining portion (northern side) = 60 acres = Net acidic mine water
  - Mine pool portion (southern side) = 400 acres = Net alkaline mine water

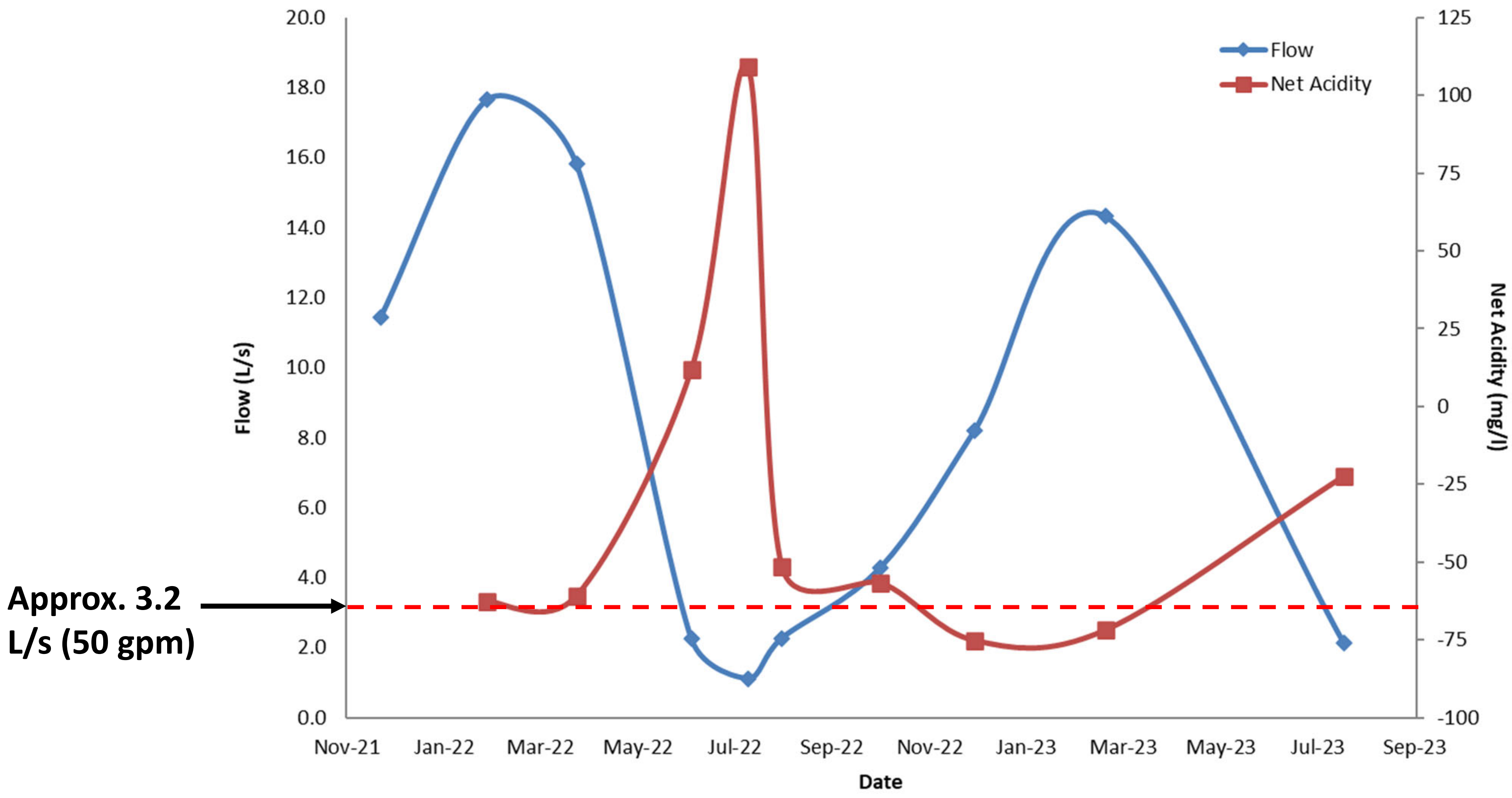
Mine Water Characterization (cont.)

- Post mine closure a mine pool developed that overflows the anticline seasonally and combines with free-draining portion
- During low flow periods, <3.16 L/s (<50 gpm), no mine pool overflow, only free-draining portion discharges at portal
- Raw mine water is net alkaline >6 months/yr with flows ranging: 3.16 L/s (50 gpm) to >18.92 L/s (>300 gpm)
- Mine water contains:
  - Elevated dissolved CO_2 (34 – 235 mg/L)
  - Elevated dissolved Fe^{2+} (5.0 – 19.0 mg/L)
  - Low dissolved Al (net acidic only)

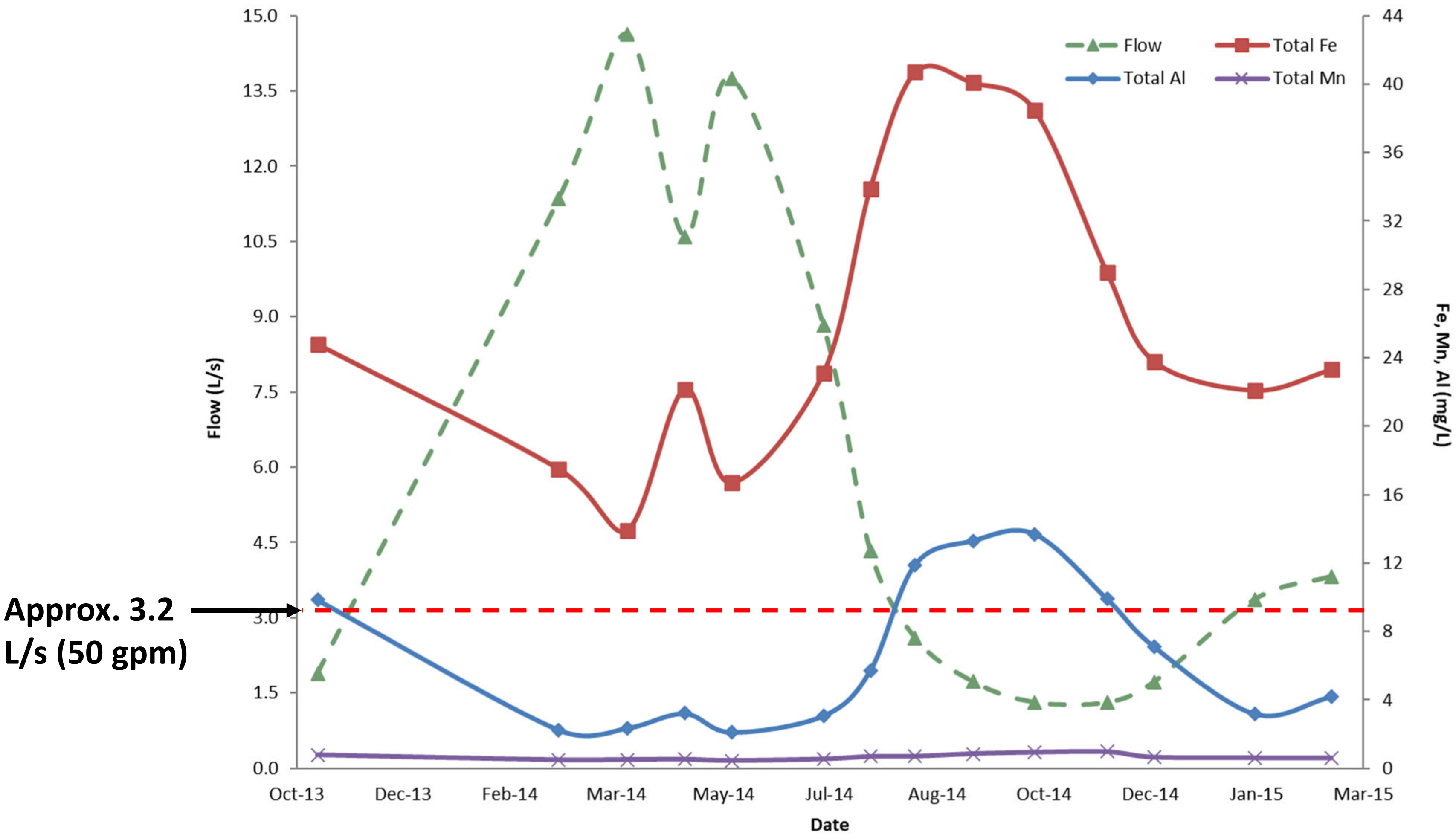
Seasonal Variations of Flow Rate & Net Acidity 2013 - 2015



Seasonal Variation of Flow Rate & Net Acidity 2022 - 2023

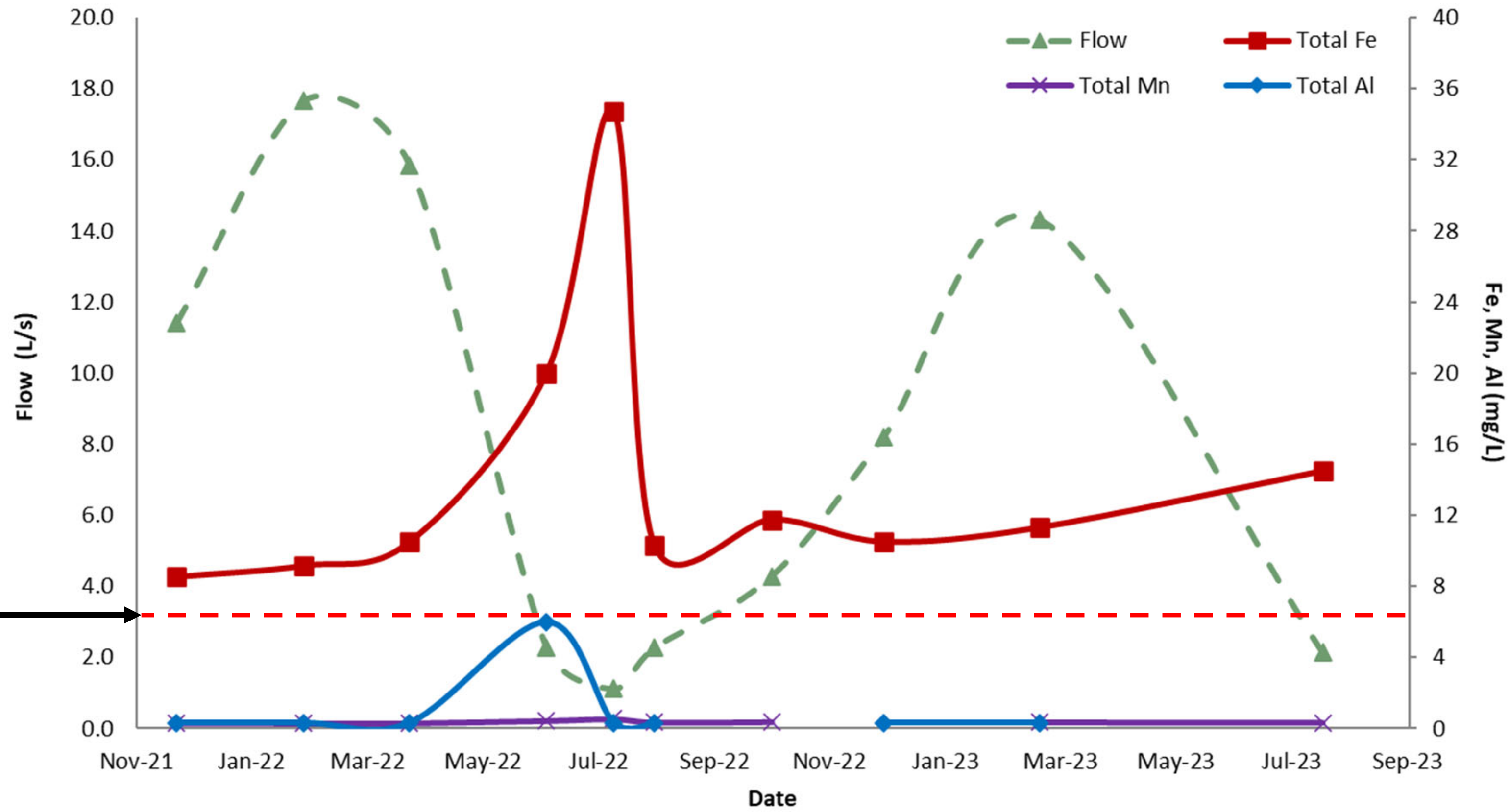


Seasonal Variation of Flow Rate & Total Metals 2013 - 2015



Seasonal Variation of Flow Rate & Total Metals 2022 - 2023

Approx. 3.2 L/s (50 gpm)



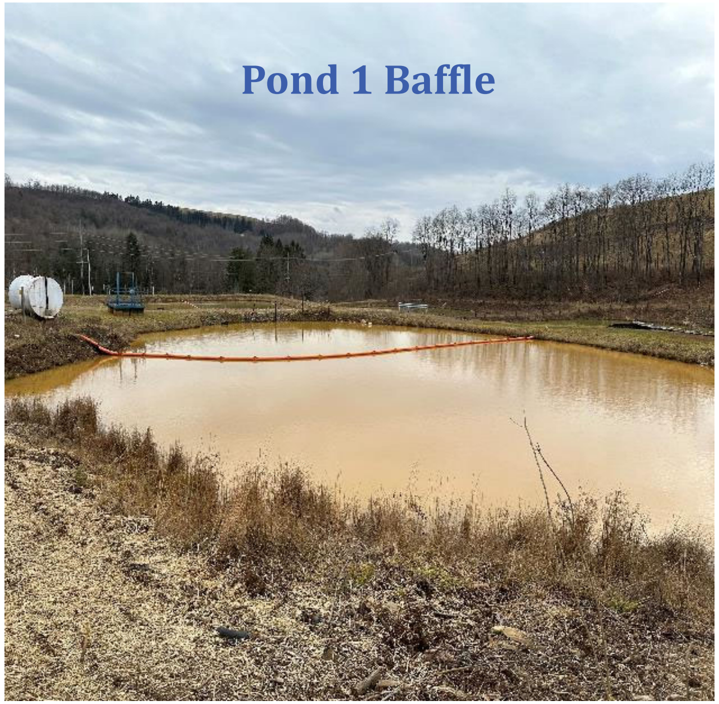
Mine Water Treatment Evolution

- Evolving treatment methods based on varying mine pool water quality & quantity
  - Initially used CaO until 2014
  - Use 25% NaOH to present (added after Pond 1)
- Pond 1 initially received lime treated mine water and filled with iron and both unreacted lime and calcite (85% CCE)
- Ponds 2, 3, & 4 provide further oxidation, settling and storage of iron precipitates
- Sludge periodically injected back into the B&T #20 mine pool behind anticline (recently performed)
- No baffles used, pipes used to set water levels and serve as primary outfalls for each pond
- Due to receiving stream separating Ponds 1 and 2 from Ponds 3 and 4, maintenance of Ponds 3 and 4 was challenging

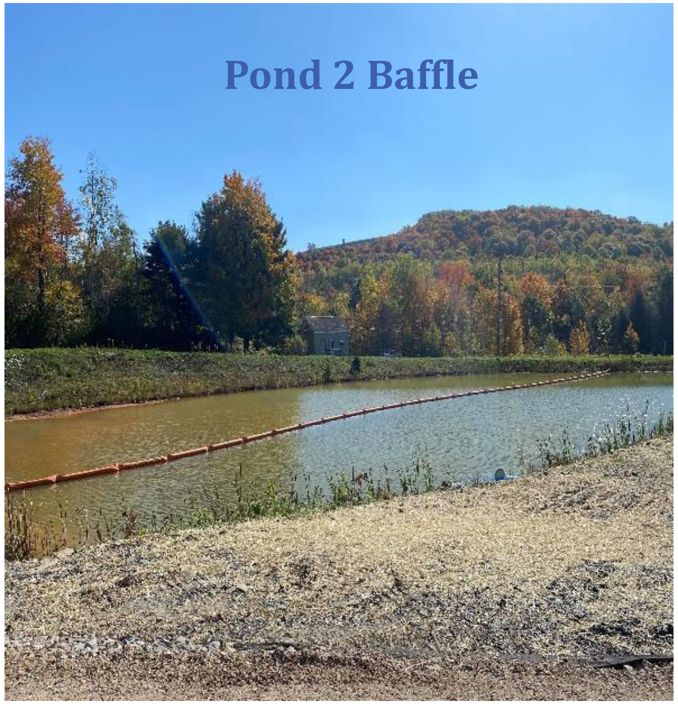
Recommended Improvements - Completed

- Improve inflow ditch to Pond 1 from mine portal to improve decarbonation
- NaOH addition at Pond 1 outfall
- Conversion from NaOH drip system to a PLC based pH-controlled pinch valve system
- Replace and modify outfall pipes for each pond and ability to bypass all ponds for maintenance
- Construction of a permanent stream crossing for ease of maintenance at Ponds 3 and 4
- Installation of baffles in Ponds 1 and 2
- Land acquisition for sludge disposal line and borehole
- Improvements provide for successful hybrid passive/active treatment approach based on seasonal water quality changes

PLC Based pH-Controlled Pinch Valve System for NaOH Addition



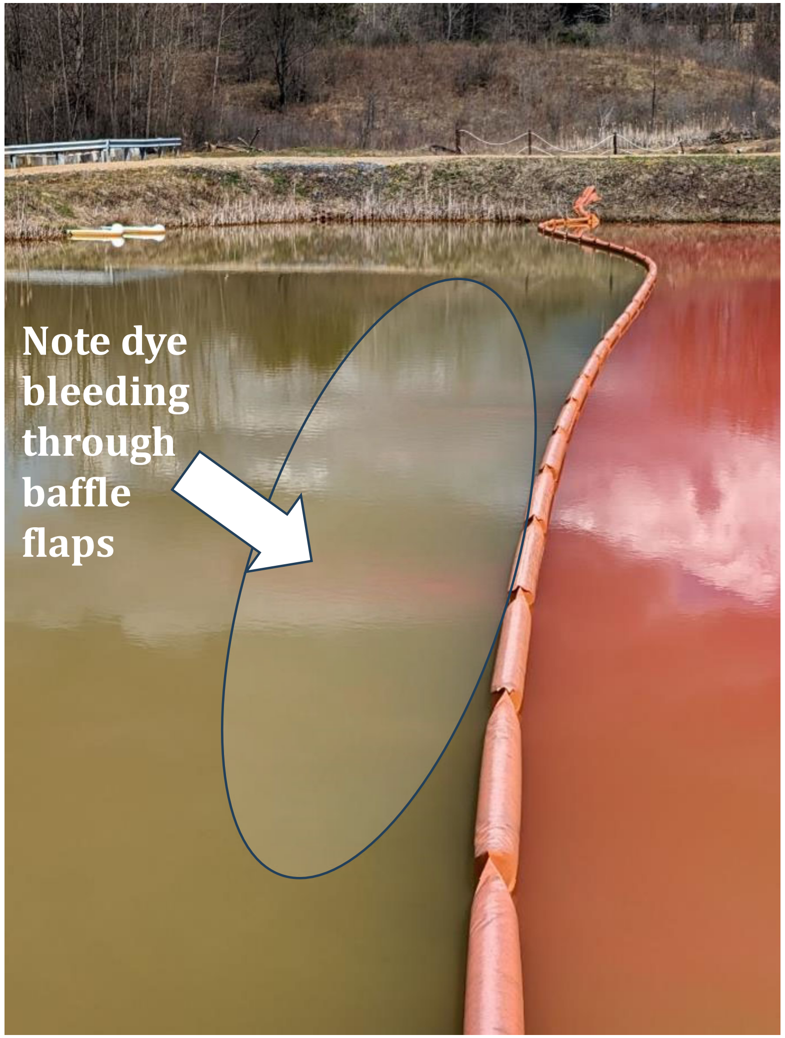
Pond 1 Baffle



Pond 2 Baffle

Improved Raw Water Channel into Pond 1

Dye Tracer Test March 2024: Pond 2



Summary Results of Treatment Optimization (Pond 1)

		CO_2 Removed			Iron Oxidized		Iron Precipitated		Acidity Reduction		25% NaOH Savings	
Date	Flow (L/s)	mg/l	%	as $CaCO_3$ mg/l	mg/l	%	mg/l	%	mg/l	kg/day	L/day	$ @$0.32/L
12/20/2021	11.4	N.M.	N.M.	0	4.84	86%	4.3	50%	8.7	0.54	21.7	$ 6.94
2/24/2022	17.7	42.9	78%	48.78	5.61	75%	3.8	42%	58.9	5.68	227.1	$ 72.67
4/20/2022	15.8	12.4	39%	14.10	6.34	79%	5.19	49%	25.5	2.20	88.2	$ 28.21
6/30/2022	2.3	29.9	74%	34.00	9.87	52%	9.2	46%	51.8	0.65	25.7	$ 8.21
8/4/2022	1.1	113.2	98%	128.72	21.6	64%	21.9	63%	167.6	1.01	41.1	$ 13.14
8/25/2022	2.3	12.5	73%	14.21	7.14	85%	8.24	80%	27.1	0.34	13.4	$ 4.30
10/25/2022	4.3	101.5	91%	115.41	9.97	98%	9.43	80%	133.4	3.13	124.9	$ 39.97
12/22/2022	8.2	45	39%	51.17	N.M	N.M	7.18	68%	51.2	2.29	91.6	$ 29.32
3/13/2023	14.3	143	61%	162.60	8.49	90%	6.5	58%	177.9	13.87	556.1	$ 177.95
8/7/2023	2.1	22.9	65%	26.04	10.96	89%	11.11	77%	45.8	0.52	21.5	$ 6.87
N.M. = Not Measured		**Avg =**	**69%**		**Avg =**	**80%**	**Avg =**	**60%**			**2022 Avg =**	**$ 27.98**
											Est. Cost Savings Year 2022 =	**$ 10,210.97**

Note: Existing conveyance ditch and Pond 1 function as passive treatment components of the existing system. The planned decarbonation/aeration tray system prior to Pond 1 will replace the conveyance ditch for passive treatment of both B&T #20 mine drainage (& Victor #10).

Recommended Additional Improvements

- Further improvements contingent on introduction of Victor #10 abandoned mine discharge
  - Based on loading, Victor #10 & B&T #20 proportion would be a 70/30 split
  - Victor #10 flows: 4.0 – 31.5 L/s (63 – 500 gpm)
  - Elevated CO_2 (21 – 276 mg/L) & dissolved Fe^{2+} (6.3 – 29 mg/L)
  - Similar water quality seasonal variation
    - Flow <200 gpm = Net acidic & higher dissolved Fe^{2+}
    - Flow>200 gpm = Net alkaline & lower dissolved Fe^{2+}
- New sludge disposal line and borehole
- Decarbonation/aeration tray system
- Conveyance and hydraulic system
  - Combine Victor #10 and B&T #20
  - Eliminate surface runoff comingling with B&T #20

Decarbonation/Aeration Tray (Example)

PADEP BAMR Wildwood Treatment Facility located in Allegheny Co., PA (USA)

Final Notes & Acknowledgments

- Successful passive/active hybrid treatment approach reduces chemical costs
  - Passive decarbonation/aeration of raw mine water using improved ditch to off-gas dissolved CO_2
  - Use of improved raw water channel and Pond 1 for CO_2 off-gassing and the oxidation and settling of Fe^{2+} prior to NaOH addition reduces chemical costs
  - Completed improvements along with future upgrades will allow for co-treatment with Victor #10 mine discharge to improve the W. Branch Susquehanna River headwaters
- Important to characterize any seasonal variations in mine pool quality and quantity to maximize water treatment efficiency
- Innovative and low-cost technologies available for controlling chemical addition
- Thank you to my co-authors, Rich Beam (OSM), Roger Rummel (PADEP BAMR), Dean Baker (PADEP BAMR – Ret.), & Steve Fisanick III (PADEP BAMR – Ret.)

B&T #20 Treatment Facility March 2024

Brad Shultz, P.E.
Mining Engineer
bshultz@osmre.gov
717-576-2950