Boyce Park AMD Treatment System
SRI O&M TAG Project #43 Request #2
OSM PTS ID: PA-281

Requesting Organization: Allegheny County Parks (in-kind partner)
Requesting Organization Representative: Amy Miller, Allegheny County Conservation District
Dates Work Performed On-Site: 7/6/2023-8/11/2023

Initial Site Visit, Observations, and Identified Needs: BioMost, Inc. (BioMost) and Stream Restoration Incorporated (SRI) met with Allegheny County Parks representatives on 7/6/2023 to discuss site needs. It was determined that initial water sampling and test pits would provide further information about the system prior to other decisions regarding maintenance or improvements. Based upon flow (or lack thereof) through various components, it was assumed that treatment media within most system components was either clogged or degraded after 16+ years.

Work Completed: On 7/11/2023, BioMost mobilized equipment to the site. Test pits were excavated in BP4 VFW #1 and it was determined that removal of compost material and washing remaining limestone would improve system performance. The following additional maintenance and upgrades were performed:

- Limestone was removed from system once washed to inspect the underdrain and assess flow paths.
- Larger diameter holes drilled in underdrain pipes for higher flow.
- Removal of stop logs for the upper underdrain system.
- New riser at outlet of Manual Flush Valve #2 installed to maintain flow through the system and streamline maintenance/flushing.
- Re-set access gate.

A similar approach was taken for the BP4 VFW #2 component once a test pit was excavated. Similarly, the compost was removed from the pond surface. However, the limestone was not removed as it was still permeable. Instead, the pond was filled with clean water from the system which was flushed several times through Manual Flush Valve #3 into the constructed wetland. The flush valve was also excavated and serviced as it had become difficult to operate. This approach reduced maintenance work required while hopefully extending system life.

The BP2 Limestone Pond appeared to be entirely occluded with aluminum precipitates and the siphon was not performing adequately for treatment. The following maintenance was performed:

- Limestone in the pond removed and washed.
- Underdrain repaired and re-set as appropriate.
- Larger diameter holes drilled in underdrain pipes for increased flow during flush events.
- Siphon vault cleared of sediment and debris.
- Vegetation cleared from pond embankments as needed.
- Placement of additional high-quality limestone to improve system performance/replace dissolved stone.
- Raw water flow measurement pipe and plunge pool installed.

A novel approach was taken in the BP3-VFW component. An inlet pool was left in place to better utilize the limestone remaining in the pond at a thickness of approximately three feet. The underdrain piping was shortened to remain within the new media footprint. In addition to the above design adjustment, the following maintenance was performed:

- Removal of degraded compost.
- Stone washing.
- Underdrain perforation improvements.
- Removal of stop logs in Agri Drain structure (abandoned for now).
- Installation of riser pipe at VFW outlet to maintain water level above the media.
- Vegetation cleared from pond embankments as needed.
- Re-set access gate.

Water Quality Data and System Evaluation: Water sampling was conducted by SRI three times following the 2023 maintenance, with each monitoring event varying in rainfall, and therefore flow, through the system. Water quality data collected prior to the 2023 maintenance, between 2009 to 2021, is available on Datashed.org with the most recent pre-maintenance data shown below in Table 2. Sample point descriptions are described in Table 1, with the sample point names matching what is on Datashed and the data tables below, while having the "Description" column listing the points' alternative names as shown on Boyce Park AMD Treatment System's original schematic. Overall sampling results suggest an improvement in AMD treatment as well as flow through the system following maintenance. Removal of compost and washing limestone greatly improved the permeability of the treatment media allowing more water to flow through the vertical flow ponds. However, results also indicate insufficient treatment during high flow sampling events due to a combination of 1) increased flow overwhelming the system and 2) significantly worsened chemistry of the raw discharges during high flow, both of which are described in more detail below.

The Boyce Park AMD treatment system has three raw AMD discharges entering the system, each at different locations. On the south-eastern side of the system is the BP4 discharge, which flows through a series of 4 small ponds made up of 2 vertical flow ponds each of which are followed by a settling pond before discharging to a spillway and mixing with the BP2/BP3 water before entering the final wetland. The BP4 discharge can be characterized as acidic (50 mg/L to 630 mg/L hot acidity) with elevated metals and particularly high aluminum content (24 mg/L to 82 mg/L) and maintains a lower flow rate than the discharges found on the opposite side of the system. At the north-western side of the system is the BP3 discharge, which has higher flow and typically less acidic (12 mg/L to 200 mg/L hot acidity) as compared to BP4, while also containing moderately high concentrations of aluminum (7.5 mg/L to 22 mg/L). BP3 enters a larger-sized VFP, as compared to the VFPs on the BP4 end, and then empties to a long settling pond labeled "BP2/BP3-Pond" before exiting through the final wetland. The other discharge, BP2, also enters on the northern end of the system but to the east of the BP3 discharge where it enters the siphon-based, auto-flushing limestone pond before entering the BP2/BP3-Pond. The BP2 discharge was found to be acidic (79 mg/L to 359 mg/L hot acidity) with elevated aluminum for all sampling events except for the sampling conducted on 12/17/2024 during low flow.

The pre-maintenance sampling conducted on 5/19/2021 (Table 2) had relatively low flow entering the system (combined 18 gpm) but had higher flow measured to be exiting the final wetland (62 gpm). The difference in flow measurements may indicate that the treatment system intercepts more flow than what is entering at the beginning of the treatment system, including potential road drainage, because all sampling events had higher measured flow leaving the system as opposed to entering. Even with the low flow entering the system on 5/19/2021, the system did not sufficiently neutralize acidity or raise pH to a desired level prior to maintenance, with the final acidity being 28 mg/L and final field pH being 4.09. Iron and manganese concentrations were below 1 mg/L in the system effluent. Unfortunately, aluminum concentrations were not reported, which is the metal of greatest concern at this system. Negligible alkalinity was measured at the system effluent and throughout the system (<3 mg/L throughout) on 5/19/2021, indicating that an insufficient amount of alkalinity was generated by the system to neutralize the acidity or to provide excess buffering downstream. Water chemistry was not the only concern at Boyce prior to maintenance, as overflowing ponds, particularly at the BP2/BP3 pond and the BP4 VFPs, were noticed during site visits.

Treatment of AMD overall improved following maintenance, despite being sampled during much higher flow for 2 of the 3 sampling events. The sampling that occurred on 12/17/2024 (Table 4) had similar and slightly higher flow entering the system (23 gpm) as compared to the 5/19/2021 sampling but had significantly improved performance. On 12/17/2024, the system effluent contained a field pH of 7.85, field alkalinity of 79 mg/L, acidity of –59.5 mg/L, and total iron, manganese, and aluminum concentrations below 0.10 mg/L (Table 4). The results indicate that the system was able to neutralize 100% of the acidity and remove 97% of the aluminum from the 3 discharges entering the system that day, suggesting greatly improved treatment following maintenance. Furthermore, there had been no visible signs of ponds overflowing or AMD bypassing treatment.

Despite the improved performance at the Boyce Park system following maintenance, the system is observed to have difficulty treating the very acidic, aluminum-laden discharges during high flow events, although it should be noted that according to the O&M plan by the designer Skelly & Loy, the system was designed based on a total flow of about 70 gpm. Two of the sampling events conducted post-maintenance were during high flow (Tables 3 and 5), with the 4/8/2024 (Table 3) sampling occurring during a period of extreme rainfall for Allegheny County. In fact, that was during the same week that the Pittsburgh "Three Rivers" were reported to have reached levels of more than 28 feet (flood stage is at 22 feet) and were at their highest level in 20 years. During the 4/8/2024 sampling, the system effluent was found to have an acidity above 150 mg/L, a pH of 4.35, and aluminum concentration above 22 mg/L. While acidity was being neutralized, no alkalinity was measured from any of the treatment components that day. Flow rates were difficult to measure due to the immense quantity of water and due to several treatment components overflowing, such as BP2/BP3 pond and the BP4 VFPs near their outlets. Additionally, runoff was found on the BP3 side of the system flowing downhill and under the fence, from the road and downhill in the rip rap past the BP2/BP3 pond outlet. In addition to the system being overwhelmed with the increased flow, the discharges themselves had more severe water quality with higher acidity and metal concentrations, which compounded the difficulties for the system. The worsened water quality was likely due to flushing of acidic and metallic salts from the underground mine during the extreme high flow event. For example, the BP4 discharge had a pH of 2.96, acidity above 630 mg/L, and aluminum of 82 mg/L, which were all the highest measured available values for that sample point found on Datashed. The BP3 discharge contained an incredibly high flow with a pH of 3.1, and acidity close to 200 mg/L, and aluminum concentration of 22 mg/L. The BP2 discharge contained similarly concerning water quality with aluminum concentration of 52 mg/L and flow overtopping the weir. Therefore, all three discharges had significantly worse water quality during the high flow, which along with the overwhelming amount of flow going through the system, caused treatment to be ineffective. Due to the extreme conditions, this was likely an unfair and unrepresentative sampling event to evaluate system performance but certainly provides indication as to the system's limitations. It should be noted that despite the poor water quality of the effluent, the system was still neutralizing 56% of the acid and removing about 70% of the iron and 50% of the aluminum loading. On that day, it was neutralizing 470 lb/day of acidity which is more than 5X that of 5/6/25 and 470X that of 12/17/24. That is quite impressive.

Table 5 provides water quality collected at the Boyce system on 5/6/2025, which was collected during a high flow period but not following an extreme precipitation event, with the final effluent flow rate measured at greater than 100 gpm. The final effluent contained a field pH of 5.5, acidity of 8, iron and manganese levels below 1 mg/L, aluminum at 2 mg/L, and an alkalinity of just 2. While effluent water quality was less than desired and treatment not fully accomplished, the system was still neutralizing 88% of the acidity and removing 93% of the iron and 88% of the aluminum during a high flow period and after 17 years of providing treatment.

Table 1: Boyce Park AMD treatment system sample point descriptions

Sample Point	Description	Coordinates
BP4 RAW	AKA **281-A3**; raw abandoned mine discharge that emanates from a pipe near the park road and flows into BP4 VFW #1; Inflow on the southern side of the system	40.463448, -79.748097
BP4 VFW #1	AKA **281-B3**; effluent of the first vertical flow pond on the southern side of the system; receives the BP4 RAW discharge	40.463695, -79.748287
BP4 Pond #1	AKA **281-C2**; effluent of the first settling pond on the southern side of the system; receives influent from BP4 VFW #1	40.463717, -79.748744
BP4 VFW #2	AKA **281-D1**; effluent of the second vertical flow pond on the southern side of the system; receives influent from BP4 Pond #1.	40.463902, -79.748940
BP4 Pond #2	AKA **281-E1**; second settling pond and last pond in series on southern BP4 side; receives influent from BP4 VFW#2 and flows into the system's final wetland	40.464158, -79.749155
BP3 RAW	AKA **281-A1**; abandoned mine discharge emanates on hillside and flows out a culvert pipe to BP3-VFW; one of two inflows on the northern end of the system	40.464840, -79.750149
BP3 VFW	AKA **281-B1**; effluent of the BP3-VFW that empties into the large BP2/BP3 settling pond	40.464809, -79.749880
BP2 RAW	AKA **281-A2**; abandoned mine discharge that emanates near park road and flows into a limestone pond; One of the two inflows on the northern end of the system	40.465137, -79.749740
BP2 Siphon	AKA **281-B2**; effluent of the siphon-based, auto-flushing limestone pond that receives the BP2 RAW discharge and flows into BP2/BP3 settling pond. Can only be sampled when the actively flushing	40.464986, -79.749567
BP2/BP3 Pond	AKA **281-C1**; Effluent of the large settling pond located in the middle of the system that receives flow from BP2 and BP3 components; flows into the final wetland	40.464219, -79.749310
SYS Out	AKA **281-F**; Effluent of the final wetland and final effluent of the Boyce Park passive treatment system	40.463623, -79.749067

Table 2: Monitoring results at Boyce Park on 5/19/2021 prior to maintenance

Sample Point	Flow	Field pH	Lab pH	Field Temp	Sp. Cond	Lab Alk	Acidity	T. Fe	T. Mn	SO4	TSS
BP4 RAW	2.7	1.93	3.09	13.3	1,336	0	266	3.48	1.21	464	<5
BP4 VFW #1	NM										
BP4 Pond #1	NM										
BP4 VFW #2	NM										
BP4 Pond #2	8.7	--	4.12	--	1,279	0	161	0.64	1.21	415	<5
BP3 RAW	8.4	2.28	3.41	12.9	887	0	76	0.99	0.41	327	<5
BP3 VFW	35.4	2.58	3.52	16.6	866	0	69	0.92	0.47	327	<5
BP2 RAW	6.4	2.84	4.44	12.9	848	0	79	0.43	0.56	395	22
BP2 Siphon	NM										
BP2/BP3 Pond	61.8	4.19	5.11	19.6	812	3	13	0.25	0.42	305	6
SYS OUT	--	4.09	4.82	22.2	894	2	28	0.17	0.66	329	<5

Units for all flow measurements are in gpm, temperature in degrees Celsius, specific conductivity are in µmhos/cm, and all units for alkalinity, acidity, metals, sulfate, and total suspended solids (TSS) are in mg/L. NM – Not Monitored or Measured

Table 3: Monitoring results at Boyce Park on 4/8/2024 after maintenance but following extreme precipitation

Sample Point	Est. Flow	Meas Flow	Lab pH	Sp. Cond	Lab Alk	Field Alk	Acidity	T. Fe	T. Mn	T. Al	SO4	TSS
BP4 RAW	50	50	2.96	1,862	<0.1	0	630	8.25	2.21	82.49	997	<5
BP4 VFW #1	NM	NM										
BP4 Pond #1	NM	NM										
BP4 VFW #2	NM	NM										
BP4 Pond #2	45	45	3.83	1,501	<0.1	0	397	3.42	2.49	57.11	806	<5
BP3 RAW	*>200	*340	3.10	1,289	<0.1	0	200	3.01	1.02	22.30	514	<5
BP3 VFW	**>200	340	3.48	1,132	<0.1	0	155	2.34	0.96	19.55	569	8
BP2 RAW	underwater		3.56	1,374	<0.1	0	356	0.90	1.47	52.54	746	<5
BP2 Siphon	NM	NM										
BP2/BP3 Pond	**>200	*340	4.14	1,002	<0.1	0	111	1.27	0.83	12.95	511	<5
SYS OUT	**>200	390	4.35	1,106	<0.1	0	151	1.13	1.22	22.14	586	5

Units for all flow measurements are in gpm, specific conductivity are in µmhos/cm, and all units for alkalinity, acidity, metals, sulfate, and total suspended solids (TSS) are in mg/L. Flow values with an asterisk are used to indicate an assumed or estimated flow based upon measurements made in other locations, while flow values with two asterisks indicate the flow was difficult to impossible to determine due to extremely high flows and overflowing ponds in some locations. NM – Not Monitored or Measured

Table 4: Monitoring results at Boyce Park on 12/17/2024 after maintenance during a low flow period

Sample Point	Flow	Field pH	Lab pH	Field ORP	Field Temp	Sp. Cond	Field Alk	Lab Alk	Acidity	T. Fe	T. Mn	T. Al	SO4	TSS
BP4 RAW	1.5	4.16	4.31	401	9.2	1,808	0	<0.1	50	0.75	0.79	24.47	540	14
BP4 VFW #1	*5.3	5.23	4.82	383	8.3	1,839	3	2	28	0.57	0.42	9.92	420	57
BP4 Pond #1	NM													
BP4 VFW #2	*5.3	6.76	6.92	236	7.5	1,535	29	30	-16	0.24	1.07	0.28	430	24
BP4 Pond #2	5.3	7.13	7.16	234	8.1	1,501	41	37	-23	0.18	0.78	0.24	385	16
BP3 RAW	*8	3.73	3.67	455	9.7	927	0	<0.1	40	0.50	0.49	7.49	388	10
BP3 VFW	8	6.88	7.45	257	7.3	1,148	89	87	-72	<0.10	<0.05	<0.10	303	10
BP2 RAW	12	6.10	5.96	255	10.9	1,151	30	31	-26	<0.10	0.15	1.67	318	24
BP2 Siphon	NM													
BP2/BP3 Pond	20	7.76	7.68	227	6.9	1,087	95	86	-72	<0.10	<0.05	<0.10	296	8
SYS OUT	35	7.85	7.56	229	8.9	1,252	79	74	-60	<0.10	0.08	<0.10	125	12

Units for all flow measurements are in gpm, oxidation-reduction potential (ORP) in millivolts (mV), temperature in degrees Celsius, specific conductivity are in µmhos/cm, and all units for alkalinity, acidity, metals, sulfate, and total suspended solids (TSS) are in mg/L. Flow values with an asterisk are used to indicate an assumed or estimated flow based upon measurements made in other locations. NM – Not Monitored or Measured

Table 5: Monitoring results at Boyce Park on 5/6/2025 after maintenance during moderate to high flow

Sample Point	Flow	Field pH	Lab pH	Field ORP	Field Temp	Sp. Cond	Field Alk	Lab Alk	Acidity	T. Fe	T. Mn	T. Al	SO4	TSS
BP4 RAW	15	3.06	3.18	517	12.8	1,420	0	<10	290	3.35	1.00	43.60	724	< 5
BP4 VFW #1	5	3.99	3.90		13.5	1,290	0	<10	210	2.06	0.87	36.50	684	5
BP4 Pond #1	NM													
BP4 VFW #2		4.53	4.40	303	18.0	1,390	0	<10	95	0.19	0.95	19.40	625	9
BP4 Pond #2	19	5.53	4.39	283	16.1	1,380	1	<10	100	0.15	0.96	18.10	567	6
BP3 RAW	*59	3.51	4.46	329	12.9	888	0	<10	12	1.32	0.43	12.20	406	< 5
BP3 VFW	59	4.61	4.59	317	14.0	904	0	<10	48	0.76	0.37	9.00	368	11
BP2 RAW	stagnant	4.39	4.29	342	12.3	1,030	0	<10	110	0.31	0.53	18.80	470	< 5
BP2 Siphon	NM													
BP2/BP3 Pond	61	4.48	4.86	294	18.1	901	0	<10	21	0.13	0.43	3.40	359	7
SYS OUT	105	5.60	6.04	225	16.0	1,040	2	<10	8	0.09	0.50	2.00	340	7

Units for all flow measurements are in gpm, oxidation-reduction potential (ORP) in millivolts (mV), temperature in degrees Celsius, specific conductivity are in µmhos/cm, and all units for alkalinity, acidity, metals, sulfate, and total suspended solids (TSS) are in mg/L. Flow values with an asterisk are used to indicate an assumed or estimated flow based upon measurements made in other locations. NM – Not Monitored or Measured

Recommendations & Future Considerations: Most of the post-maintenance water monitoring was conducted during periods of high flow that were greater than the indicated design parameter. On-going water monitoring and site inspections should continue to document system performance and identify maintenance issues. An updated regular maintenance schedule "Boyce Park AMD System Maintenance" document should be followed by park staff and is available on www.datashed.org. As the system is now 17 years old and monitoring indicates it is not able to fully treat higher flow events, there will likely be a need in the not-too-distant future to consider beginning the process of seeking funding to redesign and then rebuild the treatment system. It is important to keep in mind that this process will take several years from the decision to seek funding until construction is complete. This process could be started earlier if the group is not happy about the current treatment performance. Depending on the funding source utilized, the DEP may require monthly monitoring for one year prior to completion of the design. It is imperative that both chemistry and flow are measured throughout the system for use in the design process and should probably include investigations into other sources of water entering the system. DEP will likely also want to see water monitoring of the stream to demonstrate the "value" of the system. The understanding of AMD chemistry as well as treatment techniques has evolved since the Boyce system was originally constructed and should be considered for the next version of the treatment system. For example, converting the BP2 siphon-based limestone bed to one that uses an Agri Drain SmartDrain would likely improve treatment performance. During the design phase, there should be consideration of washing and reusing the existing limestone within the system as much as possible or could potentially be used by the park where needed.

Photo Log

Top: BP3-VFW filling with water after stone cleaning and underdrain improvements (8/9/23).
Bottom Left: BP3-VFW riser outlet and valve installed (8/11/23).
Bottom Right: BP3-VFW raw water inlet box cleared of roots and debris (8/11/23).

Top Left: Washing stone in BP2 autoflusher (7/19/23).
Top Right: BP3-VFW underdrain pipes exposed during stone cleaning (8/2/23).
Bottom Left: BP2 autoflusher after washing and stone added (8/11/2023).
Bottom Right: BP2 raw water inlet pool added for flow measurements (8/11/23).

Top Left: Test pit to evaluated condition of treatment media in BP4-VF#1 (7/11/23).
Top Right: Flushing and washing BP4-VFW#2 (8/10/23).
Bottom Left: BP4-VF#1 after maintenance completed (8/11/2023).
Bottom Right: After excavation, BP4-VFW#2 flush valve was cleaned exercised (8/4/23).