BIG RUN ABANDONED MINE DRAINAGE TREATMENT SYSTEMS: CURRENT STATUS AND IMPROVEMENT RECOMMENDATIONS TECHNICAL REPORT

PREPARED BY

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SCOPE OF WORK

Skelly and Loy, Inc. prepared this document to provide background information on Norfolk Southern and Blackleggs Creek Watershed Association's (BCWA) Big Run sub-watershed mine drainage remediation projects as well as to provide representative data to understand the progress and success of the site. The project targets a 4.4-mile segment of Blacklegs Creek downstream from the confluence with Big Run. In order for the project to be a success, this segment must be eligible for removal from the Department of Environmental Protection's (PA DEP) impaired streams list [United States Environmental Protection Agency {U.S. EPA} 303(d) listing]. The timing for the delisting was originally set for 2012. However, construction and corrective action required the project to delay functionality until 2013. Therefore, BCWA and the PA DEP continue to work together to improve the system challenges as they occur. Finally, recommendations to resolve current system functions will be provided near the end of this document for consideration by the project partners and funding agencies.

HISTORICAL INFORMATION

The Blacklegs Creek watershed drains 45 square miles and is located primarily in southwestern Indiana County, Pennsylvania, and is the first tributary to drain into the Kiskiminetas River. It has 52 abandoned mine drainage (AMD) discharges in only 100 miles of stream. The BCWA's (established circa 1986) mission is to restore the Blacklegs Creek watershed to its natural condition so that it may support a healthy aquatic habitat from the headwaters to its confluence within the Kiskiminetas River watershed. To meet this mission, multiple AMD treatment systems were constructed throughout the watershed to help to remediate the AMD impacts. One such area targeted for AMD treatment is a tributary of Blacklegs Creek named Big Run, where a multiple phase restoration plan is complete with the exception of some needed improvements to some of the constructed treatment systems. The final Big Run Phase IV treatment system, referred to as Big Run #3, was completed in October 2013 including the delivery and addition of hydrated lime material to conclude the remediation efforts of four large AMD discharges to the Big Run sub-watershed. Funding for the multi-phase project was provided by sources including the Growing Green Program, Office of Surface Mining Clean Streams Initiative Program, U.S. EPA Section 319 Non-Point Source Management Program, Norfolk Southern Railway Company, Foundation for PA Watersheds, and a variety of other partners.

SITE DESCRIPTION

Big Run is an 8.7-square-mile sub-watershed of Blacklegs Creek. The Big Run AMD remediation project consists of four chronological phases: Phase I (Big Run #2 passive AMD treatment system), Phase II (Big Run #7 passive AMD treatment system), Phase III (Big Run #8 passive AMD treatment system), and Phase IV (Big Run #3 semi-active AMD treatment system). Work has been completed for Phase I (2003) and Phase II (2006), with some improvements and modifications to the Phase I Big Run #2 system including the cleaning/ stirring of the existing limestone, addition of limestone to handle the higher-than-anticipated flows, and experimental use of baffles recommended by PA DEP for use in the limestone bed (2007-2008). The Big Run #7 Phase II passive AMD treatment system required stirring and cleaning of the limestone in the limestone pond to maximize treatment efficiency and permeability. Phase III Big Run #8 was constructed in 2010 and the limestone material in Pond 1 has been stirred at least once since construction. Phase IV consists of a semi-active system where additional pH adjustment and alkalinity is imparted via a water-powered tipping bucket using hydrated lime from a 70-ton silo unit to the passively pre-treated #7 and #8 and raw #7A combined discharges prior to discharge into Big Run to account for the untreated Big Run #3. The Big Run #3 AMD discharge located upstream of the treatment systems must be treated in-stream since the source cannot be accessed due to property owner restrictions. The Phase IV project was completed in 2013 with lime not officially added until late October 2013. Figure 1 illustrates a snapshot of the location of each treatment system relative to Big Run and Blacklegs Creek. A complete 7.5-minute USGS quadrangle of the area, noted as Figure 7, is located at the end of this report.

The Big Run #2, #7, and #8 AMD treatment systems all use passive treatment incorporating the use of high calcium carbonate limestone to impart alkalinity to the high flow net acidic AMD sources within large limestone beds followed by settling ponds/wetlands for capturing and settling the precipitated iron, aluminum, and manganese. Each limestone bed has the ability to be flushed using manual flushing structures to periodically remove accumulated metal precipitates from the limestone void spaces and prolong the effective treatment of the limestone material.

The Phase I Big Run #2 system is a stand-alone treatment system that has an independent discharge to Big Run and consists of a vertical stand pipe that distributes the raw AMD into a horizontal flow limestone pond. The water then flows through piping connected to an in-line water level control structure and into a polishing wetland. The wetland outlet enters

Big Run directly upstream of the other treatment systems. The Phase II Big Run #7 system remediates an AMD discharge that emanates from a visible, but securely closed, abandoned mine entry using a wet mine seal. Piping was installed back into the entry to collect the AMD and convey it under Big Run to a large open limestone bed. After a contact time determined by flow and water level using an in-line water level control structure, the water is output to a long and narrow settling pond with floating baffles that outfalls through a culvert to the lime addition location of the Phase IV system. The Phase III Big Run #8 system consists of an open limestone bed, a settling pond followed by a second open limestone bed hydraulically connected to a piping system that delivers the output to the Phase IV system. During construction of the Big Run #8 treatment system, a new AMD discharge was discovered and referred to as the #7A AMD discharge. The #7A AMD discharge was captured and combined with the Big Run #8 system outfall to the Big Run #3 system for treatment rather than bypassing it directly into Big Run. However, this caused a higher design flow and higher construction and treatment costs for the Big Run #3 and #8 systems. The Big Run #8 AMD discharge originates in a subsurface tunnel from abandoned underground mine workings that directly discharge into Big Run and required the use of an elaborate wet mine seal structure and hydraulic control system with valves and standpipes to back up the AMD in the tunnel and workings in order to convey the AMD into the available area for providing passive treatment referred to as the Big Run #8 system.

The Phase IV Big Run #3 remediation system utilizes semi-active treatment and is designed to provide an efficient means to add alkalinity to the Big Run watershed. Utilizing the outfalls from the Big Run #7, #7A, and #8 systems as a pathway for additional alkalinity will compensate for the inability to capture and treat the net acidic Big Run #3 discharge outside of the Big Run stream. Additionally, in times of high flow, each of the four major discharges (Big Run #2, #3, #7, and #8) vary greatly in flow rates, taxing existing passive treatment systems and allowing for untreated AMD to directly enter Big Run. The Phase IV Big Run #3 system provides for the addition of alkalinity accomplished in a manner that does not add the alkaline material directly to the stream but helps to ensure net alkaline conditions in the stream with the ability to add excess alkalinity as needed during high flow periods to the majority of AMD sources (Big Run #7, 7A, and 8). This not only addresses the Big Run #3 discharge but assists the watershed as well as two of the three existing systems with the treatment of their discharges during times of high flow and is explained below.

The outfalls from #7, #8, and untreated #7A operate a water-driven tipping bucket attached to a storage silo that feeds hydrated lime [$Ca(OH)_2$] into the water. The lime dissolves in the combined #7, #8, and #7A effluents within a 300-linear-foot rock-lined mixing channel, secondly though a large settling pond with a floating baffle followed by a large polishing wetland prior to final discharge into Big Run. Several design aspects have been incorporated into the Big Run #3 project to maximize mixing efficiencies to dissolve the lime material and promote ease of maintenance for the system components. The settling basin incorporates a deep entry area to promote settling of any precipitates followed by a floating baffle to reduce velocities and allow the water additional time to enhance alkalinity addition and metals precipitation. The polishing wetland prepares the water for final discharge to Big Run by removing nearly all of the precipitated metals/suspended solids.

FIGURE 1
BIG RUN TREATMENT SYSTEM LOCATIONS – NOTE: BL15 IS NOTED AS "BR BEFORE TREATMENT SYSTEMS" AND BL10 IS NOTED AS "BR DOWNSTREAM OF ALL TREATED DISCHARGES"

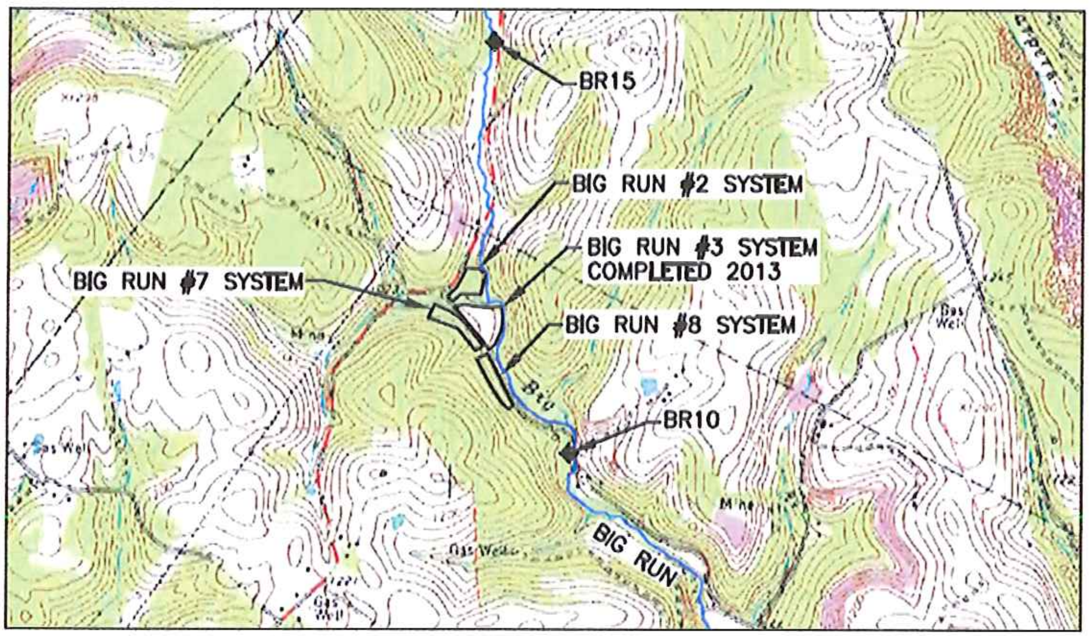
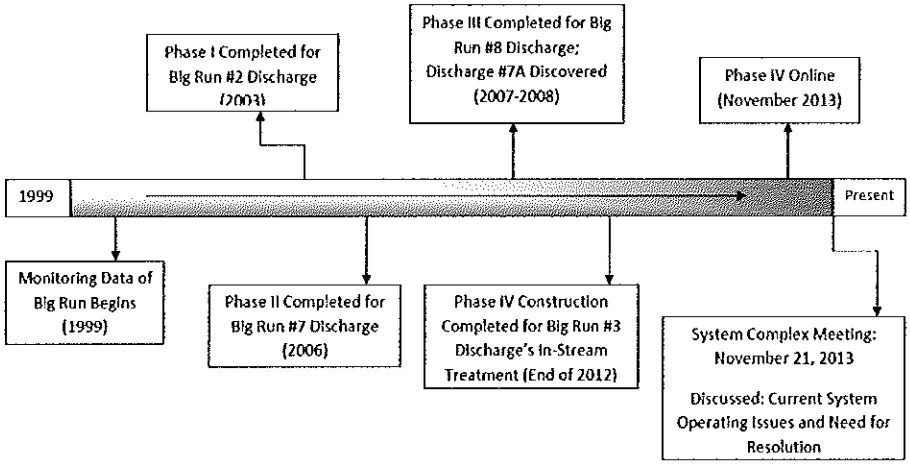


FIGURE 2
TIMELINE OF BIG RUN TREATMENT SYSTEMS



CURRENT CONDITIONS AND EFFORTS

Now that the Phase IV Big Run #3 treatment system is entirely online and working efficiently based on the first round of water samples in November 2013, it requires frequent and somewhat extensive maintenance. Maintenance of the system is led by Mr. Art Grguric of Wetland Construction, a subcontractor in direct coordination with BCWA. Mr. Grguric brought up the need for system improvements in a November 21, 2013, site meeting with all project partners involved with the treatment systems. The main challenge lies within the Big Run #8 system due to large amounts of precipitation and clogging of the first open limestone bed by aluminum and iron precipitates. The bed has a flushing system but, due to metals precipitation and rapid clogging, the flushing must occur on a more regular basis than the design originally intended. Additionally, the flushing capacity is limited by the minimal elevation gradient between the ponds in the Big Run #8 system. To maintain the treatment system efficiency, the limestone in the bed has been washed and stirred after less than one year of continuous use. Comparatively, this action should not be needed for at least more than one year. The clogging of the Big Run #8 system limestone ponds acts similar to a domino effect, raising the water level in the mine workings and producing a higher flow to discharge through Big Run #7 causing additional performance issues and creating excessive loading beyond the design criteria for the Big Run #7 limestone pond.

Lastly, but less severe, Mr. Grguric mentioned that two valves within the Big Run #2 and #8 systems are in need of repair. One valve, located within the Big Run #2 system, is to be fixed with Growing Greener grant money in 2014. The second valve controlling the mine seal in the Big Run #8 system during times of high flow could potentially be eligible for WPCAMR Quick Response funds according to representatives at the November 21, 2013, meeting.

COLLECTED DATA SUMMARY

Water Quality

According to the site's permitting requirements, BCWA is responsible for quarterly monitoring of the system (water quality only), lower Big Run, and the lower 4.4 miles of Blacklegs Creek for a minimum of 5 years after construction is complete, which started in 2013. Water quality summarized below was collected by the Kiski-Conemaugh Stream Team (Stream Team) and members of BCWA.

TABLE 1
BIG RUN AT MOUTH

DATE	PH	COND. US/CM	ALK. MG/L $CACO_3$	TOTAL IRON MG/L	FERROUS IRON MG/L	TOTAL MN MG/L	TOTAL ACIDITY	TOTAL AL MG/L	FLOW GPM
4/29/2005	4.6		9.2	2.3		1.8	50.2	7.9	Normal
10/6/2005	4.1		4.8	2.8		2.1	119	10.3	Normal
6/27/2006	5.7		10.2	2		1.2	9	4.5	High
5/18/2008	6.9		20.6	2.1	0.9	1.3	-1.8	3.9	Normal
5/3/2009	5.7		8.2	2.9	1.48	1.95	20.8	5.523	Normal
5/3/2010	4.7		8.8	2.9		1.93	40.2	6.911	Normal
5/2/2011	4.6	961	9.4	1.9	0.66	1.77	30.8	7.01	Normal
6/26/2012	4.6	1031	8.6	2.3		2.21	37.8	7.132	Normal
8/8/2012	4.9		8.6	2.7		1.79	24.4	4.805	Normal
10/28/2012	4.9	982	9	3.3		2.12	7.8	5.178	Normal
1/14/2013	7.2	614	35.6	0.7		0.68	-25	1.517	High
4/17/2013	6.96	583	41	2.8		0.75	-30.6	4.393	High
7/23/2013	6	790	2.2	1.8		1.65	1.6	4.623	
10/21/2013	7.1	700	32.4	2.4		1.76	-0.4	3.938	
AVG =	5.6	808.7	14.9	2.3	1.01	1.64	20.3	5.5	Not Measured
N =	14	7	14	14	3	14	14	14	

TABLE 2
BIG RUN ABOVE AMD TREATMENT SYSTEMS/DISCHARGES

DATE	PH	COND. US/CM	ALK. MG/L $CACO_3$	TOTAL IRON MG/L	FERROUS IRON MG/L	TOTAL MN MG/L	TOTAL ACIDITY	TOTAL AL MG/L	FLOW GPM
4/29/2005	7.5		86	0.6		0.6	-69	<.5	Normal
10/6/2005	7.8		137.4	0.4		0.2	-81	<.5	Normal
6/27/2006	6.6		66	0.7		0.3	-52	<.5	High
5/18/2008	7		77	0.7	0.1	0.5	-60.8	<.2	Normal
5/3/2009	6.7		90.2	0.5	0.08	0.60	-76.2	<.2	Normal
5/3/2010	7.4		73	0.6		0.30	-57.2	<.2	
5/2/2011	6.9	1095	82	0.4	0.07	0.40	-69.6	<.2	Normal
6/26/2012	7.9	1063	80.4	0.7		0.38	-69	<.2	Low
8/8/2012	8		99.6	0.3		0.14	-93.4	<.2	Low
10/28/2012	8	970	131.6	0.5		0.20	-127	<.2	Low
1/14/2013	7.5	464	50.8	0.5		0.12	-45.4	0.221	High
4/17/2013	7.4	453	53.6	3.7		0.31	-43	5.005	High
7/23/2013	8	930	109	<.300		0.12	-78.8	<.500	
10/21/2013	7.6	578	88.2	0.8		0.34	-36.6	<.500	
AVG	7.5	793.3	87.5	0.74	0.08	0.32	-68.5	0.373	Not Measured
N =	14	7	14	14	3	14	14	14	

TABLE 3
BIG RUN #2 RAW DISCHARGE AND SYSTEM OUTFALL

		PH	COND. US/CM	ALK. MG/L $CACO_3$	TOTAL IRON MG/L	FERROUS IRON MG/L	TOTAL MN MG/L	TOTAL ACIDITY	TOTAL AL MG/L	FLOW GPM
Raw 1999-2013	Avg.	5.3	1012.3	16.7	2.56	2.42	1.79	14.4	3.91	2240.3
	N =	62	48	60	59	39	47	43	47	12
Outfall 2004-2013	Avg.	6.2	1093.8	56.1	1.75	1.29	1.59	-34.5	2.13	1585.2
	N =	41	29	39	40	33	36	32	38	11

TABLE 4
BIG RUN #7 RAW DISCHARGE AND SYSTEM OUTFALL

		PH	COND. US/CM	ALK. MG/L $CACO_3$	TOTAL IRON MG/L	FERROUS IRON MG/L	TOTAL MN MG/L	TOTAL ACIDITY	TOTAL AL MG/L	FLOW GPM
Raw 1999-2013	Avg.	3.3	1135.6	0	2.57	0.48	2.89	157.6	17.4	1580.4
	N =	64	53	62	62	46	56	46	54	33
Outfall 2006-2013	Avg.	5.6	901.7	71.6	0.60	0.27	2.26	-13.5	7.61	Not Measured
	N =	10	9	10	10	8	9	10	10	

TABLE 5
BIG RUN #8 RAW DISCHARGE AND SYSTEM OUTFALL

		PH	COND. US/CM	ALK. MG/L $CACO_3$	TOTAL IRON MG/L	FERROUS IRON MG/L	TOTAL MN MG/L	TOTAL ACIDITY	TOTAL AL MG/L	FLOW GPM
Raw 1999-2013	Avg.	3.1	1364.9	0	18.1	11.40	3.39	256.1	25.1	826.6
	N =	45	34	43	41	25	35	29	36	8
Outfall 2010-2013	Avg.	6.8	1294	135	<0.3	0.04	3.08	-112.4	0.47	Not Measured
	N =	5	4	5	5	3	4	5	5	

TABLE 6
WATER QUALITY EFFECT OF #7A ON #8 AT THEIR CONFLUENCE

		PH	COND. US/CM	ALK. MG/L $CACO_3$	TOTAL IRON MG/L	FERROUS IRON MG/L	TOTAL MN MG/L	TOTAL ACIDITY	TOTAL AL MG/L	FLOW GPM
#8 Outfall 2010-2013	Avg.	6.8	1294	135	<0.3	0.04	3.08	-112.4	0.47	Not Mea-sured
	N =	5	5	5	5	3	4	5	5	
#7A with #8 Outfall 2010-2013	Avg.	5.5	858.4	24.5	<0.3	0.07	1.82	-2.7	4.9	Not Mea-sured
	N =	8	8	7	8	7	6	8	8	

TABLE 7
BIG RUN #3 INFLUENT, TEMPORARY, AND FINAL OUTFALLS TO BIG RUN

		PH	COND. US/CM	ALK. MG/L $CACO_3$	TOTAL IRON MG/L	FERROUS IRON MG/L	TOTAL MN MG/L	TOTAL ACIDITY	TOTAL AL MG/L	FLOW GPM
#7 Outfall 2006-2013	Avg.	5.4	901.7	61.3	0.67	0.27	2.26	-2.4	8.3	Not Measured
	N =	9	9	9	9	8	9	9	9	
#7A with #8 2010-2013	Avg.	5.4	828.3	18.3	<0.3	0.07	1.82	2.3	5.3	Not Measured
	N =	7	7	6	7	7	6	7	7	
#3 Temp Outfall 2013	Avg.	5.1	711.6	64.8	<0.3	0.03	0.97	13.3	3.8	Not Measured
	N =	5	5	6	6	6	6	6	6	
#3 Final Outfall 2013	Avg.	6.7	1058	59	<0.3	0.03	0.97	-51	<0.5	Not Measured
	N =	1	1	1	1	1	1	1	1	

The #3 Temp Outfall is the outfall from the inline structure in the large Settling Pond that is a bypass from entering the final polishing wetland prior to the start of lime addition in Nov. 2013.

TABLE 8
AVERAGES OF BIG RUN MOUTH COMPARED TO SYSTEM FINAL OUTFALLS INTO BIG RUN AND BIG RUN DOWNSTREAM OF ALL TREATED DISCHARGES

		PH	COND. US/CM	ALK. MG/L $CACO_3$	TOTAL IRON MG/L	FERROUS IRON MG/L	TOTAL MN MG/L	TOTAL ACIDITY	TOTAL AL MG/L	FLOW GPM
BR Mouth (2005-13)	Avg.	5.6	808.7	14.9	2.4	1.01	1.64	20.3	5.6	Not Measured
	N =	14	7	14	14	3	14	14	14	
Big Run #2 (Phase I) Final Outfall (2004-13)	Avg.	6.2	1093.8	56.1	1.75	1.29	1.59	-34.5	2.1	1585.2
	N =	41	29	39	40	33	36	32	38	11
Big Run #3 (Phase IV)Final Outfall 2013	Avg.	6.7	1058	59	<0.3	0.03	0.97	-51	<0.5	Not Measured
	N =	1	1	1	1	1	1	1	1	
BR#10: Big Run DS of Treatment (2004-13)	Avg.	5	1006.8	9	3.3	1.65	2.13	35.6	6.9	8266
	N =	101	87	98	99	80	90	49	81	39

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TABLE 9
WATER QUALITY DATA FOR BLACKLEGS CREEK ABOVE AND BELOW BIG RUN CONFLUENCE

		PH	COND. US/CM	ALK. MG/L $CACO_3$	TOTAL IRON MG/L	FERROUS IRON MG/L	TOTAL MN MG/L	TOTAL AL MG/L
Upstream of Big Run (2000-2011)	Avg.	7.41	612.80	81.60	0.45	0.10	0.78	0.77
	N =	11	5	11	9	6	11	8
Downstream of Big Run (2005-2011)	Avg.	6.88	657.00	60.86	0.91	0.12	0.97	1.75
	N =	7	1	7	6	3	7	7

FIGURE 3
pH TREND OF BLACKLEGS CREEK WITH RESPECT TO BIG RUN CONFLUENCE

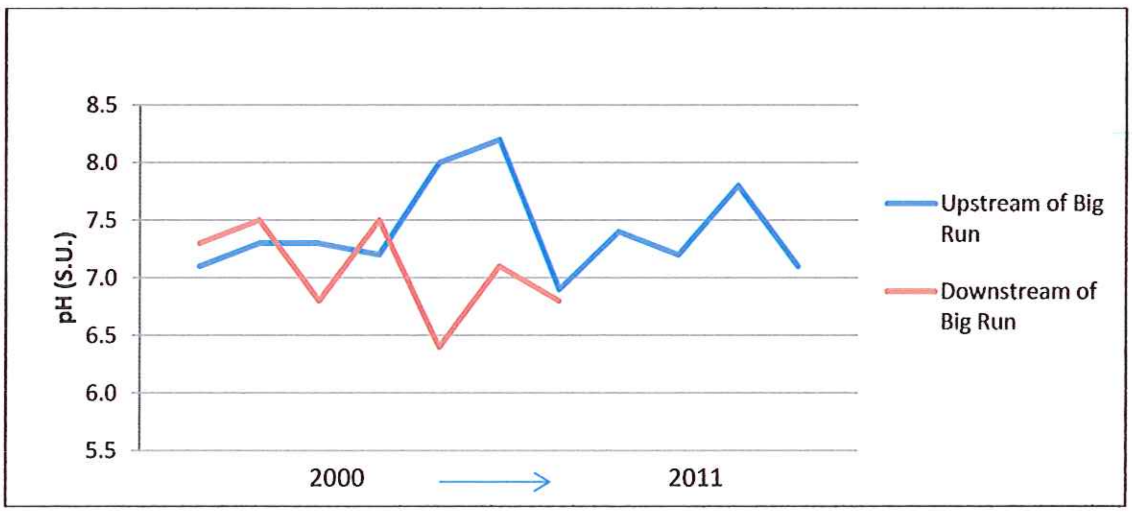


FIGURE 4
ALKALINITY TREND OF BLACKLEGS CREEK WITH RESPECT TO BIG RUN CONFLUENCE

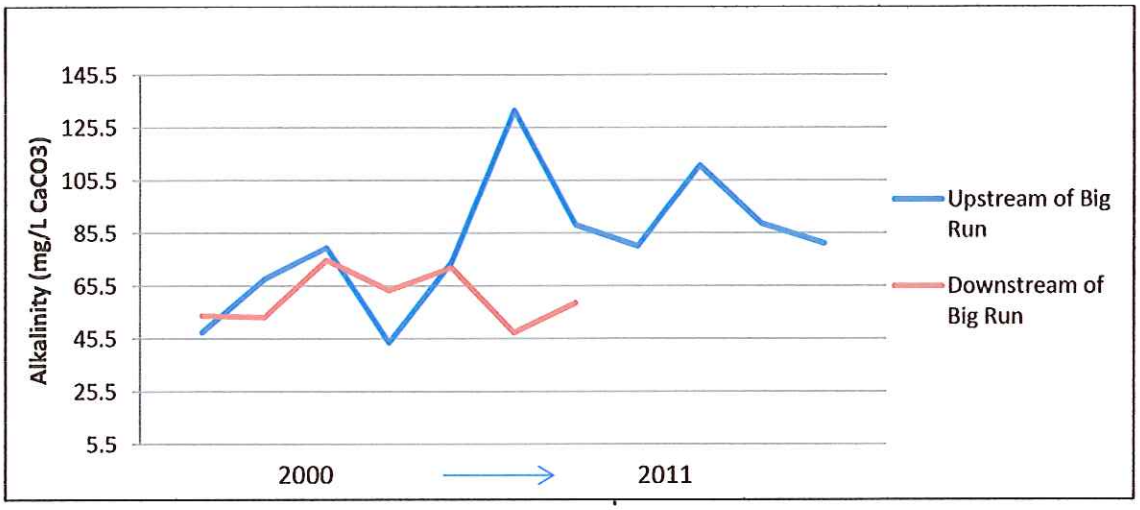


FIGURE 5
ALUMINUM TREND OF BLACKLEGS CREEK WITH RESPECT TO BIG RUN CONFLUENCE

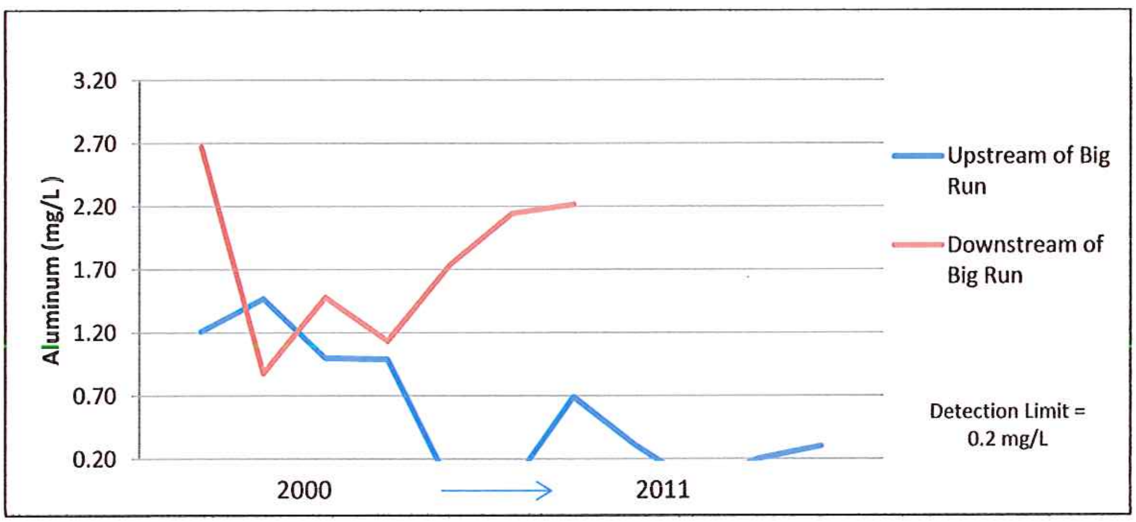
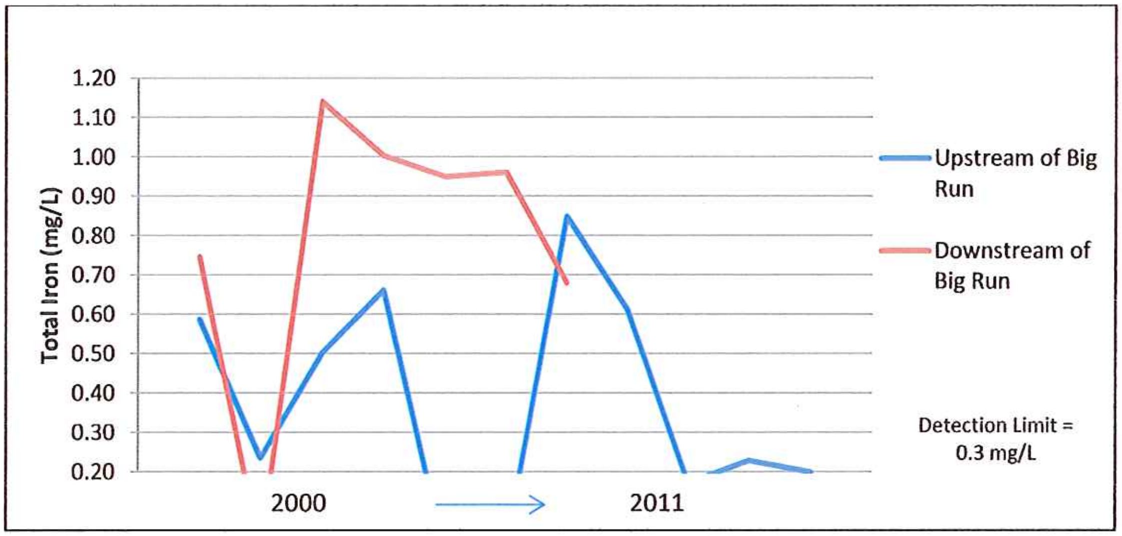


FIGURE 6
IRON TREND OF BLACKLEGS CREEK WITH RESPECT TO BIG RUN CONFLUENCE



Benthic Macroinvertebrates and Fish

PA DEP conducted a fish survey in September 2013 at three locations in Big Run and two locations in Blacklegs Creek, one upstream and one downstream of the Big Run confluence. Some fish were found in Big Run upstream of the treatment systems, and no fish were found in Big Run at the mouth. Both locations in Blacklegs Creek, upstream and downstream of Big Run, had reasonable numbers of fish species with a few more found upstream of the confluence. In the Spring of 2013, the Stream Team and Mr. Grguric performed a macroinvertebrate sampling using protocol provided by PA DEP; however, these samples were not accepted (processed for species identification) by the corresponding PA DEP personnel. Other than the sampling performed in the Spring of 2013, a complete benthic macroinvertebrate survey has not been performed on Big Run or Blacklegs Creek since 2005. The Stream Team has indicated that they will perform a biological survey at the historic locations in Big Run and Blacklegs Creek on behalf of BCWA in the Spring of 2014 to assess the full operation of the treatment systems in the Big Run watershed.

DATA DISCUSSION

The BCWA, through an arrangement with the Stream Team, has historically conducted a long-term monitoring plan for all of the identified AMD sources and treatment system outfalls since the watershed assessment and systems construction was started in 2004 (Big Run systems). This monitoring program has involved the collection of field water quality data, flow measurements (when feasible but very difficult with such high flow AMD discharges), and water samples for analysis by PA DEP. These data have provided valuable information necessary to assess the AMD sources and the treatment systems' design and performance. In addition, sample locations were established in Big Run and Blacklegs Creek to establish the baseline conditions in the streams prior to the implementation of the treatment systems and the improvements realized as each system was completed starting in 2004 with Big Run #2 and ending in 2013 with the startup of the Big Run #3 semi-active treatment system using hydrated lime addition into the outfalls of the Big Run #7 and #8 passive systems.

Big Run upstream of the AMD sources and treatment systems displays extremely good water quality with pH levels averaging 7.5, hot acidity averaging -68.5 mg/L indicating net alkaline conditions, and very low levels of iron and aluminum both averaging less that 1.0 mg/L (refer to Tables 1 and 2). However, the five primary AMD sources, #2, #3, #7, #7A, and #8, all provide significant loading of AMD pollutants into Big Run and have historically impaired the stream to its mouth and confluence with Blacklegs Creek. The Big Run #2 passive treatment system is the only one to have remained in operation since its construction in 2004 providing some remediation of this high flow source and the stream since that time. The Big Run #2 system on average removes approximately 30% of the iron and 50% of the aluminum in the AMD and provides net alkaline water to Big Run with pH levels averaging greater than 6.0 (see Table 3). The Big Run #7 AMD source was passively treated for several years following construction completion in 2006. To construct the Big Run #8 and #3 treatment systems, the Big Run #7 system was not in operation in order to bypass the AMD around the various work areas, which resulted in limited data for the final outfall of the system. The Big Run #7 final system outfall data indicate that, after a few years of operation, in 2008 the system was not performing as anticipated. After some O&M activities and the completion of the Big Run #8 system and a majority of the Big Run #3 system, the system was placed back into operation for nearly all of 2013. The water quality of the final outfall of the Big Run #7 system in 2013 was greatly improved since the system was typically removing more than 75% of the iron and greater than 50% of the aluminum and generating net alkaline water with pH levels greater than 6.0 (see Table 4). The addition of the Big Run #3 system that went online in 2013 will serve as tertiary treatment for the Big Run #7 AMD during periods of high flow and when the passive system is in need of maintenance.

The Big Run #8 passive AMD treatment system was operated a brief period of time following the completion of its construction in 2010, but then in 2013 it was operated nearly the entire year and allowed for water quality measurements of the system outfall. The collected data indicate that the passive treatment system was able to remove nearly all of the iron and aluminum levels to less than 1.0 mg/L and to generate net alkaline water with pH levels averaging 6.8 (see Table 5). This level of contaminant and loading reduction from an AMD discharge historically averaging 825 gallons per minute (gpm) is important for the restoration of Big Run and with the addition of the Big Run #3 system to serve as tertiary treatment for Big Run #8 during high flow periods and when the passive system requires maintenance. During the construction of the Big Run #8 treatment system, the Big Run #7A was encountered and measured and a collection system was installed to bypass the AMD around the Big Run #8 system because of contaminant overloading concerns. The Big Run #7A AMD was hydraulically connected and mixed with the final outfall of the Big Run #8 system just upstream of the Big Run #3 treatment system tipping bucket and lime addition structure. The effect of the raw Big Run #7A AMD on the Big Run #8 system outfall water quality is considerable with the increase in aluminum levels to 4.9 mg/L, change from net alkaline to net neutral, and average pH reduced from 6.7 to 5.6 (see Table 6).

The Big Run #3 semi-active treatment system was substantially completed in early 2013 and was allowed to receive the outfalls of the Big Run #7 and #8 (and raw #7A) treatment systems; however, lime material was not available for addition to the water. During this time period, the water was allowed to enter the first pond, a large settling pond, and then discharged to the Big Run #7 bypass channel and into Big Run. Water quality of the outfall from the settling pond to Big Run was monitored five times in 2013 to assess the combined outfalls from the Big Run #7 and Big Run #8 treatment systems and the raw #7A AMD after plenty of aeration and settling in a portion of the Big Run #3 system basins without lime addition. In October 2013, BCWA was able to purchase hydrated lime for the tipping bucket and lime dispensing storage structure. The addition of lime material was initiated in late October/early November 2013 to the Big Run #7 and #8 treatment system outfalls and the water was allowed to flow from the settling pond into the final polishing wetland prior to discharge to Big Run, allowing the system to operate per its design plan. Prior to lime addition, the water was not allowed to enter the wetland, but up to six inches of surface water were allowed to remain in the wetland to promote establishment of the wetland vegetation needed for polishing treatment prior to final discharge. Table 10 summarizes the averages of the outfall from the first settling pond during the first five sampling events in 2013 without lime addition, the same location approximately one month after the start of lime addition, and at the final outfall of the Big Run #3 system (polishing wetland outfall) with lime addition sampled in November 2013 (see also Table 7).

Overall, comparable data of the Big Run systems' performance can be seen in Table 8. However, it should be noted that only one sample has been collected and analyzed for the Big Run #3 final outfall to date. Likewise, Table 9 provides a view of Blacklegs Creek upstream and downstream of the Big Run confluence. Although the water quality data do not represent Blacklegs Creek's pre-construction or post-completion of Phase IV, the amount of contaminant loading removed from the Big Run system (see Table 11) implies that the degradation of Blacklegs Creek by Big Run is strongly reduced. Figures 3 through 6 provide visuals of Blacklegs Creek's water quality parameter trends upstream and downstream of the Big Run confluence.

TABLE 10
WATER QUALITY EFFECT OF LIME ADDITION/FULL OPERATION OF BIG RUN #3 SYSTEM ON COMBINED BIG RUN #7, #7A (RAW), AND #8 OUTFALLS IN 2013

		PH	COND. US/CM	TOTAL ACIDITY MG/L	ALK. MG/L $CACO_3$	TOTAL IRON MG/L	FERROUS IRON MG/L	TOTAL MN MG/L	TOTAL AL MG/L	FLOW GPM
Combined Sources @ Settling Pond Outfall (No Lime)	Avg.	5.1	711.6	24.8	1.7	<0.3	0.07	1.3	4.3	Not Mea-sured
	N =	5	5	5	5	5	5	5	5	
Combined Sources @ Settling Pond Outfall (Lime Add.)	Avg.	7.4	1056	-44.4	64.8	<0.3	0.03	1.9	1.3	Not Mea-sured
	N =	1	1	1	1	1	1	1	1	
Combined Sources @ Final Outfall (Lime)	Avg.	6.7	1058	-51	59	<0.3	0.03	1	<0.5	Not Mea-sured
	N =	1	1	1	1	1	1	1	1	

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TABLE 11
EFFECT OF LIME ADDITION/FULL OPERATION OF BIG RUN #3 SYSTEM ON COMBINED BIG RUN #7, #7A (RAW), AND #8 OUTFALLS PRIMARY CONTAMINANT LOAD REDUCTIONS

	ANNUAL IRON LOAD (TONS/YR)	ANNUAL MANGANESE LOAD (TONS/YR)	ANNUAL ALUMINUM LOAD (TONS/YR)	ANNUAL ACIDITY LOAD (TONS/YR)
All Raw AMD Sources (#2, #3, #7, and #8)	56.9	28.7	145.6	1,261
Passive Treatment of #2, #7, and #8 (+ Raw #3)	13.8	24.1	58.2	-239.6
Percent Reduction (Passive Only)	75.7%	16.0%	60.0%	119.0%
Passive Treatment of #2, Passive and Lime Treatment of #7 and #8 (+ Raw #3)	12.8	15.8	33.7	-258.8
Percent Reduction (Passive and Lime Treatment)	77.5%	44.9%	76.9%	121.0%

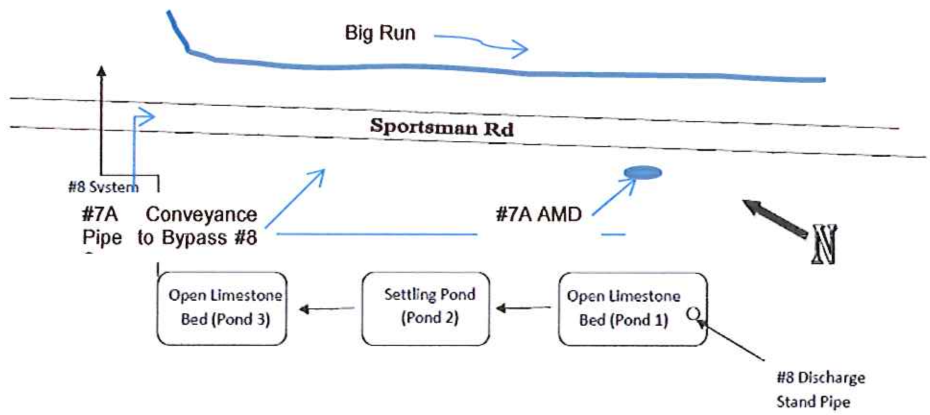
Assumes average measured flow rates for all raw AMD discharges and treatment system outfalls; Contaminant concentration used for loading calculations are average values of all collected data for each source/outfall.

RECOMMENDATIONS

As previously mentioned, there are two valves within the Big Run #8 and #3 systems that are in need of repair/replacement. With funding, these are simple fixes, according to Mr. Grguric, and should be resolved in the 2014 year.

The Big Run #8 (Phase III) improvements require a much more involved modification to reduce the annual operations and maintenance while providing reasonable pre-treatment of the AMD that minimizes the amount of lime needed to fully treat the water and provide excess alkalinity into Big Run. The Big Run #8 discharge is producing more precipitates at a faster rate than originally thought due to higher flows and severe chemical characteristics. This increase in precipitate production within the limestone causes the initial passive treatment system to be compromised. Figure 7 describes the system's current schematic layout. The following options are being considered as potential solutions according to discussions at the November 21, 2013, meeting.

FIGURE 7
BIG RUN #8 PASSIVE TREATMENT SYSTEM SCHEMATIC LAYOUT



Recommended options for improvements to Big Run #8 system (Phase III) include the following.

1. Continue to clean/stir the first limestone bed (Pond 1) at least twice a year and flush more frequently, at least twice per month, especially during high flow periods. This will result in high annual maintenance costs and does not eliminate the possibility for the water levels in underground mine workings to increase that will result in more water entering and impacting the Big Run #7 passive system. This option is not preferred but could be a temporary fix until funds are made available for one of the other options.

2. Channelize the water through the surface of the first limestone bed (Pond 1) to avoid clogging of the limestone surface by precipitates. The loss in passive treatment improvements to the AMD may be offset by dosing more hydrated lime at the silo in the Big Run #3 system. This option also eliminates issues when the Big Run #8 AMD source is hydraulically restricted by permeability of the first limestone bed that backs water into the underground mine workings and ultimately adding flow into the Big Run #7 system. This option reduces the passive pretreatment of the Big Run #8 discharge and the frequency of stirring/ cleaning the limestone material in Ponds 1 and 3 but would increase the cost of lime needed to adequately treat the AMD for the necessary improvements in Big Run and Blacklegs Creek.

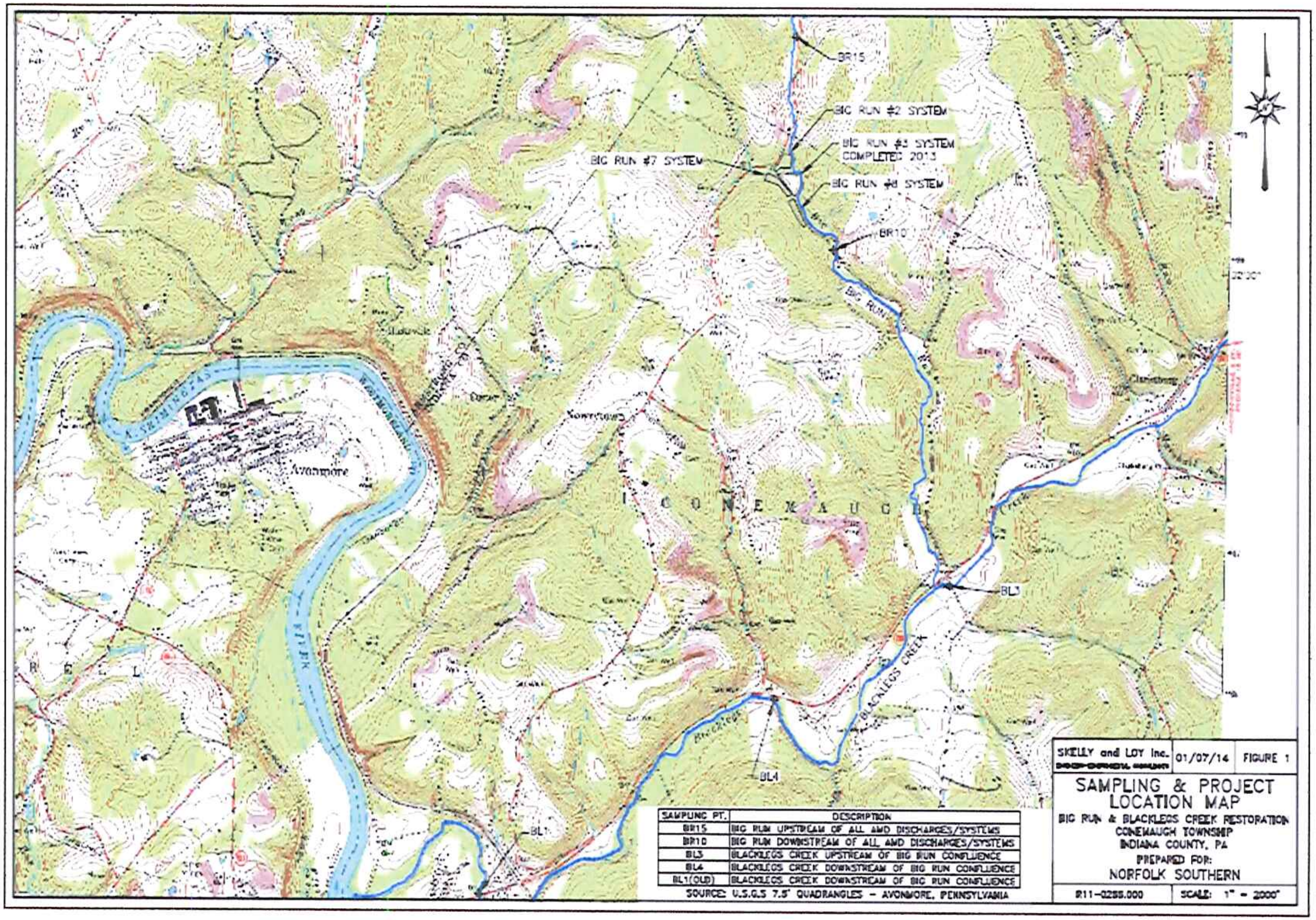
3. Remove all of the limestone from the first limestone bed (Pond 1) and use it for maintenance (limestone replenishment) in other Big Run systems (e.g., Big Run #2 or #7). Pond 1 would then be converted to function as a pre-treatment aerobic wetland to remove and accumulate ferric iron precipitates. Pond 2 would remain as a settling pond, while Pond 3 would retain the limestone bed with the option of removing the limestone material in the future depending on the determined frequency needed to maintain the permeability of the limestone through stirring/cleaning operations. If the permeability of Pond 3 is able to be

maintained for at least one year and provide some level of pre-treatment of the Big Run #8 AMD, then the cost savings realized through the amount of hydrated lime needed to treat the combined AMD sources in the Big Run #3 system in conjunction with the reduced maintenance efforts for both systems will be achievable. This option is considered as a long-term solution since the aerobic wetland and settling pond would provide considerable sludge capacity, minimize the potential for backing the Big Run #8 water into the underground mine workings resulting in increased flows to the Big Run #7 system, and require maintenance of the limestone in Pond 3 (estimated once a year) and to remove the sludge from Ponds 1 and 2 every two to five years based on flow conditions. In order to maintain permeability of the limestone, Pond 3 would require periodic flushing using the in-line structure at an estimated frequency of at least once a month.

Other remaining items that must be completed to maintain the effectiveness and long-term operations and maintenance of the AMD treatment systems include the following.

- Installation of the flush line from the in-line structure at the Big Run #7 limestone pond underneath Sportsman Road and into the bend of the Big Run #3 rock-lined mixing channel
- Construct the sludge dewatering pond originally designed in the northwestern corner of the Big Run #3 site adjacent to the upstream end of the settling pond (refer to the Big Run #3 design plans for the proposed location and layout).

FIGURE 8
7.5 MINUTE USGS QUADRANGLE OF PROJECT AREA



SAMPLING PT.	DESCRIPTION
BR15	BIG RUN UPSTREAM OF ALL AMD DISCHARGES/SYSTEMS
BR10	BIG RUN DOWNSTREAM OF ALL AMD DISCHARGES/SYSTEMS
BL3	BLACKLEGS CREEK UPSTREAM OF BIG RUN CONFLUENCE
BL4	BLACKLEGS CREEK DOWNSTREAM OF BIG RUN CONFLUENCE
BL1(OLD)	BLACKLEGS CREEK DOWNSTREAM OF BIG RUN CONFLUENCE

SOURCE: U.S.G.S 7.5' QUADRANGLES - AVONMORE, PENNSYLVANIA