WATERSHED-BASED PLAN FOR LAMBERT RUN OF THE WEST FORK RIVER

Prepared By: The National Mine Land Reclamation Center
Funded By: West Virginia Department of Environmental Protection
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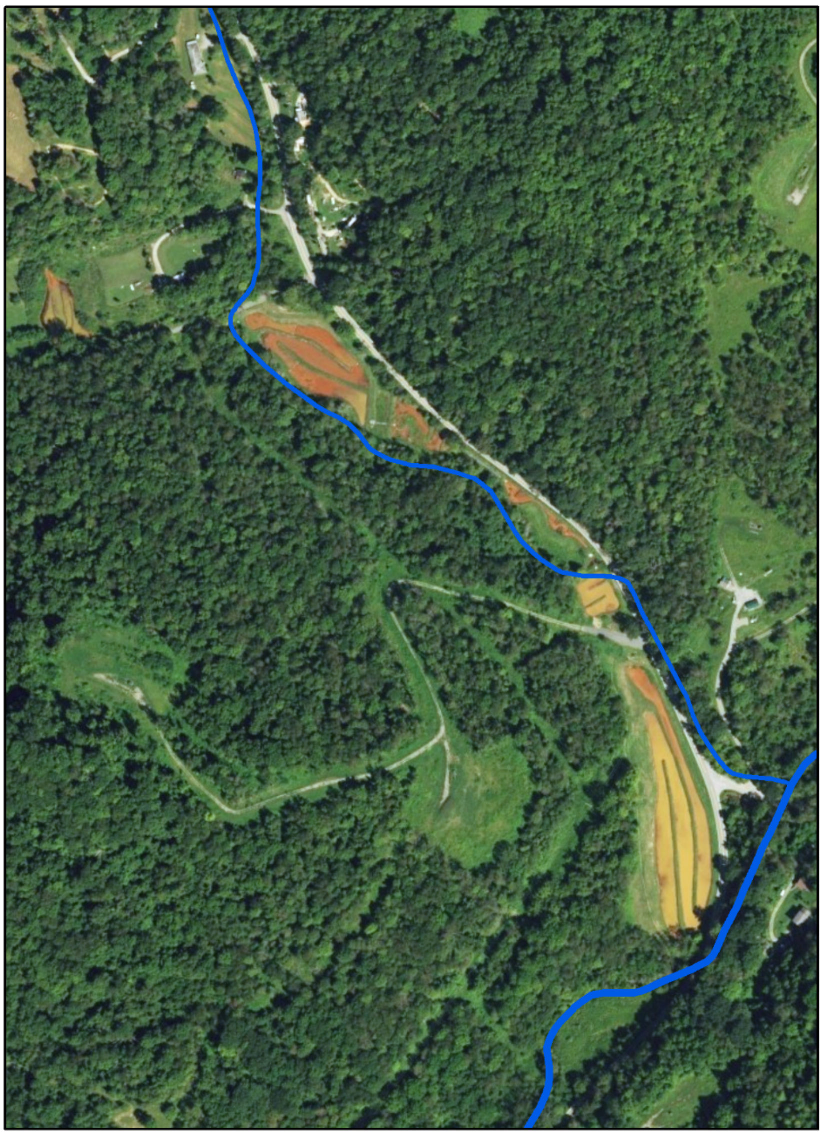

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BMP – best management practice
GWF – Guardians of the West Fork Watershed
WVWRI – National Mine Land Reclamation Center
OSMRE – Office of Surface Mining Reclamation and Enforcement
RLR – required load reduction
RM – river mile
SWS—Subwatershed
TMDL – Total Maximum Daily Load
USEPA – United States Environmental Protection Agency
WBP – Watershed-based Plan
WVDEP – West Virginia Department of Environmental Protection
WVDNR – West Virginia Division of Natural Resources

INTRODUCTION

This document is a nine-element watershed-based plan[1] (WBP) for Lambert Run in Harrison County, West Virginia. Its purpose is to chart a course by which nonpoint source pollution in the Lambert Run watershed can be decreased to the point that the streams in the watershed meet water quality standards and attain all their designated uses.

The streams fail to meet standards for total iron and for fecal coliform bacteria. This WBP, however, only addresses one cause of one of the pollutants: iron pollution from abandoned mines. Section 1, which discusses causes and sources of pollution, will address this choice further. If contributions of iron from other sources are great enough to impair the streams, their magnitude and a solution will become more obvious when the overwhelming contribution from abandoned mines is reduced.

This WBP is an update of an earlier WBP, which created and enabled an experienced team to improve Lambert Run. Partners in the restoration project have had the following roles:

Guardians of the West Fork Watershed (GWF), a grassroots, citizens' watershed association, unifies citizens by calling attention to the problem, calling for a solution, partnering with entities possessing knowledge and resources to bring about change, securing resources available to non-profit organizations, and coordinating the work of partners.

Landowners: When GWF and its partners identify a worthwhile project, landowners often provide additional information, and may provide land for construction of water remediation projects.

West Virginia Water Research Institute: WVWRI possesses the technical expertise to manage watershed restoration projects. It writes proposals for nonpoint source pollution remediation to WVDEP, works with GWF and other partners to hire engineers and contractors to design and build the projects, supports GWF in obtaining additional resources, and completes all necessary reporting.

West Virginia Department of Environmental Protection Watershed Improvement Branch: WVDEP-WIB administers Nonpoint Source Pollution Program funds, supplied by USEPA, oversees the projects, and provides encouragement, guidance, and support to GWF.

United States Environmental Protection Agency: USEPA administers the national Nonpoint Source Pollution program and oversees WVDEP's work within that program.

Office of Surface Mining Reclamation and Enforcement: OSMRE provides additional funding for projects related to abandoned mines as well as expertise in working with or near abandoned mines.

The successes flowing from this plan will strengthen the ability of GWF to gather partners to address fecal coliform issues as well as any remaining iron pollution in the Lambert Run watershed.

[1] E.G., A QUICK GUIDE TO Developing Watershed Plans to Restore and Protect Our Waters. https://www.epa.gov/sites/production/files/2015-12/documents/watershed_mgmnt_quick_guide.pdf

Watershed background

The Lambert Run watershed is in Harrison County, West Virginia (Figure 1). It drains to the West Fork River, which flows another 22.6 miles from the confluence to Fairmont, where it and the Tygart River form the Monongahela River, which flows into the Ohio, and Mississippi Rivers (Table 1).

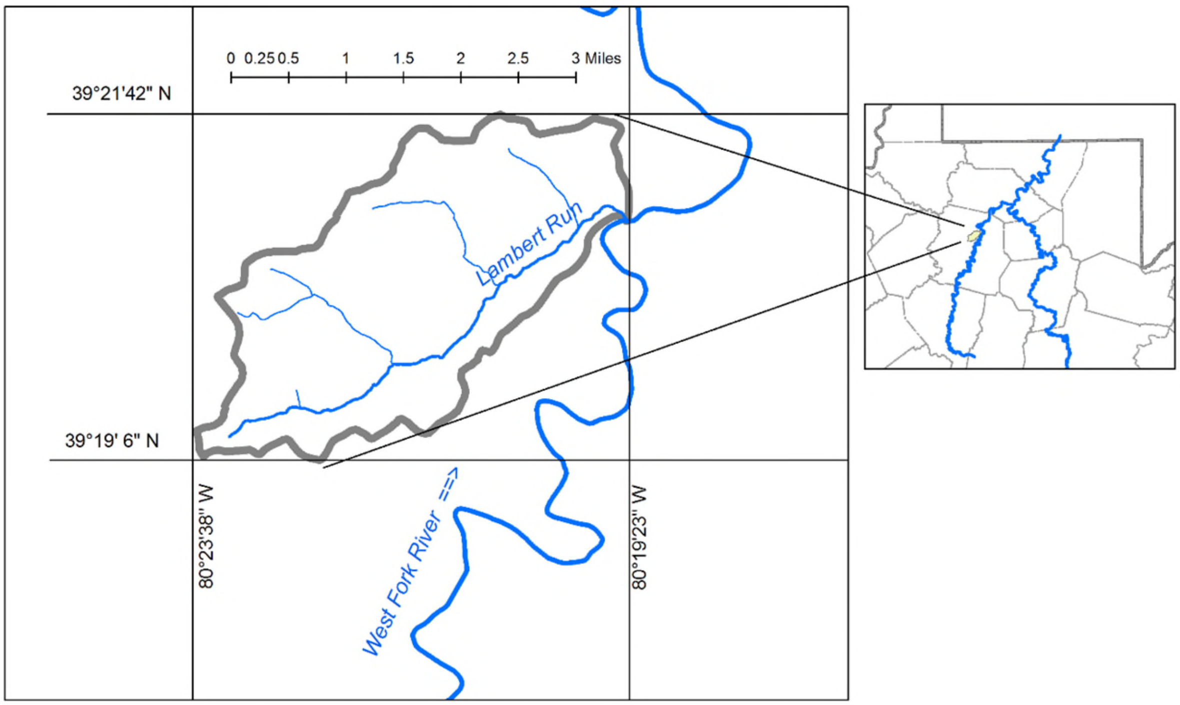

Figure 1: Location of the Lambert Run watershed, in Harrison County, WV.

Table 1: Hydrological Unit Codes for Lambert Run and receiving waters

Watershed Name	HUC level	HUC code
West Fork	8-digit	05020002
Lower West Fork River	10-digit	0502000206
Limestone Run-West Fork River	12-digit	050200020602

The West Fork watershed occupies much of Marion, Harrison, and Lewis Counties in West Virginia. The river has one large United States Army Corps of Engineers dam, Stonewall Jackson Dam, and smaller dams in Worthington, Clarksburg, and Salem. Three dams, Two Lick Dam, Highland Dam, and West Milford Dam, were recently removed from the river.

GFWF is developing a Water Trail to draw attention to the river as a recreation resource. Lambert Run, which in the 1990s and early 2000s added turbid red water to the West Fork (Figure 2) and is now adding almost entirely clear water (Figure 3), will be marked with an information kiosk for those paddling by. It will be an even better achievement to note once the remaining pollution is removed.

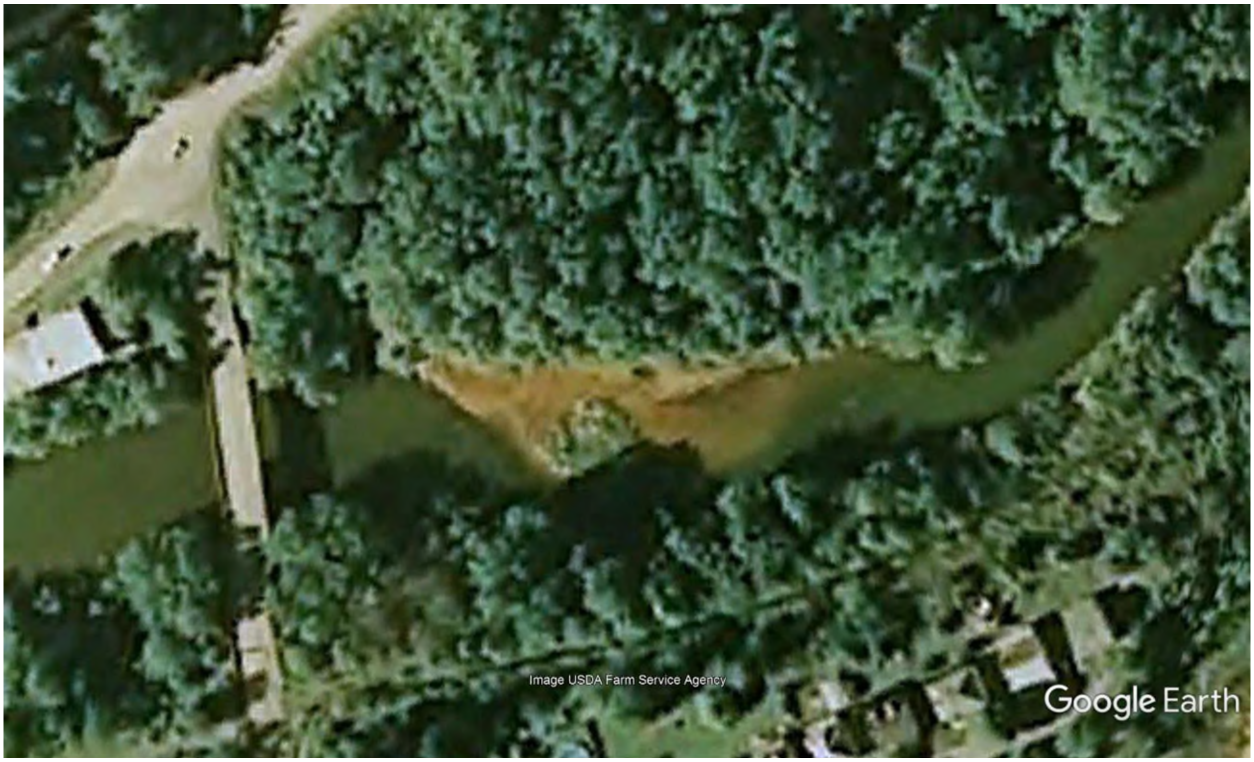

Figure 2: 2007 imagery of the mouth of Lambert Run in Google Earth reveals a plume of turbid, red water in the West Fork.

Figure 3: 2016 imagery at the same site shows a delta of sediment below Lambert Run, but relatively clear water.

The Pittsburgh Coal Seam underlies approximately 89% of the watershed. There is underground mining under 79% of the watershed, undisturbed coal under 7%, and strip mines amount to 3% of the watershed area. However, the mines are not limited by watershed boundaries. The underground mined areas under the watershed extend beyond the watershed boundaries. The total area of underground mines continuous with those underneath the Lambert Run watershed, and which may discharge to it, is equal to 141% of the area of the watershed. Although the Pittsburgh Coal Seam generally dips toward the northwest, the watershed lies between the Wolf Summit Anticline to the west and the Shinnston Syncline to the east. The local dip of the coal is more or less northeast, toward the mouth of the stream.

History of remediation

Remediation work on Lambert Run started in 1996, when WVDEP recognized the stream to be impaired by mine drainage, and still continues (Table 2). In 2002, the 303(d) list indicated that its water quality violated standards for pH, as well as total Al, Fe, and Mn. A Total Maximum Daily Loads analysis (TMDL) was completed in 2002. After that time, changes in both water quality and water quality standards allowed violations of the Al and Mn standards to be dropped. In 2003, Guardians of the West Fork and WVDEP completed a Watershed Based Plan for Lambert Run. The plan called for eight mine drainage remediation projects to remove iron from nine abandoned mine discharges in the watershed.

Four projects, Site 3, Site 5, Site 8, and Site 9, were built after the completion of the first TMDL but before 2010 and 2011, when data were gathered for a second TMDL (published in 2014). In 2012, the unnamed tributaries at river mile 1.49 and at river mile 2.77 were added to the 303(d) list for iron violations. The 2014 303(d)-list document recognized that Lambert Run now meets the pH standard. After that, two additional projects, Site 6 and Site 7 were built.

Site 7 discharges 87,976 pounds of iron per year according to measurements by WVWRI. According to the TMDL, it discharges 53,373 pounds of iron per year, and accounts for 91% of the iron discharged by abandoned mines and 68% of the iron discharged by all nonpoint sources to Lambert Run. It is by far the largest source of iron to Lamberts Run. Without a successful solution to Site 7, Lambert Run cannot meet standards. A Site 7 project was built, but it removes only 70% of the iron from the Site 7 source. This plan calls for additional work at that site. The project changed the hydrology of the Lambert Run watershed in an important way. The Site 7 source is in subwatershed 1470 and discharged to UNT/Lambert Run RM 1.49. However, the Site 7 Project consists of a series of five wetlands through which the water from Site 7 flows directly to Lambert Run without entering UNT/RM 1.49 (Figure 4). While the project only removes 70% of Site 7’s iron from Lambert Run, it removes 100% of Site 7’s iron from SWS 1470 because of how the flow was changed. A few recent measurements of UNT/RM 1.49 have not violated the iron standard.

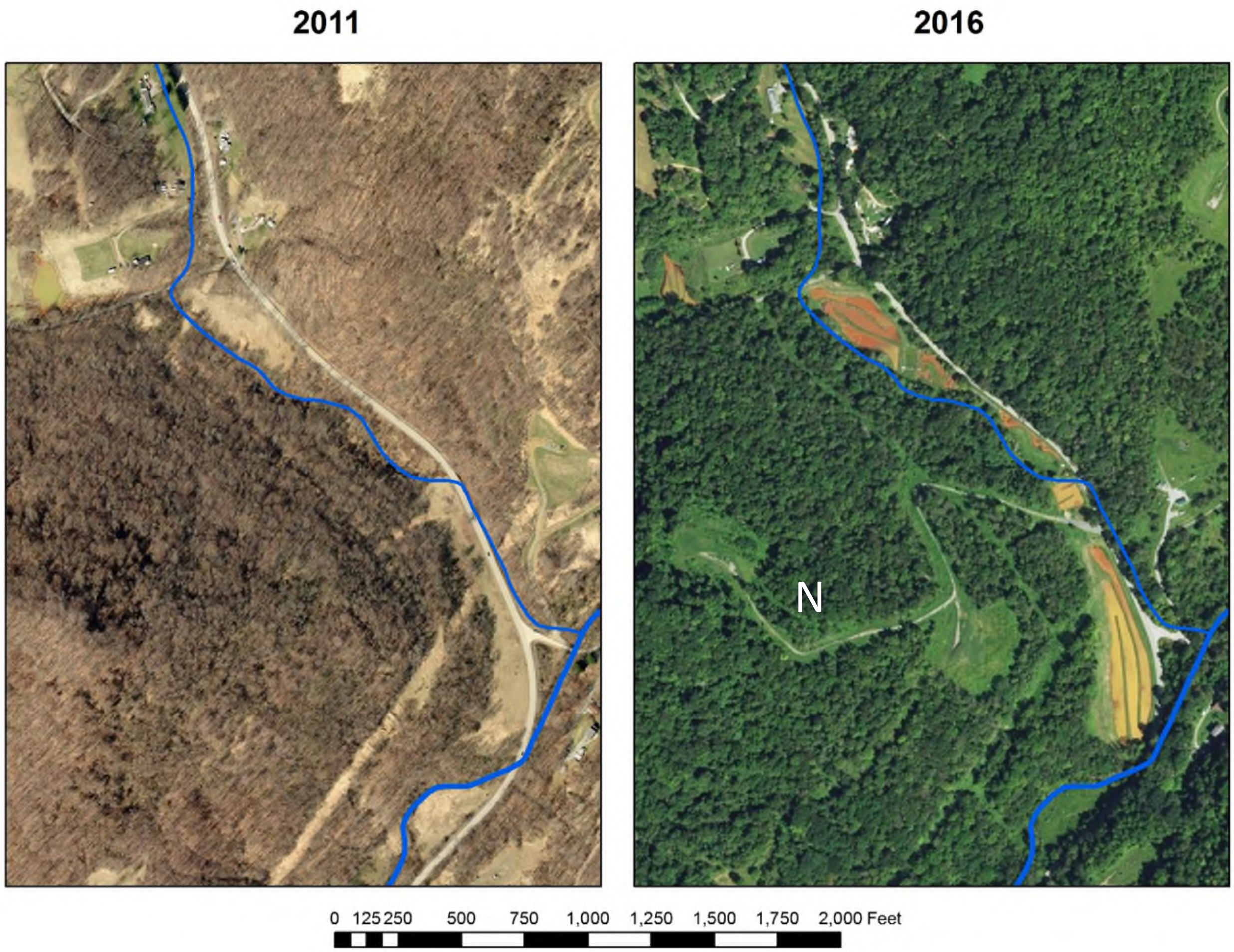

Figure 4: The Site 7 Project (right-hand picture) carries mine drainage from a pond that is visible at the top of the pictures directly to Lambert Run, which cuts across the bottom, right corner of the map, without flowing through UNT/RM 1.49.

Table 2: Remediation and water quality monitoring timeline for the Lambert Run watershed

Date	Event
1996	Added to 303(d) list
2000-2001	Data collection for first TMDL
2002	First TMDL published
2003	Watershed Based Plan completed
2006	Site 3 completed
2007	Site 8 completed
2009	Site 5 and Site 9 completed
2010-2011	Data collection for second TMDL
2012	UNT RM 1.49 and UNT RM 2.77 added to 303(d) list Site 6 completed
2014	Second TMDL published
2015	Site 7 completed
2016	Site 8 repairs completed
2016-2017	Data collection for this WBP
2017	Site 9 repairs completed

Geography and Impairment

Lambert Run is 4.5 miles long and has four tributaries according to the United States Geological Service National Hydrography Dataset. There is also one tributary to one of the tributaries (Figure 5).

Because projects were completed after the last TMDL analysis of the watershed, the data that WVDEP used to evaluate the streams may not be up to date. WVWRI has collected additional data. Table 3 compiles the WVDEP and WVWRI data for iron impairment. WVWRI data indicate that all segments of Lambert Run and the two largest tributaries remain impaired (≥10% of tests exceed the iron standard), whereas WVDEP data show no impairment in Lambert Run upstream from RM 2.77, despite its 303(d) listing.

Because the Site 7 project took polluted water that was originally discharging to UNT/Lambert Run RM 1.49 and ran it through a system discharging directly to the mainstem upstream from the tributary, the largest load and largest required load reduction have moved from SWS 1470 to SWS 1471.

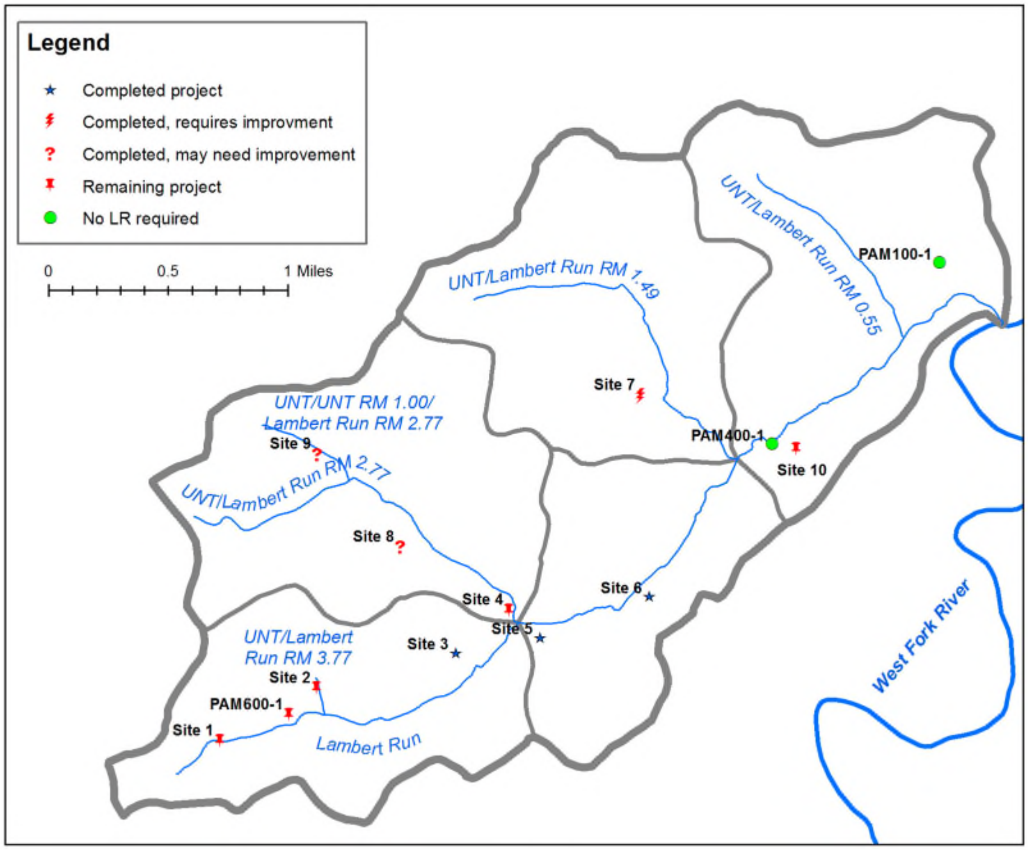

Figure 5: Lambert Run has four tributaries and one tributary to a tributary. Thirteen possible mine drainage sources have been identified, but no work is needed at six of them.

1. Causes and sources of impairment

Impairment summary

The stream system consists of a mainstem, four tributaries, and one tributary to one of the tributaries (Table 3). WVDEP has added the mainstem and the two larger tributaries to the list of impaired streams base on total iron concentrations that exceed the water quality standard of 1.5 mg/L.

*Table 3: Water bodies in the Lambert Run watershed. Streams with stream codes in **boldface** appear on the 303(d) list of impaired streams.*

Stream name	Stream code	Subwatershed	Samples exceeding total iron criterion	
			WVDEP	*WVWRI*
Lambert Run downstream from RM 1.49	**MW-32**	1469	12 of 16 (75%)	5 of 17 (29%)
UNT/Lambert Run RM 0.55 (Rose Run)	MW-32-A	1469	No measurements	0 of 7 (0%)
UNT/Lambert Run RM 1.49	**MW-32-B**	1470	12 of 12 (100%)	No measurements
Lambert Run between RM 1.49 and RM 2.77	**MW-32**	1471	0 of 10 (0%)	2 of 16 (13%)
UNT/Lambert Run RM 2.77	**MW-32-C**	1473	2 of 12 (17%)	4 of 14 (29%)
UNT/UNT RM 1.00/Lambert Run RM 2.77[A]	MW-32-C-1	1473	No measurements	No measurements
Lambert Run	**MW-32**	1472	0 of 12 (0%)	3 of 14 (21%)
UNT/Lambert Run RM 3.77[B]	MW-32-D	1472	No measurements	7 of 7 (100%)

[A]Site 9 occupies a significant portion of the watershed UNT/UNT RM 1.00/Lambert Run RM 2.77. Its outlet violated the criterion 50% of the time during monitoring. It has, however, undergone maintenance. No actual instream measurements have been taken in this stream.
[B]The TMDL identifies UNT/Lambert Run RM 3.77 as a source of iron pollution where reductions must occur, but the UNT has not been added to the 303(d) list.

Causes of impairment

According to the TMDL for the West Fork River, the Lambert Run stream system receives iron from abandoned mines, oil and gas facilities, urban residential land, unpaved roads, agriculture, background sources, and streambank erosion (WVDEP, 2014). The TMDL calls for reductions in iron loads from abandoned mines, oil and gas facilities, urban residential land, unpaved roads, and agriculture. The largest sources are abandoned mines (Figure 6).

This WBP only addresses abandoned mines. First, it will not be possible to completely assess the effects of the other causes until the large contribution of abandoned mining is eliminated. Second, we believe the TMDL underestimated the load from abandoned mines. WVWRI's direct measurement of loads, using actual flow measurements and sampling of the discharge, at several of the seeps indicated that discharges were larger than those calculated by the TMDL (Table 4). In addition, the iron discharged from the abandoned mines, which is usually in the ferrous form, does not behave conservatively. It oxidizes to the ferric form, reacts with water to form ferric hydroxide, and sinks to the streambed in slow or still water. For example, the average load of iron just downstream from RM 1.49 on seven dates in 2016 and 2017 was 43,000 lbs/year. The average load near the mouth on those same dates was 28,000 lbs/year. Iron that is stored on the streambed probably becomes suspended and moves downstream at high flows.

WVWRI data is more valuable for this WBP for a second reason. Three additional projects that reduce iron loads from abandoned mine sources were constructed after WVDEP gathered the data in support of the TMDL, but before WVWRI gathered their data, which therefore provide more current information on the watershed.

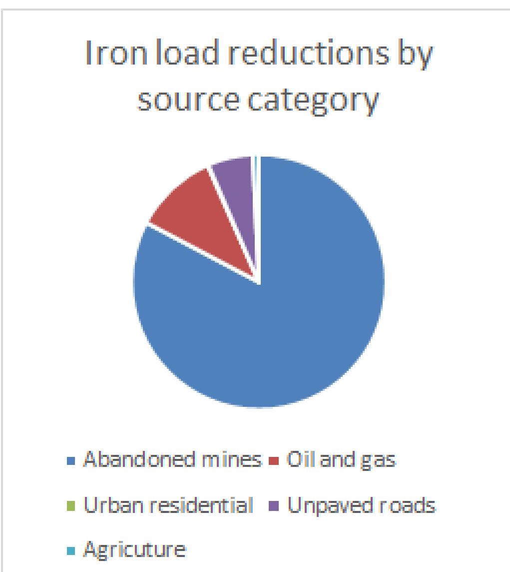

Figure 6: There are several causes of iron pollution in the Lambert Run watershed.

Table 4: Comparison of iron load estimates for abandoned mine land iron sources. TMDL estimates are described in WVDEP (2014). WVWRI estimates are averages of several measurements of flow and concentration.

Source identified in TMDL	WVWRI site name	Load Estimate (lbs/year)	
		TMDL	*WVWRI*
MW160-PAM600-3	1	238	143
MW160-PAM600-1		180	
MW160-PAM600-2	2	1,880	6,556
MW160-PAM500-1	3	35	141
MW16B-PAM100-1	4	788	3,393
MW160-PAM200-1	5	156	1,429
	6		
MW16A-PAM100-1	7	53,373	87,976
MW16B-PAM200-1	8	584	2,659
MW16B-PAM300-1	9	146	2,733
MW160-PAM300-1	10	614	6,433
MW160-PAM400-1		20	
MW160-PAM100-1		59	
Total		**57,815**	**277,017**

Sources of impairment

The Lambert Run WBP from 2003 identified ten abandoned mine drainage sources that contribute iron to the streams of the Lambert Run watershed (Table 5, Figure 5). The TMDL identified three additional sites that were not identified in the WBP.

Table 5: Abandoned mine sources of iron to Lambert Run and its tributaries. Italics indicate sources from which the TMDL did not call for load reductions.

Site	TMDL sources	Subwatershed	Segment	Latitude	Longitude
1	MW160-PAM600-3	1472	Upper mainstem	39.3238	-80.3824
2	MW160-PAM600-2	1472	UNT/RM 3.77	39.3257	-80.3772
3	MW160-PAM500-1	1472	Upper mainstem	39.3290	-80.3660
4	MW16B-PAM100-1	1473	UNT/RM 2.77	39.3310	-80.3622
5	MW160-PAM200-1	1471	Middle mainstem	39.3299	-80.3614
6		1471	Middle mainstem	39.3328	-80.3523
7	MW16A-PAM100-1	1470	UNT/RM 1.49	39.3439	-80.3516
8	MW16B-PAM200-1	1473	UNT/RM 2.77	39.3349	-80.3708
9	MW16B-PAM300-1	1473	UNT/RM 2.77	39.3407	-80.3769
10	MW160-PAM300-1	1469	Lower mainstem	39.3418	-80.3404
	MW160-PAM600-1	1472	Upper mainstem	39.3251	-80.3796
	MW160-PAM100-1	*1469*	*UNT RM 0.55*	*39.3521*	*-80.3285*
	MW160-PAM400-1	*1469*	*Lower mainstem*	*39.3412*	*-80.3417*

2. Load Reductions

The purpose of this plan is to describe management measures that will reduce iron loads to each subwatershed of the Lambert Run watershed from the current, baseline, loads to targets that match the TMDL. TMDLs should be the loads that each reach can receive and not be impaired. Management measures sufficient to restore water quality will be described in Section 3. This section will identify the load reductions that the measures must and will satisfy.

Thirteen abandoned mine sources have been identified by WVWRI and WVDEP (Table 6). The TMDL calls for load reductions at seven of these. Of the six where no reduction is required, two have loads that are too small, and four correspond to sources that have already been treated by GWF and WVWRI. Of the seven where reductions are required, two are sites where projects have been completed, and five are sources that have never been addressed. Three of the five required new projects may not account for any water quality violations. This plan calls for additional monitoring before undertaking those projects.

Table 6: WVDEP and WVWRI have identified thirteen abandoned mine land sources if iron pollution to the Lambert Run watershed.

Done/New	Load Reduction is needed	Load Reduction not needed
Completed projects	Site 7[A] Site 8	Site 3 Site 5 Site 6 Site 9
New projects, definite	Site 2 Site 4	
New projects, uncertain	Site 1 MW160-PAM600-1 Site 10	
No project needed		MW160-PAM100-1 MW160-PAM400-1

[A]Site 7 is a large project, and we anticipate two additional phases will be needed to reduce the load adequatedly.

Although project loads will meet the needed load reductions, there are uncertainties about the balance for some of the subwatersheds (Table 7). Uncertainties include:

- WVDEP chose not to segment Lambert Run into impaired and unimpaired reaches. Therefore, the uppermost part of Lambert Run was designated as impaired even though all of twelve total iron measurements met the water quality standard.
- WVWRI's direct measurements of loads discharging from underground mines generally do not match with TMDL estimates (Table 4). If WVWRI's measurements are correct, projects may lead to much larger load reductions than the TMDL calls for.
- Iron loads and concentrations may have changed in the time since the data for the TMDL were collected (See Table 2), especially following projects at Site 6 and Site 7 as well as project improvements at Site 8 and Site 9.

Table 7: Projects will reduce iron pollution loads in each watershed.

Subwatershed	LR needed (lbs/year)	Projects, *Completed* and **remaining**	Baseline Load from project	Notes and uncertainties
1469	384	**Site 10**	384	Site 10 adds a significant load, but dilution calculations suggest load reductions upstream will be sufficient.
1470	53,300	*Site 7*	53,300	Load has been reduced by 70% and moved to SWS 1471.
1471	260	*Site 5* *Site 6* **Site 7**	53,300	The TMDL does not call for reductions at Site 5 or Site 6. Site 7 must be treated.
1472	1,900	*Site 3* **Site 2**	1,600	Following treatment of Site 2, Site 1 and MW160-PAM600-1 may or may not still be necessary
1473	1,100	*Site 8* *Site 9* **Site 4** **Site 8**	 564 353 (146 and 127)	In Site 8, the growth of wetland vegetation may have made the project more effective, and improvements may not be needed

Subwatershed 1472

SWS 1472 is that portion of the watershed that drains to Lambert Run upstream from river mile 2.77 (Figure 7). Three discharges add iron to the water: Site 1, Site 2, and MW160-PAM600-1. The TMDL calls for a load reduction of 1,900 lbs/year (Table 8). The TMDL estimated that the largest source, Site 2, adds 1,600 lbs/year. This WBP calls for a project to reduce the mine drainage from Site 2 and monitoring to determine the condition of Lambert Run upstream from Site 2, and the loads from Site 1 and MW160-PAM600-1.

None of WVDEP's samples in 2010 and 2011 at river mile 2.8 nor any of WVWRI's samples downstream from Site 3 in 2016 and 2017 violated the water quality standard. However, 3 of 7 (43%) of samples downstream from river mile 3.77 site exceeded the standard, indicating that at least part of the reach is probably impaired by Site 2, which discharges mine drainage to UNT/Lambert Run RM 3.77. According to the TMDL, there are four abandoned mine sources of iron to this subwatershed, and they discharge a total of 2,333 lbs/year. Other causes of iron pollution contribute 3,185 lbs/year. The TMDL calls for reducing the abandoned mine load of iron by 1,877 lbs/year and iron from other causes by 1,870 lbs/year.

According to the TMDL, eliminating the load from Site 2 cannot satisfy the needs of the TMDL. However, there are reasons why it might. First, there are no measurements of the mainstem of Lambert Run upstream from Site 2 in the WVDEP data set, so it might not be impaired at all. Second, load measurements which were based on both flow and iron concentration measurements, at the mouth of UNT/RM 3.77, which receives the water of Site 2, found a pollutant load of 6,600 lbs/year. Elimination of as little as 30% of this load would provide the necessary load reduction for the subwatershed, but the treatment project will be designed to remove at least 80%, or 5,300 lbs/year. This WBP, therefore, schedules additional monitoring to assess impairment upstream from Site 2 and to determine whether Site 1 and/or MW160-PAM600-1 must be treated to eliminate that impairment.

A mine drainage treatment project was constructed at Site 3. The TMDL assigned no load reduction for its discharge and this WBP calls for no additional work there.

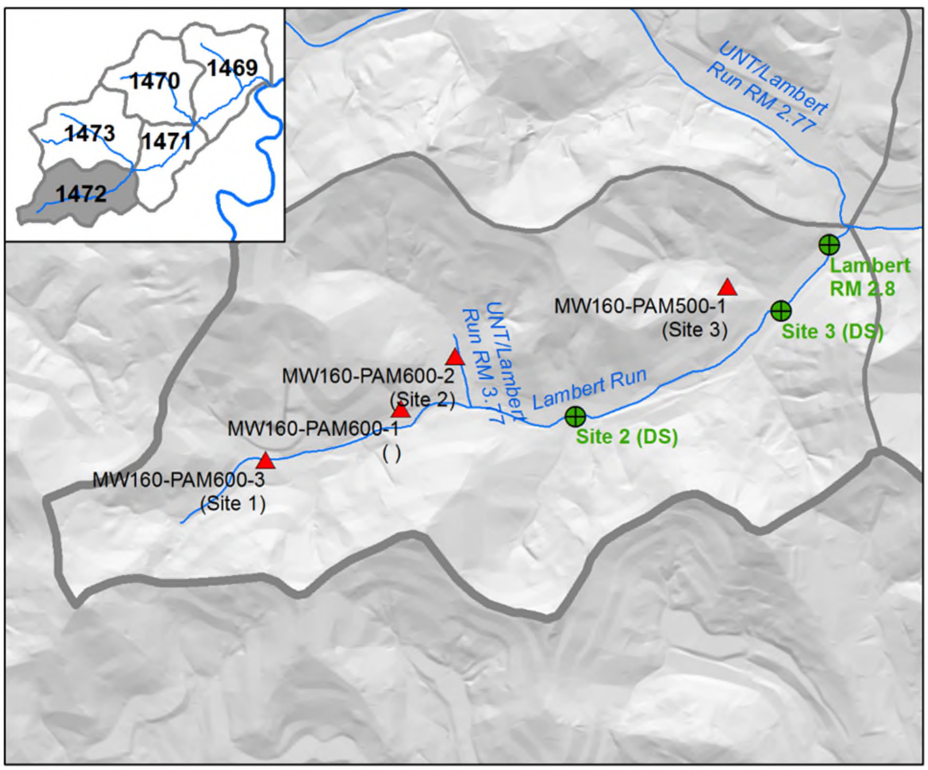

Figure 7: Subwatershed 1472 contains the headwaters of the mainstem of Lambert Run.

Table 8: Total iron loads from abandoned mine sources in subwatershed 1472.

-------------------- TMDL information --------------------				---------- WVWRI information ----------		
Site name	*Baseline*	*Target*	*RLR*	*Site name*	*Measured load*	*Reduction from planned project*
MW160-PAM600-3	238	92	146	Site 1	143	0
MW160-PAM600-1	180	53	127	Not measured		0
MW160-PAM600-2	1,880	277	1,603	Site 2	6,556	5,245
MW160-PAM500-1	35	35	0	Site 3	141	0
Other causes	3,185	1,316	1,870			
Totals	5,519	1,772	3,747		6,840	5,245

Subwatershed 1473

There are three mine drainage sources in SWS 1473, which is the watershed of the unnamed tributary to Lambert Run at river mile 2.77 (Figure 8). GWF and its partners have already constructed treatment projects at Site 8 and Site 9. Site 4, which is very close to the confluence of the UNT with Lambert Run, remains untreated. The TMDL calls for reductions of 564 and 353 lbs/year from Site 4 and Site 8, respectively, but no reduction is needed from Site 9. The TMDL calls for a 1,120 lbs/year reduction in iron from abandoned mine sources but calls for only 917 lbs/year from specified sources.

This WBP calls for a new mine treatment project at Site 4 and an upgrade project at Site 8. While projects that reduce iron loads by 80% of the TMDL estimates may not be adequate to restore the subwatershed, direct load measurements, including both flow and iron concentration determinations, indicate those projects will suffice (Table 9).

Uncertainties: There may be no need for additional work at Site 8. WVDEP collected 12 samples from UNT/RM 2.77 downstream from Site 8 and found no violations of the iron standard. However, two of seven samples taken by WVWRI downstream from Site 8 did violate the standard. WVWRI and GWF performed some minor repairs to Site 8 just before those samples were taken. These repairs will allow vegetation to grow more thickly in the Site 8 wetlands. The project may have become effective enough that no additional work is required. Nevertheless, Site 8 discharges the second biggest iron load in the Lambert Run watershed, and this plan presumes a project will be needed.

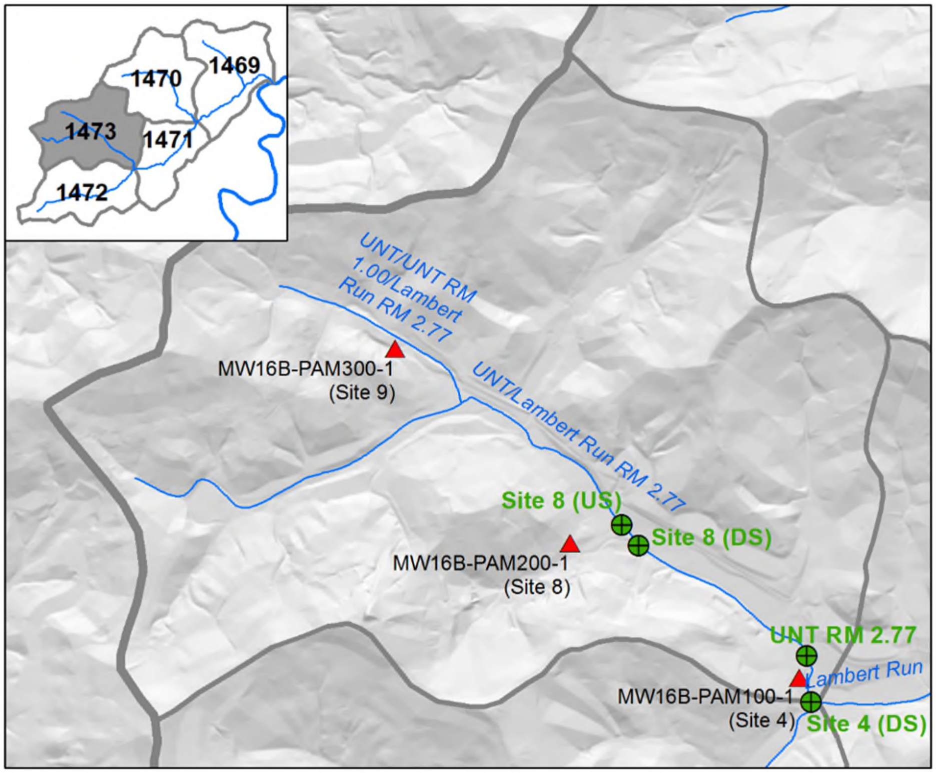

Figure 8: Subwatershed 1473 contains the unnamed tributary to Lambert Run at river mile 2.77.

Table 9: Reducing iron loads (lbs/year) measured at one source in SWS1473 will provide a greater reduction than that required by the TMDL model.:

-------------------- TMDL information --------------------				---------- WVWRI information ----------		
Site name	*Baseline*	*Target*	*Reduction*	*Site name*	*Measured load*	*Reduction from planned project*
MW16B-PAM100-1	788	224	564	Site 4	3,393	2,714
MW16B-PAM200-1	584	230	353	Site 8[A]	2,931	2,345
MW16B-PAM300-1	146	146	0	Site 9[A]	2,636	
Other causes	5,084	1,734	3,350			
Totals	6,601	2,334	4,268		8,960	5,059

[A]Loads are discharges from treatment projects, not the loads entering into and being reduced by those treatment projects.

Subwatershed 1471

The TMDL calls for a reduction of 384 lbs/year from abandoned mines but does not identify any source to be addressed. The TMDL identified Site 5 as MW160-PAM200-1 but called for no load reduction there. During the TMDL study none of the total iron measurements exceeded the water quality standard. Nevertheless, the TMDL called for 1,744 lbs/year in iron reductions. Two projects have affected this reach since then. GWF and WVWRI completed the Site 6 project, which decreased loads of iron into Lambert by 22,800 lbs/year. The second project was Site 7, where a mine drainage source to UNT/Lambert Run RM 1.49 was diverted through a series of five ponds directly to the Lambert Run mainstem. The source discharges 87,976 lbs/year of iron. The Lambert 7 project captures approximately 70% (62,583 lbs/year) iron and reduces the load to Lambert Run, but it adds 25,355 lbs/year to SWS 1471 (Figure 10). Improvements to the BMPs at Site 7 that will decrease the load even more are described in Section 3.

While WVDEP detected no impairment in this reach, 13% of WVWRI's samples from this reach upstream from the Site 7 Project exceeded the iron standard. The team will continue to monitor upstream from the Site 7 discharge, but expects that the Site 2 and Site 4 projects in the two watersheds upstream, along with the project at Site 6, will cause such a decrease in the stock of iron precipitate on the streambed, as well as a decrease in the concentrations upstream, that violations of the iron standard will become rarer than 10% of the samples in this reach.

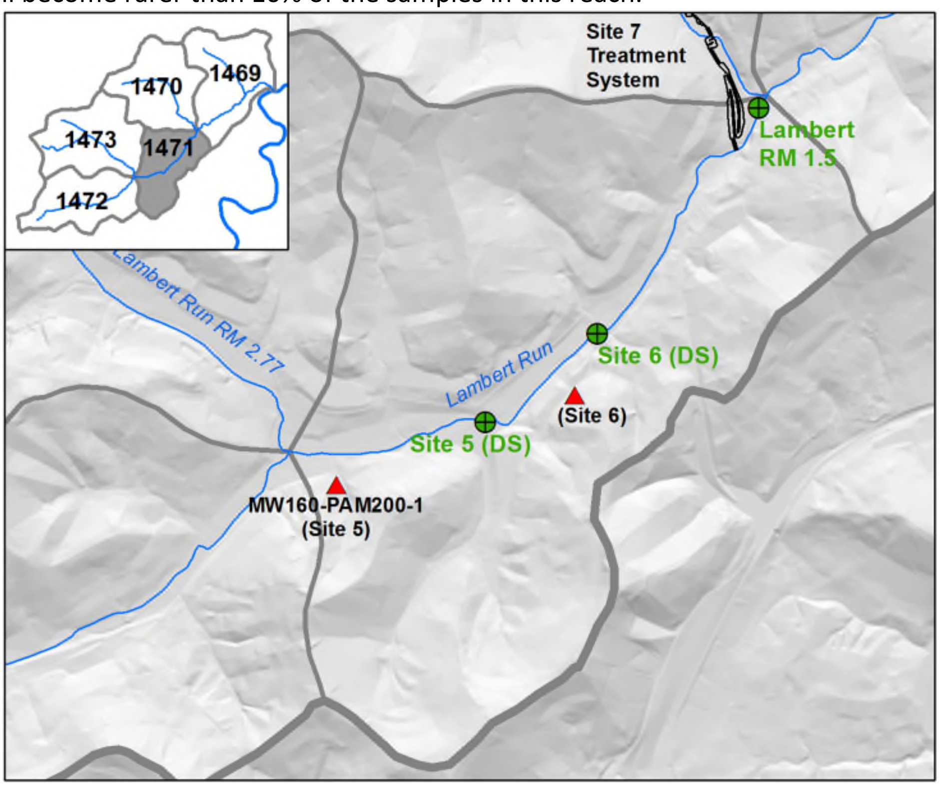

Figure 9: Reducing iron loads (lbs/year) measured at one source in SWS1471 will provide a greater reduction than that required by the TMDL model.:

Table 10: This table seems to need a heading

-------------------- TMDL information --------------------				---------- WVWRI information ----------		
Site name	*Baseline*	*Target*	*RLR*	*Site name*	*Measured load*	*Reduction from planned project*
MW160-PAM200-1	156	156	0	Site 5	1,429	0
Not measured				Site 6	Recent project reduced load by 22,800	
Not assigned to SWS 1471				Site 7	25,355	20,268
Other causes	2,904	1,419	1,484			
Totals	3,060	1,575	1,484		26.784	20,268

Figure 10: The discharge from the Site 7 project causes a plume of iron in Lambert Run near the downstream end of SWS 1471.

Subwatershed 1470

The Site 7 Project diverts the flow from Site 7 through approximately three acres of settling ponds and discharges it to the mainstem in SWS 1471 (Figure 12, Figure 11). The load from this discharge was 53,373 lbs/year according to the TMDL and 87,976 lbs/year according to WVWRI's measurements (Table 11Table 11: The one iron source in SWS 1470 is large but has been diverted to SWS 1471.). Because the water is diverted to the Lambert Run mainstem, the entire load has been removed from SWS 1470 (Figure 12).

Within SWS 1470, the unnamed tributary to Lambert Run at river mile 1.49 retains a reddish color, consistent with the high loads of iron it received for several decades, but not one of five recent total iron measurements violated the water quality standard. Visitors to Site 7 frequently see fish in the unnamed tributary. Although a project to improve treatment at Site 7 is described below, its purpose is to improve water quality is SWS 1471 and 1469. No additional projects are planned in SWS 1470.

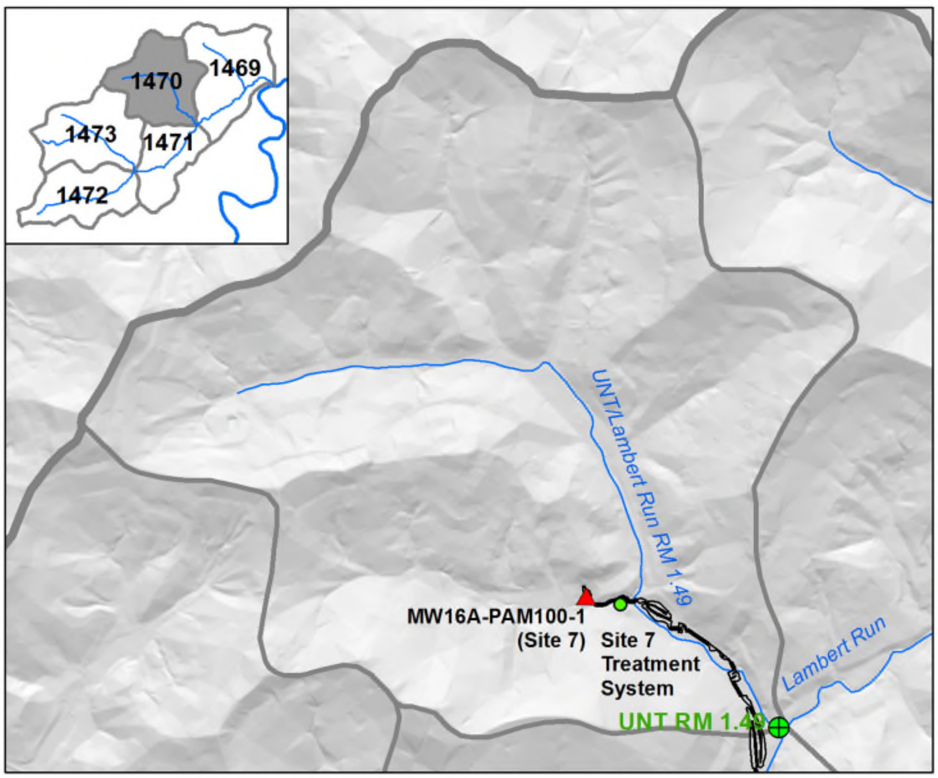

Figure 11: SWS 1470 contains only one mine drainge source, which has been diverted to the mainstem.

Table 11: The one iron source in SWS 1470 is large but has been diverted to SWS 1471.

-------------------- TMDL information --------------------				---------- WVWRI information ----------		
Site name	*Baseline*	*Target*	*RLR*	*Site name*	*Measured load*	*Reduction from completed project*
MW16A-PAM100-1	53,373	2,502	50,871	Site 7	87,976	87,976
Other causes	3,940	1,546	2,394	`		
Totals	57,313	4,048	53,265		87,976	87,976

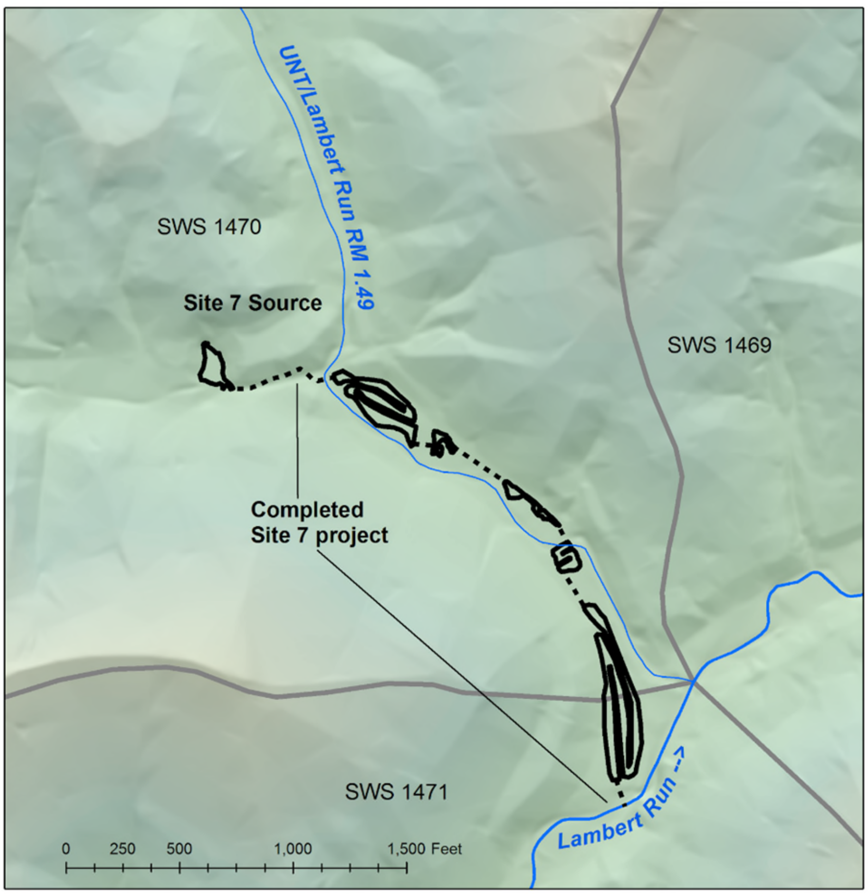

Figure 12: The Site 7 project diverts mine drainage from UNT/Lambert Run RM 1.49 directly to the mainstem.

Subwatershed 1469

SWS 1469 is the downstream-most subwatershed and its discharge is the mouth of Lambert Run into the West Fork River. Lambert Run is visibly laden with iron as it passes through this reach. 75% of the WVDEP's and 29% of WVWRI's samples exceeded the iron standard. However, the largest source of iron is not the abandoned mines that discharge in that subwatershed, but the Site 7 seep, which rises in SWS 1470 and discharges to Lambert Run in SWS 1471 (Table 10). The load at the upstream end of Lambert Run in SWS 1469 is approximately 43,000 lbs/year, whereas that at the mouth is approximately 15,000 lbs/year. The greatest annual change in the watershed is apparently the accumulation of 28,000 lbs/year on the stream bed of Lambert Run.

WVDEP and WVWRI both identified only one mine drainage source where a load reduction may be necessary (Table 12). Site 10 discharges 6,433 lbs/year according to WVWRI data. During earlier projects, Lambert Run will be monitored both up- and downstream from Site 10 to determine whether, after additional treatment to Site 7, Site 10 adds enough iron to cause Lambert Run to exceed the standard. If it does, GWF and its partners will treat it with the project described in Section 3. This reduction exceeds the reduction of 2,690 lbs/year, which the TMDL called for (
Table 12).

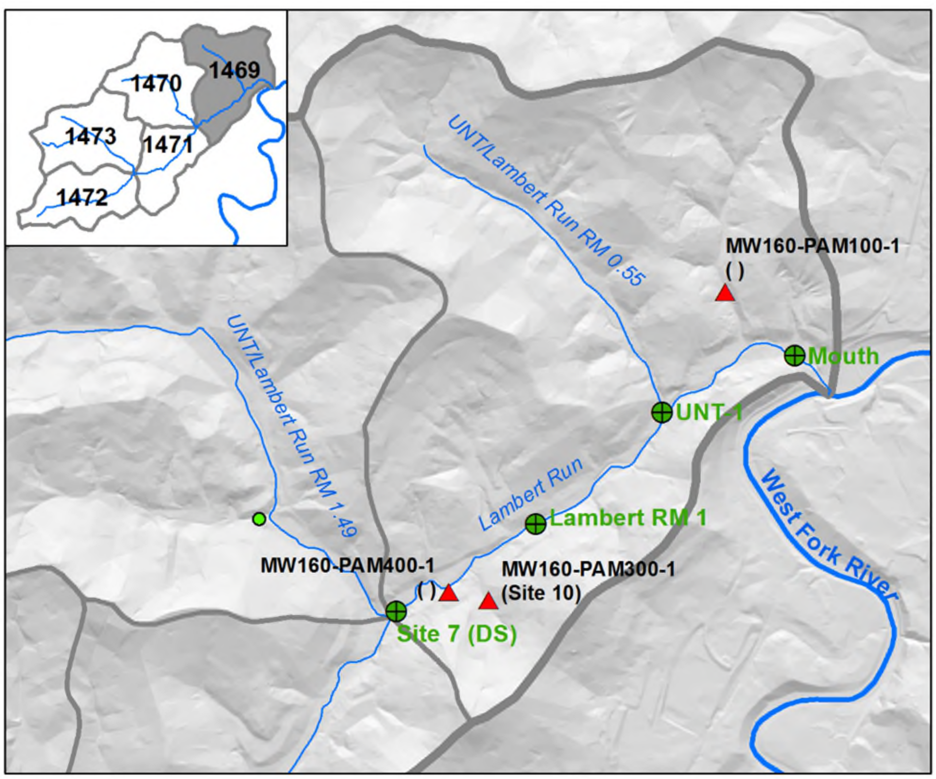

Figure 13: SWS 1469 contains three sources, two of which require not reductions.

Table 12: Only one of the three mine drainage sources in SWS 1469 adds a significant amount of iron

-------------------- TMDL information --------------------				---------- WVWRI information ----------		
Site name	*Baseline*	*Target*	*RLR*	*Site name*	*Measured load*	*Reduction from planned project*
MW160-PAM100-1	59	59	0			
MW160-PAM300-1	614	230	63	Site 10	6,433	5,146
MW160-PAM400-1	20	20	0			
Other causes	4,860	2,555	2,305			
Totals	5,554	2,865	2,689		6,433	5,146

3. Nonpoint source management measures

Nature of the pollution

This WBP calls for four to six projects in the Lambert Run watershed that will eliminate more of the iron load than the TMDL calls for. The largest project, Site 7, will require two phases of work while three sites with smaller loads will each require just one project. One completed project may need to be upgraded to protect the unnamed tributary at RM 2.77, and one project might be needed to improve Lambert Run upstream from RM 3.77.

The mine drainage from the remaining sites in the Lambert Run watershed is not acidic, so there is no need for BMPs to introduce alkalinity into the water. There is hardly any dissolved aluminum in the water because aluminum is insoluble in the pH range in this mine drainage (6.6 to 8). Ferric iron is also insoluble in this range. However, the mine drainage does contain concentrations of iron in the ferrous form that cause the streams to exceed the iron standard. Ferrous iron can be removed from solution by allowing it to combine with oxygen and oxidize to ferric iron, which then becomes the insoluble compound ferric hydroxide, and sinks to the bottom of the water column.

Although these chemical changes require BMPs that are simpler than those needed for acid neutralization, treatment of this kind of mine drainage has obstacles. The two most important obstacles are dissolved carbon dioxide in the mine drainage and the slow rate at which ferric hydroxide settles. Dissolved CO_2 depresses the pH of the solution and delays the oxidation of ferrous ion to ferric ion. Second, ferric hydroxide is a light, amorphous material with a large amount of surface area and a strong affinity for water. As a result, it does not sink out of the water column quickly.

The problem posed by dissolved CO_2 can be solved by aerating the water and degassing the CO_2, but aeration aggravates the settling problem. Somerset Environmental Solutions aerated water from Site 7 for 30, 60, and 90 seconds and compared that water with an unaerated sample (Figure 14). Although increased aeration led to the appearance of more precipitate, there was little evidence of material settling to the bottom of the sample. Small particles created by rapid oxidation sink out of the water column even more slowly because of their size.

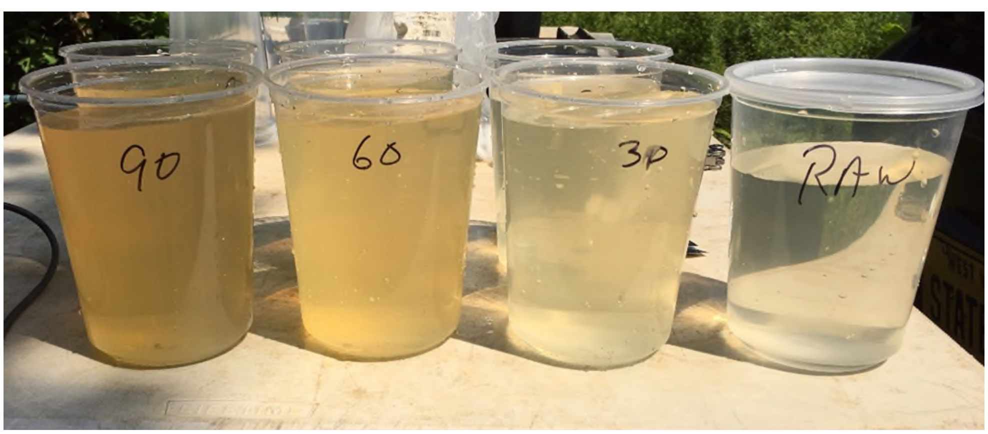

Figure 14: Samples receiving 30, 60, and 90 seconds of aeration with a Maelstrom oxidation unit show steadily increasing amounts of ferric hydroxide in suspension.

There are seven approaches to treating this kind of water. Three are completely passive, two require inputs of energy but not of chemicals, and two require chemicals (Table 13**Error! Reference source not found.**). GWF and partners have no funding stream for a continuous supply of chemicals, so the BMPs in this plan are limited to those that are completely passive or that can be supplied with enough energy by solar power or falling water.

BMPs by project

The smaller projects, Site 2, Site 4, and Site 10, can be treated with ponds for oxidation and wetlands for removing precipitates. Site 3 and Site 5 discharge similar loads of iron and are treated adequately with ponds and wetlands totaling approximately one acre. Site 8 has a larger load (8,894 lbs/year) and is almost treated adequately with 0.38 acres of ponds. Site 7, however, is so large that it may require a different approach.

Site 2, Site4, and Site 10 have discharges and iron loads that are roughly similar, and their BMPs will be of a similar size (Table 14). In addition to a pond and a wetland, each project will have some riprapped channel, a pipe to move the drainage to where there is space for treatment, and a final channel to convey the water to the receiving stream.

Table 13: Approaches to treating alkaline mine drainage fit into three different categories.

Category	BMP	Advantage	Disadvantage
Completely passive	Ponds	Allows for exchange of gases with the atmosphere, especially degassing of CO_2. Still water allows solids to settle.	It is difficult to both use area efficiently and keep water still enough for settling.
	Wetlands	Provides surface area, organic flocculent chemicals	Vegetation establishment phase requires passing more polluted water to streams; Establishment may be difficult
	Install additional surface area	Provides surface area where iron may stick and autocatalyze additional oxidation	No examples of a successful implementation of this approach are known.
Inputs of energy, no chemicals	Aeration	Aeration removes CO_2, raises the pH, and accelerates oxidation.	In addition to the energy requirement, the iron hydroxide particles are often too small to settle.
	Gentle mixing (less vigorous than aeration)	Mixing can keep iron hydroxide precipitate in suspension, which will provide surface area for more rapid oxidation.	In addition to the energy requirement, no examples of a successful implementation of this approach are known.
Inputs of chemicals	Oxidant (hydrogen peroxide)	Oxidation of ferrous iron is a required step for removing iron from solution.	In addition to the perpetual need for chemicals, rapid oxidation may produce ferric hydroxide particles too small to settle.
	Flocculant	Removes particles from the water column by causing them to stick together and sink faster.	The need for flocculants will be perpetual.

Table 14: BMPs to be used at Site 2, Site 4, and Site 10.

BMP	Purpose	Dimensions and notes
Riprapped channel	The turbulent flow over riprap provides a first opportunity for drainage to degas CO_2.	Site 2 will have room for only a 20-foot channel. Site 4 and Site 10 will have room for 50-foot channels.
6-inch pipe	Convey drainage to a place that is convenient for additional BMPs.	Each site will require a pipe approximately 700 feet long.
Ponds	In a pond, water will continue to degas CO_2 and most of the oxidation from the ferrous to ferric state will occur.	A 0.4-acre pond, 2.5 feet deep, is planned for each site.
Wetlands	Water will be passed slowly and evenly through shallow, well-vegetated wetlands which will remove iron hydroxides from the water column.	Site 2 and Site 10 will use a 0.4-acre wetland. The Site 4 discharge will be combined with the wetland for drainage on Site 5, which has excess capacity.
Riprapped channel	Additional channel will convey the water from the wetlands to the stream	We estimate 30 feet of additional channel at each site.

Site 7

Site 7 adds the largest load of iron, roughly 88,000 pounds per year, to the watershed. Site 7 is the discharge from a pond that receives water from three different abandoned, underground mines. The pond discharges an average of 925 gpm with an iron concentration of approximately 22 mg/L. GWF and its partners have already constructed a series of five ponds at Site 7. They remove approximately 63,000 lbs/year, or 71% of the iron measured at the discharge. The final concentration is 6 mg/L, and the iron is visible in Lambert Run downstream. To lower iron concentration in the Site 7 water to the water quality standard, the original load must be decreased by 82,000 lbs/year or 19,000 lbs/year more than the current level. To attain twice the water quality standard and rely on dilution at the discharge into Lambert Run, the load must be reduced by 75,000 lbs/year, or 12,000 lbs/year more than the current level.

In general, settling ponds and wetlands should be adequate for removing large loads of iron from alkaline mine drainage. Removal of 88,000 lbs/year in the three acres of settling pond and wetland provided corresponds to an iron removal rate of 8.4 g m^{-2} day^{-1}. The Marchand system in Southwestern Pennsylvania reduces the concentration of iron from an 1,800 gpm flow from 72 to 3 mg/L in a system covering 44,600 m^2. Aerial photos indicate that most of the load is removed within the first half of this system, which occupies 22,000 m^2. The Marchand system removes almost 16 g m^{-2} day^{-1} over the entire project, and almost 33 g m^{-2} day^{-1} in the first half. The performance of the Marchand system suggests that Site 7 could be improved.

A few problems with Site 7 have been identified. First, the oxidation from ferrous to ferric iron is slow. GWF tested the oxidation rate by measuring total and dissolved iron concentrations through the Site 7 Project (Figure 15). Any iron that passes through a filter is considered dissolved and is interpreted as ferrous iron that has not yet oxidized, while the difference between dissolved and total iron is interpreted as ferric hydroxide that has not yet settled out of the water column. At Site 7, both the oxidation and settling processes occur too slowly (Figure 15). Substantial concentrations of ferrous iron remain in solution even after the water has flowed through four ponds. The aeration experiment (Figure 14) confirms that the slow rate of oxidation is consistent with excess CO_2.

A second issue with some of the ponds in the Site 7 Project is that the water is moving too quickly for precipitated iron to settle. One place in pond 3 had a velocity of 1.28 feet/sec. A final problem is that the ponds, which were expected to become thickly vegetated wetlands, are not being colonized quickly.

Improving Site 7 is likely to take more than one project. This WBP calls for one project to accelerate oxidation and one project to transform the wetlands into a more effective BMP. The first of these projects will install a device to mix the water in the mine discharge with limited aeration to promote oxidation of iron on the surface of flocs of iron that has already been precipitated. Heterogeneous iron oxidation is a well-known phenomenon (e.g., Dietz, 2003), and mixing powered by falling water has been installed in several BMPs for mine drainage. Gentle mixing will accelerate the conversion of ferrous iron to ferric iron and will also cause the ferric iron to form on the surface of existing flocs, which will then settle out of suspension readily.

An extremely well executed phase-1 mixing project may decrease the load from the Site 7 Project enough to allow Lambert Run to meet the water quality standard. If it does not, a Phase 2 project will rework Pond 2 and Pond 5 in the system so that they hold thickly vegetated wetlands with slow, even flow across a wide area. Construction will call for bypassing the ponds, draining them, re-excavating to a depth of approximately 20 cm, placing level spreaders, planting vegetation, allowing vegetation to become established, and finally, returning the flow to the pond. The largest cost will be earth moving, which is estimated assuming movement of one cubic foot of material per square foot of each pond that will be worked on. Pond 5 will be reworked so that it holds a more effective wetland. The serpentine, switchback channels (Figure 16) will be re-excavated to form one channel that is shallower and has a slower velocity. Pond 2 will also be reworked according to a similar strategy.

Upgrades

WVWRI data indicated that UNT/Lambert Run RM 2.77 is impaired, particularly just downstream of the Site 8 Project. It is not certain whether maintenance at Site 8 and Site 9 completely solved the problem. If additional monitoring indicates that these projects are not removing enough iron, then upgrades will be carried out. Upgrades will include modification of existing ponds to accommodate slower, shallower, more thickly vegetated wetlands.

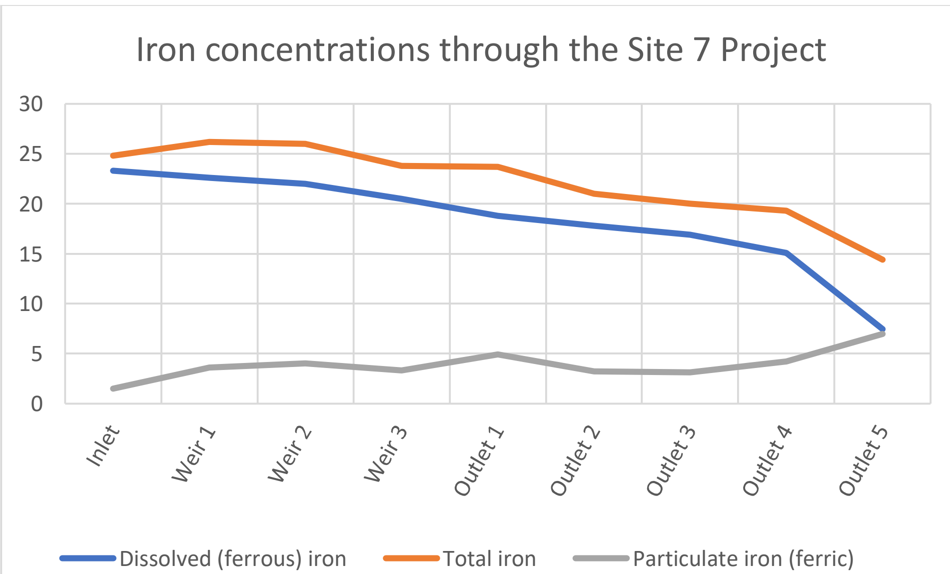

Figure 15: The chemistry of the Site 7 water changes as it flows through the existing project.

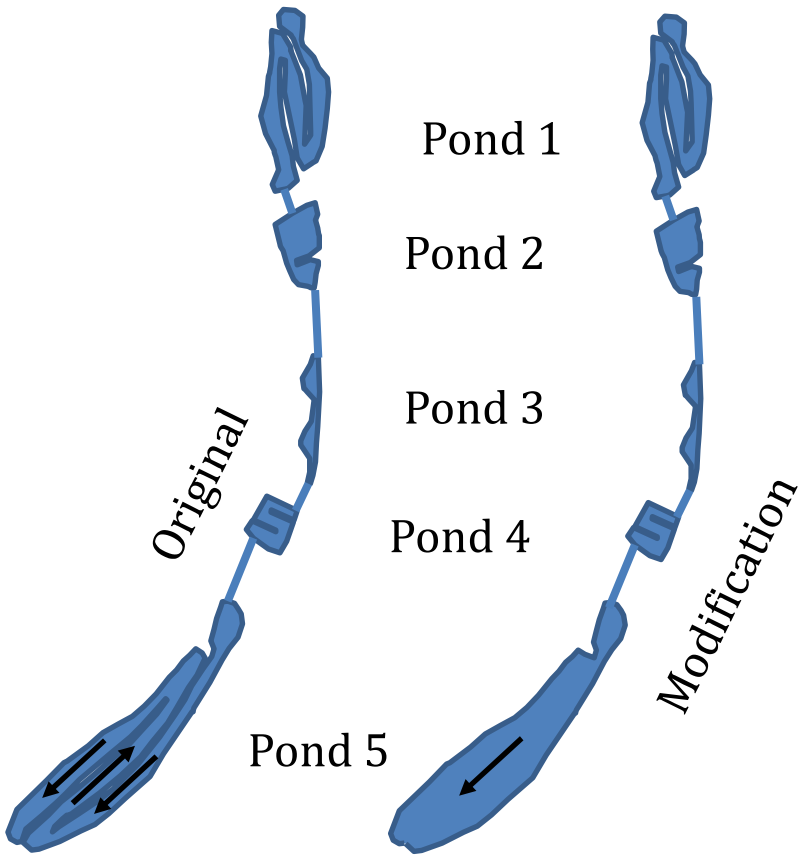

Figure 16:We propose to modify the Site 7 Project by reexcavating Pond 5 to make it wider, slower, shallower, and more densely vegetated.

4. Technical and financial assistance needed

This section will first estimate the costs of the BMPs needed, then estimate the costs of the projects needed to build those BMPs and keep the WBP on track, and then discuss likely sources for money and other resources.

Cost of BMPs

The six projects call for a total of 23 BMPs (Table 15). The costs of each BMP are estimated in Table 16.

Table 15: Each project will contain one or more BMPs.

	Site 2	Site 4	Site 10	Site 7 Phase 1	Site 7 Phase 2	Sites 8 & 9 Upgrades
Aeration/degassing channel (riprapped channel)	20’	50’	100’			
Piping	6” diameter, 700 feet	6” diameter, 700 feet	6” diameter, 700 feet			
Pond	0.4 acres	0.4 acres	0.4 acres			
Vegetated wetland	0.4 acres	0.4 acres	0.4 acres		1.8 acre	Two X 0.4 acre
Discharge channel	30’	30’	30’			
Road crossing	X	X	X			
Stream crossing		X	X			
Mixing system				X		

Table 16: Cost estimates for BMPs from Table 12.

	Site 2	Site 4	Site 10	Site 7 Phase 1	Site 7 Phase 2	Sites 8 & 9 Upgrades
Aeration/degassing channel (riprapped channel)	$1,000 (638)	$1,500 (1,376)	$3,000 (2,755)			
Piping	$10,500	$10,500	$10,500			
Pond	$27,000	$27,000	$27,000			
Vegetated wetland	$68,000	$68,000	$68,000		$123,547	$136,000
Discharge channel	$1,100 (836)	$1,100 (836)	$1,100 (836)			
Road crossing	$2,000	$2,000	$2,000			
Stream crossing		$10,000	$10,000			
Mixing system				$55,836		
Total	**$109,600**	**$120,100**	**$121,600**	**$55,836**	**$123,547**	**$136,000**

Notes: BMP costs are determined using AMDTreat as described in Appendix 1. Some calculated costs (in parentheses) were rounded up.

Cost of Projects

The cost of each project includes several components beyond just construction (Table 17). Each project will also require engineering design, project management, laboratory analysis, supplies, and transportation, and allowed operating costs. §319 funds can pay 60% of this total.

Table 17 describes the calculation of the cost of each project. Table 18 compiles the costs of all the entire projects, and the matching funds to be secured.

Table 17: This scheme translates the cost of the BMPs needed for each project into the cost of the entire project.

Item	Cost addition	Reasoning
Subcontract-Construction	Previous construction cost + $20,000	Costs are determined using AMDTreat according to the notes in the "Cost of BMPs" section, with costs of E&S and Mobilization added
Project management	$30,000	Project management salaries and benefits for the partner managing the project have ranged from $11,000 to $45,000 in recent proposals.
Lab analyses	$4,000	Lab costs from this partner have ranged from $1,300 to $4,800 in recent proposals.
Travel	$1,600	The travel line is at the low end of partner's recent proposals because of likely overlap of fiscal year projects.
Subcontract-Engineering	Construction * percentage	The cost of engineering is capped by WVDEP-WIB's conditions at 20% for projects with construction costs up to $100,00 and 15% for projects with construction costs up to $500,000.
Subcontract-Watershed Association	$5,500	GWF completes many tasks, including some monitoring, communication with landowners, some construction oversight, and securing matching funds. NPS funds support them partially.
Operational funds	Total * 11.11%	Operational costs are to take up no more than 10% of an award.

Table 18: Project costs are based on BMP costs from Table 13 and the calculation scheme in Table 14.

Project	BMP, E&S, Mob.	Engineering	Management	Lab, Travel, and supplies	Admin	Total	§319	Match
Site 7 Phase 1	$65,836[a]	$11,167	$30,000	$8,300	$12,867	$128,670	$77,202	$51,468
Site 2	$129,600	$16,440	$30,000	$8,300	$20,816	$208,156	$124,894	$83,262
Site 4	$140,100	$18,015	$30,000	$8,300	$22,157	$221,572	$132,943	$88,629
Site 10	$141,600	$18,240	$30,000	$8,300	$22,349	$223,489	$134,093	$89,396
Site 7 Phase 2	$143,547	$18,532	$30,000	$8,300	$22,598	$225,977	$135,586	$90,391
Site 8 and Site 9 upgrades	$156,000	$20,400	$30,000	$8,300	$24,189	$241,889	$145,133	$96,756
Total							$749,851	$499,902

[a]E&S and Mobilization are reduced to $10,000 because of the small footprint of the Site 7 Phase 1 project.

Over the duration of the plan, partners will request approximately $750,000 from §319 funds. In addition, the partners will request $500,000 or more from matching sources. It is anticipated that approximately $412,500 will be requested from the United States Office of Surface Mining Watershed Cooperative Agreement Program, which generally limits its participation to 33% of the cost of a project. The remaining $87,500 will come from other sources, including foundations as well as community and in-kind contributions.

Sources of Technical and Financial Assistance

The plan will benefit from several technical assistance resources (Table 19) as well as several financial assistance sources (Table 20).

Table 19: Sources expected to supply technical assistance to the Lambert Run Watershed Based Plan

Group	Explanation
WVWRI	The West Virginia Water Research Institute is led by a world-renowned expert on mine drainage remediation. WVWRI has been providing technical assistance to watershed groups seeking to eliminate mine drainage pollution for approximately 25 years.
WVDEP	The West Virginia Department of Environmental Protection has an Office of Abandoned Mine Lands and Reclamation, an Office of Special Reclamation, a Watershed Assessment Branch, and a Watershed Improvement Branch, all of which readily share their knowledge and experience with mine drainage remediation.
OSMRE	The Office of Surface Mining Reclamation and Enforcement has a filed office in West Virginia that is staffed with people experienced with mine reclamation projects.

Additional sources of financial assistance

Table 20: Sources of Financial Assistance to support the Lambert Run Watershed Based Plan.

Group	Explanation
ASF	The Appalachian Stewardship Foundation supports projects that help reduce pollution including greenhouse gases – through cleaner technologies and simply using less electricity – and that restore clean air and water.
WVDEP	The Watershed Improvement Branch in WVDEP administers Clean Water Act §319 funds to address nonpoint source pollution. Funding can cover up to 60% of project construction costs but does not support operations and maintenance of those projects. WVDEP also has access to state funds at times.
OSMRE	The Office of Surface Mining Reclamation and Enforcement administers the Watershed cooperative Agreement Program, which provides grants to support construction of projects that address problems from abandoned mines.

5. Information and education component

The goal of GWF's public outreach is to increase the number of people who know the location of, understand the condition of, trust drinking water from, boat on, swim in, fish, and love the West Fork River. GWF is carrying out two major projects toward these goals, but also builds public outreach, transparency, and accessibility into all its activities.

The activity that has reached the most people recently is the "Float the Fork" events. On the first Saturday of June in 2018 and 2019, GWF organized float trips for anyone interested. There were more than 160 paddlers in 2018 and more than 200 in 2019. The organization arranged shuttles so that paddlers could be reunited with their cars and buy food at the end of the stretch. In 2019, they also organized a festival the evening before, which had food vendors and information tables staffed by a variety of partners. The event received good news coverage, and it will continue to be an annual event. It was canceled in 2020 due to the Coronavirus pandemic.

GWF has met several times with the West Virginia Division of Natural Resources (WVDNR) and has encouraged its staff to prioritize the construction of hand-carry boat ramps on the West Fork. WVDNR has almost completed improvements at one site and has plans to improve or establish five more. GWF will work with WVDNR to set up information kiosks where appropriate. GWF also maintains information about the West Fork River Water Trail on its website and Facebook page, including the locations of these and other access points.

All GWF's meetings are open to the public. Part of the reason GWF continues to be dedicated to remediation of Lambert Run and other tributaries is that area residents have come to meetings and complained about pollution in streams near their homes.

6. Implementation schedule

Two priorities control the implementation schedule (Table 21). Site 7 is a top priority because it may require more than one project to decrease its discharge enough to restore the stream. In addition, there are complaints by local residents about the visible red turbidity in Lambert Run downstream. It is placed first so that the results of one project can be measured before any second project is begun. Second, projects will be carried out from upstream to downstream.

Table 21: Partners will follow an ambitious program of projects to complete restoration of Lambert Run

Fiscal year	Project	Performance period
2020	Site 7, phase 1	7/1/20-9/30/23
2021	Site 2	7/1/21-9/30/24
2022	Site 4	7/1/22-9/30/25
2023	Upgrade Site 8	7/1/23-9/30/26
2024	Site 1 and MW160-PAM600-1	7/1/24-9/30/27
2025	Site 7, phase 2	7/1/25-9/30/28
2026	Site 10	7/1/26-9/30/29

7. Interim milestones

GWF and its partners will work to carry out all the projects and complete the work of the WBP by September 30, 2028. Completion of each project will be an important and notable milestone (Table 22).

Table 22: The Lambert Run Watershed Based Plan will meet the following milestones.

Date	Milestone
9/30/2023	The Site 7, Phase 1 Project will be completed by September 30, 2023.
9/30/2024	The Site 2 Project will be completed by September 30, 2024.
9/30/2025	The Site 4 Project will be completed by September 30, 2025.
9/30/2026	The Site 8 and Site 9 upgrades will be completed by September 30, 2028.
9/30/2027	The Site 7, Phase 2 Project will be completed by September 30, 2027
9/30/2028	The Site 10 Project will be completed by September 30, 2026.

8. Criteria for success

FY	Project	Completion Year	Criteria for success
2020	Site 7, Phase 1	2023	The load of total iron discharging from the entire Site 7 Project will decrease significantly. The total iron concentration at the outlet of SWS 1471 will decrease significantly.
2021	Site 2	2024	The concentration of total iron entering Lambert Run from UNT/Lambert Run RM 3.77 will no longer exceed the total iron water quality standard. No more than 20% of samples of Lambert Run immediately downstream from Site 2 will exceed the iron water quality standard. As time goes by, exceedances will decrease as iron in the streambed is depleted.
2022	Site 4	2025	The concentration of total iron at the mouth of UNT/Lambert Run RM 2.77 will no longer exceed the iron water quality standard.
2023	Site 8 and Site 9 Upgrades	2026	UNT/Lambert Run RM 2.77 will meet the iron water quality standard throughout its length.
2024	Site 1 and MW160-PAM600-1	2027	If necessary, a project to treat small sources upstream from Site 2 will be completed, and iron violations upstream from RM 3.77 will occur less than 10% of the time.
2025	Site 7, Phase 2	2028	The discharge from the entire Site 7 project will not exceed twice the iron water quality standard. The discharge from SWS 1471 (Lambert Run upstream from RM 1.49) will not exceed the iron water quality standard.
2026	Site 10	2029	There will be no detectable increase in total iron concentration in Lambert Run as it receives water from Site 10.

9. Monitoring

The work in this WBP will require extensive water quality monitoring (Table 23). Remediation projects at each source will require one year of monthly sampling that will determine the load of the pollutant from that source and characterize the polluted water, so that the BMPs selected to treat the water are appropriate. OSMRE, to which the team will apply for matching funds, requires a year-long, monthly sampling program for its WCAP grants. The team will also monitor up- and downstream from the source to document its effect on the receiving stream and to rule out the possibility that the pollution comes from other sources.

In addition, monitoring for projects is taking place, the team will monitor reaches where the need for projects is not certain. In 2021 and 2022 the team will monitor Site 1, MW160-PAM600-1, and Site 8, and points downstream from those sources to determine if they are causing streamwater to violate standards. Based on the data, the team will decide whether to propose Site 1 and MW160-PAM600-1 as a project or Site 8. Similarly, in 2022 and 2023, the team will monitor Site 10 as well as up- and downstream on the receiving stream. Dilution calculations will determine whether work at Site 10 will be needed in addition to improvements at Site 7, which causes the segment of Lambert Run upstream from Site 10 to violate standards.

Table 23: Monitoring will direct measurements of pollution sources and of various reaches to confirm the need for projects.

Period	Remediation Target	Planning target
Jul 2021 - Jun 2022	Site 2	Site 1, MW160-PAM600-1, Site 8
Jul 2022 - Jun 2023	Site 4	Site 10
Jul 2023 - Jun 2024	Site 8 (or Site 1 and MW160-PAM600-1)	Monitoring for chemical and biological recovery
Jul 2024 - Jun 2025	Site 1 and MW160-PAM600-1 (or Site 10)	Monitoring for chemical and biological recovery
Jul 2025 - Jun 2026	Site 7, Phase 2 planning	Monitoring for chemical and biological recovery
Jul 2026 - Jun 2027		Monitoring for chemical and biological recovery

Project partners will develop a QAPP in early 2021 to support sampling and to make sure all working and funding partners agree how the data will lead to good decisions.

Measurements will be taken to quantify and characterize the pollution entering the stream and to determine whether stream reaches are impaired (Table 24).

Table 24: Measurements will be taken to characterize the pollution, to estimate loads, and to determine whether the stream meets the water quality standard.

Measurement	Method	Reason
Flow	Open channel flowmeter or bucket and stopwatch	Load is flow x concentration
Total iron	Lab measurement (usually EPA 200.7)	At sources, determine pollutant load. In stream, determine whether standards are met
pH	Potentiometric in lab and field	influences BMPs to be used for treatment
Hot acidity	Titrimetric	influences BMPs to be used for treatment
Dissolved aluminum	Lab measurement (usually EPA 200.7)	influences BMPs to be used for treatment
Other dissolved metals	Lab measurement (usually EPA 200.7)	influence BMPs to be used for treatment
Sulfate	Lab measurement (usually EPA 300.0 or Standard Methods 4500SO4)	influences BMPs to be used for treatment
Specific conductance	Conductivity meter in lab and field	supports data consistency check, good general water quality characterization.

Appendix 1

AMDTreat calculations

Calculations of the costs of BMPs relied on AMDTreat[2]. A number of adjustments were made to the default price database based on recent bids (Table 25).

Table 25: Some prices from AMDTreat's Default Database were modified based on unit prices in recent bids.

Item	Defalut value	Used value
Excavation	$5.50/cubic yard	$10/cubic yard
Limestone	$22/ton	$60/ton
Organic matter cost (purchase and spreading)	Purchase $20/cubic yard Spreading $4.5/cubic yard	$60/cubic yard (purchase and spreading)
Revegetation cost	$1,600/acre	Minimum value, even for small areas, of $100

Some Rule-of-Thumb prices were obtained from experienced WVDEP project managers

Table 26: Experienced project managers have suggested rule-of-thumb prices for road and stream crossings.

Item	Rule-of-thumb price
Laying pipe under a road	$85/foot
Laying pipe under a creek	$150/foot

[2] See https://amd.osmre.gov/. Version 5.0+ was used.