Upper Jennings Run – Watershed Implementation Plan

Allegany County, Maryland

TETRA TECH

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PRESENTED TO

Allegany Soil Conservation District
12407 Naves Crossroad, N.E.
Cumberland, MD 21502

PRESENTED BY

Tetra Tech, Inc.
tetratech.com
661 Andersen Dr.
Pittsburgh, PA 15220

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ACRONYMS/ABBREVIATIONS

Acronyms/Abbreviations	Definition
ALD	Anoxic Limestone Drain
AMD	Acid Mine Drainage
AML	Abandoned Mine Land
ANC	Acid Neutralizing Capacity
AnW	Anaerobic Wetland
BIBI	Benthic Index of Biological Integrity
COMAR	Code of Maryland Regulations
CWA	Clean Water Act
EPA	Environmental Protection Agency
GPM	Gallon per Minute
LA	Load Allocation
LMA	Land Management Administration
MBSS	Maryland Biological Stream Survey
MDE	Maryland Department of the Environment
MDAS	Mining Data Analysis System
NPS	Non-Point Source
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
O&M	Operation and Maintenance
OSM	Office of Surface Mining
RAPS	Reducing Alkalinity Producing Systems
SMCRA	Surface Mine Control and Reclamation Act
TMDL	Total Maximum Daily Load
UMCES	University System of Maryland Center for Environmental Science
USGS	United States Geologic Service
VFW	Vertical Wetland
WIP	Watershed Implementation Plan
WLA	Waste Load Allocation

EPA Review Criteria	Location Within Plan
A-Identification of Causes & Sources of Impairment	Section 4
B - Expected Load Reduction	Section 5 and 9
C - Proposed Management Measures	Section 5 and 9
D - Technical and Financial Assistance Needs	Section 6
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1.0 INTRODUCTION

The watershed study area of Jennings Run (Jennings) is located in Allegany County, Maryland and flows from its headwaters near the city of Frostburg, Maryland to the town of Mount Savage, Maryland. Jennings Run continues beyond the study area to its confluence with Wills Creek at the town of Corriganville, Maryland. Wills Creek is part of the larger Potomac River watershed which in turn is part of the Chesapeake Bay Watershed. Jennings Run is included in the 8-digit basin listing (basin code-02141003) low pH for in the 2009 Environmental Protection Agency (EPA) approved Total Maximum Daily Load (TMDL) titled *Western Maryland pH TMDLs for the Casselman River, Georges Creek, Savage River, Upper North Branch of the Potomac River, and Wills Creek Watershed* (Maryland Department of the Environment, 2009). The Wills Creek 8-digit basin is also identified as impaired for bacteria and sediments, and TMDLs have been developed for both pollutants (Maryland Department of the Environment, 2006 and 2009b).

After summarizing the impairments of the watershed, this plan temporarily focuses on Abandoned Mine Land (AML) discharges and documents the nonpoint sources of Acid Mine Drainage (AMD). Load reductions are determined, management measures are recommended, and costs are projected. This plan addresses the technical and financial assistance needs, proposed implementation schedule with milestones and measurable goals, and provides an outreach and education program. In the future, this plan will also address the sediment impairment within the Jennings Run portion of the Wills Creek basin. The bacteria impairment for the Wills Creek basin is not applicable to nonpoint sources in the Jennings Run sub watershed and therefore is not addressed in this plan, see Maryland Department of the Environment 2018 Memorandum (Maryland Department of the Environment 2018).

1.1 PURPOSE

The purpose of this document is to provide a comprehensive Watershed Implementation Plan (WIP) for the headwaters of Jennings Run with respect to Non-Point Sources (NPS) of acidity. In the future, this plan will also address nonpoint sources of sediment as well. A NPS is defined by the EPA as: pollution generally resulting from land runoff, precipitation, atmospheric deposition, drainage, seepage or hydrologic modification. Jennings Run receives acid loading from AML discharges throughout the headwaters of the watershed. The intent of this project is to establish a comprehensive, holistic approach toward assessment and eventual pollution abatement and mitigation of existing water quality problems. The WIP will provide a framework for future efforts by the Maryland Department of the Environment (MDE) Land Management Administration (LMA) for prioritizing and coordinating restoration/planning activities with private citizens as well as federal, state and local government agencies.

The WIP will serve as a working template/framework to guide future mitigation/planning and monitoring efforts and will assist in setting mitigation priorities. Phased priority identification of sources and solutions will assist stakeholders with planning and performing more efficiently when restoring and identifying NPS outfalls and related impacts, providing the means for more efficient use of limited funding.

1.2 OBJECTIVES

The primary objective of this plan is to identify major NPS discharges within the study area in the headwaters of Jennings Run and review existing analytical data associated with these discharges.

The second objective of this plan is to incorporate elements of studies conducted by Appalachian Laboratory University System of Maryland Center for Environmental Science (UMCES) in 2000 and 2015 to supplement the data recorded during the 2008 TMDL study and generate a priority list of impaired stream segments for which mitigation strategies can be developed. Since funding may not be available to address every problem, a phased approach will allow for more time to acquire access and develop relationships with associated stakeholders in an attempt to implement effective mitigation projects in those impaired segments.

- During Phase I, pH management measures will be implemented on the number one priority sub watershed in the study area. This area is considered the biggest contributor of acid loading to the watershed. Pre- and post-implementation water quality and biological community sampling will be conducted to evaluate the effectiveness of management measures used.
- Phase II will include pH management measures for the remaining sub watersheds with AML impairments as spelled out in the TMDL report. Pre and post implementation water quality and biological community sampling will be conducted to evaluate the effectiveness of management measures used.
- Phase III will consist of water quality and biological assessments to evaluate the success of the completed mitigation measures. This success will be determined by meeting water quality improvement goals. If it is determined that the completed mitigation projects have failed to meet water quality goals, this phase will be a contingency plan to propose alternative methods to be used as an attempt to meet these goals.

The third objective of this plan is to demonstrate that the WIP strategy will restore the study area of Jennings Run to support their designated uses and remove the watershed from the Maryland 303(d) list of impaired waters for low pH.

1.3 LIMITATIONS OF THE WIP

This plan is based on data generated as a result of previous studies within the watershed. In addition, this assessment focused on the main impairments of the streams within the watershed, namely acid mine drainage from abandoned mine lands. As such, water quality parameters evaluated were generally limited to pH, metals and flow. The biological community will be monitored periodically for reactions to mitigation efforts but is not a primary component of this WIP.

2.0 SUB WATERSHED CHARACTERISTICS

The Jennings Run study area is located on the eastern slope of Big Savage mountain in the Appalachian Plateau Province, which is characterized by rugged, well dissected landscape with dendritic drainage patterns. Elevations in the province range from 1000'-3000'. The watershed study area includes 20.5 stream miles and occupies an area of approximately 14.2 square miles or 9,088 acres (USGS, 2017) (Figures 1 and 2). For this plan, the watershed was divided into 8 sub watersheds that coincide with a 2015 Jennings Run Project by UMCES Appalachian Laboratory (Morgan & Hilderbrand, Jennings Run Project: 2014 -2015, 2016) .

Sub Watersheds

1. Located in the most Northwest portion of the study area, this sub watershed includes two tributaries that combine and enter into the mainstem of Jennings Run at its headwaters. Borden Tunnel Leach Bed treatment system is in the headwaters of this sub watershed and treats AML discharges from previous mining activities. Portions of this sub watershed are on the 303(d) list.
2. Located in the most Southwest portion of the study area, this sub watershed includes the start of the mainstem of Jennings Run, with sub watershed 1 draining into it. There are three mine related discharges within this watershed, these three discharges are close to pH neutral.
3. Located in the southwestern portion of the study area, there is only one small tributary and a small portion of the mainstem located in this sub watershed. There are no AML discharges in this sub watershed that are causing impairment.
4. Located in the central portion of the study area, this sub watershed includes one small tributary and a short section of the mainstem of Jennings Run. There are no AML discharges in this sub watershed that are causing impairment.
5. Located in the central portion of the study area, the sub watershed includes two tributaries and a portion of the mainstem of Jennings Run. Also located in the southern headwaters of this sub watershed is the Commonwealth (Evergreen) treatment system which was installed to treat AML discharges in the 1980's. This system is no longer functioning properly. Portions of this sub watershed are on the 303(d) list.
6. Located in the east central portion of the study area, this sub watershed includes no tributaries and only a portion of the mainstem of Jennings Run. There are no AML discharges in this sub watershed that are causing impairment.
7. Located in the Northeastern portion of the study area, this is the largest sub watershed in the study area. Several tributaries in this sub watershed of Jennings Run enter the mainstem. The Bessemer Treatment system, built in the 1980's, is no longer functioning properly, and is located in the headwaters of the sub watershed. Portions of this sub watershed are on the 303(d) list
8. Located in the most northeastern portion of the study area. This sub-watershed includes one small tributary and a portion of the mainstem of Jennings Run. According to the TMDL study, there is some AML impairment in this sub watershed. Portions of this sub watershed are on the 303(d) list.

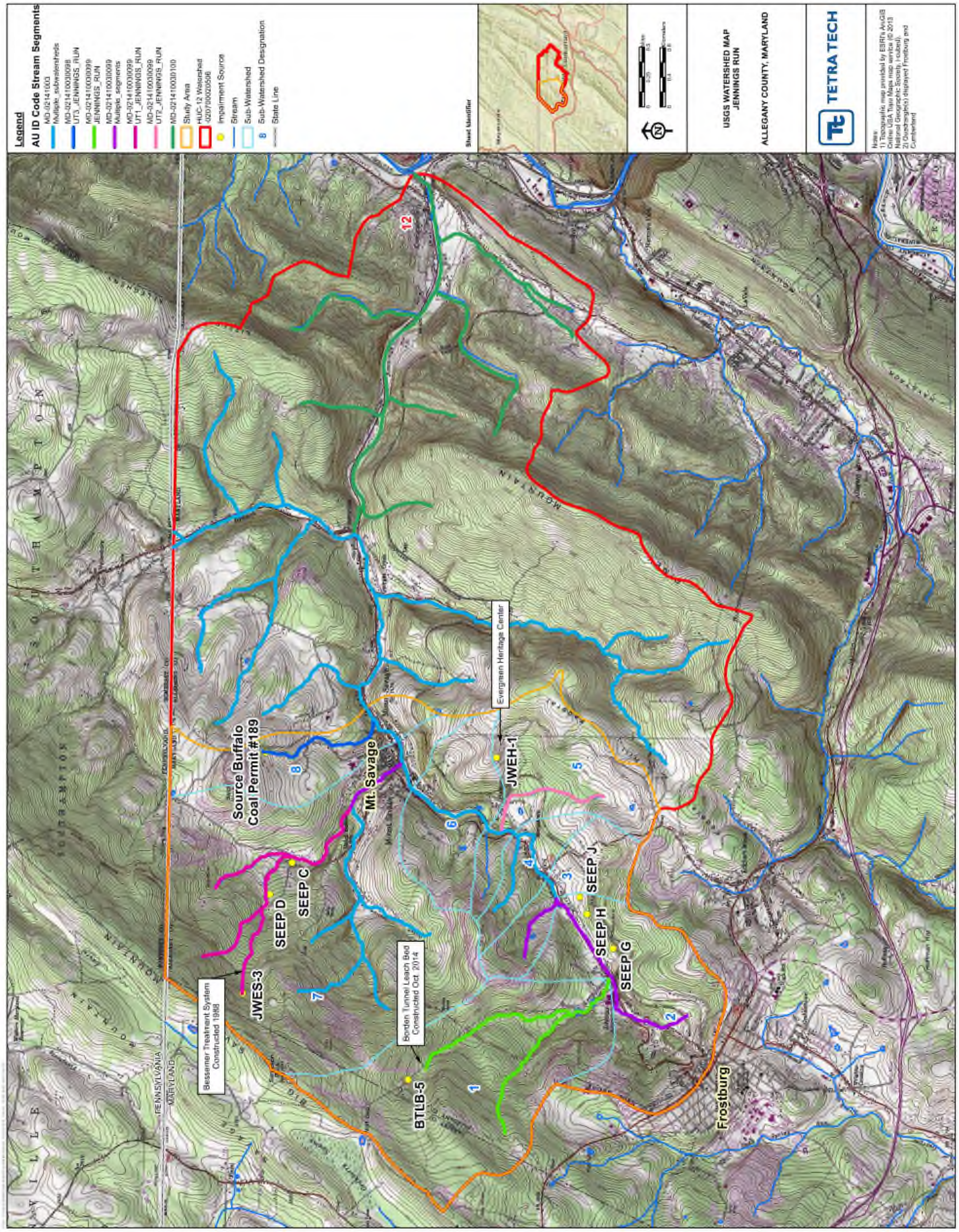


Figure 1 Watershed Area Map

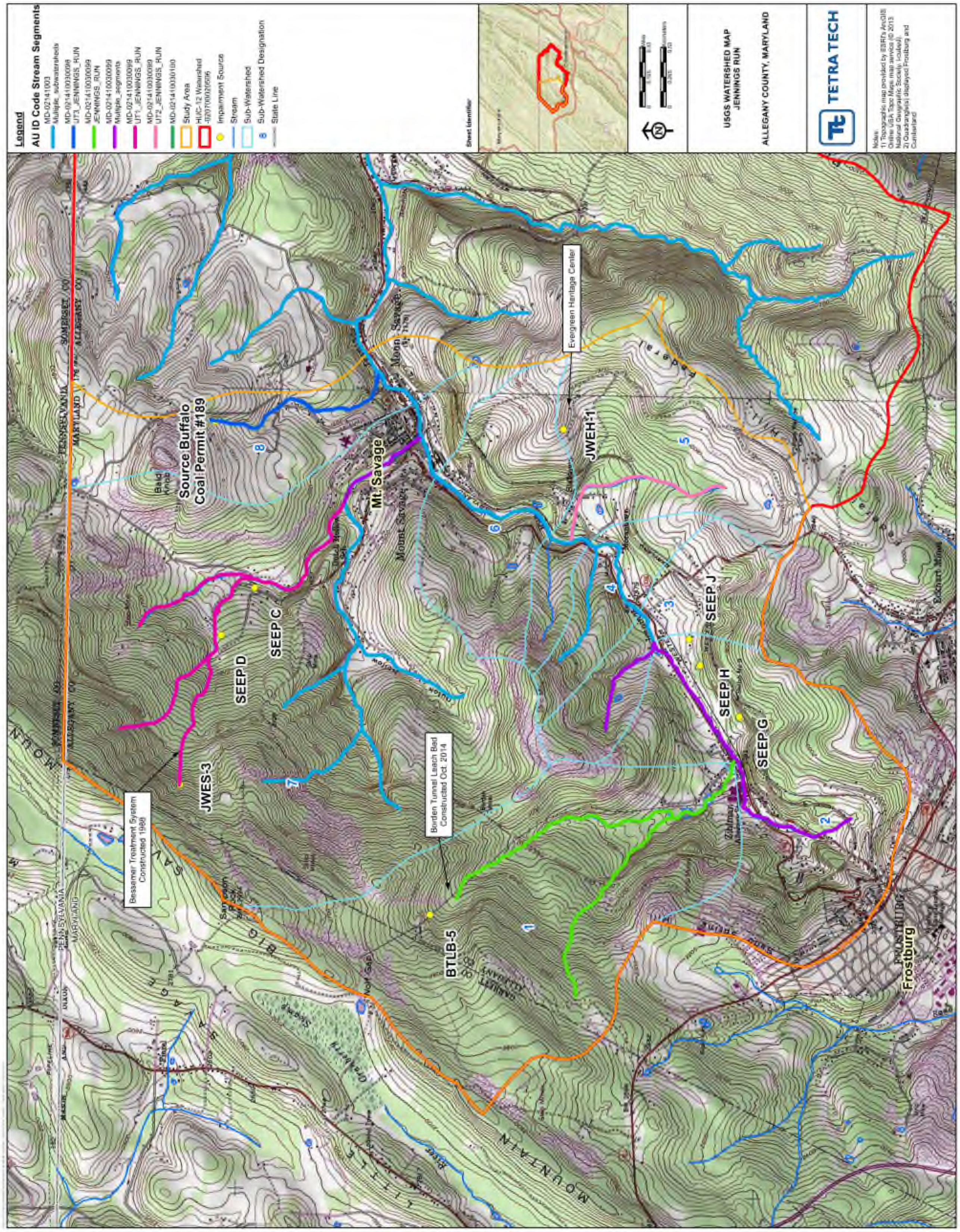


Figure 2 Study Area Detail

2.1 HYDROLOGY

The climate, geology, soils and land cover in the study area of Jennings Run influences the quantity, timing and quality of the water exiting the watershed. When precipitation enters the study areas its first interaction is with existing vegetation and litter layers. Water that is not lost to evaporation or evapotranspiration travels either overland, shallow subsurface or by groundwater to the stream.

The study area is located at temperate latitudes in the Allegheny Mountains with an annual average temperature 48.04°F and an annual average precipitation 44.5 inches based on data from the National Oceanic and Atmospheric Administration (NOAA) National Center for Environmental Information Frostburg 2 station (station number 183415) from 1972 through 2018 (NOAA, 2017) .

2.2 GEOLOGY

The geologic formations within the study area can be found in Figure 3 and are discussed in detail below:

Formations Description (Maryland Geological Survey, 1968)

Pm- Pennsylvanian Monogahela Group- Interbedded claystone, argillaceous limestone, shale, sandstone, and coal beds; Waynesburg coal at top; Pittsburgh coal at base; thickness 240 feet in west, increases to 375 in east.

Pd- Permian Dunkard Group- Red and green shale, siltstone, and sandstone, with thin lenticular beds of argillaceous limestone and thin beds of impure coal; thick-bedded, white conglomeratic sandstone at base; thickness greater than 200 feet

Pc- Pennsylvanian Conemaugh Group – Includes the rocks between the base of the Pittsburgh coal and the top of the Upper Freeport coal; consists of two unnamed members which are separated by the Barton coal; both members are gray and brown claystone, shale, siltstone, and sandstone, with several coalbeds; lower member also contains redbeds and fossiliferous marine shales; thickness 825-925 feet.

Pottsville – Interbedded sandstone, siltstone, claystone, shale, and coal beds; conglomeratic orthoquartzite and protoquartzite at base; thickness 60 feet in northeast increases to 440 feet in southwest.

PAP- Pennsylvanian Allegany and Pottsville Formation- Allegany- Interbedded sandstone, siltstone, claystone, shale and coal beds; Upper Freeport coal at top; where present, Brookville coal defines base; thickness 275 feet in north east, increases to 325 feet in the south and west.

MMC- Mississippian Mauch Chunk Group - Red and green shale, reddish-purple mudstone, and red, green, brown, and gray thin-bedded sandstone; thickness 500 feet win wet, increases to about 800 feet east.

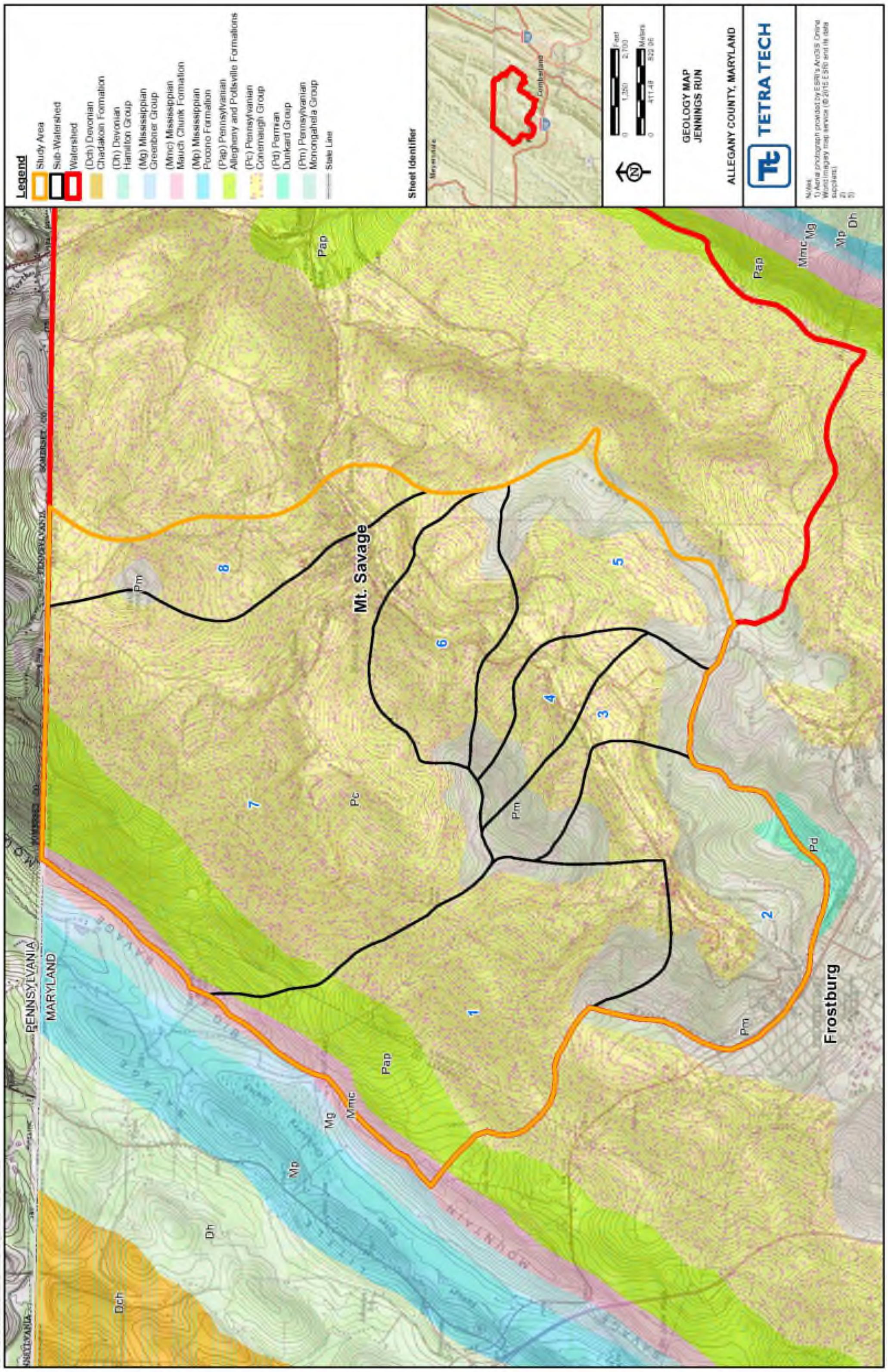


Figure 3 Geology Map

Hydrologic Soils

The Natural Resources Conservation Service (NRCS) has defined four hydrologic soil groups providing a means for grouping soils by similar infiltration and runoff characteristics during periods of prolonged wetting. Typically, clay soils (Group D) that are poorly drained have the lowest infiltration rates with the highest amount of runoff, while sandy soils (Group A) that are well drained have high infiltration rates, with little runoff. The runoff potential of C group soils is moderately high when thoroughly wet and water transmission through the soil is somewhat restricted. The Jennings Run study area mainly consists of C soils.

2.3 LAND COVER AND LAND USE

The dominant land cover of the study area is temperate forest with residential areas concentrated along the stream bank. The only other land use in the study areas is a minimal portion of institutional and commercial use in the eastern portion of the study area and agriculture spread throughout the study area, Figure 4. (Maryland Department of Planning, 2017)

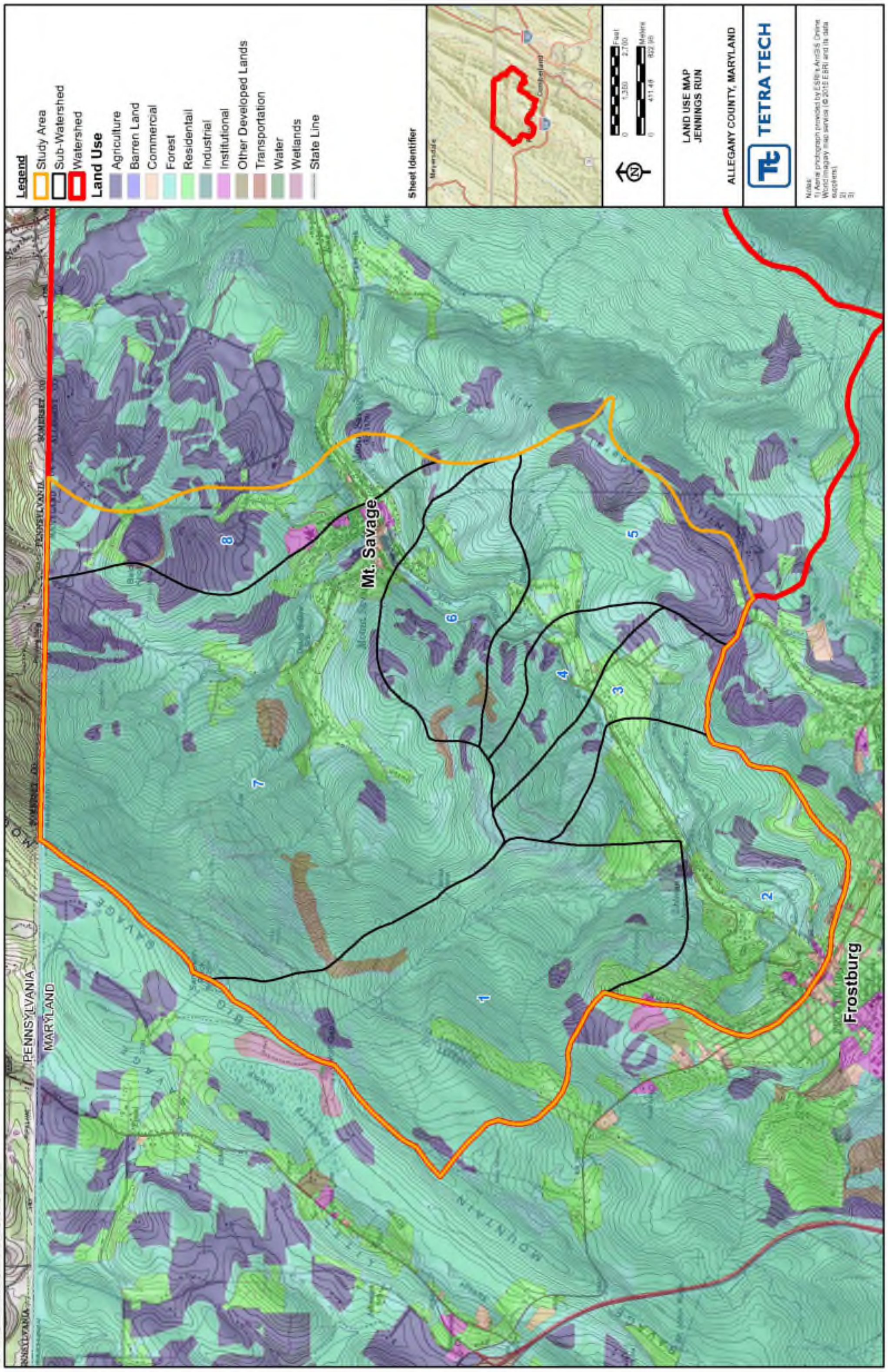


Figure 4 Land Use Map

2.4 ACTIVE PERMITS

Located within the study area are two types of active permits, a National Pollutant Discharge Elimination System Permit (NPDES) and two non-coal mine permits. There are no active coal mine permits within the study area. These permits are discussed below (Maryland Department of the Environment, 2017) :

2.4.1 NPDES

Within the study area there is one NPDES permit (State Discharge Permit No. 08-DP-0678, NPDES Permit MD 0000272) issued to Advent Industries, LLC for the Mount Savage Firebrick facility located at 17091 Mount Savage Road, Frostburg, MD 21532, 39.668687° N, -78.916122° E. The facility produces firebrick and has three permitted outfalls with no process water being discharged from the site.

2.4.2 Non-Coal Mine Permits

There are two non-coal mine permits located within the study area.

- Borden No. 1 Sandbank Road (permit no 91-SP-0400) is 54 acres and located off Sandbank Road along the Allegany Garrett county line, 39.686656°N, -78.948041° E. The permit holder is Ritchie Trucking and Excavating, Inc.

- Blank Road Shale Pit (permit no 02-SP-0592) is 4.95 acres located off of Blank Road in the northeast corner of Allegany County, 39.705674° N, -78.903897° E. The permit holder is Allegany Aggregates Inc.

2.4.3 Coal Mine Permits

There are currently no active coal mine permits or applications for coal mine permits located in the study area.

2.5 HISTORICAL BACKGROUND

Numerous coal seams and abandoned coal and clay mines exist within the Jennings Run Study area. Coal mining activities in the watershed began in the middle 1800s with the peak occurring around World War II. Due to the length of time and extent that mining occurred in the study area it is difficult to locate mining on all historic mapping; however, Figure 5 gives an illustration of the extent of past mining in the watershed. Data was provided from MDE AML. Each “Mine Opening” will have associated underground “Mining Areas”, although documentation of the extent of those mining areas is not available.

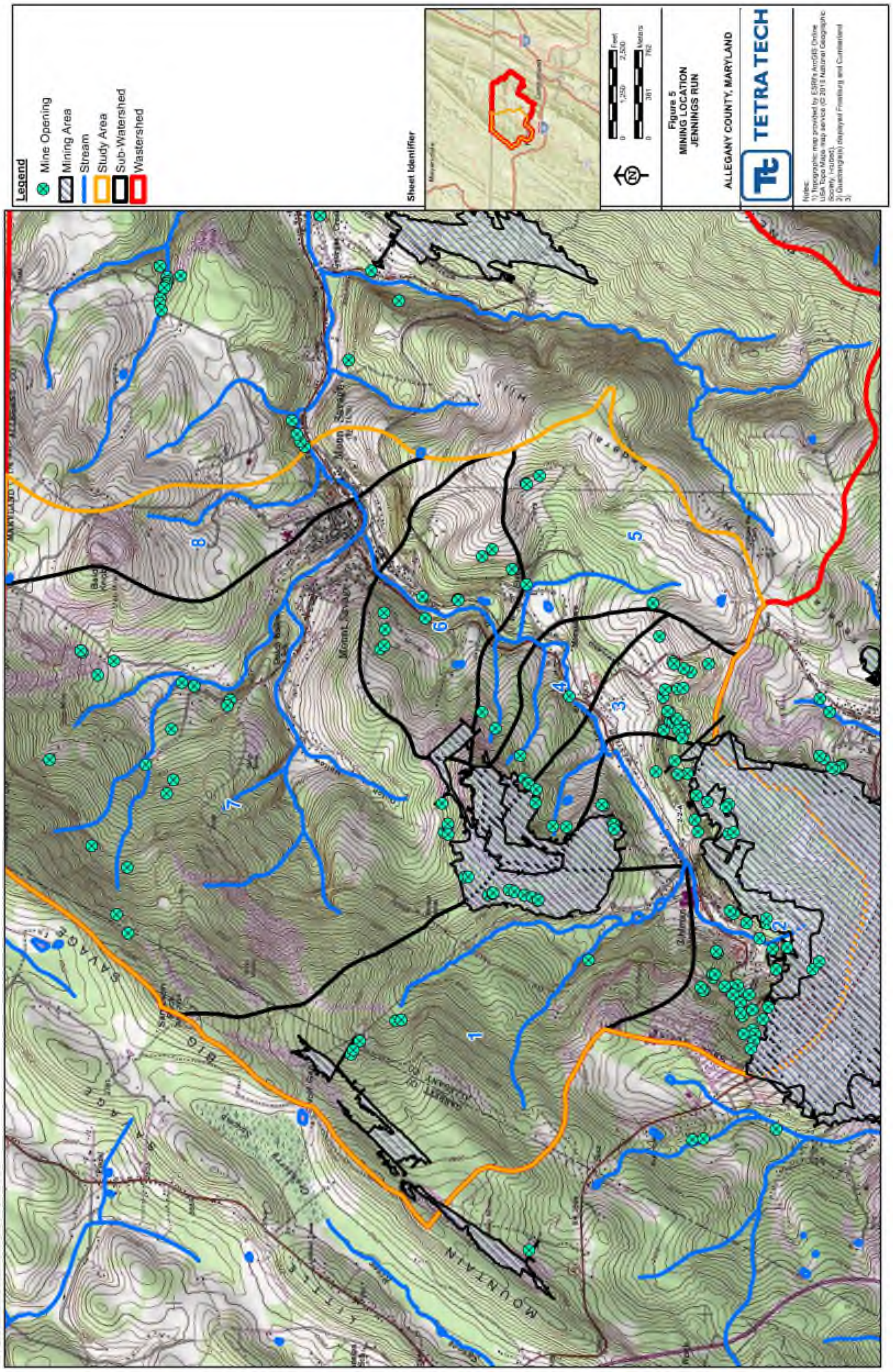


Figure 5 Extent of Mining in the Jennings Run Study Area

3.0 WATER QUALITY

3.1 TMDL SUMMARY

Jennings Run watershed tributaries are included as part of Western Maryland low pH Total Maximum Daily Loads (TMDLs). Reduction goals in the TMDL were calculated using the Mining Data Analysis System (MDAS) to represent the source-response linkage for pH. MDAS is a comprehensive data management and modeling system capable of representing loads for nonpoint and point sources in the watershed and simulating in stream processes. The model manipulates concentrations of pH influencing parameters (iron, aluminum, ammonia, nitrogen, nitrate and sulfate) to estimate pH and develops reductions in these parameters that it determines would lead to achievement of TMDL endpoints.

TMDLs and source allocations were developed on a sub watershed basis for each of the impaired watersheds in Table 2. TMDL allocations include the Load Allocations (LA) for nonpoint sources and the Waste Load Allocations (WLA) for point sources. A top-down methodology was followed to develop these TMDLs and allocated loads for sources. Headwaters were analyzed first because their loadings effect downstream water quality. Loading contributions were reduced from applicable sources to these waterbodies until pH criteria were met. The loading contributions of unimpaired headwaters and the reduced loadings for impaired headwaters were then routed through downstream waterbodies. Using this method, contributions from all sources were weighted equitably, and pH criteria were achieved through the system. Reductions in sources affecting impaired headwaters ultimately lead to improvement downstream and effectively decreased necessary loading reductions from downstream sources (Maryland Department of the Environment, 2009).

Allocations were assigned so that pH did not fall below the water quality standard of 6.5. The model was run for the period of December 1, 2004 through November 30, 2005. This produced loads that were then summed over the year to create annual loads (Maryland Department of the Environment, 2009).

The results of the modeling process were used to produce baseline conditions demonstrating model derived, low pH impaired streams. TMDL endpoints represent the water quality targets used to quantify TMDLs and their individual components. The water quality criteria for pH allow no values below 6.5 or above 8.5.

3.2 WATER QUALITY STANDARDS

Maryland water quality standards consist of two components that are relevant to Jennings Run: (1) designated and existing uses; and (2) narrative or numeric water quality criteria necessary to support those uses. Furthermore, water quality standards serve the purpose of protecting public health, enhancing the quality of water, and protecting aquatic resources. Maryland's water quality standards require that water quality in the impaired sub watersheds support their designated uses.

Maryland's water quality standards for parameters included in the MDAS model are presented in Table 1, as are EPA's national recommended water quality criteria (Maryland Department of the Environment, 2009). Segments of the Jennings Run study area covered by this plan are on the 303(d) list for AML- related pollutants. Table 1, shows that Maryland does not currently have standards for the parameters included in the MDAS model and is a contributing factor for selecting pH standards as the end point for the WIP as determined in the TMDL (Maryland Department of the Environment, 2009)

Table 1 Water Quality Standards

Parameter	Maryland		EPA	
	Value	**Comment**	**Value**	**Comment**
Acidity	-		-	
Alkalinity	-		20 mg/L	
Aluminum	-		750 µg/L 87 µg/L	Aquatic Life Freshwater instantaneous concentration at pH 6.5-9.0 Aquatic Life Freshwater maximum continuous concentration at pH 6.5-9.0
Ammonia Nitrogen	-		-	Varies based on pH and temperature
Iron	-		1.0 mg/L 0.3 mg/L	Aquatic Life Freshwater Continuous concentration Human Health for consumption of water and organism
Nitrate	-		10 mg/L	Human health for consumption of water and organism
pH	6.5-8.5		6.5-9.0 5.0-9.0	Freshwater continuous range Human health for consumption of water and organism
Sulfate	-		-	

3.3 WATER QUALITY OBJECTIVES AND GOALS

The Jennings Run watershed is on the 303(d) list as impaired by pH, therefore this WIP will focus on meeting Maryland pH water quality standards established in the Code of Maryland Regulations (COMAR). These standards require pH's to be no less than 6.5 and no greater than 8.5. this will be attempted through the increase in net alkalinity (mg $CaCO_3$ /l) and not the reduction of intermediary chemicals used in the TMDL MDAS Model (Maryland Department of the Environment, 2009).

TMDL Implementation – Reasonable Assurance

Section 303(d) of the Clean Water Act (CWA) and EPA regulations requires reasonable assurance that TMDLs will be implemented. TMDLs represent an attempt to quantify the pollutant load that may be present in a waterbody and still ensure attainment and maintenance of water quality standards. The Western Maryland TMDLs identify the necessary overall load reduction for those pollutant loads established by these TMDLS. This will occur through changes in current land use practices, including the mitigation of AMD. Although the derived TMDLs are based on best professional judgement using current data in the calibrated model, meeting these TMDLs might not be necessary if alternative mitigation and future monitoring prove that pH is being corrected without reducing these parameters (Maryland Department of the Environment, 2009).

3.4 DESIGNATED USES

All stream segments in the Jennings Run Study area should be fishable and swimmable and should be healthy enough to support biological communities. The Federal Clean Water Act (CWA) and state regulations have determined a set of interlinked water quality goals. COMAR has designated all reaches of Jennings Run in the study area III-P – Nontidal Cold Water and Public Water Supply (COMAR 26.08.02.08R(4((b)). The numeric criteria for PH requires that pH values not be less than 6.5 or greater than 8.5 (COMAR 26.08.02.03-3(4)).

3.5 RECENT STUDIES

3.5.1 2000 & 2016 Appalachia Laboratory University System of Maryland Center for Environmental Science Appalachian Laboratory (UMCES) Evaluation

A study was originally conducted in 1999 and 2000 by the Appalachia Laboratory UMCEs to look at the comprehensive water quality and biological health of the watershed. This study described the benthic macroinvertebrate and fish communities of Jennings Run and the nearby Aarons Run, as well as assessing the physical habitat and water quality prior to any restoration work.

In order to show impairments more effectively the watershed was broken up into sub watersheds and for this study only sub watersheds 1 through 8 are considered. The study concluded that during high flows, AML sources were found in sub watershed 1, sub watershed 5, and sub watershed 7 (Note the study did not include sub watershed 8 even though it is listed on the 303D). Fish populations sampled within the sub watersheds were good, only two stations sampled had no fish and those were found in sub watersheds affected by AMD discharges. Once restoration is complete, there should be adequate fish refugia to facilitate the return of fish communities. The study recommends that the remediation efforts focus on sub watersheds 1 and 7 (Morgan, Gates, & Kline, 2000).

In 2014 and 2015 Appalachia Laboratory UMCES returned to the sampling sites from the 2000 report and sampled for benthic macroinvertebrates, fish communities, water quality and assessed the physical habitat. The key findings of the study showed several AMD discharges in the Jennings Run watershed affecting the health of the stream. The AMD discharges all tend to have low pH, elevated specific conductance, high sulfate concentrations, high total dissolved solids, elevated metals and detectable mineral activity. Overall the specific conductance readings in the Jennings Run watershed are elevated, which potentially indicates that AMD is not the only source of pollution but that anthropogenic stressors contribute. In general, the watershed supports a poor to very poor benthic community. However, there are several stream reaches that support healthy benthic populations that would facilitate recolonization of impaired stream reaches once restored. Fish population numbers do show some traditional AMD discharge stressors although the presence of Brook Trout in 8 of the 12 sampling sites indicate that there is adequate water quality to support the species. Adequate fish refugia in portions of Jennings Run would facilitate the recolonization of the stream once remediation efforts are completed (Morgan & Hilderbrand, Jennings Run Project: 2014 -2015, 2016).

3.5.2 2009 Revised TMDL Study

The Western Maryland pH TMDL's for the Casselman River, Georges Creek, Savage River, Upper North Branch of the Potomac River, and Wills Creek Watersheds was used to determine the impaired stream segments. This study was conducted by the Maryland Department of the Environment and used sampling that was performed in 2005. The water quality data from the 2005 sampling was used this data to determine sources of impairment as listed below (Maryland Department of the Environment, 2009):

- In baseflow conditions, there is most likely no major source of acidification if the acid neutralizing capacity of the stream is greater than 200 µeq/L
- For areas where agriculture represents greater than 50 percent of the drainage area and the nitrogen nitrate level is greater than 100 µeq/L, there is strong probability that agriculture is a major influence of stream acidification.
- If sulfate levels are greater than 500 µeq/L, there is the potential that the stream can be affected by both AMD and atmospheric deposition.
- If the conductivity is greater than 80-100 µS.cm, the stream is considered AMD-influenced
- If the levels of organic ions are greater than the levels of nitrate and sulfate, there is a potential the stream is acidified by organic acids
- If the concentration of dissolved organic carbon is greater than 8 mg/L, the stream could be influenced by organic sources and atmospheric depositions.
- Stream water quality can be broken into three levels of acidification depending on the levels of acid neutralizing capacity (ANC):
    - Low (ANC > 50 and ≤200 µeq/L): this level has episodic acidification, especially during high intensity storm events, and occasionally long-duration storms.
    - Very Low ANC >0 and ≤ 50 µeq/L): This level has chronic acidification where small acid inputs would drive the stream below 0 µeq/L.
    - Acid (ANC ≤ 0 µeq/L): These streams have a baseflow ANC that remains below 0 µeq/L.

Results of the 2009 MDE TMDL study are detailed in Section 4.1 below.

4.0 NON-POINT SOURCE INVENTORY

Acid impaired waters in the study area of Jennings Run have been identified by several efforts and include potential AMD impairments in smaller headwater tributaries, a map identifying all of these sources can be found in Figure 6. A list detailing the origin and dates for all of the water quality samples can be found in Appendix B. Source assessments determined from the TMDL survey are provided in Table 2.

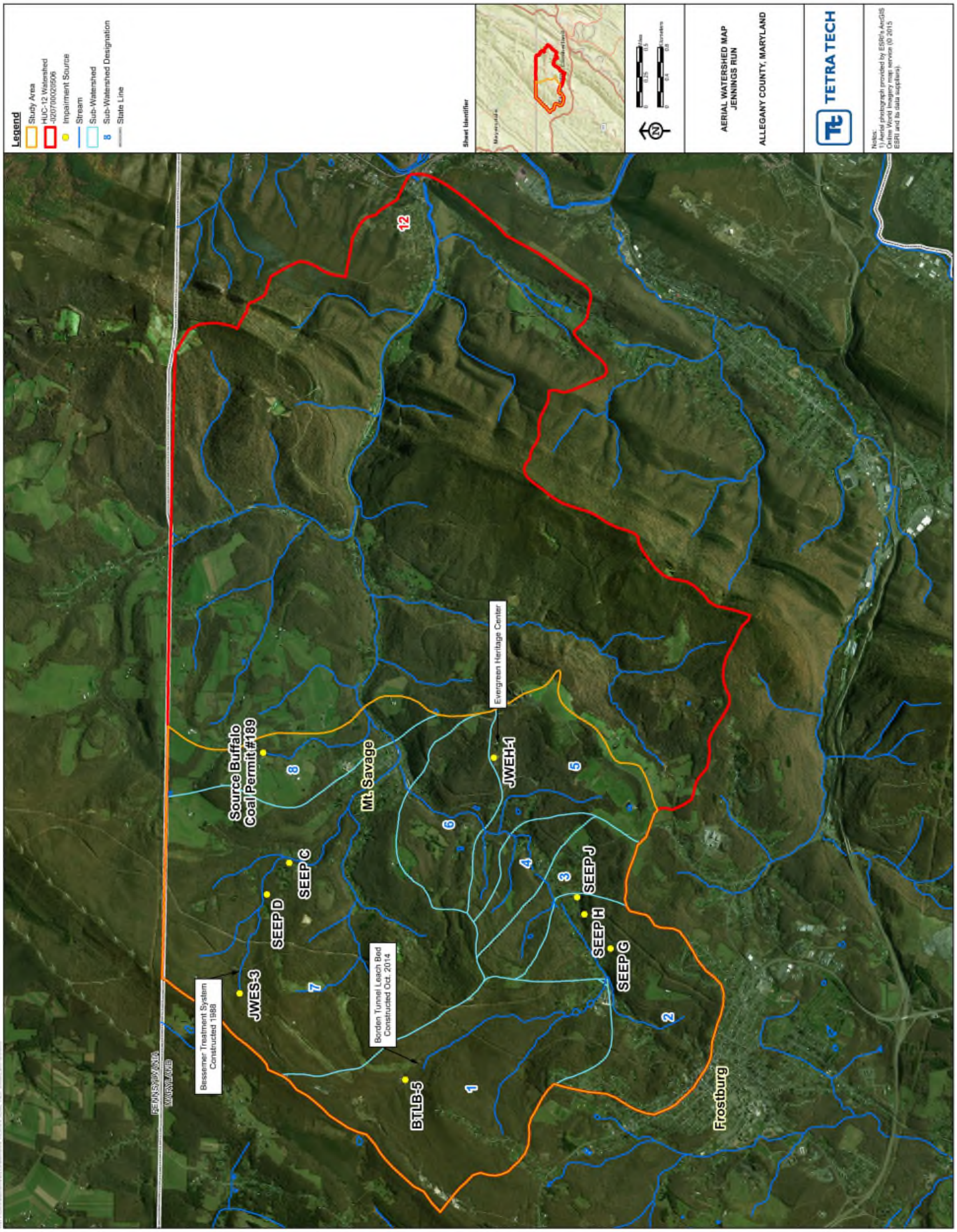


Figure 6 Impairment Map

4.1 TMDL SOURCE ASSESSMENT

Streams in the study area were monitored in 2005 to determine the acid loading and pH during different seasons for the western Maryland pH TMDL. MDE analyzed the monitoring results following the impairment characterization method summarized in 3.5.2; the results are listed in Table 2. Spatial distributions of the sub watersheds are presented in Figure 1.

Table 2 Source Assessments Determine from TMDL Survey

Station Code	Sub-Watershed	Stream Segment	pH Source Assessment	pH Min	pH Med	pH Max
JEN0092	1	Jennings Run	AMD	4.83	6.7	7.17
UJF0002	5	UT to Jennings Run	AMD	4.42	5.85	6.13
UJH0015	7	UT to Jennings Run	AMD	3.72	5.85	6.22
UJH0011	7	UT to Jennings Run	AMD	3.99	5.76	6.17
UJN0005	8	UT to Jennings Run	AMD	4.2	6.72	7.48

4.2 IDENTIFIED ACID IMPAIRMENTS

Acid impairments as a result of AMD have been identified in four of the eight sub watersheds. Portions of each of these sub watersheds are on the 303(d) list. These impairments are described in the following sections for each sub watersheds.

4.2.1 Sub Watershed 1 (Figure 7)

Sub Watershed 1 is on the 303(d) list (TMDL Station JEN00092) due to a mine opening at the headwaters of one of the two tributaries (BTLB 5). This mine opening is an acidic AML discharge. In 2014 the Borden Tunnel Leach Bed was installed and is effectively treating a small percentage of the water from the stream. This treatment is slightly raising the downstream pH in an attempt to improve water quality.

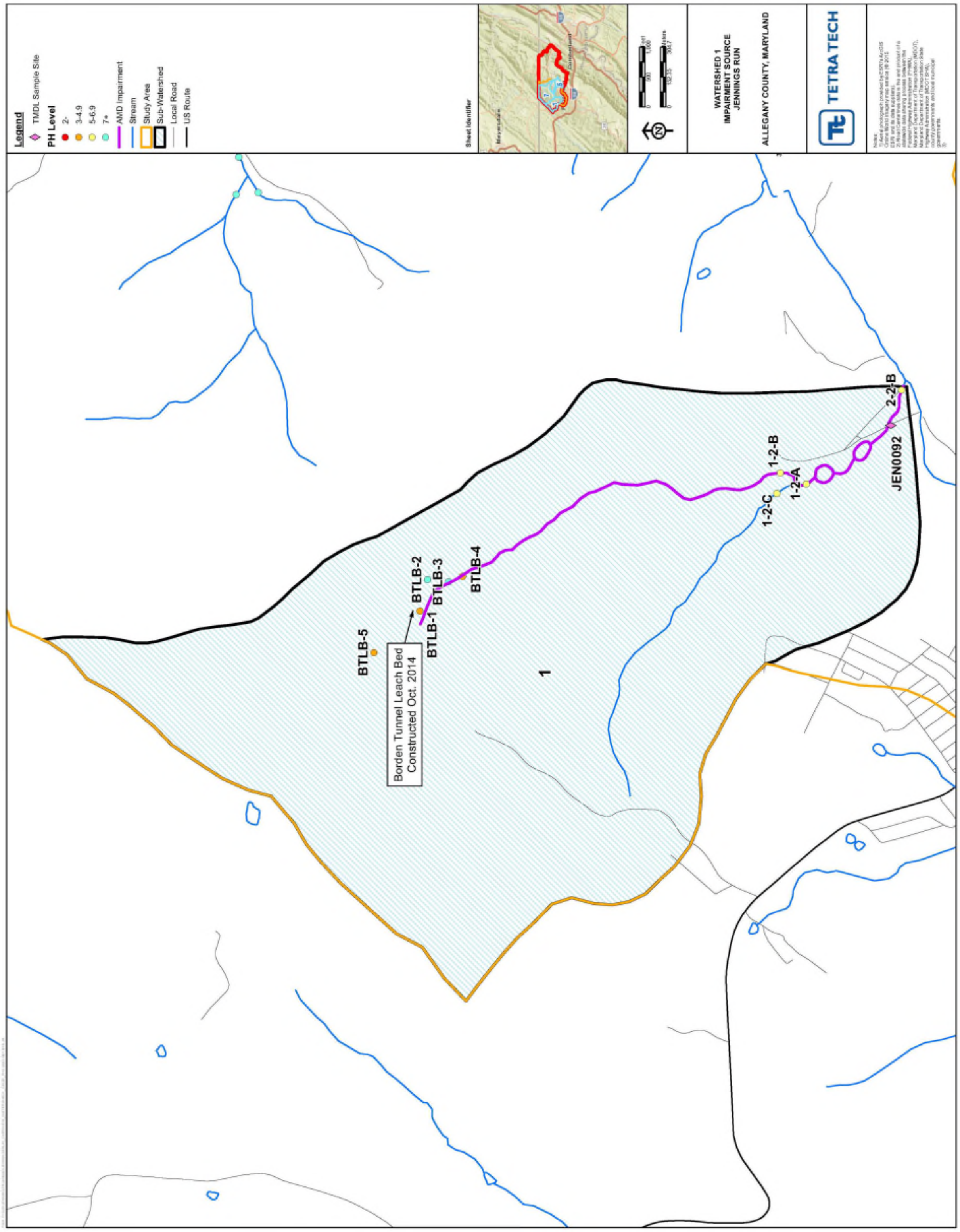


Figure 7 Sub Watershed 1 Impairment Sources

4.2.2 Sub Watershed 2 (Figure 8)

Sub Watershed 2 is not listed on the 303(d) list however there are three sources of impairments located within (Seep G, Seep H and Seep J) this sub watershed. These three seeps were identified in the UMCES studies. All three are small discharges associated with abandoned mines. The water quality of these discharges is minimal compared to other discharges in the sub watershed. However, there are elevated levels of TDS and sulfate.

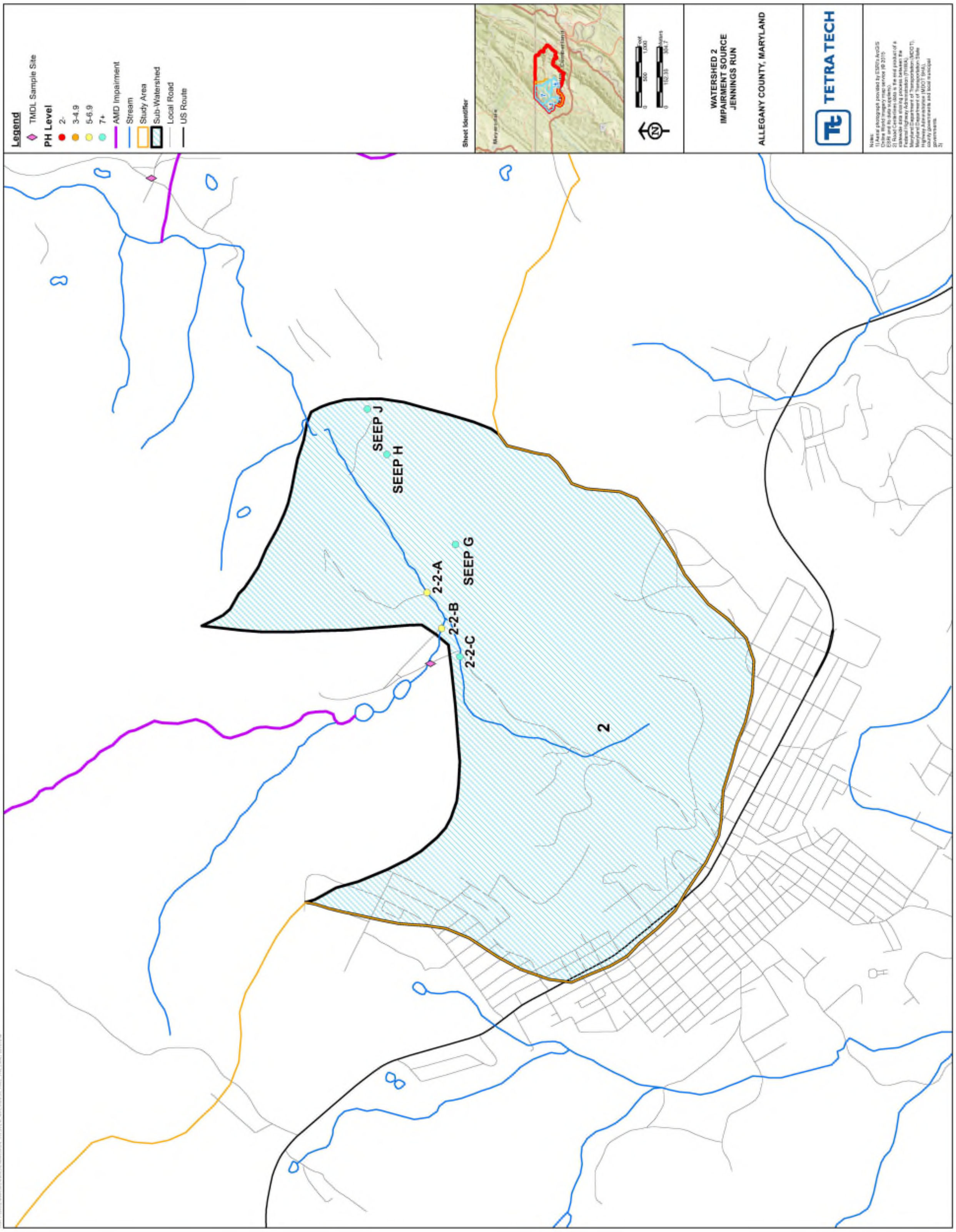


Figure 8 Sub Watershed 2 Impairment Source

4.2.3 Sub Watershed 5 (Figure 9)

Sub Watershed 5 is on the 303(d) list (TMDL Station UJF002) due to AMD impairment in the vicinity of the Evergreen Heritage Center, this mine opening is an acidic AML discharge (JWEH-1). This contributes to low pH throughout the entire sub watershed making this the second worst sub watershed in the study area. The Commonwealth passive treatment system was installed in 1987 using early treatment technology and is no longer effectively treating the water resulting in continued acid loading.

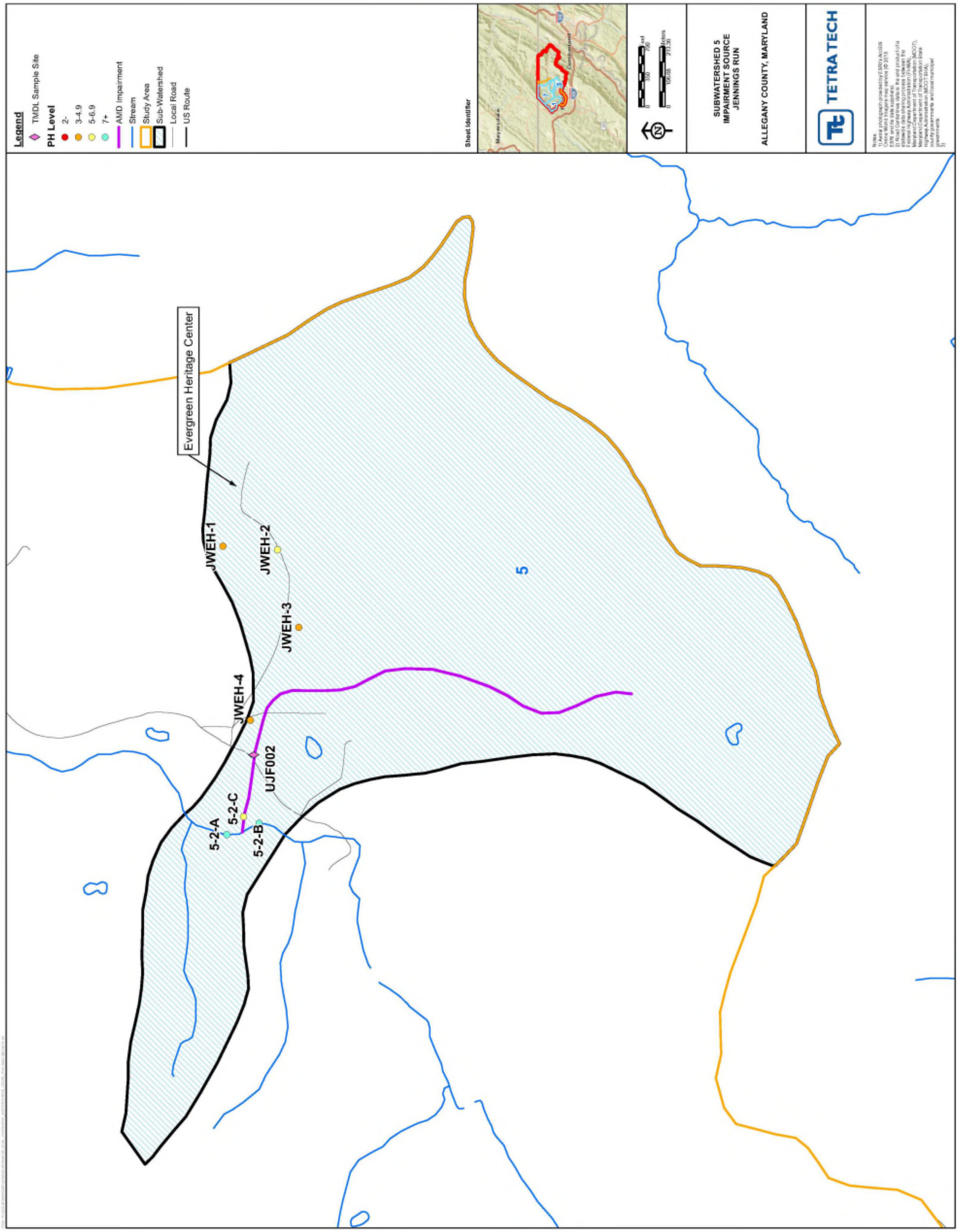


Figure 9 Sub Watershed 5 Impairment Sources

4.2.4 Sub Watershed 7 (Figure 10)

Sub Watershed 7 is found on the 303(d) list (TMDL Stations UJH0015 & UJH0011) due to a mine opening at the headwaters of the sub watershed (JWES 3). This mine opening is discharging large amounts of acid and aluminum laden water. In addition, in this sub watershed there are two seeps (Seep C and Seep D) which are also a source of impairment. This contributes to the low pH throughout the entire sub watershed making this the worst sub watershed in the study area. The Bessemer passive treatment system was installed in 1988 and is not effectively treating the water resulting in continued acid loading.

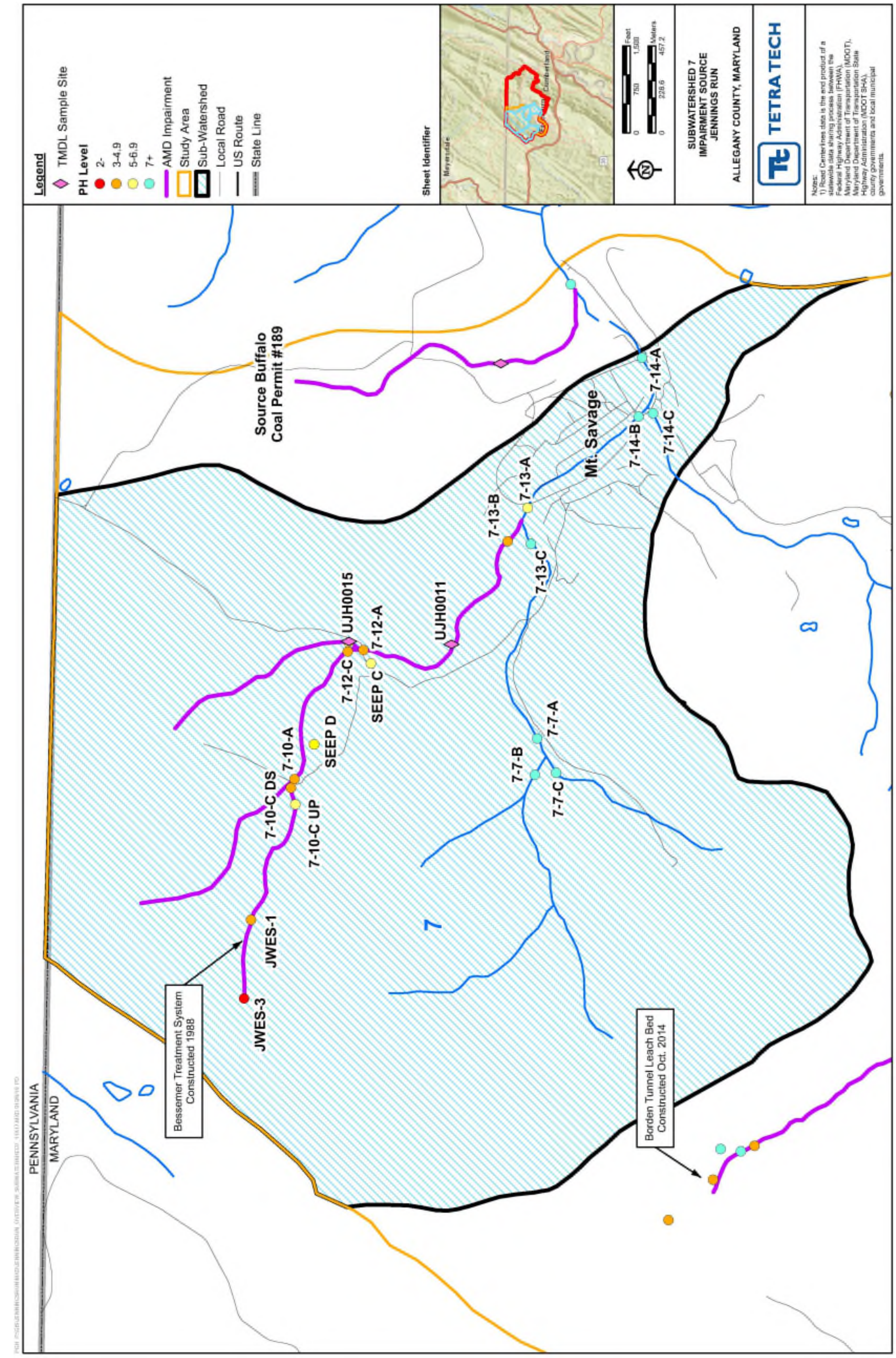


Figure 10 Sub Watershed 7 Impairment Sources

4.2.5 Sub Watershed 8 (Figure 11)

Sub Watershed 8 is found on the 303(d) list (TMDL Stations UJ005) for AMD, however past water quality data for this sub watershed does not indicate low pH values but does show elevated values for Aluminum and Sulfate which are commonly found in in AML discharges. The source of impairment in this sub watershed is the former Buffalo Coal permit number 189.

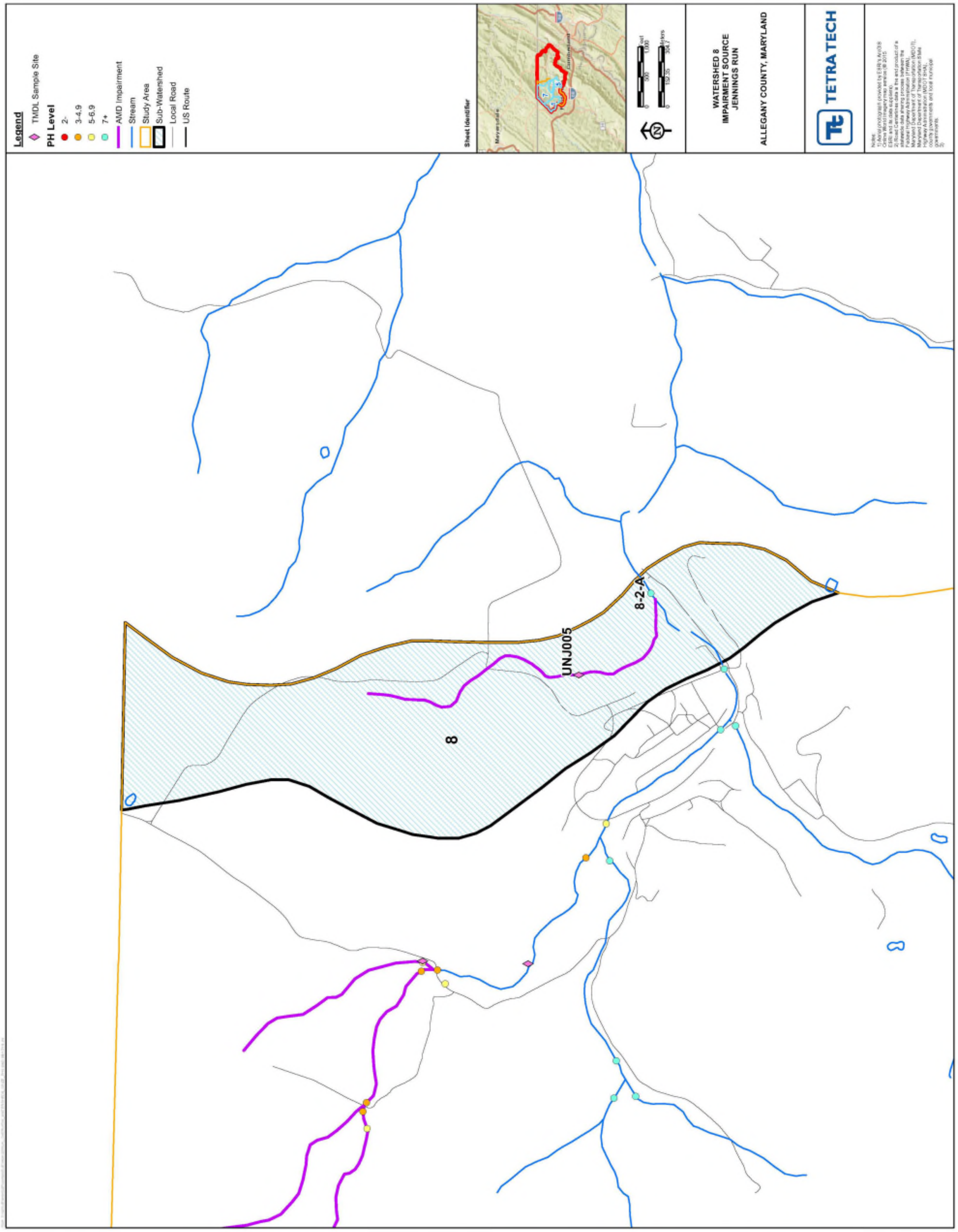


Figure 11 Sub Watershed 8 Impairment Source

5.0 NON-POINT SOURCE MANAGEMENT

Due to the number and distribution of pH impairments in the study area, MDE LMA has decided to implement treatment projects in a three-phase approach. This approach will consider the amount of acid load to the individual streams, the load contributed by these streams to the mainstem of Jennings Run, site suitability for project size, accessibility to the site for implementation and treatment technologies selected for each stream

5.1 EXISTING TREATMENT SYSTEMS

In the past there have been attempts to passively treat the AMD in the study area through the installation of 3 treatment systems as detailed in Table 3.

Table 3 Existing Treatment Systems

Treatment System	Installation
Commonwealth (Evergreen Heritage)	**1987**
Bessemer Treatment System	**1988**
Borden Tunnel Leach Bed	**October 2014**

5.2 LOAD REDUCTIONS AND PROPOSED MANAGEMENT MEASUREMENTS

To meet the TMDL targets in the study area, this plan prioritizes reducing loads at the greatest sources of AMD: station codes JEN0092, UJF0002, UJH0015, UJH0011 and UJN0005. Proposed management measures of both passive and active treatment will be implemented in a phased approach. The first phase involves passive treatment enhancements to the existing Bessemer treatment system located in station code UJH0011.

5.3 POTENTIAL TREATMENT TECHNOLOGIES

A variety of passive treatment technologies have been constructed in the Appalachian region and elsewhere for treating AMD including aerobic ponds and wetlands, anoxic limestone drains, limestone leach beds as well as reducing and alkalinity-producing systems.

Selection of the most effective passive treatment system design depends on site specific conditions, treatment goals, flow rates, and influent water quality. Passive system elements are often used sequentially in units as part of an overall passive treatment system. Some of the more important water quality parameters in passive system design include levels of dissolved oxygen, ferric iron, aluminum, and acidity (whether the water is net acidic or net alkaline). Although the goal of the passive systems in this project is pH adjustment, levels of acidity and metals will determine the type of passive system appropriate for a given discharge. Selection of an inappropriate system will potentially lead to premature system failure. The recommendations in this report are therefore conservative, and the assumptions must be validated with additional water quality sampling, flow monitoring, and field investigations prior to detailed final design. It is also important that treatment of AMD is performed with minimal intrusion of surface water runoff, therefore segregation of AMD and diversion of surface runoff are of great importance. The following list describes in depth the various measures that may be used to control AMD. Numbers in brackets following the name of the method indicate the potential load reductions when the method is used correctly an in the proper situation. (Pavlick, Hansen Evan, & Christ, 2010)

Aerobic Ponds and Wetlands (AeW) [Wide Range] - These remove sediment and metals from net alkaline water through oxidation, precipitation, and settling of metals. Aerobic ponds and wetlands are not effective in treating net acidic water or creating pH adjustment and thus are used in combination with other passive treatment technologies for treatment of acidic water. They often are placed upstream or downstream of a passive acid neutralizing system to prevent precipitates from clogging the system or to capture the precipitates discharged from it.

Anoxic Limestone Drain (ALD) - These are buried beds or trenches of limestone that add alkalinity to mine water. The mine water must be kept anoxic to promote limestone dissolution and prevent ferric iron oxides from armoring the limestone or plugging the system. The specific quality of the water has a great influence on the effectiveness of the system. Therefore, this system should not be used unless specific and extensive water quality data is available.

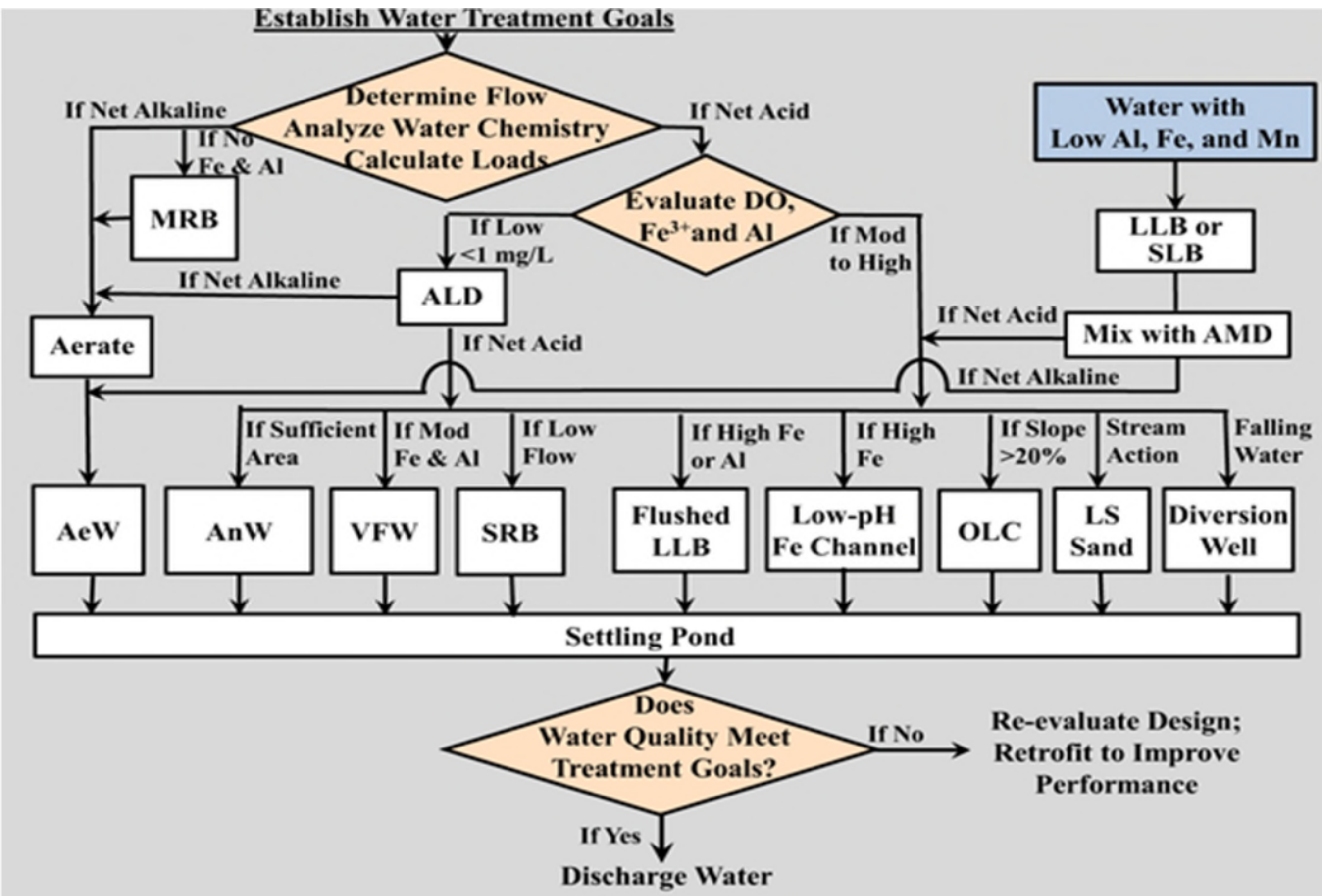
Limestone Leach Beds (LLB) [50%]- These ponds are filled with limestone for the treatment of acidic water. They are similar to ALD's but are not covered and thus do not maintain anoxic conditions. When AMD containing dissolved metals is neutralized within a limestone leach bed, the metals precipitate out of solution as hydroxides, therefore a flushing mechanism to periodically remove accumulated metal precipitates is recommended. Hydroxides can inhibit treatment by accumulating in the limestone bed and by armoring the limestone itself.

Reducing and Alkalinity-Producing Systems (RAPS) [25 g acidity/m^2] - This is a general term covering reducing systems such as vertical flow ponds. A typical RAPS may include a shallow pond with a layer of compost placed on top of a limestone layer with a perforated pipe collection and discharge system. The water flows down through the compost to remove oxygen and to reduce ferric iron to ferrous iron. The limestone then adds alkalinity under anoxic conditions. To keep the systems from clogging with metal precipitates, the perforated pipe system includes a valve arrangement, so the water may be periodically flushed out of the pond and into a lower level pond or downstream wetland.

Active Treatment [100%] – A variety of active treatment methods exist for AMD. There are a number of alkaline chemicals that can be mixed with the AMD affected water. The mixture may then be aerated and is finally passed through ponds allowing metal hydroxides to settle out as sludge.

5.4 TECHNOLOGY SELECTION

The flow chart, in Figure 12, for selecting a passive AMD treatment system based on water chemistry and flow is adapted from (Hedin, Nairn, & Kleinmann, 1994).



Key: MRB- Manganese Removal Bed, ALD – Anoxic Limestone Drain, AeW – Aerobic Wetland, AnW – Anoxic Wetland, VFW – Vertical Flow Wetland, SRB – Sulfate Reducing Bioreactor, LLB – Limestone Leached, OLC – Open Limestone Channel, LS – Limestone, SLB – Slag Leached

Figure 12 Technology Selection Flow Chart

The data used for the following designs was obtained from several sources, a list of all the sample locations, the sampler and dates sampled can be found in Appendix B.

5.4.1 Bessemer Treatment – Sub Watershed 7

For Phase I of the WIP installation of treatment systems will be focused on the non-functioning Bessemer Treatment system in sub watershed 7. In the case of this site the available water quality and flow data is limited and difficult to interpret. Additional water quality data will be obtained prior to any design or improvements. The existing treatment system is not functional. The water averages a pH of 3.0 after discharge and the mine opening upstream of treatment the average pH is 4.6.

Very little flow data is known to be available. Two flow rates measured at the treatment system discharge were provided in the "Analysis or Aarons Run and Jennings Run Benthic Macroinvertebrates, Fishes, Physical Habitat and Stream Water Quality" report by Morgan, Gates and Kline dated December 2000. The measured values were 19.3 gallon per minute (gpm) (May '99) and 12.5 gpm (March 2000). Flow rates downstream after a tributary confluence at sample location 7-10A were measured at between 14 and 42 gpm.

Design of the passive AMD system will conservatively assume influent water quality for the proposed system is represented by the effluent water quality of the failed existing system, to account for the worst-case scenario. Using the flow chart in Figure 10, the passive treatment options applicable to a net acidic water with high levels of iron and aluminum is a limestone leach bed with a flushing system, or a 'Flushed LLB' as given on the chart. Other possible choices include an anaerobic wetland (AnW) or a vertical flow wetland (VFW). Although not shown on the chart, a RAPS in the form of a vertical flow pond as described in Section 5.3 has comparable selection criteria and components to a vertical flow wetland. Based on the limited data available for selection and design, a limestone leach bed is the recommended passive treatment alternative. Final determination of the optimal passive system must include detailed investigation of the site and the existing system, as well as required water quality and flow measurement data.

Design of a limestone leach bed is based on a minimum detention time at the design flow rate. This detention time varies in publications from 30 minutes to as much as 15 hours, however the amount of limestone required is likely to be the controlling design factor. The limestone quantity is based on the influent acid load, $CaCO_3$ content of the limestone, and the design life. Assuming limestone at 85% $CaCO_3$, a design life of 20 years, and influent acidity of 237 mg/l yielded a lime requirement of 1,030 cy. Assuming 4 feet of limestone and a 2:1 length to width requirement for the leach bed yielded a 120-foot long by 60-foot wide by 4-foot deep bed requirement. The bed should be provided with a piped underdrain and flushing mechanism discharging into a settling pond or wetland prior to discharging from the site. This will prevent iron and aluminum precipitates from prematurely clogging the bed and prevent precipitates escaping the site and impacting downstream stream beds. Using U.S. Office of Surface Mining (OSM) and United States Geologic Survey (USGS) AMD Treat software the acid load reduction is calculated at 10 tons per year.

Review of LIDAR mapping of the Bessemer site obtained from The Maryland 'iMap' data portal (imap.maryland.gov) indicates potentially favorable site topography. The site topography shows what appears to be the existing treatment system; the layout and dimensions of which may match up well with the recommended leach bed and discharge pond as discussed previously. It is possible that rehabilitation of the existing system may achieve the desired pH adjustment, but of additional site investigation and detailed analysis is required to confirm this.

5.4.2 Evergreen Heritage/Commonwealth Site – Sub Watershed 5

A portion of Phase II of the WIP installation of treatment systems will be focused on the non-function Evergreen Heritage/Commonwealth system in sub watershed 5. In the case of this site, the available water quality and flow data is very limited. The existing treatment system was constructed in 1987 but nothing else is known. Sample location JWEH-1 at the small pond inlet is believed to be most representative of AMD discharging from the site. Water testing in 2015 revealed a pH of 4.5 at the pond influent with iron, aluminum, and manganese levels of 1.18, 3.2, and 6.11 mg/l, respectively. Total acidity was also low at 23 mg/l.

Very little flow data is known to be available. One flow rate of 6.3 gpm was measured at the pond inflow in January 2018.

Design of the passive AMD system will assume pond inflow water quality as a basis for design. A rounded design flow of 20 gpm is also assumed by applying a safety factor of 3 to the only observed flow rate. Using the flow chart in Figure 12, several passive treatment options may be applicable to a net acidic water with fairly low levels of iron and aluminum such as found at the pond inflow. Based on the limited data available for selection and design, a limestone leach bed is the recommended passive treatment alternative. An open limestone channel may also be utilized with check dams along its length and a settling pond or wetland at its discharge to prevent precipitates from escaping the site. Final determination of the optimal passive system must include detailed investigation of the site and the existing system, as well as required water quality and flow measurement data.

Design of a limestone leach bed is similar to the design of the Bessemer system using the following parameters Assuming limestone at 85% $CaCO_3$, design flow rate of 20 gpm, a design life of 20 years, and influent acidity of 237 mg/l JWES-2) yielded a lime requirement of 1,030 CY. Assuming 4 feet of limestone and a 2:1 length to width requirement for the leach bed yielded a 70-foot long by 35-foot wide by 4-foot deep bed requirement. Using AMD Treat software, the acid load reduction is calculated at 0.3 tons per year.

5.4.3 Borden Tunnel Site – Sub Watershed 7

The Borden Tunnel Leach Bed AMD treatment system reportedly discharges net alkaline water with pH ranging from 7.3 to 8.1 and relatively low metals (BTLB-2), however the Maryland Department of the Environment believes the system is undersized and would like to see it expanded or another system added. In the case of this site the available water quality and flow data are limited and difficult to interpret.

Design of the passive AMD system will assume pond inflow water quality as a basis for design. Sample location BTLB-1 appears most representative of the chemistry of AMD to be treated. BTLB-1 is a sample site on the mainstem of the tributary from which a portion of the water is diverted into the treatment system providing the inlet water source. Water testing in 2015 and 2016 revealed a lab pH ranging from 3.63 to 3.86 with average total iron, aluminum, and manganese levels of 0.7, 2.9, and 0.5 mg/l, respectively. Total acidity averaged 31 mg/l.

Using the flow chart in Figure 12, several passive treatment options may be applicable to a net acidic water with fairly low levels of iron and aluminum such as found at the pond inflow. Based on the limited data for selection and design and the know effectiveness of the current leach bed system, an additional limestone leach bed is the recommended passive treatment alternative. The estimated size of the proposed leach bed system does not include a reduction due to the size of the existing system. Final determination of the optimal passive system must include detailed investigation of the site and the existing system, as well as required water quality and flow measurement data.

Design of a limestone leach bed for the Borden Tunnel discharges is similar to the design of the Bessemer and Evergreen system using the following parameters Assuming limestone at 85% $CaCO_3$, design flow rate of 375 gpm, a design life of 20 years, and influent acidity of 31 mg/l (BTLB-1) yielded a lime requirement of 6,450 or 10,320 Tons. Assuming 4 feet of limestone and a 2:1 length to width requirement for the leach bed yielded a 300-foot long by 150-foot wide by 4-foot deep bed requirement. Using AMDTreat software, the acid load reduction is calculated at 190 tons per year. Due to the size of the proposed leach bed it is likely several smaller leach beds would be required in series.

5.4.4 Additional Sub Watersheds

The water quality impacts for sub watersheds 2 and 8 are less in severity with the pH of these discharges near neutral. During Phase II of this plan smaller passive treatment systems in the form of sand filters will be designed for each individual impairment site. Load reductions for these sites will significantly less than the three larger impairments due to its neutral pH.

5.4.5 Load Reductions

The measures outlined in the previous sections will provide for the desired acid load reduction to keep maintain the pH of the impaired waters to between 6.5 to 8.5 per the Maryland Water Quality Goals. The expected load reductions of the three larger impairments can be found in Table 4.

Table 4 Expected Load Reductions

Site	Sub Watershed	Load Reduction in Tons/year
Bessemer*	1	10
Evergreen*	5	0.3
Borden Tunnel	7	190

*Based on the impairments indicated by 30-year-old historic data for Evergreen and Bessemer, both projects will need to complete a minimum of monthly on yearlong pre-design water quality assessment. Pre-construction loading will be recalculated for the project tin order to determine the true success of the project.

6.0 TECHNICAL AND FINANCIAL ASSISTANCE/BENEFITS

To meet TMDL standards, it will take a combination of federal, state, private and public partnerships to work jointly to provide the desired outcome or restoring the watershed.

6.1 TECHNICAL ASSISTANCE NEEDS AND PARTNERS

Technical assistance will be solicited for the following tasks:

- Locating funding
- Watershed Characterization
- Project site selection
- Project design and engineering
- Project implementation and management
- Water quality and biological monitoring
- Outreach

6.1.1 Maryland Department of the Environment (MDE)

Two MDE programs have responsibilities associated with watershed plan implementation.

The MDE, Land and Material Administration (LMA) is the lead agency for reclamation of abandoned mines including those in the Jennings Run study areas. They are responsible for coordinated funding for the project, sampling and analysis used to characterize impairments in the watershed, ranking the projects importance and implementation effort. They will also manage project implementation, coordinate outreach programs and conduct further sampling to document the effectiveness of projects.

The MDE Water and Science Administration is the lead agency for TMDL development, TMDL implementation, NPS management and water quality planning, water quality impairment tracking and reporting, and water quality monitoring.

6.1.2 Appalachian Laboratory UMCES

MDE LMA contracted Appalachian Laboratory UMCES to provide detailed assessments of AMD impairments and potential sources within the Jennings Run watershed. Their efforts have contributed greatly to understanding the nature and extent of pH impairment within the Jennings Run watershed. Future assistance may include sampling for biological communities, both benthic and fish, water quality and habitat assessment.

6.1.3 Other Technical Resources

There exists a multitude of agencies that may help contribute to this project in the future at the local, state and federal level. These partners may provide expertise in AMD mitigation, project design and funding.

6.2 FINANCIAL ASSISTANCE NEEDS

Implementation costs for AMD projects can be variable depending on the characteristics of the project. Aspects of the cost include:

- Capital costs include the cost of planning, design and construction for the project.
- Maintenance costs include ongoing material costs for operations.
- Operational costs include ongoing labor costs for operation, maintenance and monitoring.

6.2.1 Capital Cost

The estimated capital cost for the installation of the passive systems can be found in Table 5.

Table 5 Capital Cost

Treatment Site	Sub Watershed	Capital Cost
Bessemer	7	$425,000
Borden Tunnel	1	$478,610
Evergreen	5	$150,000

6.2.2 Operation and Maintenance Cost

Passive treatment systems for acidic mine water, including the limestone beds suggested for use at acidic discharges within the Jennings Run watershed, are not maintenance free. A buried limestone system should be periodically inspected and flushed, the downstream accumulation of precipitates occasionally removed for disposal, vegetation encroachment kept to a minimum, and water sampling performed to verify system performance and regulatory compliance as applicable. The cost associated with these items are client and site specific as they depend on the availability of manpower, labor rates, proximity to the sites, proximity to labs, and ease of access to name a few factors influencing operation and maintenance costs. Long term maintenance could also include partial or complete reconstruction of the systems, which have been sized conceptually with adequate limestone for a 20-year lifespan.

Although costs are site specific, the AMDTreat software tools have been used to conceptually estimate O&M costs for the proposed additions to the existing Bessemer, Borden Tunnel, and Evergreen passive leach bed systems. The costs include allowances for labor assuming monthly site visitation for routine inspection by one individual, general maintenance assumed to be 3.5% of initial construction cost per year, occasional sludge removal (metal precipitates) from downstream catchments, and water sampling assuming monthly sampling of all 3 sites in one day. These costs are summarized in Table 6 with the following assumptions:

- One laborer inspects all 3 sites in one day
- Labor Rate at $35/hr.
- Maintenance at 3.5% of Construction Cost
- Sludge Removal Coast at $0.06/Gallon
- Water monitoring and sampling: one sampler sampling once per month, lab costs at $27/sample, 3 samples per site
- Maintenance includes site and access upkeep and occasional repairs to component replacements.

Table 6 Operation and Maintenance Costs

Site	Routine Monthly Inspections	Maintenance at 3.5% of Construction Cost/per year	Sludge Removal/ per year	Water Monitoring and Sampling/ per year	Annual Operation and Maintenance Cost
Bessemer	$3,350	$12,100	$1,180	$4,580	$21,210
Borden Tunnel	$3,350	$12,100	$1,180	$4,580	$21,210
Evergreen	$3,350	$2,020	$1,170	$4,580	$11,120

6.2.3 Operation and Maintenance Funding

Treatment of AMD requires on going operation and maintenance to mitigate continuing pollution sources and meet water quality standards in the streams that receive acid mine drainage.

To meet this need, MDE uses the Acid Mine Drainage Abatement and Treatment Fund (AMD Account) to pay for operation and maintenance costs associated with acid mine treatment systems in Maryland. The AMD account, and interest earned by unexpended funds in the AMD Account, are currently used to pay for operation and maintenance of 53 existing active and passive systems. The AMD account will also be used to pay for the operation and maintenance costs for the treatment systems that will be implemented consistent with this watershed plan.

6.2.4 Monitoring Funding

There are two categories of monitoring costs anticipated by this watershed plan:

-Operational monitoring cost: The cost for staff time for field monitoring and for analytical services will be paid for by the Acid Mine Drainage Abatement and Treatment Account (AMD Account), which is part of the Abandoned Mine Land Grant, and;

-Water quality progress monitoring cost: The cost for staff time for field monitoring and for analytical services for the water quality component of this project will be covered in part by MDE's Targeted Watershed Project, which is funded by the Federal 319(h) Grant.

Funding sources are listed in Table 7.

Table 7 Funding Sources

Type	Source Name	Strategic Use
Federal	319(h) Grant, Federal Clean Water Act	Implementation consistent with an EPA-accepted watershed plan. Also, before/after monitoring of BME implementation.
Federal	Watershed Cooperative Grant	Watershed planning, stakeholder outreach and education for non-profit recipients
Federal	Abandoned Mine Land Grant, Federal Surface Mine Control and Reclamation Act – AMD Account	Operation and maintenance of mine reclamation projects. Costs of monitoring associated with operation of mine reclamation projects.
State	Water Quality Revolving Loan	Stream corridor restoration and protection
State	Maryland General Obligation Bond – Mining Remediation Program Funds	Financing for state-owned capital improvements

7.0 INFORMATION, EDUCATION AND PUBLIC PARTICIPATION

This section of the Plan includes the stakeholder outreach strategy including planning for public meetings, listing of stakeholders identified to date, and education and outreach materials. This strategy can be found in Table 8, with identified stakeholders listed in Table 9.

Table 8 Stakeholder Outreach Strategy

Stakeholder Outreach Strategy for the Jennings Run Watershed Implementation Plan	
Preliminary Outreach and Education 2019-2020	Initiate outreach with key stakeholders focusing on: 1) Landowners potentially affected by watershed plan Phase I, 2) Groups and individuals potentially interested in plan goals, 3) Partner agencies concerned with acid mine drainage remediation or NPDS pollution management.
Draft Plan Public Participation 2019-2020	Upon release of the watershed plan, input from stakeholders and the public will be gathered and, as appropriate, incorporated as a watershed plan update. A public meeting will be held in late 2019 and cooperation with interested groups.
Implementation Outreach 2019-2025	For stream segments where remediation is anticipated, pre-implementation outreach: with landowner and other stakeholders who have a direct stake in the remediation will be conducted. Input gathered during pre-implementation outreach will be used to help assess the feasibility of BMP implementation. For key landowners and stakeholders identified during pre-implementation outreach, communication will be continued throughout the remediation implementation as needed to maintain stakeholder support. Post – implementation outreach will be addressed through Annual Progress Reporting and End Phase Assessment.
Annual Progress	Each year progress will be evaluated by in MDE LMA
End Phase Assessments 2023, 2028, 2032	Progress toward meeting milestones will be assessed and findings in the form of watershed plan updates will be made available to the public. Input from stakeholders and the public will be gathered and, as appropriate, may be incorporated into the watershed plan as a plan update. If the assessment findings indicate that the plan should be modified, a plan addendum will be released to the public. Changes in water quality impairment (delisting) will be made public (MDE internet). Interest in a public meeting will be solicited and, if the solicitation generates interact a public meeting will be held.

Table 9 Identified Stakeholders

Stakeholders Identified in the Jennings Run Study Area	
Citizen Groups	Eastern Brook Trout Joint Venture Potomac Valley Fly Fishers Wild Turkey Federation Trout Unlimited Appalachian Landscape Conservation Cooperative
Landowners	Private Landowners, State of Maryland, Department of Natural Resources Barrellville Sportsman Club Savage Mountain Hunting club Piney Run Hunting Club Evergreen Heritage Center Great Allegheny Passage Western Maryland Scenic Rail Road
Government	Allegany County (various agencies, elected officials) DNR: Fisheries Service, Wildlife and Heritage MDE: Mine Permitting and Abandoned Mine Land Reclamation, NPS Management, Permitting Maryland Office of Tourism US EPA: NPS management USGS Allegany Soil Conservation District
Private Business/Education	Frostburg State University Allegany County Chamber of Commerce

8.0 IMPLEMENTATION SCHEDULE AND MILESTONES

Since funding may not be available to address every problem, a phased implementation schedule with milestones and measurable goals are detailed in Sections 8.1 – 8.3. Because of the uncertainty of securing the required funds from a variety of agencies in a short period of time, the schedule, milestones and measurable goals are divided into five-year phases and no final end date is projected for implementing all of the reductions in this plan.

Due to site constraints throughout the study area passive treatment options are preferred and therefore are the first choice for implementation. If passive treatment systems become unfeasible then active treatment will be explored.

Many details are provided for Phase I, which lasts from 2018-2023 because these mitigation efforts are more explicit. The schedule, milestones, and goals are designed to expand upon existing efforts within the watershed. Fewer details are provided in Phase II and III because of the difficulty in predicting the number, location and types of mitigation projects to be funded. These Sections will be revisited in future iterations of this WIP.

8.1 PHASE I (5 YEARS-2019-2023)

Phase I will implement pH management measures on the number one priority watershed, Sub watershed 7, Bessemer. This is the biggest contributor of acid loading to the watershed and will provide the most relief. Phase I will also include an update to the plan to address the sediment impairment and TMDL for the watershed.

8.1.1 Revise Plan to Address Sediment TMDL

MDE has identified the Wills Creek 8-digit watershed as impaired by both bacteria and sediment, in addition to the low pH impairments listings for certain segments in the watershed. TMDLs have been developed for both of these pollutants. The bacteria impairment in the Jennings Run sub watershed, however, is caused primarily by combined sewer system overflows, for which Allegany County has a consent decree with MDE to eliminate. Therefore, addressing the bacteria impairment in the Jennings Run sub watershed would fall outside the scope of this watershed plan. The Wills Creek sediment TMDL is based on the results of Maryland Biological Stream Survey (MBSS) sampling at 10 stations, 4 of which are located within the project area. The stations sampled indicate a sediment impairment in the project area due to bar formation, channel alteration, and the presence of erosion (Maryland Department of the Environment, 2018).

In 2019, MDE will be working with the Allegany County Planning Department, Allegany County Soil Conservation District, and City of Frostburg to develop a planned implementation strategy and schedule to address the sediment impairment in the sub watershed. Once these strategies and schedule for implementation have been outlined, the Jennings Run Watershed Implementation Plan will be revised to address the sediment impairment and TMDL.

8.1.2 Secure Implementation Financing

- *Secure funds for reclamation projects*- Each year of the project implementation, LMA will secure funds to pay capital costs from the 319 program and alternative sources
- *Secure funds for operation and maintenance*- LMA will also ensure that sufficient operation and maintenance funds are spent from a set-aside fund or other potential sources to keep all projects in the watershed functioning properly.

8.1.3 Coordinate Project Design and Materials

<u>January 2019-December 2019</u>

- *Begin pre-implementation monitoring-* The LMA has coordinated with the MDE 319 monitoring group to begin pre-implementation monitoring of water quality in accordance with the proposed monitoring strategy. Additional samples may be taken in Spring 2019
- *Develop specs and site design-* The LMA will plan and implement the project in sub-watershed 7 to improve existing water quality in the watershed.
- *Permits-* Identify and acquire all the necessary permits to place the proposed measures in non-tidal freshwater streams.
- *Select Contractor's-* Bid out scope to make sure that the contractors necessary to build leach beds and treatment ponds are in place.
- *Determine Limestone Source-* A list of suitable quarries with high quality limestone will be developed. The $CaCO_3$ content of the limestone will analyzed. These results will be used to determine overall effectiveness of the systems.
- *Develop operations and maintenance plans-* Once the plan is completed, the LMA will develop operations and maintenance plans for completed Phase I projects, the Operation and Maintenance (O&M) plan will be an adaptive management plan with regards to addition of extra limestone to leach beds and cleaning of treatment ponds.

5-Year Goal

- *Reassess the big picture-* At the end of each year, LMA and partners will reassess the strategic priorities for AMD mitigation in the watershed. This assessment will be used to track improvements over time and to help plan additional mitigation projects in other Sections of the watershed, including the potential for active systems as well as determining operations and maintenance priorities for Phase I and II management measures.
- *Phase II preliminary analysis-* Site selection and initial design of Phase II will take place in order to prepare for the next 5-year implementation goal. Identify all potential stakeholders for site selection and begin outreach.

8.1.4 Measurable Goals for Phase I (5 Years - 2019-2023)

By the end of Phase I in March 2023, the following measurable goals will be achieved:

- *Project Implementation* – pH mitigation project will have been installed in sub-watershed 7 in the Jennings Run study area. This project will function well enough that water discharged from this site will meet COMAR based effluent limitations for pH (6.5).
- *Water Quality Monitoring* – Instream water chemistry measurements will show that this sub watershed is meeting water quality standards for pH. Measurements in the mainstem of Jennings Run below this sub watershed will also show that it is meeting standards (6.5-8.5).

- *Biological Monitoring* – Biological communities at the end of the five-year period will show improvement in diversity of species and size of communities. Pollution intolerant species should begin to recolonize areas that were previously too acidic for their survival.
- *Document Results* – Biological communities at the end of the five-year period will show improvement in diversity of species and size of communities. Pollution intolerant species should begin to recolonize areas that were previously too acidic for their survival.
- *Outreach for Phase II* – LMA will have created an inventory of implementation projects in other sub watersheds, a preliminary monitoring plan created, preliminary pH mitigations calculations and designs in place. The Jennings Run WIP will need to be evaluated at this time to determine if modifications are warranted in order to continue with the next implementation phase.

8.2 PHASE II (5 YEARS 2023-2028)

Phase II will include pH management measures for the remaining sub watersheds with AML impairment, sub watersheds 1 and 5, Borden Tunnel and Evergreen respectively.

8.2.1 Secure Landowner Permissions, Permits and Establish Agreements to Operate and Maintain

- *Secure funds for reclamation projects* – Funding sources will depend on the successful implementation of Phase I projects.
- *Investigate other funding sources* –Future sources of funding will be investigated at this time.

8.2.2 Coordinate Project Design and Materials

November 2023-June 2028

- *Select Mitigation Technologies* – Based on the results of Phase I project assessments, LMA will decide whether or not to continue with the technologies evaluated in Phase I, or to use different technologies to address acidity in the Phase II remediation areas.
- *Develop specs and site design* – Secure the personnel and resources needed to accomplish this task.
- *Select Contractor's* – Bid out scope to make sure that the contractors necessary to build treatment systems.
- *Determine Limestone Source* A list of suitable quarries with high quality limestone will be developed. The $CaCO_3$ content of the limestone will analyzed. These results will be used to determine overall effectiveness of the systems.

5-year goals

- *Modify watershed, operations and maintenance plans* – Make adjustments to the operations and maintenance plan to include the needs of Phase II projects.
- *Reassess the big picture* – At the end of each year, AML and partners will reassess the strategic priorities of the Phase II remediation sites. This assessment will be used to track progress over time help evaluate the potential for additional mitigation, and address including active treatment options and operations and maintenance priorities for Phase I and Phase II management measures.

8.2.3 Install Management Measures

- *Install projects* – Secure landowner permissions, acquire permits and establish agreements to operate and maintain mitigation projects.
- *Operate and maintain existing sites* – Continue Phase I O&M as well as incorporating the needs of projects in the Phase II remediation areas.
- *Begin monitoring project effectiveness* – Continue to assess Phase I and Phase II implementation in accordance with the proposed monitoring strategy

8.2.4 Measurable Goals for Phase II

By the end of Phase II in December 2028, the following measurable goals will be achieved:

- *Project Implementation* - pH mitigation projects will have been installed on all priority impaired streams of the Jennings Run WIP. These projects will function well enough that water discharged from these sites meet technology based effluent limitations for pH (6.5).
- *Water quality monitoring* – Instream water chemistry measurements will show that all treated tributaries of the project meet pH standards (6.5-8.5)
- *Biological Monitoring* – Biological communities at the end of the ten-year period will show improvement in diversity of species and size of communities. Pollution intolerant species should begin to recolonize areas that were previously too acidic for their survival

Based upon the results of Phase I and Phase II, Phase III has been developed with two possible scenarios. Phase IIIA assumes that mitigation measures address all or most of the acid loading in the watershed and requires no additional mitigation projects. Phase III B assumes the installed earlier fail to adequately address the acid loading in the watershed.

8.3 PHASE IIIA (FIVE YEARS - 2028-2033)

8.3.1 Secure Additional Funding

- *Secure funds for reclamation projects* – Capital costs and long-term O&M funds need to be determined according to whatever grants or alternative funding sources are developed in the future.
- *Secure funds for operation and maintenance*

8.3.2 Continue Operations and Maintenance

- *Operation and Maintenance* -Follow O&M plan for the installed treatment system
- *Select contractor/s* – Bid out scope to make sure that the contractors necessary to maintain the treatment systems installed.

8.3.3 Measurable Goals for Phase IIIA

By the end of Phase II in December 2028, the following measurable goals will continue to be achieved:

- *Implementation* – pH mitigation projects will have been installed on all impaired streams in Phase I and Phase II of the Jennings Run WIP.
- *Water Quality Monitoring* – Instream water chemistry measurements will show that all treated tributaries of the Jennings Run study area are meeting water quality standards for pH. Measurements in the Jennings Run mainstem below these projects will also show that it is meeting standards. These projects will function well enough that water discharged from these sites meets technology-based effluent limitation for pH.
- *Biological Monitoring* – Biological communities at the end of the fifteen-year period will show improvement in diversity of species and size of communities throughout the entire watershed. Pollution intolerant species should begin to recolonize areas that were previously to acidic for their survival.

8.4 PHASE IIIB (FIVE YEARS - 2028-2033)

This phase was designed as a contingency plan in the event that passive mitigation technologies fail to adequately address the acid load in the Jennings Run study area.

8.4.1 Secure Additional Funding

- *Secure Funds for upgrades or additional reclamation projects* – Since environment goals met, Capital costs and long-term O&M funds need to be determined according to whatever grants or alternative funding sources have been leveraged the future.
- *Secure funds for operation and maintenance*.

8.4.2 Coordinate Project Design and Materials

- *Develop specs and site design* – Select appropriate active dosing equipment, or comparable future technology to address the size of waters no being adequately mitigated.
- *Determine Limestone Source.*
- *Modify operations and maintenance plans* – Modify plan to accommodate revised passive treatment options or active dosing equipment
- *Reassess the big picture* – Set new end goals for acid load mitigation and biological recolonization within previously impaired waters.
- *Select Contractor/s* – Bid out scope to make sure that the contractors necessary to construct doser pads, supply electricity and install equipment.

8.4.3 Install Management Measures

- *Build new projects* – As funds are secured, new projects will be built. In the short term, the sites selected will be prioritized based on acid loading and available funding.
- *Operate and maintain existing sites* – Look into the potential of using set-aside funds for operations and maintenance of newly installed projects where applicable.
- *Begin monitoring project effectiveness* – Once baseline standards are determined, allow time for the project to begin working and sample at regular intervals to reflect seasonal changes.

8.4.4 Measurable Goals for Phase IIIB

By the end of Phase III in December 2033, the following measurable goals will be achieved

- *Implementation* – pH mitigation projects will have been installed on all impaired streams in Phase I and Phase II of the Jennings Run WIP. These projects will function well enough that water discharged from the sites meet technology based effluent limitations for pH (6.5).

- *Water Quality Monitoring* – Instream water chemistry measurements will show that all treated tributaries of the Jennings Run study area are meeting water quality standards for pH. measurements in the mainstem of Jennings Run below these projects will also show that it is meeting standards.
- *Biological Monitoring* – Biological communities at the end of the fifteen-year period will show improvement in diversity of species and size of communities throughout the entire watershed. Pollution intolerant species should begin to recolonize areas that were previously too acidic for their survival.

8.5 MILESTONES

The success of projects will be determined according to the achievement of 3 objective milestones. The milestones follow the natural recovery of streams after the disturbance has been lifted. The first milestone of stream recovery is the improvement of water chemistry to numerical water quality standards and TMDL targets, determine by, continued monitoring of water quality to track the changes after construction. The second milestone is the return of benthic macro invertebrates to the stream. Biological assessments will be performed to monitor the streams biological condition of the stream.

9.0 LOAD REDUCTION EVALUATION

Overall, success of this watershed plan will be determined by the extent that the Maryland water quality standards are met in previously impaired stream segments of the Jennings Run study area identified in the Western Maryland pH TMDL. In addition, there are other important measures of success to be considered by meeting pH standards across the watershed and by supporting more healthy populations of benthic macroinvertebrates and fish. This section presents quantitative and qualitative criteria for gauging progress and success. This section also presents approaches to adaptive management based on both criteria. Adaptive management allows for flexibility to address the uncertainties and provide for problem-solving strategies. Results of adaptive management, such as watershed plan updates and addenda, will be made available to the public. When a watershed plan addendum is available for public consideration, an opportunity for a public meeting will be offered, see Section 7.

9.1 STREAM SEGMENT CRITERION FOR PH

In each stream segment receiving BMP implementation, the stream segment criterion for pH is to meet the Maryland water quality standard for pH, which is to maintain pH within the 6.5 – 8.5 range. To document that this criterion is met, sub watershed monitoring as described in Section I, monitoring will be conducted periodically to measure success in each stream segment following installation of a system or a group of systems.

Interim water quality indicator milestones for Jennings Run Study area stream segments:

- 50% meet the pH standard by the end of 2023 (end of Phase I), Sub watershed 7, Figure 9;

- 75% meet the pH standard by the end of 2033 (end of Phase II), Sub watersheds 1 and 5, Figures 7 and 8;
- 100% meet the pH standard by the end of 2038 (end of Phase III).

Adaptive management threshold criteria for pH in stream segments that will trigger a watershed plan update or addendum include, but are not limited to:

- Participation of key landowners is a prerequisite for implementation along each stream segment. In order to maximize the rate of watershed plan implementation, the priority order of implementation among stream segments may be changed so that stream segments with willing participation by landowners become highest priority for implementation. Additionally, if land access permission is withdrawn priorities for implementation may be reconsidered.
- Each time a streams segment pH impairment is remedied, the information will be used to update Maryland's 303(d) list of impaired waters.
- If the pH standard is not met in a stream segment where systems have been implemented, the system will be adjusted to the degree feasible to ensure that the pH standard within the stream segment is met. If appropriate, the watershed plan updates of addenda will present changes that reflect new information and understanding at the stream segment scale.
- If the system technology envisioned by this plan is found to be inappropriate or ineffective at meeting pH standards in a stream segment, appropriate alternative system technologies will be selected, and a watershed plan addendum will be issued that presents reasons for the change, the new direction for watershed plan implementation, and the associated costs.
- If the interim water quality indicator milestones of stream segments (above) are not attained by the target year, then the watershed plan will be modified by adding an addendum that presents reasons that a plan modification is needed and changes to the plan such as revised schedule and milestones.

9.2 WATERSHED CRITERIA FOR PH

For the Jennings Run study areas, the watershed criteria for pH includes two elements: 1) to meet Maryland Water Quality Standard for pH across the watershed so that the Jennings Run study area does not appear on Maryland's 303(d) list of impaired waters, and 2) to meet the TMDL for pH for the Jennings Run study area. To meet these criteria, stream segment monitoring and watershed monitoring as described in Section I will be conducted and collectively analyzed to measure progress toward meeting these criteria.

Adaptive management threshold criteria for pH stream segments will trigger updates and/or modifications to this watershed implementation plan. Plan updates and addendum will be made available to the public. An opportunity for a public meeting will be offered at the end of each watershed plan phase (Section 7).

- No later than the end of each watershed plan phase, the findings from the monitoring analysis and other appropriate information will be used to review progress to meeting watershed plan goals and objectives.

If this review, finds that watershed plan implementation is not on track to meet the watershed criteria for pH, either a watershed plan update or addendum that represents the findings and implications for the watershed plan will be made available.

9.3 STREAM SEGMENT CRITERION FOR BIOLOGY

For each stream segment that is 1) receiving BMP implementation prescribed in this watershed plan, and 2) has a biological impairment that both appears on Maryland's 303(d) list of impaired watersheds and the source assessment indicated that the impairment is caused by low pH, the Stream Segment Criteria for Biology is to attain a "fair" or "good" Index of Biotic Integrity for benthic macroinvertebrates and fish. After the stream segments meet pH standards, stream segment monitoring for biology described in Section 1 will be conducted to measure progress and document success in meeting this criterion.

Adaptive management threshold criteria for biology for stream segments that will trigger update or motivation to this water plan are as follows

- Each time a stream segments biological impairment is remedied, this information will be used to update Maryland's 303(d) list of impaired waters. When Maryland's list of impairments is changed as a result of watershed plan implementation, a watershed plan update will be issued that presents the listing change and implications for the watershed plan.
- If stream biological health does not improve within several years of successful pH mitigation monitoring, additional analysis should be conducted to ascertain if other impairments appear to be limiting improvement. After the analysis is completed, watershed plan update or addendum will be made available showing the present findings of the analysis and any changes to the watershed plan that are appropriate as a result.

10.0 MONITORING

Baseline historic conditions of water quality in the Jennings Run study areas have been documented through Appalachian Laboratory UMCES studies and the 2009 TMDL study. Measuring project success, will require a comprehensive stream monitoring strategy to determine that pH levels are being met according to individual designated use of each stream and over the entire Jennings Run study areas. MDE Field Services Target Watershed and Biology Assessment group will be tasked with collecting water quality data prior to and after implementation of acid mitigation projects. In accordance with the proposed implementation schedule, the detailed monitoring schedule will be conducted in a phased approach with emphasis on evaluation of project effectiveness. Biological Integrity will be used in a qualitative manner to determine the effect of the acid reduction has on sensitive benthic species in impaired streams.

10.1 PHASE I MONITORING PLAN

10.1.1 Water Quality Monitoring

Water quality samples will be collected monthly from 12 stations once a month from April through November 2019. Analysis will include pH, specific conductance, alkalinity, ferric iron, ferrous iron, manganese, aluminum, calcium, magnesium and sulfate. All specified analysis will be performed in accordance with standard protocols (USEPA 1987,1999). The stations are listed in Table 10.

In-situ water quality parameters including pH, dissolved oxygen (when appropriate), conductivity, and water temperature will be measured using a handheld water quality meter. Stream flow measurement will also be taken at each sample site so that constituent loads can be calculated in the future.

Table 10 Water Quality Monitoring Stations

Station
Seep F/JWES-3
JWES-1
7-10-C DS
7-10-A
7-12C
7-12-B
UJH0015
7-12-A
Seep C
UJH 0011
7-13B

10.1.2 Benthic Assemblage Monitoring

MDE Maryland Biological Stream Survey (MBSS) monitoring group biologists are responsible for performing field biological sampling, as well as, the laboratory processing and taxonomic identification for all benthic organisms collected at each site. Two benthic sample stations will be established at each pH mitigation site to document biological response over time. Both sample stations will coincide with the water sampling sites as feasible. One benthic station will be established as close to the remediation site as possible, making sure that it is outside any negative influence from the treatment operation. A second site will be established further downstream, preferably below the confluence with the next downstream tributary, in order to document sustained biological effect. Samples will be extracted during the March/April MBSS Spring Index period. Staff biologists will coordinate as appropriate with the LMA and share personnel and resources as necessary. MBSS techniques and protocols will be followed. the exact location for each mitigation site have yet to be determine.

10.1.2.1 Field Sampling

All field sampling will be performed under guidance established by the MBSS. The Maryland Biological Stream Survey: Round Four Field Sampling Manual, January 2017, will serve as the authority. MBSS methods include qualitative sampling of best available habitats incorporating approximately 20 square feet of substrate within each 75-meter designated station. All samples will be collected from riffle areas, as practical. This is typically the most productive habitat in stream ecosystems. A 540 µm mesh D-net will be used to trap organisms dislodged from the sample area. The composite sample is condensed in the field with a standard 540 µm sieve bucket, placed in a sample jar with appropriate field label, and preserved with ethanol. Each sample is then sub-sampled to approximately 100 individual macroinvertebrates in the laboratory using a random-grid picking/sorting process. Most organisms are identified to genus, if possible, using stereoscopes. Chironomidae are slide-mounted and identified using compound microscopes. Habitat conditions will be assessed using standard MBSS methodology. In-situ water quality parameters will be recorded at each station with a multi-parameter field instrument.

10.1.2.2 Laboratory Methods

All benthic macroinvertebrates will be processed and identified through guidance established in the MBSS protocol. The laboratory manual “Laboratory Methods for Benthic Macroinvertebrate Processing and Taxonomy” Maryland Department of Natural Resources, November 2000, will serve as the basis for analysis of all field samples collected.

10.1.2.3 Data Analysis and Report

Each station will be ranked qualitatively according to the protocols established for calculation of the Benthic Index of Biological Integrity (BIBI) score (Stribling et al. 1998), where “good” equals 4.0-5.0, fair: equals 3.0-3.9, Poor equals 2.0-2.9 and “very poor” equals 1.0-1.9. Each BIBI score will be compared against the percentage of the best attainable stream physical habitat in order to assess relationships between habitat and biology. The Benthic IBI will be calculated using Non-Coastal Plain metrics (Mercurio, Chaillou, & Roth, 1999).

10.1.2.4 Habitat Assessment

Habitat conditions will be assessed using standard MBSS methodology targeting riffle/run prevalent streams. This methodology involves the field observation for eight parameters, including: instream habitat, epifaunal substrate, velocity, depth diversity, pool/glide/eddy quality, riffle/run quality, embeddedness, shading, and trash rating. Each category contains a maximum value of twenty. Overall habitat will be rated as a percentage of the best possible score. The four categories are Excellent 76-100, Good 51-75, Fair 26-50and Poor 0-25 (Maryland Department of Natural Resources, 2017).

10.1.3 Performance Monitoring

Sampling conducted through the duration of Phase I will be used to evaluate the effectiveness treatment system operation and maintenance.

10.2 PHASE II MONITORING PLAN

The second phase of monitoring will be modified continuation of the Phase I plan to evaluate long term effects and adjustment to the number of sites selected for Phase II of implementation. The monitoring plan will need to be revised and adjusted according to any trends observed from the Phase I mitigation projects yet maintaining the integrity of the data collected during Phase I and Phase II.

This phase of the monitoring plan should start to be revised in the fourth year of Phase I to create a seamless transition between the two phases and include baseline monitoring in new project areas. This phase should also continue the monitoring of Phase I project areas. Frequency and number of sites depends upon the success of projects implemented.

10.3 PHASE III MONITORING PLAN

The third phase of monitoring will include a modified continuation of the Phase II monitoring plan evaluating long-term effects of the treatment systems and to adjust the types of monitoring and number of sites selected for Phase III observance or implementation. The monitoring plan will need to be revised and adjusted according to any trends observed from the Phase I and Phase II mitigation projects. Revision of the monitoring plan for this phase is entirely dependent upon results from the previous phases for implementation and monitoring.

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Appendix B – Sample Location Details

Sample ID	Sampler	Dates Sampled
BTLB-1	AMLD	2015-2016
BLTB-2	AMLD	2015-2016
BTLB-3	AMLD	2015-2016
BLTB-4	AMLD	2015-2016
BTLB-5	AMLD	2015-2016
JWEH-1	AMLD	2015, 2018
JWEH-2	AMLD	2015, 2018
JWEH-3	AMLD	2015, 2018
JWEH-4	AMLD	2018
JWES-1	AMLD	1988 - 1997, 2015 - 2016
JWES-2	AMLD	2014-2016
JWES-3	AMLD	1988-1996, 2015-2016
UJN005	TMDL	2005
UJH0015	TMDL	2005
UJF0002	TMDL	2005
JEN00092	TMDL	2005
UJH0011	TMDL	2005
1-2A	UMCES	1999-2000, 2011, 2014-2015
1-2B	UMCES	1999-2000, 2014-2015
1-2C	UMCES	1999-2000, 2014-2015
2-2A	UMCES	1999-2000, 2014-2015
2-2B	UMCES	1999 -2000, 2011, 2014-2015
2-2C	UMCES	1999-2000, 2014-2015
3-2A	UMCES	1999-2000, 2014-2015
4-2A	UMCES	1999-2000
4-2B	UMCES	1999-2000
4-2C	UMCES	1999-2000, 2014-2015

Sample ID	Sampler	Dates Sampled
5-2A	UMCES	1999-2000, 2014-2015
5-2B	UMCES	1999-2000, 2014-2015
5-2C	UMCES	1999-2000, 2014-2015
6-2A	UMCES	1999-2000, 2014-2015
6-2B	UMCES	1999-2000
6-2C	UMCES	1999-2000
7-7A	UMCES	1999-2000, 2014-2015
7-7B	UMCES	1999-2000, 2014-2015
7-7C	UMCES	1999-2000, 2014-2015
7-10A	UMCES	1999-2000, 2014-2015
7-10C	UMCES	1999-2000, 2014-2016
7-12A	UMCES	1999-2000, 2014-2016
7-12B	UMCES	1999-2000, 2014-2015
7-12C	UMCES	1999-2000, 2014-2015
7-13A	UMCES	1999-2000, 2014-2015
7-13B	UMCES	1999-2000, 2014-2015
7-13C	UMCES	1999-2000, 2014-2015
7-14A	UMCES	1999-2000, 2014-2015
7-14B	UMCES	1999-2000, 2014-2015
7-14C	UMCES	1999-2000, 2014-2015
8-2A	UMCES	1999-2000, 2014-2015
Seep C	UMCES	1999-2000, 2014-2015
Seep D	UMCES	2014-2015
Seep F	UMCES	2015-2016
Seep G	UMCES	2015
Seep H	UMCES	2015
Seep J	UMCES	2015, 2018

Appendix A – Figures 1 through 11*

*Print in 11X17

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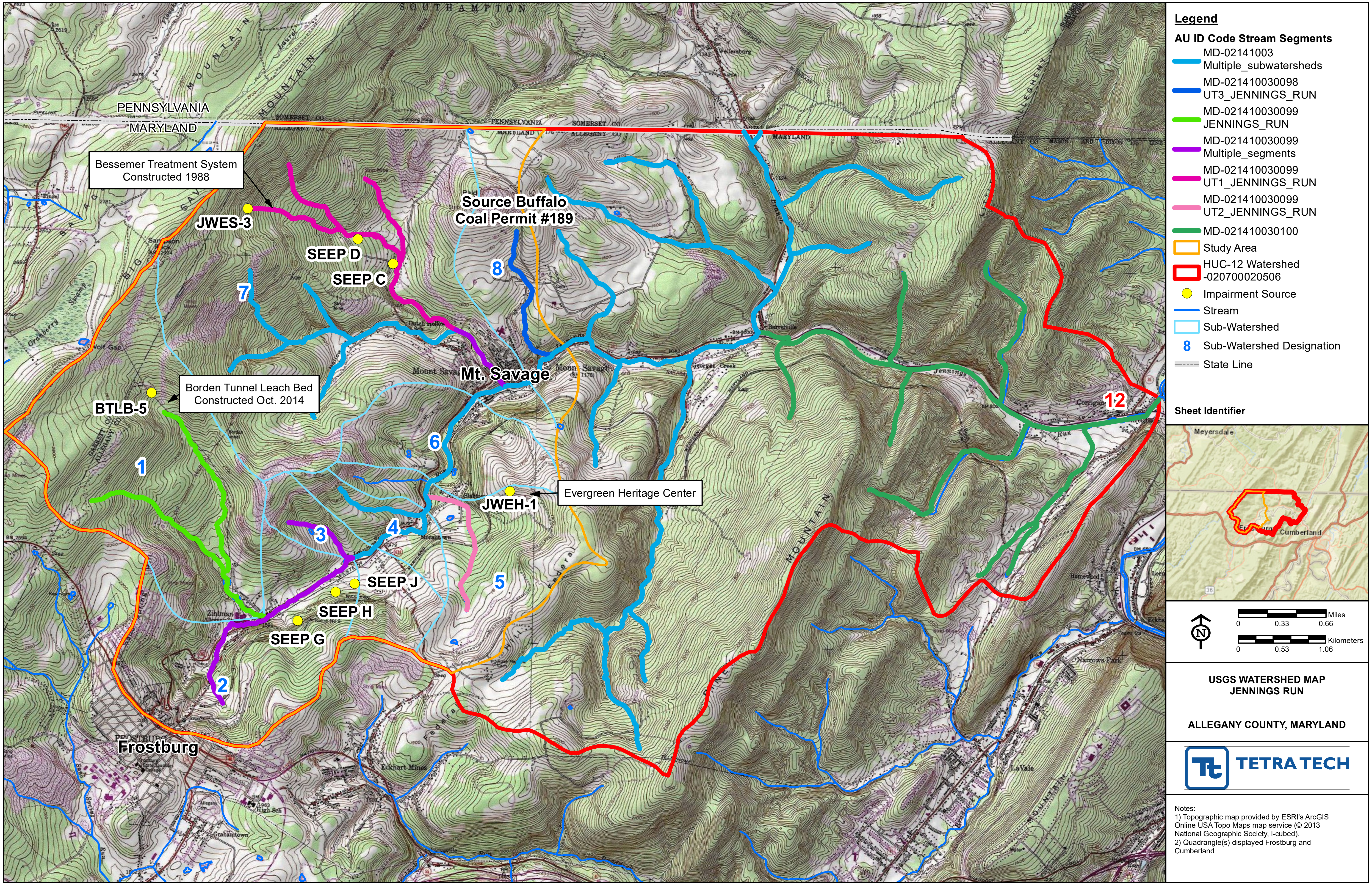

USGS WATERSHED MAP
JENNINGS RUN

ALLEGANY COUNTY, MARYLAND

TETRA TECH

Notes:
1) Topographic map provided by ESRI's ArcGIS Online USA Topo Maps map service (© 2013 National Geographic Society, i-cubed).
2) Quadrangle(s) displayed Frostburg and Cumberland

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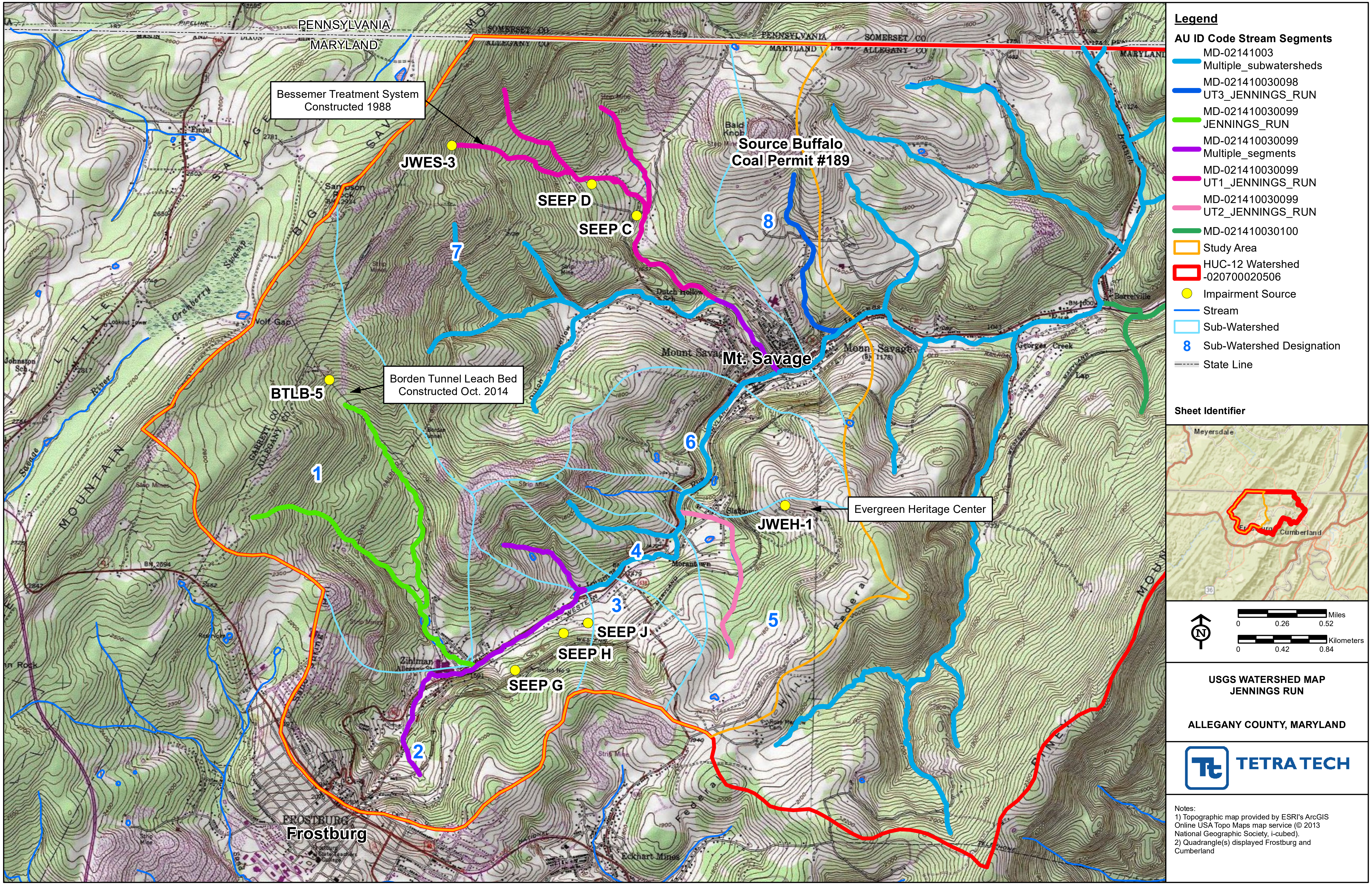

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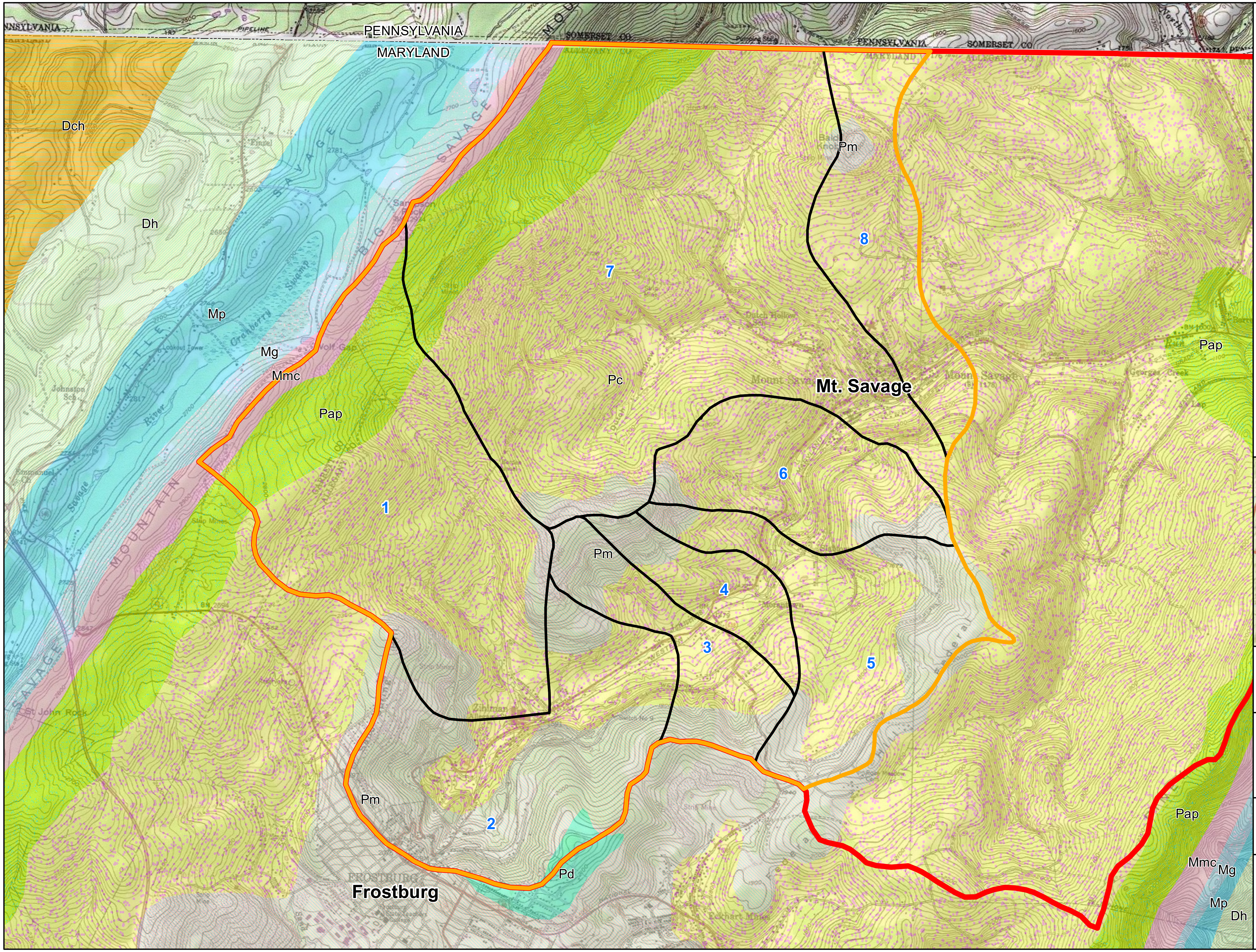
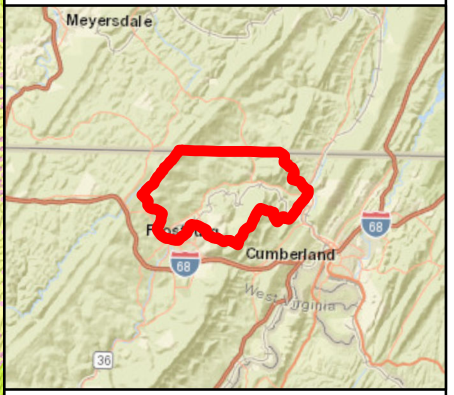


Legend

- Study Area
- Sub-Watershed
- Watershed
- (Dch) Devonian Chadakoin Formation
- (Dh) Devonian Hamilton Group
- (Mg) Mississippian Greenbrier Group
- (Mmc) Mississippian Mauch Chunk Formation
- (Mp) Mississippian Pocono Formation
- (Pap) Pennsylvanian Allegheny and Pottsville Formations
- (Pc) Pennsylvanian Conemaugh Group
- (Pd) Permian Dunkard Group
- (Pm) Pennsylvanian Monongahela Group
- State Line

Sheet Identifier



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Meters: 0, 411.48, 822.96

GEOLOGY MAP
JENNINGS RUN

ALLEGANY COUNTY, MARYLAND

TETRA TECH

Notes:
1) Aerial photograph provided by ESRI's ArcGIS Online World Imagery map service (© 2015 ESRI and its data suppliers).
2)
3)

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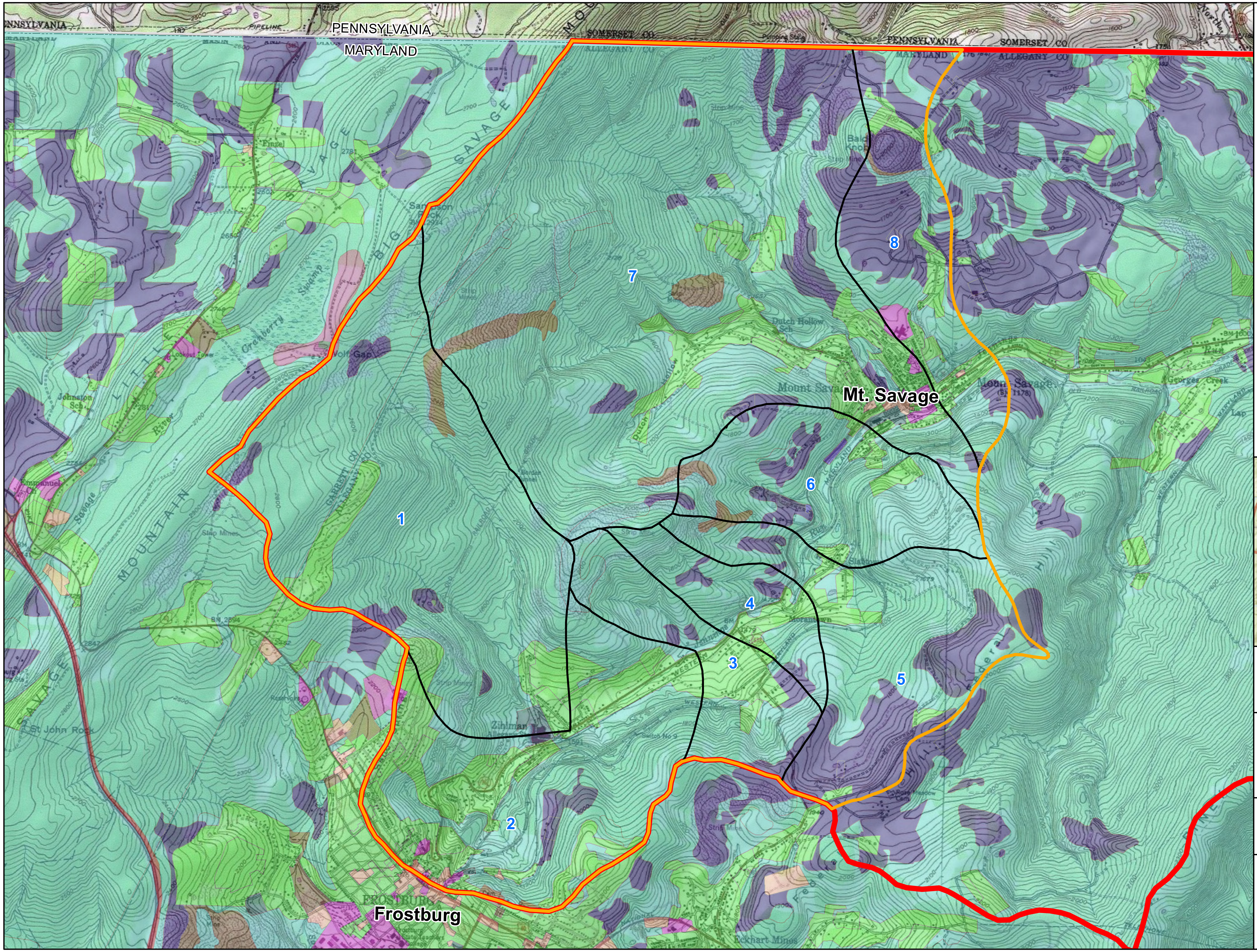


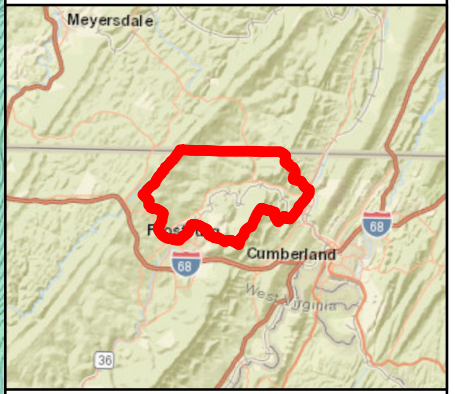
Legend

- Study Area
- Sub-Watershed
- Watershed

Land Use

- Agriculture
- Barren Land
- Commercial
- Forest
- Residentail
- Industrial
- Institutional
- Other Developed Lands
- Transportation
- Water
- Wetlands
- State Line

Sheet Identifier



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LAND USE MAP
JENNINGS RUN

ALLEGANY COUNTY, MARYLAND

TETRA TECH

Notes:
1) Aerial photograph provided by ESRI's ArcGIS Online World Imagery map service (© 2015 ESRI and its data suppliers).
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3)

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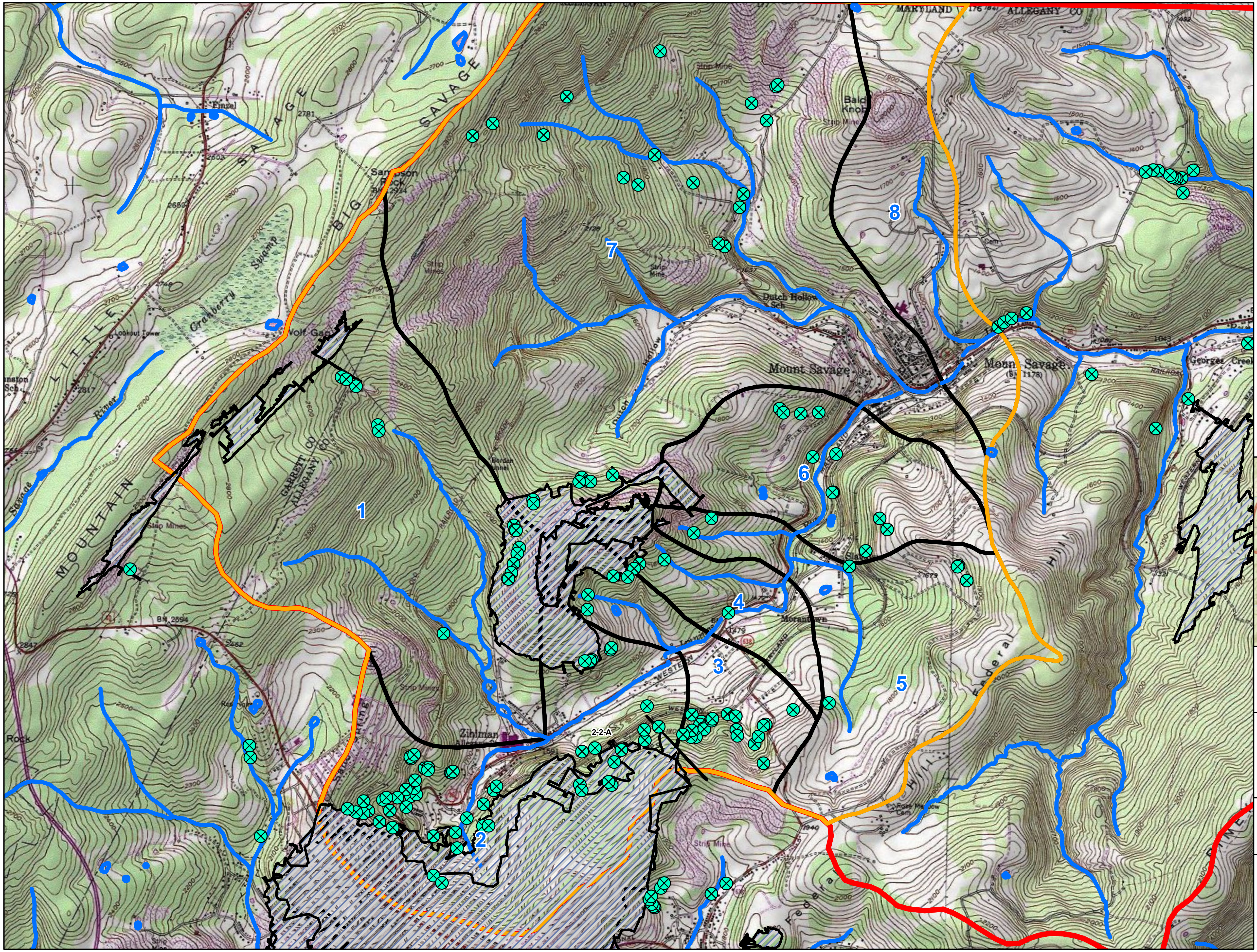
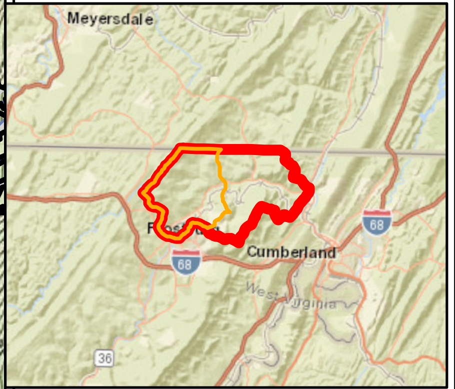


Legend

- Mine Opening
- Mining Area
- Stream
- Study Area
- Sub-Watershed
- Wastershed

Sheet Identifier



Feet: 0, 1,250, 2,500

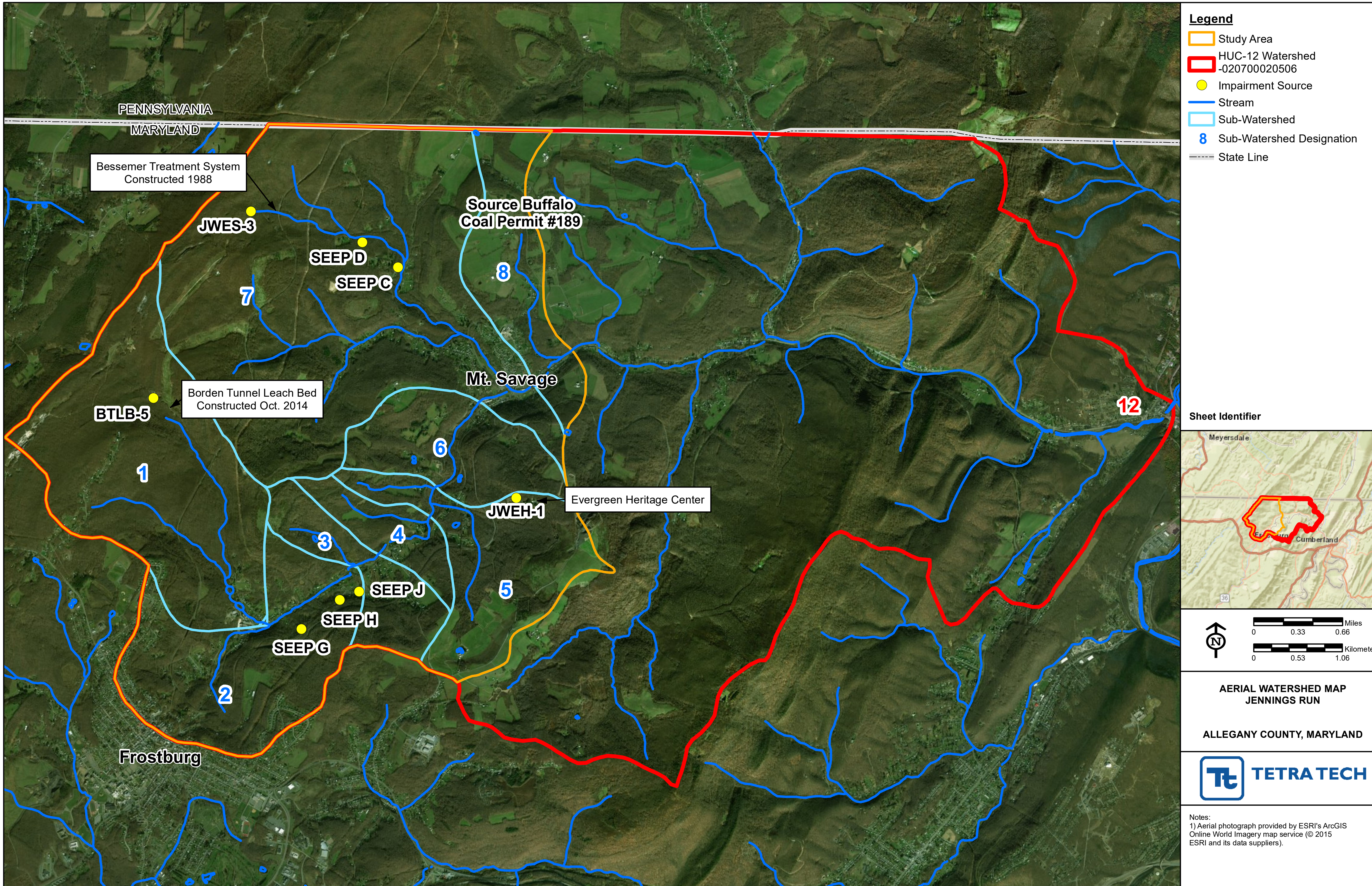
Meters: 0, 381, 762

Figure 5
MINING LOCATION
JENNINGS RUN

ALLEGANY COUNTY, MARYLAND

TETRA TECH

Notes:
1) Topographic map provided by ESRI's ArcGIS Online USA Topo Maps map service (© 2013 National Geographic Society, i-cubed).
2) Quadrangle(s) displayed Frostburg and Cumberland
3)



AERIAL WATERSHED MAP
JENNINGS RUN

ALLEGANY COUNTY, MARYLAND

TETRA TECH

Notes:
1) Aerial photograph provided by ESRI's ArcGIS Online World Imagery map service (© 2015 ESRI and its data suppliers).

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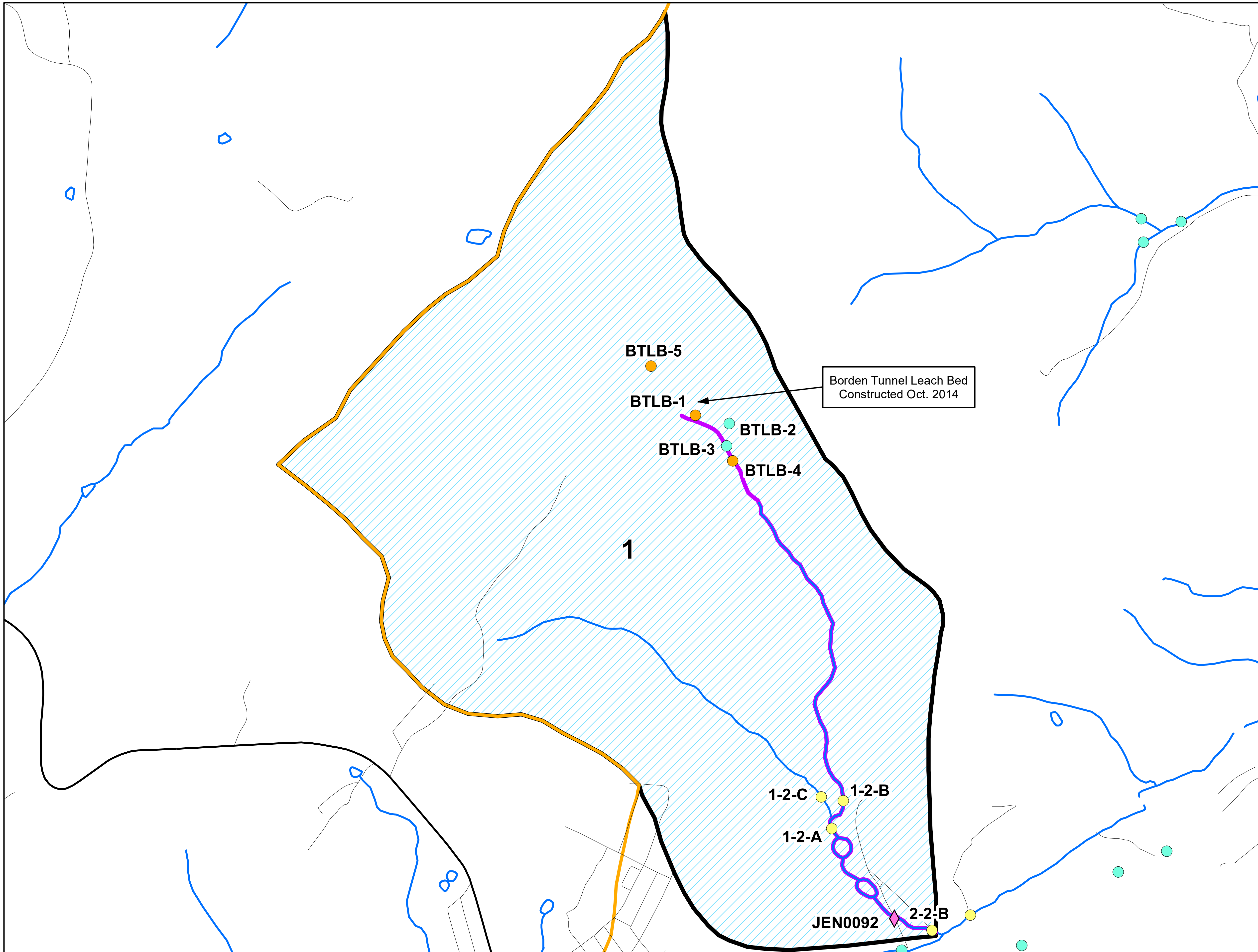
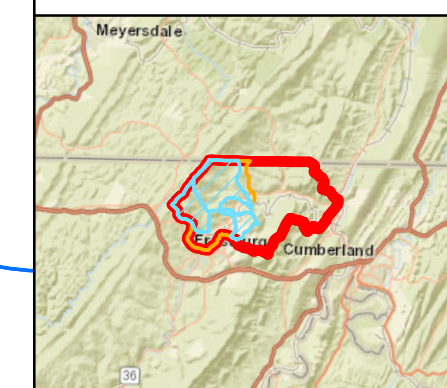


Legend

- TMDL Sample Site
- PH Level
  - 2-
  - 3-4.9
  - 5-6.9
  - 7+
- AMD Impairment
- Stream
- Study Area
- Sub-Watershed
- Local Road
- US Route

Sheet Identifier



N

Miles: 0, 0.14, 0.28

Kilometers: 0, 0.225, 0.45

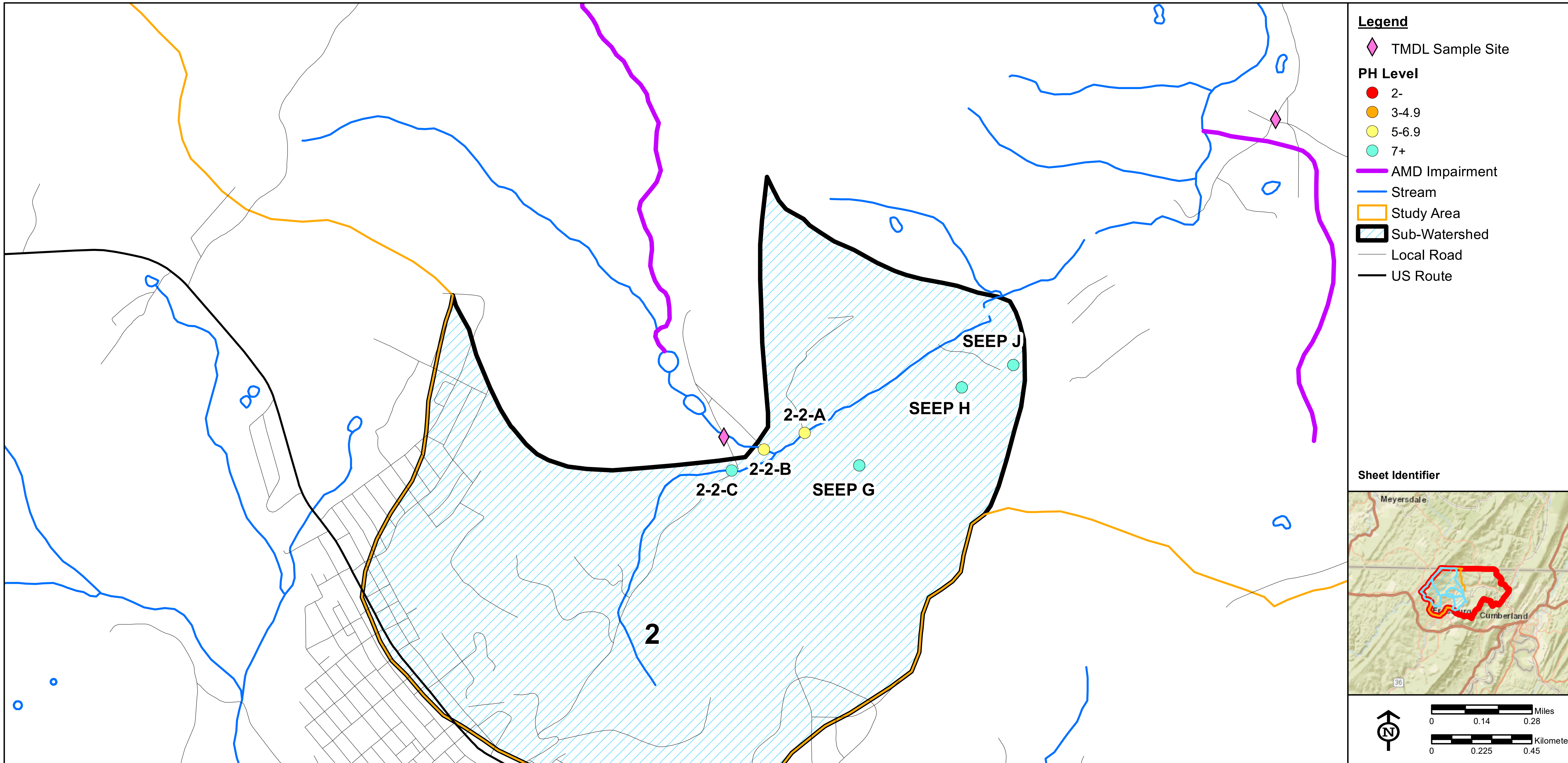
WATERSHED 1
IMPAIRMENT SOURCE
JENNINGS RUN

ALLEGANY COUNTY, MARYLAND

TETRA TECH

Notes:
1) Road Centerlines data is the end product of a statewide data sharing process between the Federal Highway Administration (FHWA), Maryland Department of Transportation (MDOT), Maryland Department of Transportation State Highway Administration (MDOT SHA), county governments and local municipal governments.

PGH P:\GIS\JENNINGSRUN\MXD\JENNINGSRUN_OVERVIEW_WATERSHED2_11X17.MXD 01/03/19 PD



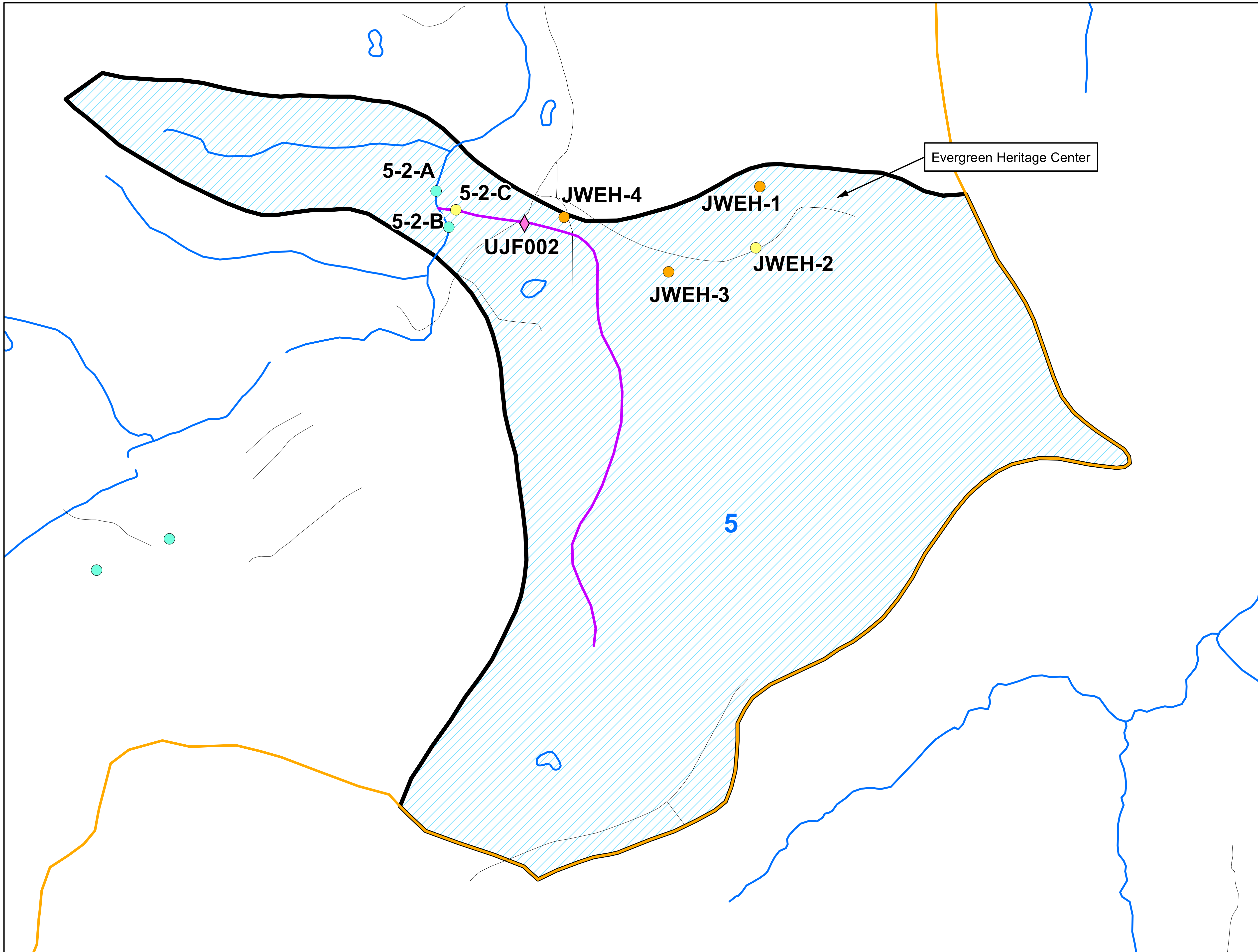
WATERSHED 2
IMPAIRMENT SOURCE
JENNINGS RUN

ALLEGANY COUNTY, MARYLAND

TETRA TECH

Notes:
1) Road Centerlines data is the end product of a statewide data sharing process between the Federal Highway Administration (FHWA), Maryland Department of Transportation (MDOT), Maryland Department of Transportation State Highway Administration (MDOT SHA), county governments and local municipal governments.

PGH P:\GIS\JENNINGSRUN\MXD\JENNINGSRUN_OVERVIEW_SUBWATERSHED5_11X17.MXD 01/07/19 PD



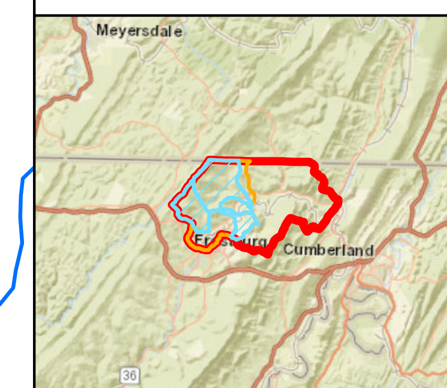
Legend

- TMDL Sample Site

PH Level

- 2-
- 3-4.9
- 5-6.9
- 7+
- AMD Impairment
- Stream
- Study Area
- Sub-Watershed
- Local Road
- US Route

Sheet Identifier



Feet: 0, 500, 1,000

Meters: 0, 152.4, 304.8

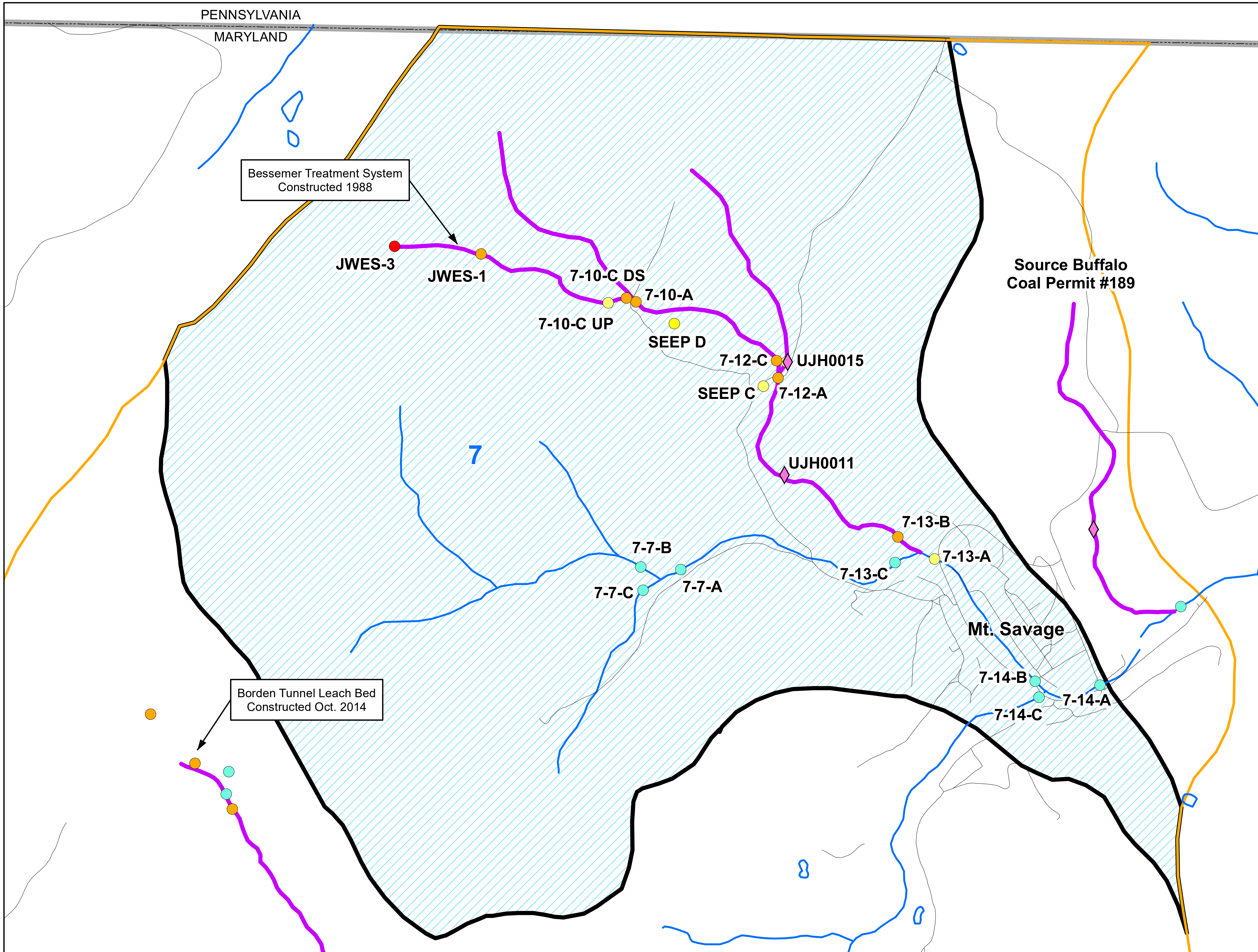
SUBWATERSHED 5
IMPAIRMENT SOURCE
JENNINGS RUN

ALLEGANY COUNTY, MARYLAND

TETRA TECH

Notes:
1) Road Centerlines data is the end product of a statewide data sharing process between the Federal Highway Administration (FHWA), Maryland Department of Transportation (MDOT), Maryland Department of Transportation State Highway Administration (MDOT SHA), county governments and local municipal governments.

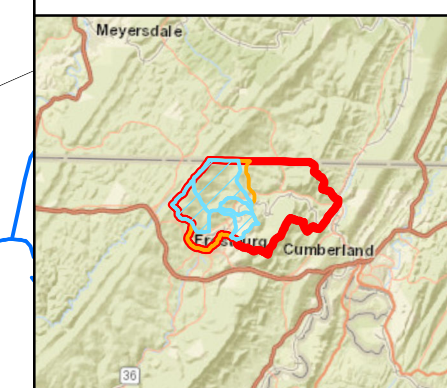
PGH P:\GIS\JENNINGSRUN\MXD\JENNINGSRUN_OVERVIEW_SUBWATERSHED7_11X17.MXD 01/28/19 PD



Legend

- TMDL Sample Site
- PH Level
  - 2-
  - 3-4.9
  - 5-6.9
  - 7+
- AMD Impairment
- Study Area
- Sub-Watershed
- Local Road
- US Route
- State Line

Sheet Identifier



N

Feet: 0, 750, 1,500

Meters: 0, 228.6, 457.2

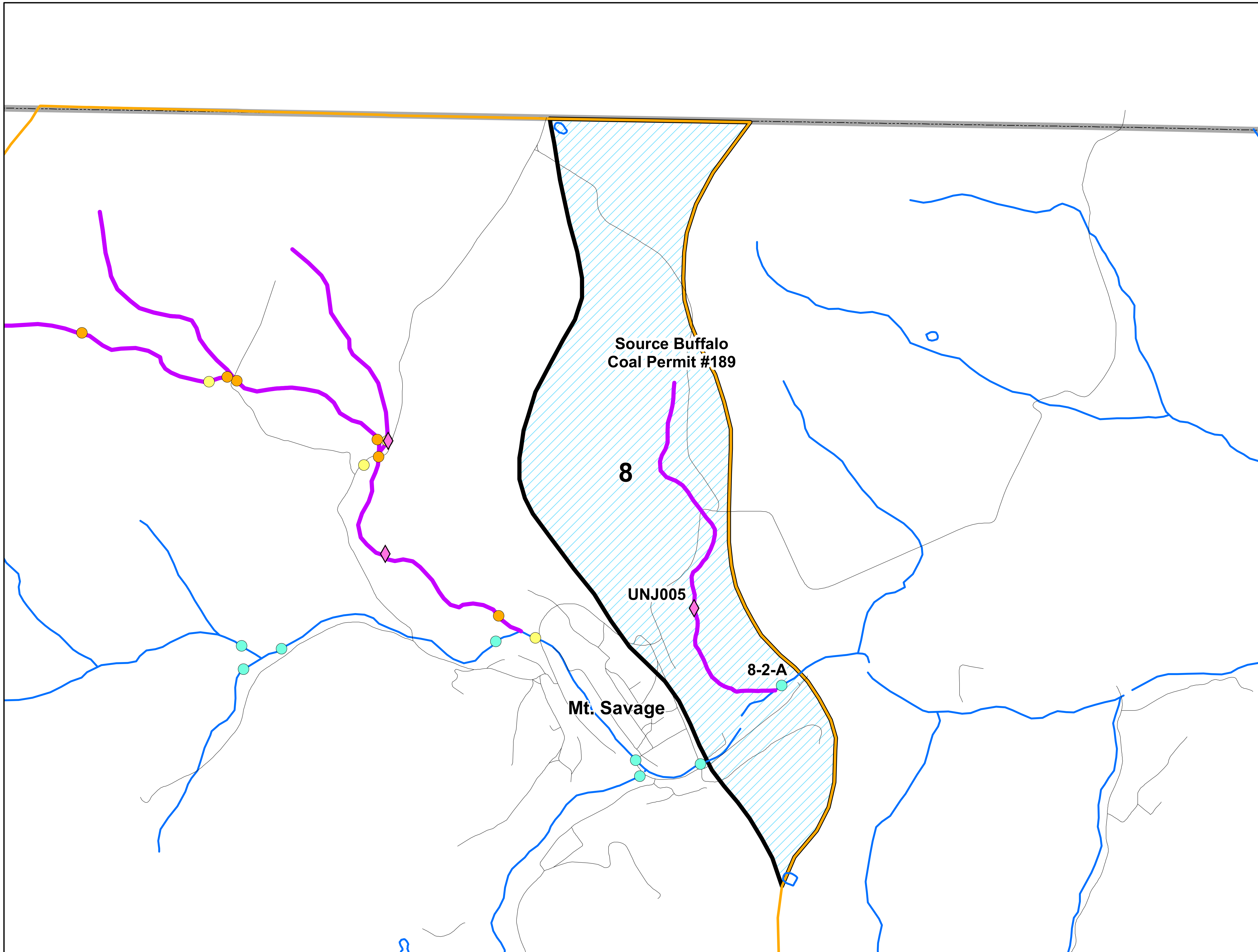
SUBWATERSHED 7
IMPAIRMENT SOURCE
JENNINGS RUN

ALLEGANY COUNTY, MARYLAND

TETRA TECH

Notes:
1) Road Centerlines data is the end product of a statewide data sharing process between the Federal Highway Administration (FHWA), Maryland Department of Transportation (MDOT), Maryland Department of Transportation State Highway Administration (MDOT SHA), county governments and local municipal governments.

PGH P:\GIS\JENNINGSRUN\MXD\JENNINGSRUN_OVERVIEW_WATERSHED8_11X17.MXD 01/07/19 PD



Legend

TMDL Sample Site

PH Level

- 2-
- 3-4.9
- 5-6.9
- 7+

AMD Impairment

Study Area

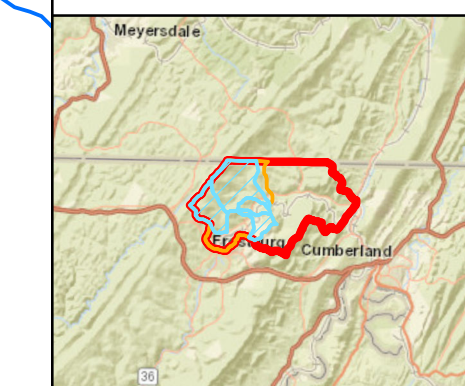
Sub-Watershed

Local Road

US Route

State Line

Sheet Identifier



N

Feet
0 750 1,500

Meters
0 228.6 457.2

WATERSHED 8
IMPAIRMENT SOURCE
JENNINGS RUN

ALLEGANY COUNTY, MARYLAND

TETRA TECH

Notes:
1) Road Centerlines data is the end product of a statewide data sharing process between the Federal Highway Administration (FHWA), Maryland Department of Transportation (MDOT), Maryland Department of Transportation State Highway Administration (MDOT SHA), county governments and local municipal governments.