Restoration Plan for Qualified Hydrologic Unit Determination
Surface Mining Control and Reclamation Act Amendments of 2006

Hydrologic Unit: Catawissa Creek

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DESCRIPTION OF WATERSHED

The area covered by this Restoration Plan for Qualified Hydrologic Unit Plan (QHUP) Development consists of the Catawissa Creek Watershed impacted by Abandoned Mine Drainage (AMD). This includes the entire mainstem of Catawissa Creek that is listed as AMD-Impaired (41.48 stream miles), and all the tributaries entering this stretch, including the AMD-Impaired major tributary of Tomhicken Creek. The portion of the Catawissa Creek Watershed requested for qualification is 153 square miles in size and encompasses 193.4 stream miles.

Catawissa Creek Watershed is located in the Eastern Middle Anthracite Coal Field. From its confluence with the Susquehanna River to Rattling Run, Catawissa Creek is classified as a Trout Stocked Fishery (TSF) in Chapter 93 of the Pennsylvania Code. From Rattling Run to its source, Catawissa Creek is classified as a Cold Water Fishery (CWF) and many of its tributaries are classified as High Quality (HQ) streams. These tributaries have documented natural trout reproduction, with several classified as Class A Wild Trout (WT). Once restored, the Pennsylvania Fish and Boat Commission (PFBC) plans to manage 18 miles of Catawissa Creek as a TSF and an additional 23.5 miles as a WT fishery.

The primary sources of AMD impairment to Catawissa Creek are from five drainage-tunnel outfalls. Two of those, Oneida #1 and #3, impact the Tomhicken Creek tributary and have been treated successfully by the Catawissa Creek Restoration Association (CCRA). Sections of Tomhicken Creek have recently been removed from PA’s Integrated List of Impaired Waters (2018) due to water quality and biological improvement after treatment.

Three other drainage-tunnel outfalls remain untreated and enter Catawissa Creek very close to one another near the headwaters in East Union Township, Schuylkill County (Figure 1). The first outfall is the relatively small Catawissa Tunnel which does not significantly impair Catawissa Creek. As will be discussed later, a native brook trout population exists in Catawissa Creek downstream of the Catawissa Tunnel.

The second outfall, the Audenried Tunnel, has the largest AMD impact to Catawissa Creek and is the eighth largest flow discharge (~24 cubic feet per second (cfs) average) in the entire Susquehanna River Anthracite Field. Upon its entry, the fish assemblage of Catawissa Creek is eradicated and does not return to any significance until the entry of Tomhicken Creek, about 15 miles downstream.

The third outfall, the Green Mountain Tunnel, enters about one-third of a mile downstream of Audenried. Even though of relatively significant flow (~4.5 cfs average), the concentration and loading of AMD parameters are inconsequential due to the extreme loading of Audenried (Table 1).

As this restoration plan will show, treatment of the Audenried Tunnel is the only project required that would restore the entire length of the Catawissa Creek mainstem to its confluence with the Susquehanna River, potentially removing nearly 45 stream miles from the Integrated List of Impaired Waters (2018). In addition, due to the high quality of tributaries entering Catawissa, many of which are classified as HQ and/or Class A, Catawissa Creek has the potential of being a regional large-river, cold-water fishery destination similar to Penns Creek or Little Juniata River.

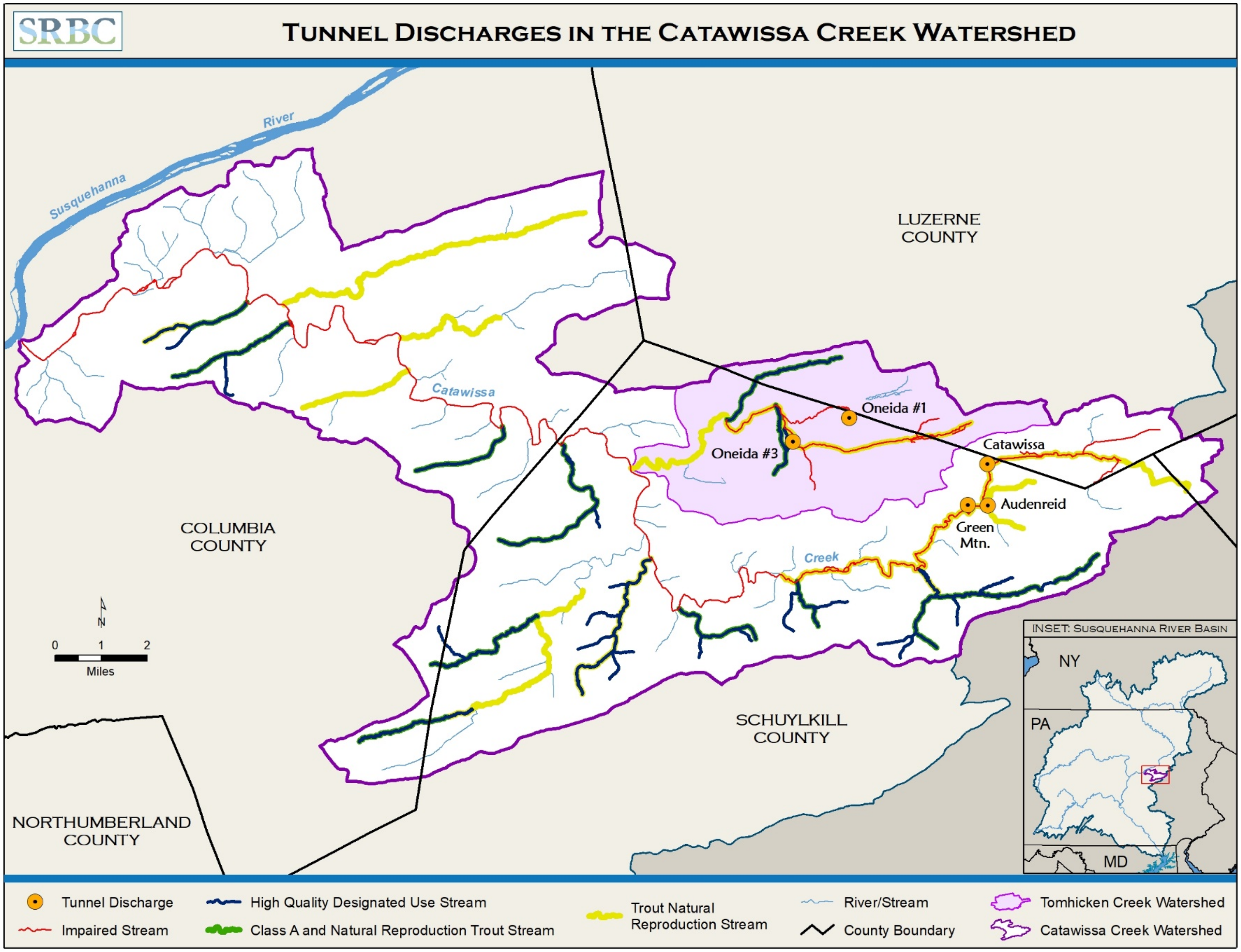

Figure 1. Map of the AMD-Impacted Streams and AMD Discharge Locations on Catawissa Creek in East Union Township, Schuylkill County

Table 1. ***Acidity and Aluminum Loading Contributions from the Three Remaining Untreated Catawissa Creek Drainage Tunnels***

	Acidity Loading	Aluminum Loading
	%	%
Catawissa Tunnel	2.4	1.5
Audenried Tunnel	89.2	93.3
Green Mountain Tunnel	8.4	5.2

HISTORICAL STUDIES AND RESTORATION PLANS

Although not all are comprehensive relative to the entire watershed and all mine discharges therein, historical studies and restoration plans included:

- United States Environmental Protection Agency (USEPA) – *Catawissa Creek Mine Drainage Abatement Project* (1977)
- GEO-Technical Services – *Design Criteria and a Conceptual Plan for the Abatement of AMD Discharges from Five Water Level Tunnels* (1982)
- PFBC – *Catawissa Creek Fisheries Management Report* (1997)

Though dated with recommendations and plans that are inconsistent with current water quality and watershed restoration needs, only water quantity data were utilized from these older studies. Studies completed after 2003 were fully investigated for not only available water quality and quantity data, but also for recommendations and plans for the restoration of Catawissa Creek from AMD impacts. Those three studies included:

1) Pennsylvania Department of Environmental Protection (PADEP) – *Catawissa Creek Watershed Total Maximum Daily Load (TMDL)* (2003)

   The Catawissa Creek TMDL calculated the amount of load reductions needed at several stations along Catawissa Creek, including Audenried and Green Mountain Tunnels, to meet water quality standards (Table 2). The calculations demonstrate that in 2003, acidity and aluminum (Al) concentrations were the main water quality issues within Catawissa Creek, and that Audenried and Green Mountain Tunnels were responsible for the majority of this loading.

   Downstream of Tomhicken Creek, there are no more AMD inputs to Catawissa Creek. As will be discussed later, Tomhicken Creek is now a source of beneficial water quality to Catawissa Creek due to the treatment of Oneida #1 and #3, although this historically was not the case.

   The headwaters of Catawissa are impacted from historical mines. Surface water is lost underground through the broken strata. However, as will be shown later, the headwaters of Catawissa Creek are not nearly as contaminated as Catawissa Creek below the Audenried and Green Mountain Tunnels.

Table 2. Catawissa Creek Pollution Loading Reduction Targets

Station	Parameter	Measured Sample Data		Allowable		Reduction
		mg/l	lbs/day	mg/l	lbs/day	%
CC1	Headwaters of Catawissa Creek					
	Fe	0.34	-	0.34	-	0
	Mn	1.74	-	0.001	-	99.9
	Al	3.2	-	0.38	-	88
	Acid	34.5	-	0.03	-	99.9
Audenried	Audenried Tunnel Outfall					
	Fe	0.7	71.3	0.56	57.1	21
	Mn	2.28	232.4	0.61	62.2	73
	Al	7.93	808.2	0.4	40.8	95
	Acid	68.08	6938.4	0.68	69.3	99
GMT	Green Mountain Tunnel Outfall					
	Fe	0.44	5.3	0.23	2.8	49
	Mn	0.64	7.7	0.62	7.4	3
	Al	2.97	35.7	0.33	4	89
	Acid	28.06	337	2.25	27	92
CC6	Catawissa at Girard Manor Road					
	Fe	0.25	46.8	0.25	46.8	0
	Mn	1.05	196.5	0.4	74.9	0
	Al	3.62	677.5	0.29	54.3	0
	Acid	33.26	6224.6	0.1	18.7	0
CC9	Catawissa DS of Tomhicken Creek					
	Fe	0.1	48.8	0.1	46.8	0
	Mn	0.53	258.7	0.4	195.5	0
	Al	1.3	634.5	0.27	131.8	0
	Acid	23.88	11654.8	0.24	117.1	96

2) The Catawissa Creek Restoration Association (CCRA) and the Eastern PA Coalition for Abandoned Mine Reclamation (EPCAMR) – *Catawissa Creek Watershed Implementation Plan* (2004)

CCRA, with the help of PADEP's 319 Program and EPCAMR, developed the Catawissa Creek Watershed Implementation Plan to address the TMDL. This document explains the various pollution sources, what projects need to be completed to meet pollutant load reductions required by the TMDL, and the estimated cost to restore Catawissa Creek.

In 2005, as a result of the implementation plan, CCRA constructed a passive treatment system for the Audenried Tunnel. The system consists of three limestone filled upflow style tanks and settling ponds and was originally designed to treat about 18 cfs. An underdrain intake system collects the polluted mine water from the discharge channel, diverts it, and splits the flow into the three tanks. Additionally, a bypass intake system and micro-hydro turbines were installed on the outflow of the tanks to generate electricity and to help flush the tanks on a regular basis to limit aluminum sludge buildup in the limestone.

3) Pennsylvania Environmental Council (PEC) – *Catawissa Creek Watershed Rivers Conservation Plan* (2010)

   This study does not focus significantly on the AMD water quality issues of Catawissa Creek.

LOCAL SUPPORT

CCRA is a very active volunteer watershed organization that works to preserve and improve water quality within the Catawissa Creek Watershed. Since its inception in 1998, CCRA has been involved in monitoring and water quality improvement projects in the watershed.

In 2001, CCRA helped bring a passive treatment system online for Oneida #1 that neutralizes the AMD discharging into Sugarloaf Creek, a tributary of Tomhicken Creek.

As a result of the Catawissa Creek Implementation Plan, CCRA constructed a passive treatment system for the Audenried Tunnel in 2005. The system consists of three limestone-filled upflow style tanks and settling ponds and was originally designed to treat about 18 cfs. An under drain intake system collects the polluted mine water from the discharge channel, diverts it, and splits the flow into the three tanks. Later, a bypass intake system and micro-hydro turbines were installed on the outflow of the tanks to generate electricity and to help flush the tanks on a regular basis to limit aluminum sludge buildup in the limestone. Unfortunately, that system was taken offline after high flow damage from Tropical Storm Lee in 2011.

In 2009, CCRA helped to complete a third treatment system to treat the water from Oneida #3 that discharges into Tomhicken Creek, the largest tributary to Catawissa Creek. Oneida #1 and #3 treatment systems have restored sections of Tomhicken Creek, which is now a source of clean alkaline water that helps dilute the AMD loading within Catawissa Creek.

CCRA continues its efforts to restore Catawissa Creek and is a partner in this effort for restoration plan qualification and the use of Surface Mine Control and Reclamation Act funds to construct an active treatment plant (ATP) to finally treat the Audenried Tunnel in total, which will restore the entire mainstem of Catawissa Creek to its confluence with the Susquehanna River. As mentioned, Catawissa Creek has the potential of becoming a large-river, regional cold water fishery destination due to HQ-CWF/Class A fisheries found on many of its tributaries.

CCRA lists the following organizations/agencies on their website (http://thecatty.org/) as partners: Columbia County Conservation District, Schuylkill County Conservation District, PA Department of Conservation and Natural Resources, USEPA, U.S. Department of the Interior Office of Surface Mining (OSM), U.S. Department of Agriculture, PFBC, Trout Unlimited, PEC, and EPCAMR. Through this restoration plan effort, the Susquehanna River Basin Commission (SRBC) will be a continuing partner as well.

BACKGROUND DATA

Due to the large amount of studies and restoration plans completed for Catawissa Creek from the early 1970s to the present, the watershed is not without available data. Lab-certified water quality data from PADEP, SRBC, and the U.S. Geological Survey were utilized for analysis. The focus area of this Restoration Plan is the eventual treatment of the Audenried Tunnel which should restore the entirety of the Catawissa Creek mainstem. However, a detailed analysis of the Green Mountain and Catawissa Tunnel discharges and their quantity statistics and water quality is essential to document how those two discharges have improved in quality over time and do not need treatment for the restoration of the Catawissa Creek mainstem.

Audenried Tunnel Quality

Audenried Tunnel drains the western portion of the Jeansville Coal Basin (Figure 2). The Audenried Tunnel is the largest flow and the worst water quality outfall that enters Catawissa Creek. The flow exiting the Audenried Tunnel averages around ten times the flow of Catawissa Creek upon their confluence. The average flow discharging out of Audenried is ~24 cfs, with a maximum recorded flow of 69 cfs collected on April 9, 1970.

Figure 2. The Audenried Tunnel Outfall into Catawissa Creek

Just like virtually all deep mine discharges, Audenried is undergoing pyrite decay and has improved over time. Audenried's pH, acidity, iron (Fe), and aluminum (Al) concentrations have all improved significantly over the last five decades (Figures 3 and 4). Since Audenried is improving over time, only recent water quality data should be considered for analysis (Table 3).

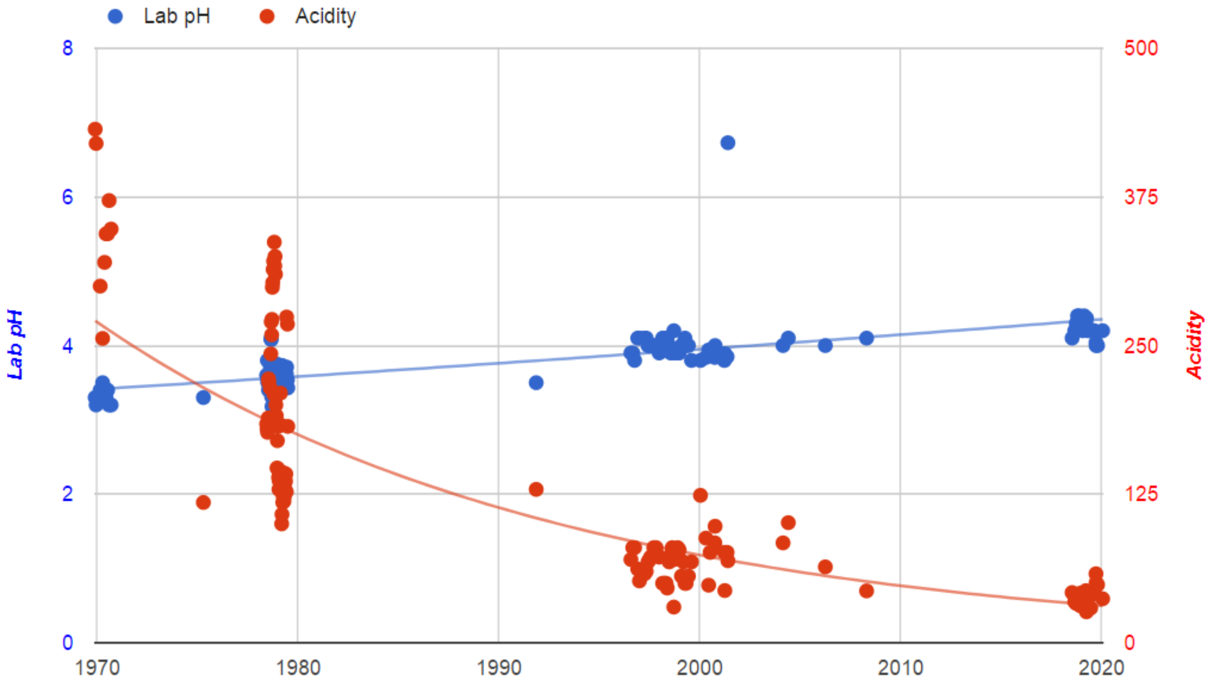

Figure 3. Audenried pH (SU) and Acidity Concentration (mg/l) Trends from 1969-2020

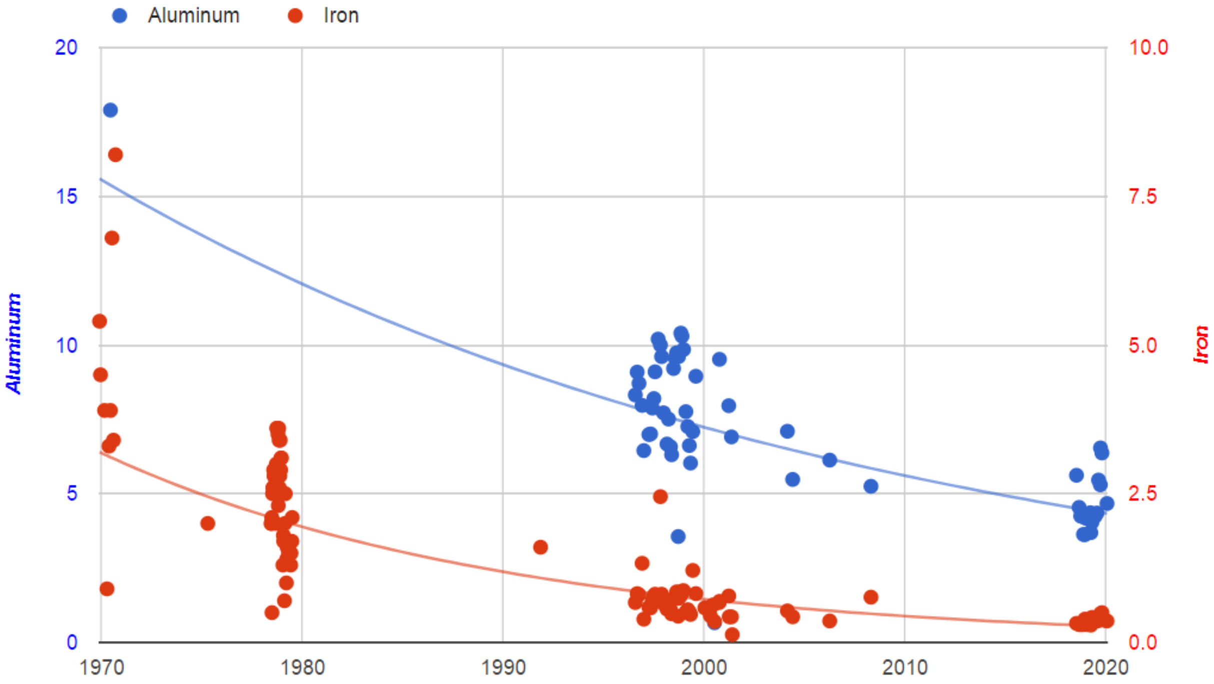

Figure 4. Audenried Total Fe and Al Concentrations (mg/l) from 1969-2020

Table 3. Water Quality Statistics for the Audenried Outfall from 2018-2020

	Lab pH SU	Acidity mg/l	Fe mg/l	Mn mg/l	Al mg/l	SO_4 mg/l	TDS mg/l
N	20	20	20	20	20	20	20
Min	4.00	26.00	0.29	0.99	3.62	90.20	156.00
Ave	4.24	38.58	0.49	1.38	4.57	125.62	235.55
Med	4.20	36.30	0.36	1.29	4.25	117.50	217.00
Max	4.49	58.00	3.05	2.08	6.54	185.50	394.00
STD	0.13	7.66	0.59	0.30	0.82	24.32	52.76
90 Percentile	4.20	50.24	0.50	2.00	6.30	170.30	305.40

Audenried Tunnel Quantity and Loading

According to the historical data, flows exiting Audenried seem to be decreasing slightly (Figure 5). This is probably due to surface reclamation and increased vegetation in the mine pool-shed that fuels Audenried. Due to this trend, the flow of Audenried from 1969-2020 and from 2018-2020 was analyzed (Table 4).

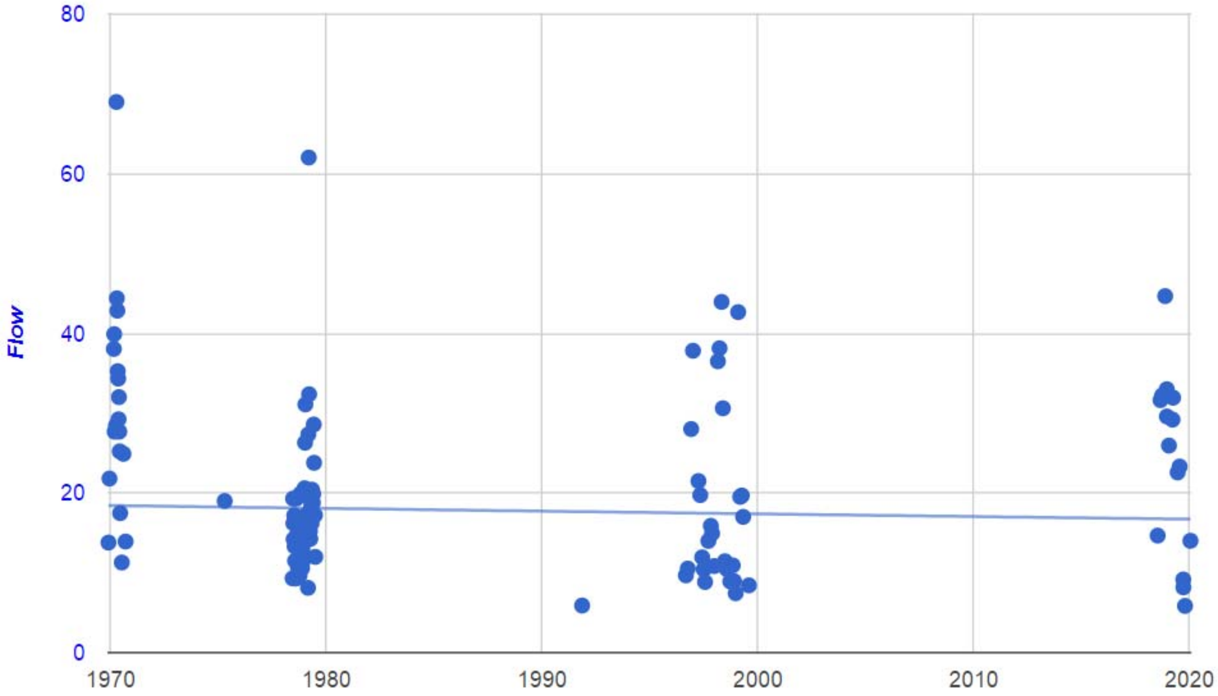

Figure 5. Audenried Flows in CFS from 1969 to 2020

Table 4. Audenried Flow Statistics from 1969-2018 and 2014-2018

	1969-2020	**2018-2020**
	CFS	**CFS**
N	117	15
Min	5.858	5.858
Ave	20.414	23.734
Med	17.010	25.947
Max	69.000	44.676
STD	11.402	10.794
90 Percentile	36.774	37.674
95 Percentile	42.960	ND
99 Percentile	67.747	ND

With a slightly decreasing flow trend and improving water quality, the 2018-2020 average flows and quality will be used when computing average AMD loading (Table 5). On average, Audenried contributes 901 tons per year of acidity, 11 tons per year of Fe, 32 tons per year of manganese (Mn), and 107 tons per year of Al to Catawissa Creek.

Table 5. Audenried Average AMD Loading

Ave Flow	**Ave Acidity**	**Ave Fe**	**Ave Mn**	**Ave Al**	**Ave SO_4**	**Ave TDS**
CFS	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**
23.734	38.58	0.49	1.38	4.57	125.62	235.55
	Acidity Load	**Fe Load**	**Mn Load**	**Al Load**	**SO_4 Load**	**TDS Load**
	lbs/day	**lbs/day**	**lbs/day**	**lbs/day**	**lbs/day**	**lbs/day**
	4,939.59	62.74	176.69	585.12	16,083.74	30,158.61

Audenried Tunnel High Flow Quality, Quantity, and Loading

Since the eventual ATP will have to be sized to accommodate the high flows from Audenried, an analysis of the high-flow quality, quantity, and loadings that could be encountered is important. Audenried has improved in quality over time and seems to have decreased in flow, so the 20 samples collected since 2018 are only being used for analysis. However, it should be noted that the absolute high flow encountered at Audenried was 69 cfs in 1970.

Since 2018, the highest flow recorded at Audenried was 44.676 cfs on November 14, 2018. The water quality and loading of Audenried on that date is found in Table 6.

Table 6. Audenried Quantity, Quality, and Loading on November 14, 2018

Flow CFS	Acidity mg/l	Fe mg/l	Mn mg/l	Al mg/l	SO_4 mg/l	TDS mg/l
44.676	35.00	0.30	0.99	3.63	90.20	192.00
	Acidity Load lbs/day	**Fe Load lbs/day**	**Mn Load lbs/day**	**Al Load lbs/day**	**SO_4 Load lbs/day**	**TDS Load lbs/day**
	8,435.28	72.30	238.60	874.86	21,738.93	46,273.55

Green Mountain Tunnel Quality

Green Mountain Tunnel drains the eastern portion of the South Green Mountain Coal Basin (Figure 6). Green Mountain enters Catawissa Creek only one-third of a mile downstream of Audenried. The average flow discharging out of Green Mountain is 4.49 cfs, with a maximum recorded flow of 10.386 cfs collected on November 14, 2018.

Figure 6. The Green Mountain Tunnel Outfall into Catawissa Creek

As with almost all deep mine discharges, Green Mountain is undergoing pyrite decay and has improved over time. Green Mountain's pH, acidity, Fe, and Al concentrations have all improved significantly over the last five decades (Figures 7 and 8). Since Green Mountain is improving over time, only recent water quality data should be considered for analysis (Table 7).

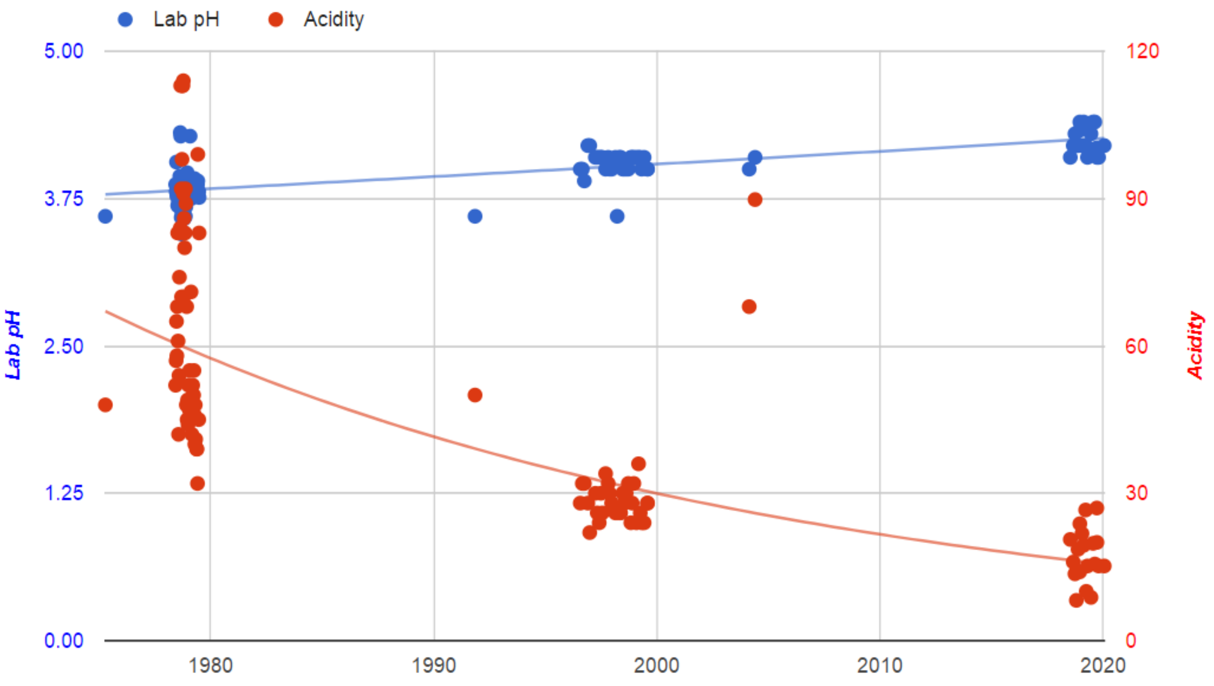

Figure 7. ***Green Mountain pH (SU) and Acidity Concentration (mg/l) Trends from 1975-2020***

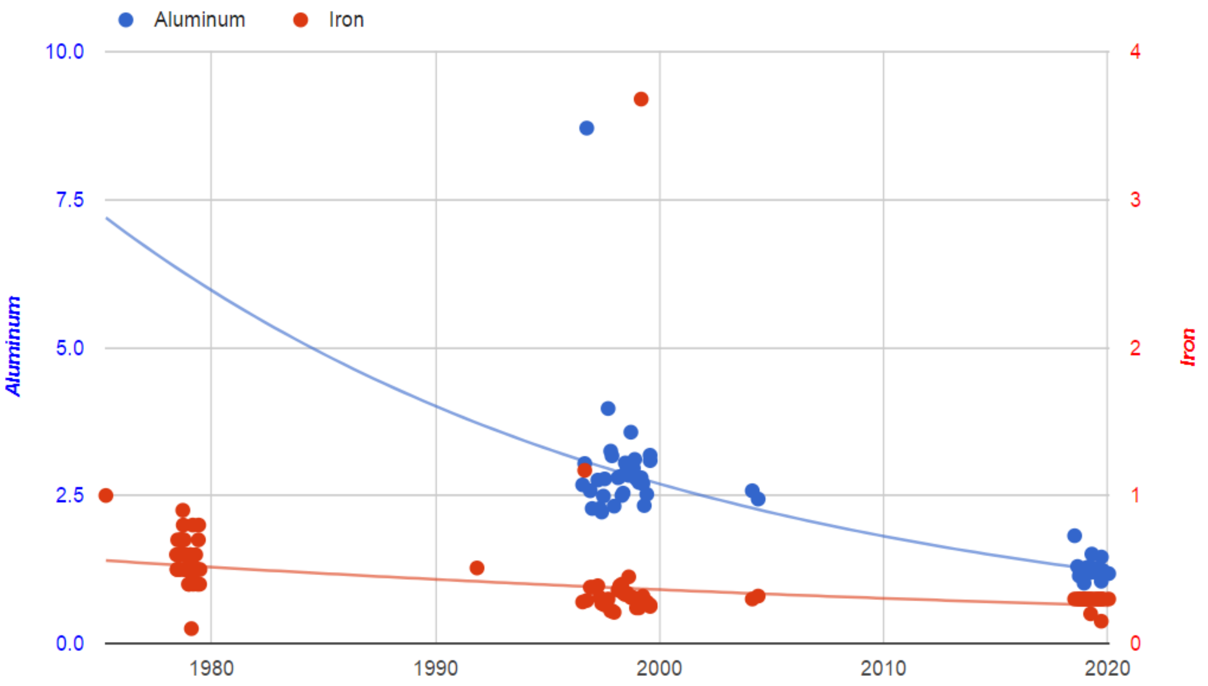

Figure 8. ***Green Mountain Total Fe and Al Concentrations (mg/l) from 1975-2020***

Table 7. Water Quality Statistics for the Green Mountain Outfall since 2018

	Lab pH	Acidity	Fe	Mn	Al	SO_4	TDS
	SU	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
N	21	21	21	20	20	21	19
Min	3.88	8.20	0.15	0.36	1.02	23.90	98.00
Ave	4.22	19.07	0.29	0.48	1.34	31.46	172.11
Med	4.20	18.60	0.30	0.44	1.23	28.00	154.00
Max	4.40	39.00	0.40	0.79	2.78	75.00	534.00
STD	0.13	7.38	0.05	0.11	0.37	11.07	88.07
90 Percentile	4.40	31.00	0.30	0.68	1.79	46.42	190.00

Green Mountain Tunnel Quantity and Loading

According to the historical data, flows exiting Green Mountain seem to be increasing (Figure 9). This is probably due to the increased precipitation that the region has received over the last three years and the large surface area that fuels the mine pool drained by Green Mountain. Due to this trend, the flow of Green Mountain from 1975-2020 and from 2018-2020 was analyzed (Table 8).

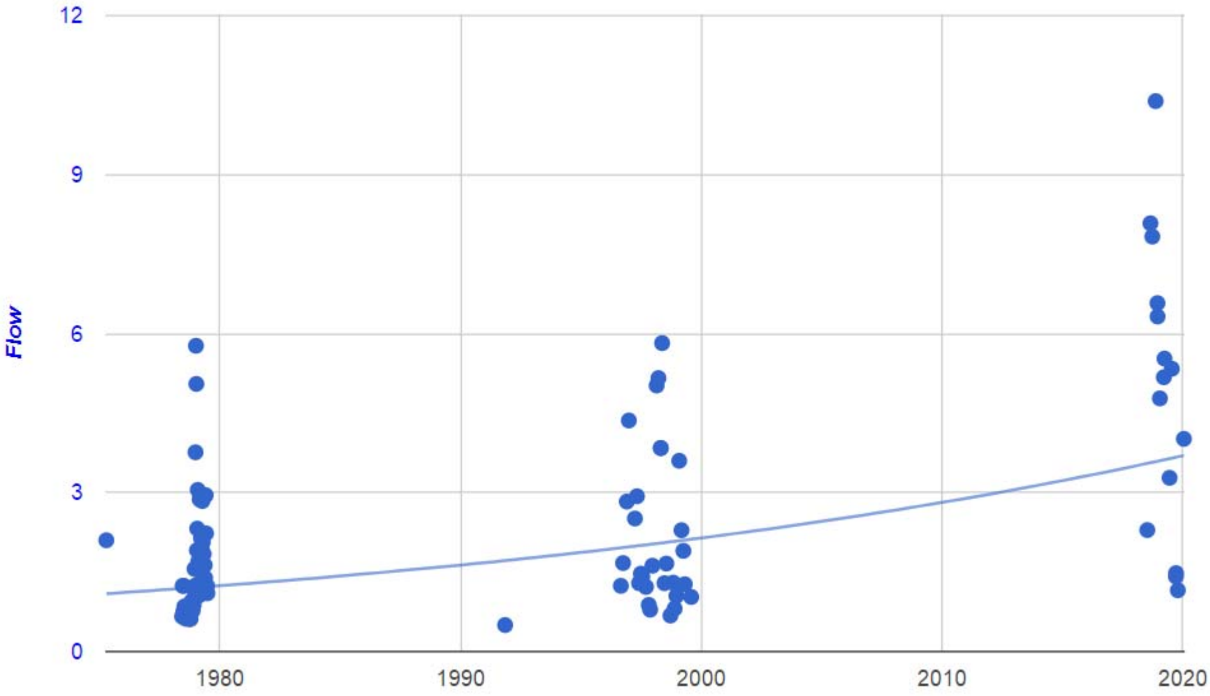

Figure 9. Green Mountain Flows in CFS from 1975 to 2020

Table 8. ***Green Mountain Flow Statistics from 1975-2020 and 2018-2020***

	1975-2020 CFS	2018-2020 CFS
N	100	17
Min	0.500	1.050
Ave	2.203	4.490
Med	1.443	4.777
Max	10.386	10.386
STD	1.909	2.712
90 Percentile	5.174	8.541
95 Percentile	6.297	ND
99 Percentile	10.363	ND

With an increasing flow trend and improving water quality, the 2018-2020 average flows and quality will be used when computing average AMD loading (Table 9). On average, Green Mountain contributes 84 tons per year of acidity, 1.3 tons per year of Fe, 2.1 tons per year of Mn, and 5.9 tons per year of Al to Catawissa Creek.

Table 9. ***Green Mountain Average AMD Loading***

Ave Flow CFS	Ave Acidity mg/l	Ave Fe mg/l	Ave Mn mg/l	Ave Al mg/l	Ave SO_4 mg/l	Ave TDS mg/l
4.490	19.07	0.29	0.48	1.34	31.46	172.11
	Acidity Load lbs/day	**Fe Load lbs/day**	**Mn Load lbs/day**	**Al Load lbs/day**	**SO_4 Load lbs/day**	**TDS Load lbs/day**
	461.91	7.02	11.63	32.46	762.01	4,168.79

Green Mountain Tunnel High Flow Quality, Quantity, and Loading

Even though treatment of Audenried is all that is needed to restore Catawissa Creek, an analysis of the high-flow quality, quantity, and loadings that could be encountered from Green Mountain is supplied. Since Green Mountain has improved in quality over time and seems to have increased in flow, the 21 samples collected since 2018 are only being used for analysis.

Since 2018, the highest flow recorded at Green Mountain was 10.386 cfs on November 14, 2018. The water quality and loading of Green Mountain on that date is found in Table 10.

Table 10. Green Mountain Quantity, Quality, and Loading on November 14, 2018

Flow CFS	Acidity mg/l	Fe mg/l	Mn mg/l	Al mg/l	SO_4 mg/l	TDS mg/l
10.386	18.60	0.30	0.36	1.18	27.80	154.00
	Acidity Load lbs/day	**Fe Load lbs/day**	**Mn Load lbs/day**	**Al Load lbs/day**	**SO_4 Load lbs/day**	**TDS Load lbs/day**
	1,042.12	16.81	20.17	66.11	1,557.58	8,628.32

Catawissa Tunnel Quality

The Catawissa Tunnel drains portions of the South Green Mountain Coal Basin (Figure 10). The Catawissa Tunnel is the first tunnel outfall impacting Catawissa Creek and enters about one-mile upstream of Audenried. The average flow discharging out of the Catawissa Tunnel is 1.320 cfs, with a maximum recorded flow of 6.050 cfs collected on May 16, 1998.

Figure 10. The Catawissa Tunnel Outfall into Catawissa Creek

The Catawissa Tunnel is remote and has not been sampled as extensively as Audenried and Green Mountain. In addition, the Catawissa Tunnel does not impact Catawissa Creek greatly as a population of native brook trout were captured downstream of the discharge. Consequently, and just like Green Mountain, the Catawissa Tunnel does not have to be treated for the restoration of Catawissa Creek.

As with almost all deep mine discharges, the Catawissa Tunnel is undergoing pyrite decay and has improved over time. The Catawissa Tunnel's pH, acidity, and Fe concentrations have all improved significantly over the last five decades (Figures 11 and 12). The aluminum concentrations have not been sampled enough for trend analysis. Since the Catawissa Tunnel is improving over time, only recent water quality data should be considered (Table 11).

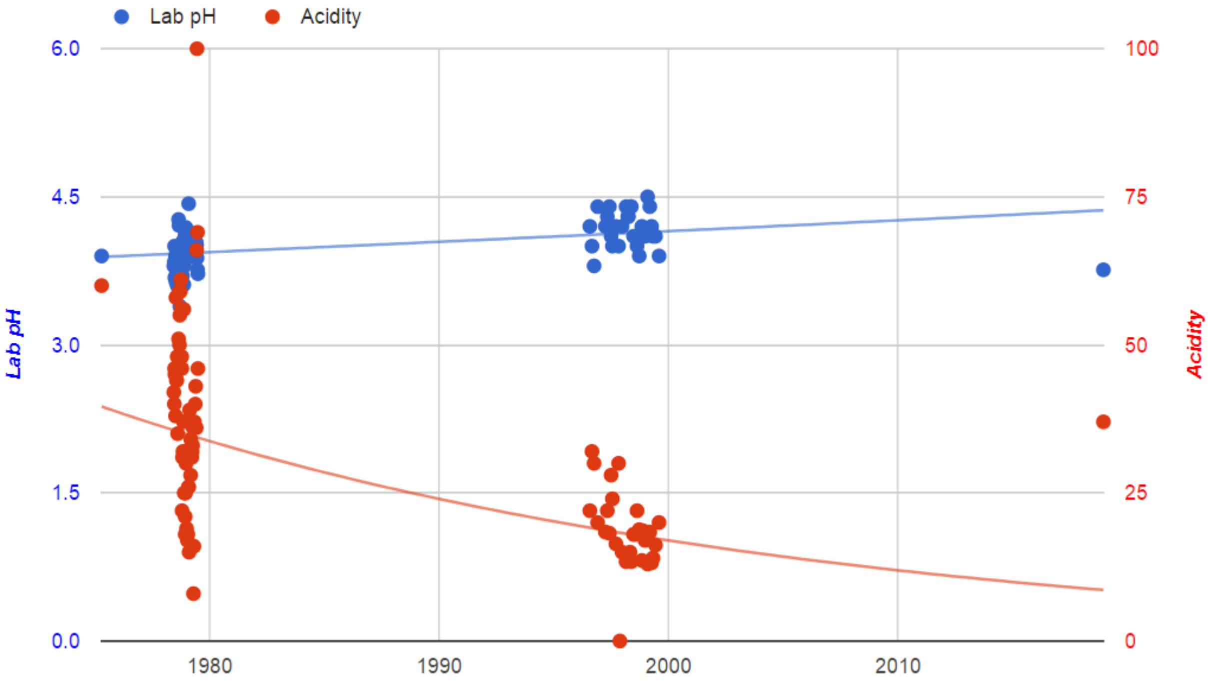

Figure 11. Catawissa Tunnel pH (SU) and Acidity Concentration (mg/l) Trends from 1975-2020

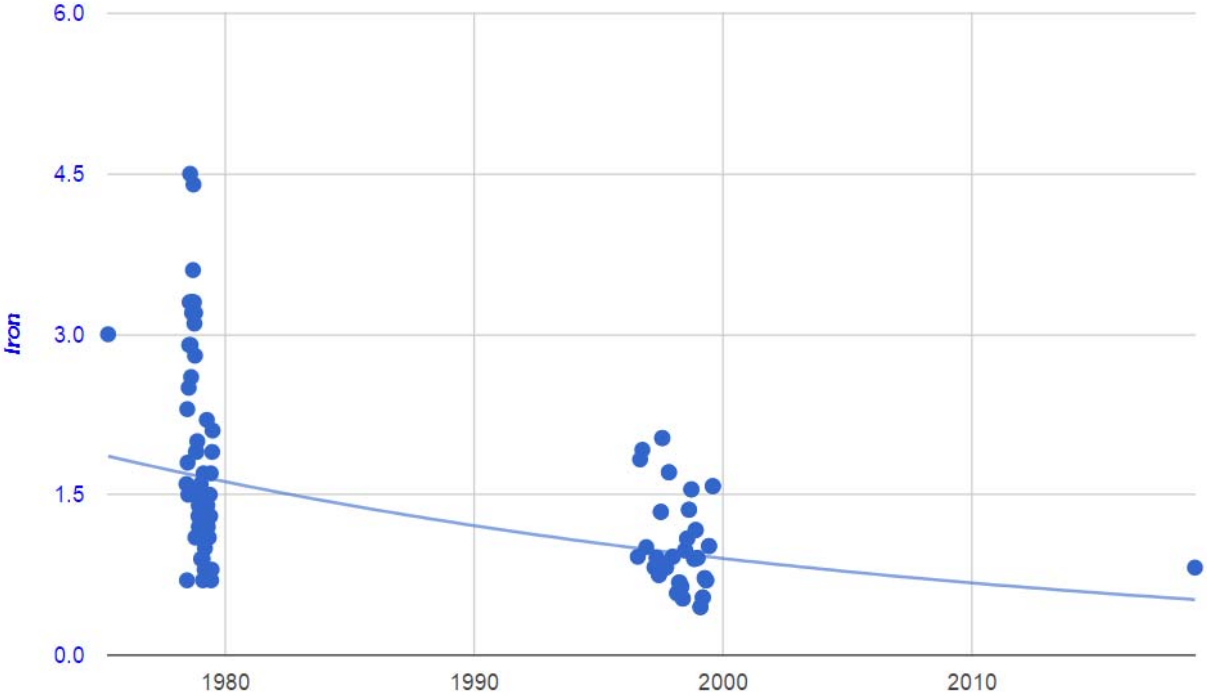

Figure 12. Catawissa Tunnel Iron Concentration (mg/l) Trend from 1975-2020

Table 11. Water Quality Statistics for the Catawissa Tunnel from 1996-1999

	Lab pH SU	**Acidity mg/l**	**Fe mg/l**	**Mn mg/l**	**Al mg/l**	**SO_4 mg/l**
N	54	54	54	54	53	24
Min	3.80	13.00	0.45	0.17	0.92	20.00
Ave	4.17	18.90	1.02	0.32	1.35	26.40
Med	4.20	18.00	0.91	0.30	1.30	20.00
Max	4.50	37.00	2.03	0.68	3.94	65.00
STD	0.17	4.91	0.42	0.11	0.26	10.60
90 Percentile	4.40	28.00	1.71	0.49	1.71	41.40

Catawissa Tunnel Quantity and Loading

Since the Catawissa Tunnel is remote and has not been consistently sampled for over a decade, an analysis of all flows collected from 1975-1999 can be found in Table 12. On average, the Catawissa Tunnel contributes 25 tons per year of acidity, 1.3 tons per year of Fe, 0.4 tons per year of Mn, and 1.8 tons per year of Al to Catawissa Creek (Table 13).

Table 12. Catawissa Tunnel Flow Statistics from 1975-1999

	1975-1999
	CFS
N	83
Min	0.110
Ave	1.325
Med	0.920
Max	6.050
STD	1.315
90 Percentile	3.020
95 Percentile	5.064
99 Percentile	ND

Table 13. Catawissa Tunnel Average AMD Loading

Ave Flow	**Ave Acidity**	**Ave Fe**	**Ave Mn**	**Ave Al**	**Ave SO_4**	**Ave TDS**
CFS	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**
1.325	18.90	1.02	0.32	1.35	26.40	ND
	Acidity Load	**Fe Load**	**Mn Load**	**Al Load**	**SO_4 Load**	**TDS Load**
	lbs/day	**lbs/day**	**lbs/day**	**lbs/day**	**lbs/day**	**lbs/day**
	135.09	7.29	2.29	9.65	188.70	ND

Catawissa Tunnel High Flow Quality, Quantity, and Loading

Even though treatment of Audenried is all that is needed to restore Catawissa Creek, an analysis of the high flow quality, quantity, and loadings that could be encountered from the Catawissa Tunnel is supplied. The highest flow recorded at the Catawissa Tunnel was 6.050 cfs on May 16, 1998. The water quality and loading of the Catawissa Tunnel on that date is found in Table 14.

Table 14. Catawissa Tunnel Quantity, Quality, and Loading on May 16, 1998

Flow	**Acidity**	**Fe**	**Mn**	**Al**	**SO_4**	**TDS**
CFS	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**
6.050	13.40	0.53	0.18	1.00	ND	ND
	Acidity Load	**Fe Load**	**Mn Load**	**Al Load**	**SO_4 Load**	**TDS Load**
	lbs/day	**lbs/day**	**lbs/day**	**lbs/day**	**lbs/day**	**lbs/day**
	437.34	17.30	5.87	32.64	ND	ND

Treatment Plant Influent Projections

As mentioned, due to Audenried contributing 89 percent of the acidity and 93 percent of the aluminum loading currently entering Catawissa Creek, only Audenried would need to be treated to restore the mainstem. The average flow, quality, and loading that would be handled by the treatment plant is detailed in Table 5. The plant will have to treat, on average, 901 tons/year of acidity and dispose of a little less than 11 tons/year of Fe, 32 tons per year of Mn, and 107 tons/year of Al, considering the effluent concentration standards of the plant. Influent to the plant will also contain, on average, 126 mg/l of sulfate (SO_4) and 236 mg/l of total dissolved solids (TDS). On average, the plant will have to treat over 15 million gallons per day (mgd) of water.

Because of the lack of storage ability within the mine pools contributing the discharge flows, the plant will have to be built to accommodate high flows and loading. The high flow quantity, quality, and loading that would have to be handled by the treatment plant is detailed in Table 6. During a high flow period, the plant will have to be able to treat around 8,435 lbs/day of acidity and dispose of a little less than 72 lbs/day of Fe, 239 lbs/day of Mn, and 875 lbs/day of Al, considering the effluent concentration standards of the plant. According to quantity data from 2014-2019, the plant will have to treat around 29 mgd of water during high flow periods.

Current Catawissa Creek Mainstem Quality

As mentioned, upstream of Audenried, Catawissa Creek is only slightly impacted by the Catawissa Tunnel (Table 15). The water quality at this station is representative of headwater streams in this area of the Susquehanna River Basin: barely net alkaline with relatively low metals and pH around 6.0. The water quality at this station is good enough to support a small but increasing population of native brook trout. Once Audenried is treated, these native brook trout, as well as natives in practically all of Catawissa Creek's tributary streams, will serve as a source of mainstem recolonizers.

After the entry of especially Audenried, and to a lesser extent, Green Mountain, the water quality of Catawissa becomes significantly impaired by AMD, particularly in terms of pH, acidity, and Al.

At the Girard Manor Road and upstream (US) Tomhicken Creek stations, the entry of small unimpaired tributary streams have improved the water quality slightly, but still does not meet water quality standards for pH, acidity, and Al.

After the entry of the larger Tomhicken Creek, which is significantly improved from past AMD impacts through the treatment of the Oneida #1 and #3 Tunnels, Catawissa Creek improves to the point that the water quality could be considered as just meeting standards, particularly since pH is greater than 6.0, alkalinity is greater than acidity, and aluminum is less than 0.75 mg/l. Catawissa Creek continues to slowly improve towards its confluence with the Susquehanna River due to the entry of numerous other small unimpaired tributaries.

Table 15. Catawissa Creek Upstream (US) and Select Stations Downstream (DS) of Audenried and Green Mountain

Location	Q	pH	Alk.	Acid.	Fe	Mn	Al	SO_4	TDS
	CFS	Lab	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
Catawissa US Audenried	6.260	5.99	6.64	5.55	0.39	0.09	0.46	18.10	58.30
Catawissa DS Green Mountain	37.124	4.44	4.28	26.74	0.47	0.91	2.97	78.75	172.40
Catawissa at Girard Manor Rd	51.971	4.84	1.05	17.06	0.13	0.66	1.66	63.14	89.00
Catawissa US Tomhicken Creek	136.351	5.15	1.00	6.65	0.10	0.29	0.93	30.95	56.00
Catawissa DS Tomhicken Creek	208.067	6.18	4.00	3.74	0.11	0.22	0.67	24.60	51.00
Catawissa Mouth	286.870	6.35	5.00	2.00	0.06	0.12	0.20	17.70	38.00

Oneida Passive Treatment Systems Summary

As mentioned, much of Tomhicken Creek has already been restored from the impacts of mine drainage due to construction of the Oneida #1 and #3 Passive Treatment Systems. These systems were constructed by CCRA with funds from PADEP and USEPA. The Oneida #1 Passive Treatment System was constructed in 2001 and Oneida #3 was constructed in 2009. Both treatment systems are oxic limestone drains (OLD) that have been extremely successful to the extent that sections of Tomhicken Creek have been removed from PA’s Integrated List of Impaired Waters. (Table 16).

Table 16. Average Water Quantity and Quality of the Oneida Passive Treatment System’s Influent and Effluent

Location	Q	pH	Alk.	Acid.	Fe	Mn	Al	SO_4	TDS
	CFS	Lab	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
Oneida #1 Influent	1.62	4.16	1.63	47.98	0.50	0.77	2.37	65.90	197.38
Oneida #1 Effluent	1.62	7.40	39.30	-27.30	0.25	0.17	0.59	65.07	284.29
Oneida #3 Influent	5.76	4.53	4.16	24.79	0.23	0.49	1.42	49.00	110.50
Oneida #3 Effluent	5.76	6.95	17.91	-6.49	0.23	0.13	0.58	28.45	107.38

RESTORATION GOALS

In recognition that funding to fully restore all AMD-impacted streams in PA does not exist, BAMR established a two-tier framework for restoration goals that can reasonably be achieved (PADEP, 2016). The Upper Tier Restoration Goal includes full aquatic life use attainment and water quality objectives met for all flow conditions. The Lower Tier Restoration Goal, applicable for the majority of AMD-impaired watersheds, includes diverse fish and macroinvertebrate communities with attainment as a recreational fishery along with an expectation that minor exceedances of some water quality objectives will occur for some flow conditions.

Upon entry, Audenried comprises a majority of the Catawissa Creek flow (~90 percent), so if Audenried is treated, Catawissa Creek is restored. In addition, since all tributaries downstream of Audenried are unimpaired by AMD, the treatment goal of Audenried is an effluent quality that creates a net alkaline condition in Catawissa Creek containing low concentrations of Al to allow for fish recolonization (particularly native brook trout).

Since Audenried and Green Mountain enter Catawissa Creek very near one another, it is very easy to test this hypothesis through a mass-balance equation to predict the treatment effluent quality needed to meet that goal.

On three separate occasions in 2018/2019, five stations were sampled within hours of each other for quantity and quality. Those five stations included:

1. Catawissa Creek Upstream of Audenried
2. Audenried Tunnel
3. Spies Run (tributary that enters Catawissa Creek between Audenried and Green Mountain)
4. Green Mountain Tunnel
5. Catawissa Creek Downstream of Audenried/Spies Run/Green Mountain

With quantities and qualities collected for each of these stations, the quality of the Audenried Tunnel Outfall (#2) can be adjusted to predict the downstream Catawissa Creek (#5) quality through a mass-balance model (Table 17-19).

Table 17. ***Mass-Balance Audenried Effluent Quality Prediction on December 11, 2018 (Yellow is predicted Audenried effluent to generate (blue) Catawissa Creek instream quality.)***

Station	**Q**	**pH**	**Acid**	**Fe**	**Mn**	**Al**	**Acid Load**	**Fe Load**	**Mn Load**	**Al Load**
	CFS	**SU**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**lbs/day**	**lbs/day**	**lbs/day**	**lbs/day**
Upstream Audenried	6.54	5.94	5.00	0.26	0.07	0.12	176.38	9.10	2.33	4.16
Audenried	33.01	4.25	31.00	0.39	1.11	3.62	5519.65	69.62	197.11	645.09
Green Mountain	6.57	4.33	14.00	0.30	0.36	1.02	496.50	10.57	12.63	36.10
Spies Run	4.01	5.78	3.00	0.08	0.01	0.08	64.90	1.80	0.30	1.71
DS Green Mountain Prediction	50.13	4.38	23.14	0.34	0.79	2.54	6257.42	91.08	212.36	687.06
DS Green Mountain Actual	52.19	4.39	22.00	0.44	0.75	2.42	6193.59	123.03	211.99	680.73
% Difference	3.95	0.230	5.18	22.72	5.33	4.96				
Predicted Effluent to Meet Negative Acidity and Al < 0.50 mg/l										
Station	**Q**	**pH**	**Acid**	**Fe**	**Mn**	**Al**	**Acid Load**	**Fe Load**	**Mn Load**	**Al Load**
	CFS	**SU**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**lbs/day**	**lbs/day**	**lbs/day**	**lbs/day**
Upstream Audenried	6.54		5.00			0.12	176.38			4.16
Audenried	33.01		-5.00			0.51	-890.27			90.81
Green Mountain	6.57		14.00			1.02	496.50			36.10
Spies Run	4.01		3.00			0.08	64.90			1.71
DS Green Mountain Prediction	50.13		-0.56			0.49	-152.50			132.78

Table 18. Mass-Balance Audenried Effluent Quality Prediction on March 28, 2018 (Yellow is predicted Audenried effluent to generate (blue) Catawissa Creek instream quality.)

Station	**Q**	**pH**	**Acid**	**Fe**	**Mn**	**Al**	**Acid Load**	**Fe Load**	**Mn Load**	**Al Load**
	CFS	**SU**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**lbs/day**	**lbs/day**	**lbs/day**	**lbs/day**
Upstream Audenried	12.05	5.79	1.91	0.11	0.10	0.26	124.19	7.15	6.50	16.91
Audenried	31.94	4.37	26.00	0.29	1.09	3.69	4479.87	49.97	187.81	635.80
Green Mountain	5.53	4.34	10.03	0.20	0.39	1.20	299.11	5.96	11.63	35.79
Spies Run	5.00	5.78	3.00	0.08	0.01	0.08	80.92	2.24	0.38	2.13
DS Green Mountain Prediction	54.52	4.51	16.95	0.22	0.70	2.35	4984.09	65.32	206.32	690.62
DS Green Mountian Actual	52.19	4.56	15.00	0.26	0.65	2.23	4222.90	73.20	182.99	627.80
% Difference	4.46	1.10	13.00	15.38	7.69	5.38				
Predicted Effluent to Meet Negative Acidity and Al < 0.50 mg/l										
Station	**Q**	**pH**	**Acid**	**Fe**	**Mn**	**Al**	**Acid Load**	**Fe Load**	**Mn Load**	**Al Load**
	CFS	**SU**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**lbs/day**	**lbs/day**	**lbs/day**	**lbs/day**
Upstream Audenried	12.05		1.91			0.26	124.16			16.90
Audenried	31.94		-3.00			0.51	-516.91			87.87
Green Mountain	5.53		10.03			1.20	299.22			35.80
Spies Run	5.00		3.00			0.08	80.92			2.13
DS Green Mountain Prediction	54.52		-0.04			0.49	-12.62			142.70

Table 19. Mass-Balance Audenried Effluent Quality Prediction on September 7, 2019 (Yellow is predicted Audenried effluent to generate (blue) Catawissa Creek instream quality.)

Station	**Q**	**pH**	**Acid**	**Fe**	**Mn**	**Al**	**Acid Load**	**Fe Load**	**Mn Load**	**Al Load**
	CFS	**SU**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**lbs/day**	**lbs/day**	**lbs/day**	**lbs/day**
Upstream Audenried	0.545	5.93	13.00	0.01	0.04	0.03	38.22	0.03	0.12	0.09
Audenried	9.164	4.04	58.00	0.38	1.77	5.30	2867.28	18.79	87.50	262.01
Green Mountain	1.416	4.18	27.00	0.15	0.53	1.05	206.25	1.15	4.05	8.02
Spies Run	0.519	6.42	11.00	0.09	0.02	0.04	30.80	0.25	0.06	0.11
DS Green Mountain Prediction	11.644	4.10	50.03	0.32	1.46	4.30	3142.55	20.21	91.72	270.23
DS Green Mountian Actual	10.890	4.42	38.00	0.09	0.97	2.80	2232.38	5.29	56.98	164.49
% Difference	6.48	0.23	24.05	71.88	33.56	34.88				
Predicted Effluent to Meet Negative Acidity and Al < 0.50 mg/l										
Station	**Q**	**pH**	**Acid**	**Fe**	**Mn**	**Al**	**Acid Load**	**Fe Load**	**Mn Load**	**Al Load**
	CFS	**SU**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**lbs/day**	**lbs/day**	**lbs/day**	**lbs/day**
Upstream Audenried	0.545		13.00			0.03	38.220571			0.09
Audenried	9.164		-6.00			0.46	-296.6154			22.74
Green Mountain	1.416		27.00			1.05	206.24543			8.02
Spies Run	0.519		11.00			0.04	30.797634			0.11
DS Green Mountain Prediction	11.644		-0.34			0.49	-21.35173			30.96

As calculated in Tables 17-19, the effluent of the eventual Audenried ATP would not have to discharge high alkalinity concentrated water to ensure net alkalinity in the Catawissa Creek mainstem. An ATP net alkalinity between 3-6 mg/l would ensure a net alkaline Catawissa Creek under the varying flow regimes sampled. In summary, higher alkaline concentrated effluent needed during low flow conditions, less needed under high flow conditions.

This analysis also allows us to estimate the average amount of lime needed and cost to treat the acid load of Audenried and impart the slight net alkalinity needed to restore the mainstem of Catawissa Creek (Table 20).

Table 20. Estimate of Lime Quantities and Associated Costs Under Varying Flow Regimes for the Audenried ATP

Sampling Date	**Audenried**	**Acid Load**	**Lime**	**Lime**	**Cost/mgd**
	mgd	**Tons/Year**	**Tons/Year**	**Cost/Year**	**$**
12/11/2018	21.33	1170	968	$242,000	$11,346
3/28/2019	20.64	912	755	$189,000	$9,157
9/17/2019	5.92	198	164	$41,000	$6,926

Using a ratings curve analysis equation of the cost/cfs value, at the average Audenried flow of 15.34 mgd, the Cost/mgd should be around $8,814. Consequently, average annual cost of lime for the ATP should be around $135,000 (AMDTreat estimates $173,000). Consequently, annual lime costs should be around $150,000 plus or minus a percentage based upon annual precipitation and flows.

Fish and Macroinvertebrates

Detailed macroinvertebrate and fish data for Catawissa Creek can be found in Appendices F and G. Below is a summary and analysis of that data.

On September 17 and 18, 2019, SRBC electrofished four reaches of Catawissa Creek, upstream and downstream of Tomhicken Creek, as well as upstream and downstream of the Audenried/Green Mountain Tunnels. Electrofishing surveys were conducted using the SRBC protocol of three passes, through a reach 10 times average wetted width, with a minimum reach length of 100 meters (Shank et al., 2016).

Downstream of Tomhicken Creek, 13 species were collected totaling 207 fish, including brown and brook trout (Appendix G). The fact that no young-of-the-year trout were caught suggests that trout in this stretch had been stocked or traveled in from unimpaired tributaries. The most abundant species in this reach were eastern blacknose dace, green sunfish, and white suckers, making up 80 percent of the fish collected. Upstream of Tomhicken, only three species of fish were collected, totaling 17 individuals. Of the 17 fish caught, 15 were creek chubs, one of the most pollution-tolerant fishes found in PA. Catawissa Creek at Girard Manor Road is located over three river miles downstream of the Green Mountain Tunnel. In three 100-meter passes, not a single fish was captured at this site. These results demonstrate that without the increased water quality from Tomhicken, the upper reaches of Catawissa Creek are nearly to completely uninhabitable to fish due to AMD loading. Upstream of Audenried Tunnel, 20 brook trout and 20 eastern blacknose dace were collected, demonstrating the minimal impairment caused by the Catawissa Tunnel.

Once the water from the Audenried Tunnel is treated, recolonization of fish populations should happen quickly from the many unimpaired tributaries that contain native brook trout populations, from Catawissa Creek downstream of Tomhicken, and from Catawissa Creek upstream of Audenried. Mainstem restoration will also allow reconnection and migration of those fish populations.

On March 28, 2019, macroinvertebrates were sampled from five sites along the mainstem of Catawissa Creek (Appendix F). Upstream of the Audenried Tunnel, macroinvertebrate indices indicate a stream that could be delisted. Index of Biological Integrity (IBI) scores generally decreased as the sites moved downstream. Water quality improves with distance from the discharges due to high water quality inputs from Catawissa Creek tributaries. As the pH increases, Al precipitates and covers the substrate, filling interstitial spaces, thus reducing available macroinvertebrate habitat. This is why sites further downstream with better water quality actually have less macroinvertebrate density. The improved water quality allows Al to precipitate, which impacts available habitat.

Macroinvertebrate recolonization will occur post-restoration, although likely not as quickly as the fish. Storms will scour precipitated metals from the substrate, opening habitat to macroinvertebrate recolonizers from the tributaries that are pushed downstream by forces, such as catastrophic and behavioral drift.

Because PFBC plans to manage 18 miles of Catawissa Creek as a TSF and another 23.5 miles as a WT fishery, SRBC believes that those combined 41.5 miles of Catawissa Creek will at least meet the Lower Tier Restoration Goals (PADEP 2016). Those miles may even achieve the Higher Tier Restoration Goals since Audenried comprises a vast majority of the watershed AMD loading.

Technology Analysis

The high flow volume of Audenried eliminates any possibility of using passive treatment technologies. Using PADEP's Risk Analysis Matrix for Passive Treatment Systems, the risk of constructing a passive treatment system would be considered as "High" (Table 21). To fit into a "Medium" risk analysis, the influent would have to be split into nearly 27 passive treatment cells during average flows.

Over the last 10 years, PADEP has identified streams where one large ATP treating large quantities of discharge water could restore significant stream miles. The Lancashire ATP has improved about 30 miles of the West Branch Susquehanna River and has created a significant brown trout fishery near the towns of Northern Cambria and Cherry Tree. The Hollywood ATP has improved about 33 miles of the Bennett Branch of Sinnemahoning Creek to the point that sections are now being stocked with trout by the PFBC. The Cresson ATP, which has just recently come online in 2019, has the potential to restore/improve 21 miles of Clearfield Creek.

In addition to these already constructed facilities, PADEP also has plans to design and construct 1) the Wehrum ATP, which will restore/improve 25 miles of Blacklick Creek; 2) an ATP in the headwaters of Little Conemaugh River, which will restore/improve 20 miles; and, 3) the Quakake ATP, which will restore/improve 11 miles of the Lehigh River. Possible large-scale ATPs have also been planned for Chartiers Creek just outside of Pittsburgh, Shade Creek in Somerset County, and in the Tioga River Watershed in Tioga County.

BAMR is committed to constructing the Audenried ATP and conducting long-term O&M of the plant once property ownership is resolved.

Table 21. PADEP Passive Treatment System Risk Analysis Matrix

Risk Analysis Matrix				
Summation of Fe and Al Concentration	**Design Flow Rate for each treatment cell**			
	< 25 GPM	**> 25 < 50 GPM**	**> 50 < 100 GPM**	**> 100 < 200 GPM**
< 5 mg/l	Low	Low	Low	Low
> 5 < 15 mg/l	Low	Medium	Medium	Medium
>15 < 25 mg/l	Low	Medium	Medium	Medium
> 25 < 50 mg/l	Medium	Medium	Medium	High
> 50 mg/l	High	High	High	High
	> 200 < 400 GPM	**> 400 < 800 GPM**	**> 800 < 1600 GPM**	**> 1600 GPM**
< 5 mg/l	Medium	Medium	Medium	High
> 5 < 15 mg/l	Medium	High	High	High*
>15 < 25 mg/l	High	High	High	High
> 25 < 50 mg/l	High	High	High	High
> 50 mg/l	High	High	High	High

Although the eventual Audenried ATP will be designed similarly to the Quakake ATP due to similar quantity and quality to be treated, the Quakake ATP is still in design so no substantive size or cost comparisons can be made at the present.

Consequently, the Hollywood ATP capital and operation and maintenance (O&M) costs will be used as a starting point to estimate costs for the Audenried ATP. According to PADEP, Hollywood treats an average of 2.88 mgd of water and treated 4.61 mgd in 2018, the wettest year on record. On average, the Audenried ATP would have to treat 15.3 mgd and a high of around 28.9 mgd because the Jeansville Mine Pool is free-draining and offers no real ability for storage. To accommodate the typical average and the infrequent high flow periods, the Audenried ATP will need multiple clarifiers and/or larger clarifiers than the Hollywood ATP. For instance, an initial estimate of clarifier size to handle 28.9 mgd is two 250-foot diameter clarifiers with a water depth of 13-18 feet, plus 1.5-2 feet of freeboard.

There could also be an option for incorporating some of the existing failed passive treatment plant features into the ATP design. For instance, there are three 120-foot diameter concrete holding tanks currently onsite that could be used for water storage or pre-treatment.

In terms of loading between the two plants, the water at Catawissa is not as degraded as the influent treated at Hollywood (Table 22). The Audenried ATP will have to treat similar acid loading compared to the Hollywood Plant. Fe at Audenried is significantly less than at Hollywood, while around 30 percent more Al would need to be treated and disposed of at Audenried. However, when combined, metal sludge disposal quantities at Audenried are expected to be about half as much as generated at Hollywood. So even though capital construction costs at Audenried will be greater than at Hollywood due to the need of larger and more clarifiers, there is the potential of lower annual treatment and disposal costs as compared to the Hollywood ATP.

Table 22. Comparison of Acidity and Metal Loading between the Hollywood ATP and the Planned Audenried ATP

ATP	Acid Load	Fe Load	Al Load	Metal Load
	Tons/Year	Tons/Year	Tons/Year	Tons/Year
Hollywood Average Flow	952	170	81	251
Audenried Average Flow	901	11	107	118
Audenried % Difference	-5	-94	32	-53
Hollywood High Flow (2018)	1467	252	129	381
Audenried High Flow	1539	13	160	173
Audenried % Difference	5	-95	24	-55

The costs to construct the Audenried ATP should be relatively comparable to the 2020 adjusted costs to construct the Hollywood ATP. As discussed, the only significant difference may be the need for a larger-sized primary and an additional secondary clarifier to accommodate the high flows at Audenried, particularly due to the lack of mine pool storage potential.

The Hollywood ATP includes two ferrous Fe oxidation reactors, a 180-foot diameter clarifier, two sludge conditioning reactors, a high-density slurry system that includes sludge recirculation technology, and a 4.5-acre polishing pond (Figure 13).

Figure 13. Aerial Photo of the Hollywood ATP

According to PADEP, the 2017 adjusted cost to construct the Hollywood ATP was $15,509,262. Adjusted to 2020 costs and the need for a larger and additional clarifier (an additional $990,121 according to OSM's AMDTreat software), capital construction costs for the Tioga ATP could be as high as $17,312,493 (www.usinflationcalculator.com). Adding in 10 percent for engineering, total design and construction could total **$19,043,742**.

Alternatives Analysis

As mentioned, due to the large volume of the Audenried Tunnel, a passive treatment system alternative or other type of active treatment is not feasible. This was proven by the failed passive Audenried Tunnel AMD Passive Treatment Project. Initiated in 2005, this passive treatment system included three circular concrete tanks filled with high calcium limestone that functioned as a large OLD. Treated water then exited these tanks into an approximately 2-acre settling basin that was significantly undersized for the amount of aluminum loading that needed to precipitate prior to re-entry to Catawissa Creek. However, even before considering those design flaws that were predicated on treatment site limitations, the passive system was significantly damaged by high tunnel flows from Tropical Storm Lee in 2011. The passive treatment system remains offline today.

In addition, the high volume of water that is to be treated from Audenried classifies it as "High Risk" in PADEP's Risk Analysis Matrix. The volume of water is so great that it would have to be split into 27 treatment cells to qualify as a “Medium Risk” under average flow conditions. A 27-cell passive treatment system would obviously not be feasible and would cover a massive area that is not available outside the 100-year floodplain downstream of Audenried. According to AMDTreat software, a 27-cell passive treatment system would be around 38 acres to adequately treat the average flow from Audenried and 71 acres to adequately treat the high flow. According to PADEP, the Hollywood ATP has a project footprint of 41 acres.

SRBC agrees with PADEP and recommends that the only cost and size feasible method for treatment of the proposed Audenried influent is a hydrated lime/clarifier ATP, similar to the Hollywood ATP that treats poorer water quality but at a reduced volume.

OPERATION AND MAINTENANCE

O&M at the Audenried ATP should be lower than the annual O&M costs at the Hollywood ATP, mainly due to the metal loading of the influent being significantly less. According to OSM’s AMDTreat software, the chemical cost of running the Audenried ATP is estimated as $173,318 per year (Appendix I). Adding in normal electrical and labor costs of other similar ATPs that include pumping of water and sludge, total yearly O&M costs of the Audenried ATP could be as high as **$541,318**.

Discharge water from Audenried can be conveyed to the proposed plant location by gravity. The proposed site also has enough room outside the 100-year floodplain to accommodate the multiple clarifiers needed to treat the amount of flow exiting Audenried.

Recent ATPs constructed by PADEP are not fully, but highly automated to the point that operational personnel are not needed at the plant at all times. Real-time monitoring instrumentation has also been installed at all the more recent ATPs to assist with O&M. PADEP is also financially committed to the long-term operational viability of the plant due to the amount of stream mileage restored.

In terms of maintenance, the most significant issue will be managing the amount of influent flows during periods of heavy precipitation. As mentioned, the Audenried Passive Treatment System was destroyed by extreme influent flows caused by heavy precipitation from Tropical Storm Lee in 2011. ATP designs will ensure that operations are in place to manage the amount of flow coming into the plant, allowing bypass when situations like a tropical storm occur.

When operating an ATP, maintenance is constant: ensuring proper flows entering, adding required lime amounts, and pumping sludge from the plant. However, unlike a passive system, an ATP allows for the real-time operation and automation of those maintenance duties, increasing the amount of control over the treatment process, which is a must with a flow the size of Audenried. Annual O&M costs for the ATP should only be around three percent of the construction costs.

Benefit/Cost Analysis

To determine the value of the benefits of restoring Catawissa Creek, PFBC's Recreational Use Loss Estimates for PA Streams Degraded by AMD for base year 2006 adjusted to 2020 were used from PADEP's *Acid Mine Drainage Set-Aside Program: Program Implementation Guidelines* document (2016).

Stream Segment #1
Chapter 93 Designation: TSF
Projected Use: TSF
Miles Restored: 14
Use Rate: 1,100 trips/year/mile
Valuation in 2020 Dollars from https://www.usinflationcalculator.com/: $100.12
Lost Value: $1,541,848

Stream Segment #2
Chapter 93 Designation: TSF
Projected Use: TSF
Miles Restored: 4
Use Rate: 1,100 trips/year/mile
Valuation in 2020 Dollars from https://www.usinflationcalculator.com/: $100.12
Lost Value: $440,528

Stream Segment #3
Chapter 93 Designation: CWF
Projected Use: WT
Miles Restored: 23.5
Use Rate: 500 trips/year/mile
Valuation in 2020 Dollars from https://www.usinflationcalculator.com/: $84.70
Lost Value: $995,225

The Net Present Value (NPV) of the benefits can be calculated using the uniform series, present worth equations, or values extracted from the uniform series present worth table in Appendix E of PADEP's *Acid Mine Drainage Set-Aside Program: Program Implementation Guidelines* document (2016).

The annual economic lost values of the portions of Catawissa Creek identified above are the basis of the project's NPV benefit Evaluation. The lost value is **$2,977,601**. The following parameters are then applied to the NPV equation:

N=50 Year
I=5%
USPWF=18.25593

Net Present Benefit = $2,977,601 x 18.25593 = **$54,358,875.40**

Total Catawissa Creek ATP Benefits	**$54,358,875.40**
Design Cost	$1,731,249.00
Capital Construction Cost	$17,312,493.00
Operation and Maintenance Cost	$9,882,263.52
Total Cost	**$28,926,005.50**
Benefit/Cost Ratio	**1.879 : 1.000***

*Costs of the plant can overrun cost projections by $25,432,869.90 and still meet the Benefit/Cost Analysis.

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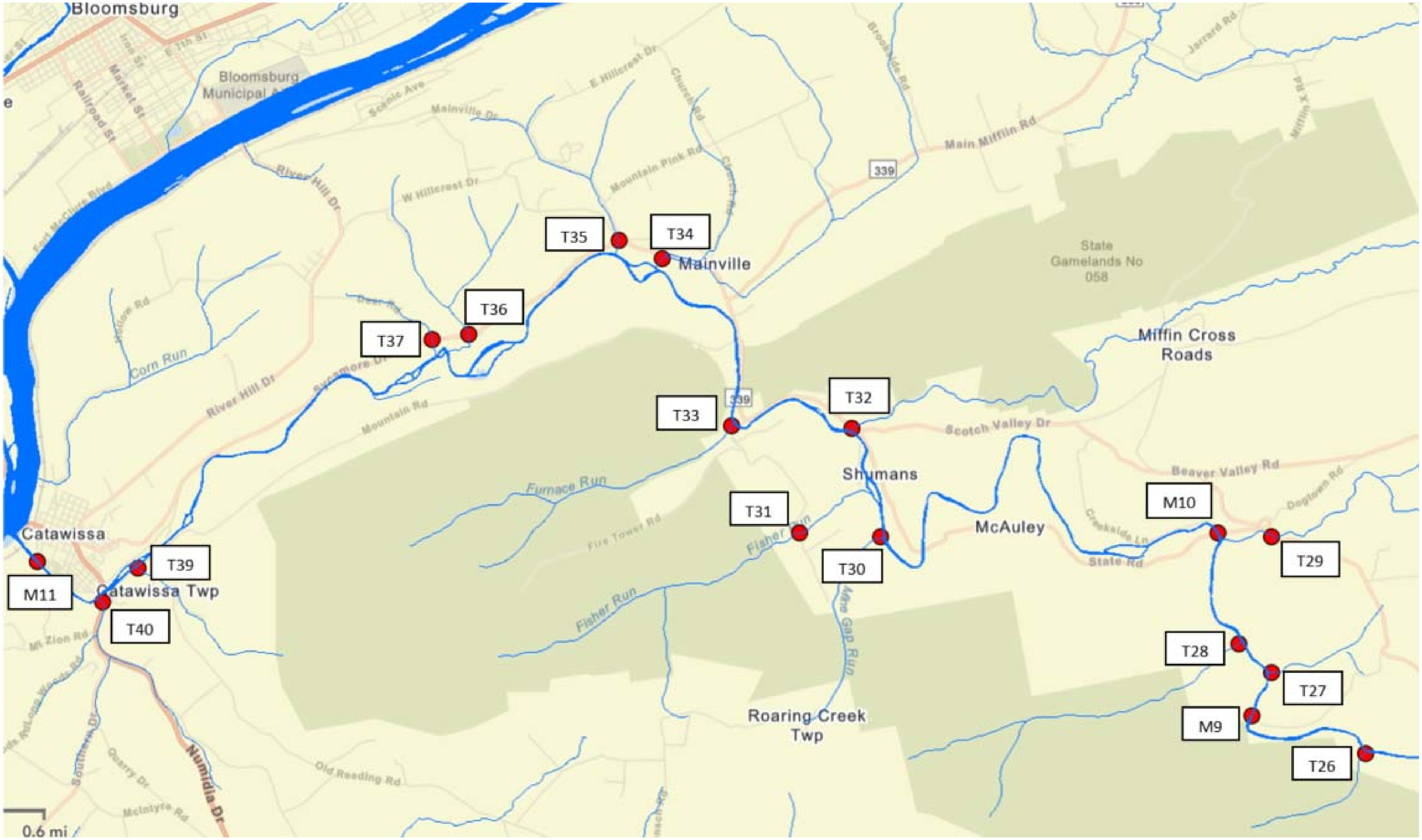
APPENDIX A

December 10-12, 2018, Sampling Station Maps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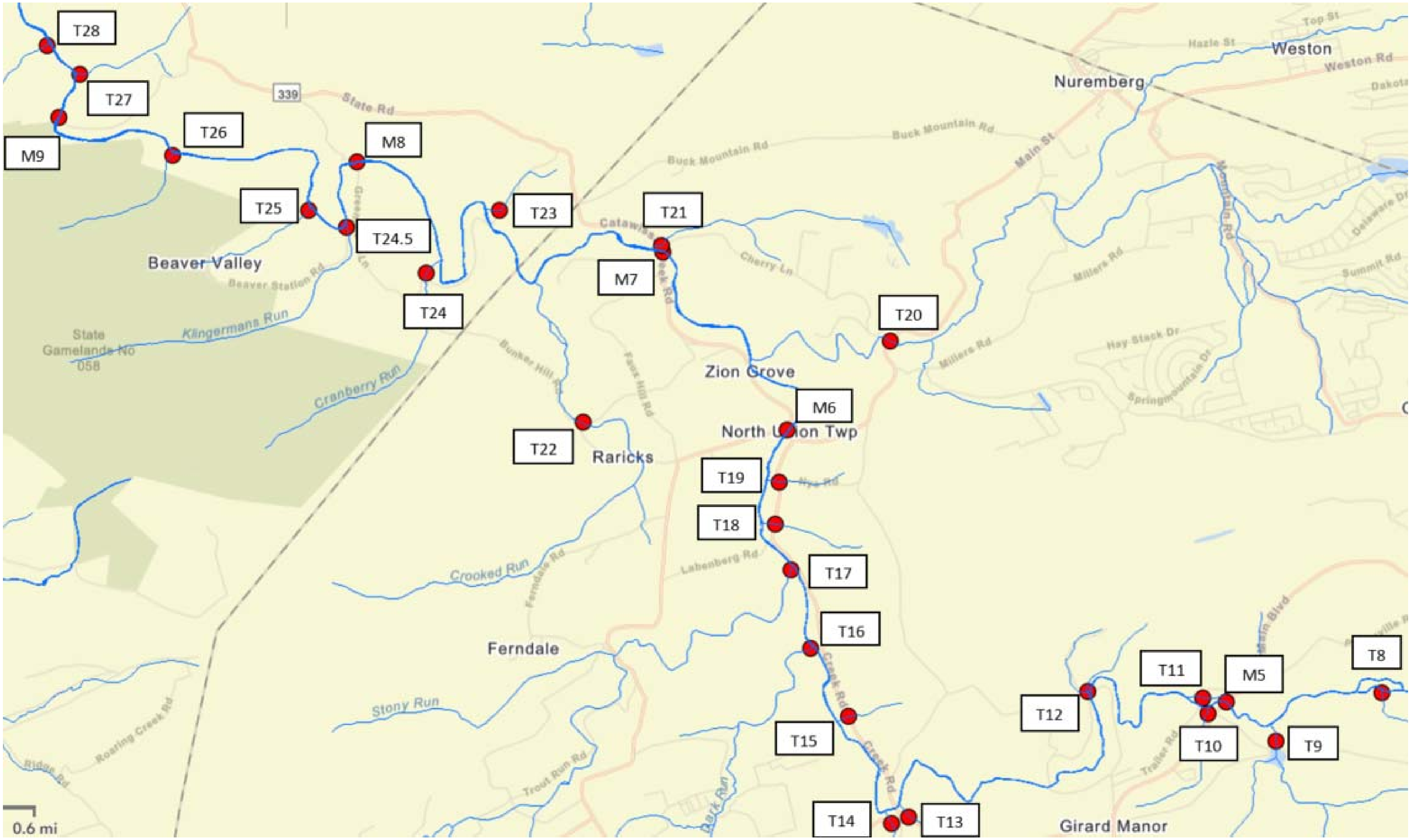
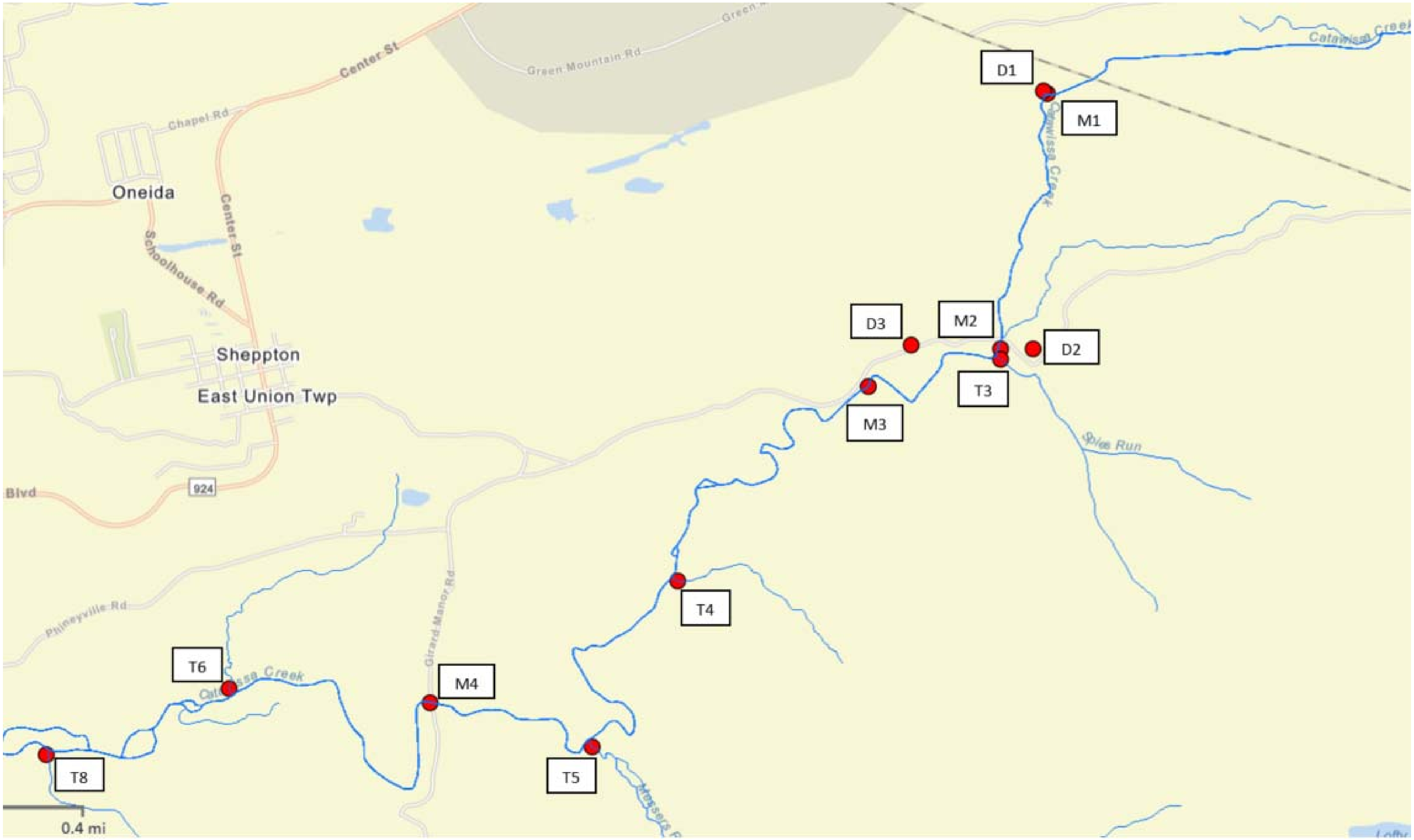
E 7th St
Iron St
Market St
Railroad St
Bloomsburg Municipal A
Scenic Ave
Mainville Dr
E Hillcrest Dr
Church Rd
Brookside Rd
Jarrard Rd
Mifflin X Rd
Main Mifflin Rd
339
Fort McClure Blvd
River Hill Dr
W Hillcrest Dr
Mountain Pink Rd
T35
T34
Mainville
State Gamelands No 058
Deer Rd
Hollow Rd
T36
T37
Corn Run
Sycamore Dr
Miffin Cross Roads
River Hill Dr
Mountain Rd
T33
339
T32
Scotch Valley Dr
Furnace Run
Shumans
Beaver Valley Rd
Dogtown Rd
M10
Fire Tower Rd
T31
Fisher Run
T30
McAuley
Creekside Ln
State Rd
T29
Catawissa
T39
M11
Catawissa Twp
T40
Fisher Run
Mt Zion Rd
Mine Gap Run
T28
T27
Roaring Creek Twp
M9
T26
Southern Dr
Quarry Dr
Numidia Dr
Old Reading Rd
McIntyre Rd
0.6 mi


T28
T27
M9
T26
M8
T25
T24.5
T23
T21
M7
T24
T20
M6
T22
T19
T18
T17
T16
T15
T12
T11
M5
T8
T10
T9
T14
T13
Beaver Valley
State Gamelands No 058
Klingermans Run
Cranberry Run
Zion Grove
North Union Twp
Raricks
Ferndale
Crooked Run
Stony Run
Girard Manor
Nuremberg
Weston
State Rd
339
Buck Mountain Rd
Main St
Millers Rd
Cherry Ln
Catawissa Creek Rd
Bunker Hill Rd
Faux Hill Rd
Labenberg Rd
Ferndale Rd
Creek Rd
Trout Run Rd
Roaring Creek Rd
Ridge Rd
Beaver Station Rd
Hay Stack Dr
Springmountain Dr
Mountain Rd
Weston Rd
Hazle St
Top St
Summit Rd
Delaware Dr
Trailer Rd
Main Blvd
0.6 mi


D1
M1
Catawissa Creek
Green Mountain Rd
Center St
Chapel Rd
Oneida
Center St
Schoolhouse Rd
Sheppton
East Union Twp
D3
M2
D2
T3
M3
Spies Run
924
Blvd
Girard Manor Rd
Phineyville Rd
T4
T6
Catawissa Creek
M4
T5
T8
0.4 mi

APPENDIX B

December 10-12, 2018, Water Quality Data

Station Name	Station Description	Lat	Long	F pH	Con	DO	Temp	Turb	Q	pH	Cond	Alk	Acid	Al	Fe	Mn	SO_4	TSS	TDS
CC-QHUP-M1	Headwaters of Catawissa	40.9106	-76.0655	5.25	78	13.18	2.2	-	3.886	5.52	80.8	2	6	0.14	0.298	0.098	<10	<5	10
CC-QHUP-D1	Catawissa Tunnel	40.9107	-76.0657	3.82	272	8.65	7	-	0.032	3.76	273.7	0	37	3.938	0.819	0.684	59.5	<5	120
CC-QHUP-M2	Catawissa Creek US Audenried	40.8978	-76.0686	5.57	73	13.26	1.45	0	6.539	5.94	66.2	3	5	0.118	0.258	0.066	<10	<5	8
CC-QHUP-D2	Audenried Tunnel	40.8978	-76.0664	4.86	308	10.14	8.13	0	33.006	4.25	317.3	0	31	3.623	0.391	1.107	137.2	<5	156
CC-QHUP-D3	Green Mountain Tunnel	40.8980	-76.0745	4.44	236	10.8	9.16	0	6.574	4.33	241.5	0	14	1.018	0.298	0.356	25	<5	98
CC-QHUP-T3	Spies Run	40.8973	-76.0686	5.36	12	13.15	1.91	0.6	4.01	5.78	13.3	2	3	0.079	0.083	0.014	<10	<5	17
CC-QHUP-M3	Catawissa DS Discharges	40.8959	-76.0773	4.38	242	11.27	7.76	0	52.187	4.39	244.9	0	22	2.418	0.437	0.753	64.5	<5	117
CC-QHUP-T4	Unnamed Trib #2	40.8862	-76.0899	6.48	20	10.8	5.7	-	0.493	6.35	21	5	-1	<0.05	0.087	<0.10	<10	<5	18
CC-QHUP-T5	Messers Run	40.8779	-76.0956	6.29	39.5	12.98	2.5	-	10.871	6.38	41.6	5	4	0.064	0.14	0.017	<10	<5	39
CC-QHUP-M4	Catawissa at Girard Manor Rd	40.8801	-76.1063	4.69	180	11.94	5.93	0	69.055	4.65	183.6	9	16	1.861	0.314	0.563	49.2	<5	75
CC-QHUP-T6	Unnamed Trib #3	40.8808	-76.1196	5.69	62	12.02	3.8	-	1.128	6.05	65	3	6	0.078	0.075	0.025	<10	<5	40
CC-QHUP-T8	Unnamed Trib #5	40.8775	-76.1317	5.76	40	11.79	5.1	-	1.024	6.42	41.9	8	1	<0.05	0.072	0.011	<10	<5	36
CC-QHUP-T9	Davis Run	40.8727	-76.1455	7.28	53	12.29	4.09	0	6.402	6.39	47.6	6	2	<0.05	0.057	0.016	<10	<5	40
CC-QHUP-M5	Catawissa at Main Blvd	40.8766	-76.1521	4.89	154	12.24	4.56	0	90.593	4.78	163.8	1	13	1.476	0.15	0.403	43.8	<5	39
CC-QHUP-T10	Unnamed Trib #6	40.8754	-76.1545	7.15	187	12.88	1.92	2.7	0.463	6.54	190.8	18	-13	0.08	0.152	0.046	13	<5	94
CC-QHUP-T11	Unnamed Trib #7	40.8769	-76.1552	7.13	71	13.19	1.31	0	0.842	6.48	74.6	10	-1	<0.05	0.09	0.028	<10	<5	48
CC-QHUP-T12	Unnamed Trib #8	40.8776	-76.1703	7.26	33	12.57	3.47	0	0.889	6.32	42.5	7	2	<0.05	0.058	<0.01	<10	<5	22
CC-QHUP-T13	Rattling Run	40.8652	-76.1938	7.32	106	12.8	2.79	0.2	4.22	6.33	111.1	9	-1	<0.05	0.05	0.013	<10	<5	54
CC-QHUP-T14	Unnamed Trib #9	40.8645	-76.1960	7.01	119.5	13.94	2.1	-	1.485	6.37	120.9	10	-2	<0.05	0.029	<0.01	<10	<5	76
CC-QHUP-T15	Unnamed Trib #10	40.8751	-76.2017	7.06	42.9	12.72	3.3	-	0.614	6.48	45	12	-4	<0.05	0.057	<0.01	<10	<5	25
CC-QHUP-T16	Dark Run	40.8819	-76.2067	7.01	154.3	14.79	0.8	-	0.709	6.47	153.7	13	-9	<0.05	0.061	0.04	12	<5	89
CC-QHUP-T17	Little Catawissa Creek	40.8897	-76.2093	6.93	66.9	14.62	1.1	-	29.147	6.46	68.6	9	17	<0.05	0.114	0.016	<10	<5	36
CC-QHUP-T18	Unnamed Trib #11	40.8942	-76.2114	7.09	46.6	11.81	5.5	-	1.287	6.48	48.7	11	3	<0.05	0.066	0.018	11.1	<5	33
CC-QHUP-T19	Unnamed Trib #12	40.8984	-76.2108	7.1	152.8	12.06	5.6	-	0.161	6.44	153.6	14	-7	<0.05	0.04	<0.01	10.3	<5	80
CC-QHUP-M6	Catawissa at Red Ridge Road	40.9035	-76.2097	5.24	125	12.99	2.94	0.2	136.351	5.26	127.8	1	7	0.947	0.104	0.294	29.4	<5	34
CC-QHUP-T20	Tomhicken Creek	40.9124	-76.1962	6.94	184	13.23	2.7	-	44.494	6.4	185.3	9	3	0.192	0.116	0.136	16.8	<5	87
CC-QHUP-M7	Catawissa at RT 339	40.9212	-76.2261	5.69	136	13.15	2.74	0.6	208.067	6.18	139.7	4	4	0.811	0.126	0.253	26.3	7	27
CC-QHUP-T21	Unnamed Trib #13	40.9219	-76.2263	6.8	61.9	13.24	2.2	-	1.933	6.37	64.4	8	-1	<0.05	0.084	<0.01	<10	<5	31
CC-QHUP-T22	Crooked Run	40.9043	-76.2366	6.54	44.9	12.4	3.4	-	5.236	6.21	46.9	4	3	0.055	0.098	0.032	<10	<5	9
CC-QHUP-T23	Unnamed Trib #14	40.9253	-76.2476	6.48	55.6	13.1	3.3	-	1.209	6.46	57.9	11	1	<0.05	0.038	<0.01	<10	<5	62
CC-QHUP-T24	Cranberry Run	40.9191	-76.2571	6.05	19.4	12.35	4	-	2.2	6.01	20.2	3	4	0.053	0.02	0.024	<10	<5	67
CC-QHUP-M8	Catawissa at Greenhouse Lane	40.9302	-76.2662	5.99	124	13.05	2.5	0.5	221.309	6.14	128.3	3	4	0.495	0.075	0.187	23.4	<5	37
CC-QHUP-T24.5	Klingerman's Run	40.9237	-76.2677	6.4	18.6	12.69	5.2	-	3.992	6.04	19.1	3	4	<0.05	0.026	0.015	<10	<5	46
CC-QHUP-T25	Unnamed Trib #15	40.9254	-76.2726	5.52	18.4	12.21	4.8	-	2.271	6	19.2	2	5	<0.05	0.02	0.013	<10	<5	36
CC-QHUP-T26	Unnamed Trib #16	40.9308	-76.2905	4.48	22.6	12.08	3.5	-	0.804	5.24	22.8	1	5	0.285	0.148	0.064	<10	<5	44
CC-QHUP-M9	Catawissa at Long Hollow Road	40.9346	-76.3054	5.94	122	13.38	1.86	0.4	230.404	6.14	124.7	3	4	0.402	0.065	0.177	22.2	<5	41
CC-QHUP-T27	Unnamed Trib #17	40.9389	-76.3027	7.39	97	14.74	2.44	4.3	1.08	6.48	95.8	14	-6	<0.05	0.062	<0.01	<10	<5	76
CC-QHUP-T28	Unnamed Trib #18	40.9417	-76.3070	5.66	21	12.4	4.3	-	4.768	6.07	20	3	4	<0.05	<0.02	0.013	<10	<5	39
CC-QHUP-T29	Beaver Run	40.9523	-76.3028	7.21	63	15.12	1.77	4.3	8.658	6.44	62.5	11	-4	<0.05	0.089	0.011	<10	<5	60
CC-QHUP-M10	Catawissa at State Road	40.9528	-76.3098	5.93	116	12.97	2.47	0.9	245.69	6.23	118.2	4	10	0.576	0.162	0.169	20.6	11	16
CC-QHUP-T30	Mine Gap Run	40.9523	-76.3541	6.74	35	13.21	3.4	0	1.104	6.24	32.7	4	3	<0.05	<0.02	<0.01	30.3	<5	26
CC-QHUP-T31	Fisher Run	40.9527	-76.3648	5.97	29	13.11	3.57	0	4.438	6.19	26.4	4	2	<0.05	0.024	<0.01	<10	<5	13
CC-QHUP-T32	Scotch Run	40.9631	-76.3579	6.61	53	13.01	2.46	0	13.565	6.62	52.2	7	0.26	0.115	0.063	0.024	11.2	<5	38
CC-QHUP-T33	Furnace Run	40.9634	-76.3736	5.67	21.4	12.08	5	-	4.361	6.13	22.4	3	3	<0.05	0.079	<0.01	<10	<5	19
CC-QHUP-T34	Unnamed Trib #19	40.9800	-76.3828	6.69	139	14.13	2.87	2.5	3.65	6.49	136.8	12	-10	0.171	0.321	0.039	<10	11	102
CC-QHUP-T35	Unnamed Trib #20	40.9818	-76.3884	6.95	163	13.65	2.7	0	1.208	6.61	165.3	23	-16	0.061	0.055	<0.01	14	<5	127
CC-QHUP-T36	Unnamed Trib #21	40.9725	-76.4082	7.05	193	13.88	2.17	2.9	0.821	6.55	192.1	21	-14	0.061	0.052	<0.01	40.3	<5	106
CC-QHUP-T37	Unnamed Trib #22	40.9719	-76.4130	7	160	13.65	2.49	2.6	0.349	6.51	160.1	12	-9	0.191	0.186	<0.01	13.5	<5	50
CC-QHUP-T39	Unnamed Trib #24	40.9493	-76.4516	5.93	67	12.43	4.63	0	0.492	6.42	69.5	9	-2	0.058	0.037	<0.01	11.7	<5	5
CC-QHUP-M11	Catawissa Mouth	40.9499	-76.4649	5.84	106	13.59	1.66	0.4	286.874	6.35	108.5	5	2	0.199	0.06	0.12	17.7	<5	38
CC-QHUP-T40	Unnamed Trib #25	40.9458	-76.4563	7.11	119	12.87	5.14	0	2.465	6.57	121.5	19	-13	<0.05	<0.02	<0.01	<10	<5	61

APPENDIX C

Audenried Tunnel Outfall Data

Sample Date	Flow	Water Temp	Spec Cond	Field pH	Lab pH	DO	SO4	Fe	Ferrous Fe	Mn	Al	Alk	Acid	TSS	TDS
	CFS	ºC	uS/cm	SU	SU	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
11/25/1969	13.79				3.3		660	5.4				0	432		
12/12/1969	21.81				3.2		500	4.5		8.1		0	420	979	
2/24/1970	38.06				3.4		480	3.9				0	300		
3/2/1970	39.91														
3/10/1970	27.69														
4/2/1970	28.46														
4/9/1970	69				3.5		366	0.9				0	256		
4/16/1970	44.4														
4/24/1970	42.85														
5/1/1970	35.27														
5/8/1970	34.34														
5/15/1970	29.24				3.4		488	3.3				0	320		
5/21/1970	32.02														
5/27/1970	27.69														
6/4/1970	25.22														
6/11/1970	17.48				3.3		454	3.9		6.7	17.9	0	344	828	
7/9/1970	11.29				3.4		550	6.8				0	344		
8/5/1970	24.91				3.2		548	3.4				0	372		
9/11/1970	13.92				3.2		500	8.2				0	348		
4/15/1975	19	10	600		3.3		280	2				0	118		
6/8/1978	9.3				3.6		265	2	0.8			0	184		
6/16/1978	19.3				3.59		242	2	1.9			0	180		
6/21/1978	16.2				3.8		279	2.1	1.6			0	184		
6/25/1978	14.2				3.51		323	0.5	0.4			0	177		
7/6/1978	17.2				3.57		337	2.5	2.5			0	189		
7/12/1978	13.3				3.4		348	2.6	2.6			0	222		
7/19/1978	11.5				3.49		336	2.6	1.8			0	219		
7/26/1978	9.3				3.45		328	2.9	1.2			0	189		
8/2/1978	9.3				3.45		333	2.8	0.9			0	182		
8/9/1978	19.3				3.5		313	2.8	1.2			0	183		
8/15/1978	14.7				3.7		378	2.8	1.3			0	214		
8/23/1978	11.5				4.09		361	2.9	2			0	243		

Sample Date	Flow	Water Temp	Spec Cond	Field pH	Lab pH	DO	SO4	Fe	Ferrous Fe	Mn	Al	Alk	Acid	TSS	TDS
	CFS	ºC	uS/cm	SU	SU	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
8/30/1978	15.9				4.08		370	2	1			0	270		
9/7/1978	10.6				3.31		373	2.7	1			0	259		
9/13/1978	9.7				3.18		363	3	1.3			0	272		
9/20/1978	14.2				3.41		362	3.6	1.8			0	299		
9/27/1978	11				3.49		385	3.6	1.8			0	303		
10/4/1978	9.7				3.6		110	2.9	0.8			0	314		
10/12/1978	10.6				3.52		368	3.5	1.7			0	321		
10/18/1978	19.9				3.42		378	2.3	2			0	209		
10/25/1978	16.2				3.29		349	3.6	2.5			0	337		
11/2/1978	14.7				3.58		362	3.4	1.3			0	317		
11/7/1978	13.3				3.48		352	2.6	2.4			0	325		
11/15/1978	10.6				3.31		342	2.8	1.4			0	310		
11/22/1978	12.8				3.36		312	3.4	2.5			0	200		
11/30/1978	11.5				3.52		309	2.9	2			0	191		
12/6/1978	11.9				3.49		298	3.1	1.4			0	208		
12/13/1978	16.7				3.75		292	3.1	1.6			0	147		
12/20/1978	13.8				3.52		280	2.5	1.6			0	170		
12/28/1978	20.6				3.51		272	2.5	1.5			0	182		
1/4/1979	26.3				3.63		237	2.5	1.5			0	146		
1/10/1979	31.1				3.67		194	1.3	1.3			0	139		
1/18/1979	17.23				3.61		228	1.8	1.8			0	129		
1/23/1979	16.72				3.66		231	1.7	1.7			0	136		
2/7/1979	15.71				3.6		250	0.7	0.7			0	143		
2/15/1979	14.24				3.56		270	2	2			0	210		
2/23/1979	8.12				3.52		241	2.5	2.5			0	183		
3/1/1979	27.35				3.6		215	1.7	1.7			0	132		
3/8/1979	62.04				3.73		165	1.7	1.7			0	100		
3/14/1979	32.38				3.73		214	1	1			0	108		
3/21/1979	19.33				3.71		218	1.4	1.4			0	131		
3/28/1979	15.22				3.6		234	1.6	1.6			0	118		
4/4/1979	14.25				3.61		213	1.7	1.7			0	123		
4/11/1979	17.23				3.64		246	1.6	1.6			0	143		

Sample Date	Flow	Water Temp	Spec Cond	Field pH	Lab pH	DO	SO4	Fe	Ferrous Fe	Mn	Al	Alk	Acid	TSS	TDS
	CFS	ºC	uS/cm	SU	SU	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
4/18/1979	18.27				3.57		192	1.6	1.6			0	119		
4/25/1979	16.21				3.57		186	1.5	1.5			0	123		
5/2/1979	20.42				3.57		248	1.5	1.5			0	134		
5/17/1979	18.8				3.57		252	1.5	1.5			0	136		
5/23/1979	19.87				3.55		261	1.5	1.5			0	142		
6/1/1979	28.58				3.62		239	1.3	1.1			0	127		
6/6/1979	23.79				3.71		253	1.5	1.3			0	274		
6/21/1979	17.23				3.54		257	1.7	1.4			0	268		
6/27/1979	12				3.43		293	2.1	0.9			0	182		
11/7/1991	5.9	10.3	623		3.5	8.5	300	1.6		3.8		0	129		
7/25/1996					3.9		114	0.67		2.31	8.32	0	70		
8/28/1996	9.68				3.9		133	0.82		2.43	9.09	0	80		
9/30/1996	10.53				3.8		156	0.8		2.62	8.71	0	80		
11/26/1996	28.02				4.1		120	1.33		1.99	7.97	6.6	62		
12/27/1996	37.83				4.1		87	0.39		1.63	6.45	5	52		
3/29/1997	21.5				4.1		74	0.59		2	6.99	5	58		
4/29/1997	19.74				4.1		112	0.58		1.99	7.01	4.8	60		
5/31/1997	11.94				4		106	0.71		2.23	7.88	3.8	68		
6/28/1997	10.43				4		91	0.78		2.3	8.2	3	70		
7/19/1997	8.85				4		153	0.81		2.61	9.1	1.6	72		
9/13/1997	14				4		138	0.77		3.06	10.2	2	80		
10/25/1997	15.89				4		119	2.45		2.88	10	2.6	80		
11/15/1997	14.94				4		113	0.81		2.81	9.61	3	74		
12/20/1997	10.85				3.9		112	0.65		2.25	7.72	0	72		
2/21/1998	36.51				4.1		56	0.56		1.74	6.67	3.8	50		
3/21/1998	38.14				4.1		92	0.61		1.9	7.51	3.6	50		
4/25/1998	43.95				4.1		109	0.55		1.82	6.58	3.8	50		
5/16/1998	30.62				4.1		110	0.48		1.78	6.31	5	46		
6/20/1998	11.45				4		134	0.73		2.5	9.21	1.8	68		
7/19/1998	10.49				3.9		152	0.76		2.67	9.57	0	74		
8/15/1998					3.9		142	0.85		2.74	9.74	0	80		
9/13/1998					4.2		61.1	0.44		1.02	3.56	5	30		

Sample Date	Flow	Water Temp	Spec Cond	Field pH	Lab pH	DO	SO4	Fe	Ferrous Fe	Mn	Al	Alk	Acid	TSS	TDS
	CFS	ºC	uS/cm	SU	SU	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
9/19/1998	8.93				3.9		171	0.74		2.67	9.61	0	70		
10/31/1998	10.93				3.9		172	0.79		2.81	10.4	0	74		
11/21/1998	8.96				3.9		166	0.86		2.96	10.3	0	80		
12/19/1998	7.44				3.9		197.4	0.87		3.14	9.85	0	78		
1/30/1999	42.67				4		128	0.51		2	7.76	2.6	56		
3/6/1999	19.52				4		115	0.55		2.09	7.26	2.6	68		
4/3/1999	19.69				4.1		85	0.51		1.9	6.62	3	50		
4/25/1999	17.01				4		113	0.47		1.79	6.03	2.2	50		
6/5/1999					4		117	1.21		2.22	7.09	3.2	56		
7/31/1999	8.43				3.8		174	0.82		2.62	8.95	0	68		
1/10/2000					3.8		160	0.58		2.2		0.1	124		
4/18/2000					3.84		126	0.45		1.6		0.1	88		
6/7/2000					3.94		136	0.63		2.5		0.4	48.4		
7/4/2000					3.93		140	0.35		1.8	0.66	0.1	76		
9/27/2000					3.84		180	0.67		2.54		0.4	84		
10/2/2000					4		176	0.69		2.68	9.52	0.1	98		
3/20/2001					3.8		176	0.78		2.16	7.96	0.1	76		
3/28/2001					3.89		154	0.43		1.8		0.4	43.9		
5/8/2001					3.85		152	0.43		1.94	6.91	0.1	76		
5/23/2001					6.73		400	0.13		2.88		0.1	69		
2/19/2004					4		137.9	0.53	0.13	2.03	7.1	0	84		
5/25/2004					4.1		121.3	0.43	0.17	1.61	5.48	0	101		
3/29/2006					4		167.1	0.36		1.83	6.13	1.6	63.8	3	
4/17/2008					4.1		106.7	0.76		1.52	5.25	2.8	43.6	8	
7/10/2018	14.667	11.7	308.3		4.1	11.7	146.1	0.32		1.68	5.62		42.2	5	256
8/27/2018	31.641	12.4	257.8		4.2	10.84	126.8	0.3		1.3	4.54		34.4	5	222
9/24/2018	32.228	12.5	248.3		4.3	10.92	108.2	0.3		1.15	4.25		33	5	212
10/17/2018		12.2	244		4.4	10.21	110.6	0.3		1.18	4.24		34.8	8	214
11/14/2018	44.676	11.3	219.6		4.4	10.65	90.2	0.3		0.99	3.63		35	5	192
12/11/2018	33.006	8.13	317.3	4.86	4.25	10.14	137.2	0.391		1.107	3.623	0	31	5	156
12/13/2018	29.594	10.4	231.6		4.3	10.49	104.5	0.31		1.28	4.19		41.8	10	192
1/17/2019	25.947	9.8	230.7		4.2	11.55	102.8	0.3		1.24	4.17		35.6	5	204

Sample Date	Flow	Water Temp	Spec Cond	Field pH	Lab pH	DO	SO4	Fe	Ferrous Fe	Mn	Al	Alk	Acid	TSS	TDS
	CFS	°C	uS/cm	SU	SU	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
2/13/2019		9.6	245.7		4.4	9.17	114.5	0.35		1.26	4.22		40.2	5	220
3/18/2019	29.194	9.7	274.3		4.3	8.89	123.2	0.33		1.31	4.36		43.8	5	252
3/28/2019	31.94	9.7	344	4.37	4.37	12.19	113.3	0.29		1.09	3.69	0	26	5	197
4/17/2019		10			4.2	9.1	110	0.42		1.11	4.04		30.8	14	208
6/13/2019	22.582	10.9	259.1		4.2	9.11	116.8	0.37		1.31	4.24		29.2	5	254
7/17/2019	23.318	11.4	263.9		4.2	9.15	118.2	0.36		1.29	4.35		40.4	5	206
8/15/2019		11.2	296.9		4.2	8.99	137.9	0.43		1.71	5.46		44.2	5	394
9/17/2019	9.164	11.28	458	3.96	4.04	10.19	185.5	0.38		1.77	5.3		58	5	280
9/19/2019	8.181	11.1	333.5		4	8.58	170.6	0.48		2.08	6.54		50.4	5	306
10/16/2019	5.858	11	350.7		4	8.15	167.6	0.5		2.02	6.37		48.8	5	300
1/16/2020	14.013	10.5	295.9		4.2	8.17	120.8	0.36		1.44	4.67		37	5	258

APPENDIX D

Green Mountain Tunnel Outfall Data

Sample Date	Flow	Water Temp	Spec Cond	Field pH	Lab pH	DO	SO4	Fe	Ferrous Fe	Mn	Al	Alk	Acid	TSS	TDS
	CFS	ºC	uS/cm	SU	SU	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
4/15/1975	2.1	9	210		3.6		76	1				0	48		
6/8/1978	0.66				3.87		66	0.6	0.3			0	52		
6/16/1978	1.24				3.81		67	0.5	0.5			0	57		
6/22/1978	0.7				4.06		70	0.5	0.5			0	65		
6/28/1978	0.76				3.77		86	0.7	0.6			0	58		
7/6/1978	1.24				3.82		83	0.6	0.5			0	68		
7/12/1978	0.85				3.69		83	0.5	0.4			0	83		
7/18/1978	0.72				3.79		90	0.5	0.1			0	61		
7/26/1978	0.66				3.72		86	0.6	0.2			0	42		
8/2/1978	0.62				3.72		88	0.5	0.2			0	54		
8/9/1978	0.77				3.68		127	0.7	0.3			0	74		
8/15/1978	0.7				3.94		100	0.6	0.2			0	83		
8/23/1978	0.7				4.31		86	0.6	0.5			0	84		
8/30/1978	0.7				4.28		120	0.7	0.4			0	113		
9/7/1978	0.7				3.59		97	0.7	0.3			0	92		
9/13/1978	0.62				3.45		97	0.7	0.3			0	70		
9/20/1978	0.7				3.62		116	0.9	0.3			0	98		
9/27/1978	0.62				3.72		108	0.8	0.4			0	113		
10/4/1978	0.62				3.87		81	0.6	0.2			0	113		
10/12/1978	0.62				3.8		99	0.6	0.6			0	114		
10/13/1978	0.62				3.8		102	0.7	0.4			0	91		
10/18/1978	0.93				3.62		100	0.5	0.5			0	70		
10/25/1978	0.89				3.58		84	0.5	0.4			0	86		
11/2/1978	0.89				3.93		86	0.5	0.2			0	80		
11/9/1978	0.85				3.72		85	0.5	0.3			0	83		
11/15/1978	0.77				3.6		110	0.6	0.2			0	92		
11/22/1978	0.85				3.68		75	0.5	0.4			0	89		
11/30/1978	0.89				3.86		72	0.5	0.3			0	48		
12/6/1978	1.02				3.86		66	0.5	0.2			0	68		
12/13/1978	1.56				3.97		64	0.5	0.4			0	45		
12/20/1978	1.24				3.83		74	0.4	0.2			0	49		
12/28/1978	3.76				3.83		74	0.5	0.3			0	44		

Sample Date	Flow	Water Temp	Spec Cond	Field pH	Lab pH	DO	SO4	Fe	Ferrous Fe	Mn	Al	Alk	Acid	TSS	TDS
	CFS	ºC	uS/cm	SU	SU	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
1/4/1979	5.77				3.88		75	0.4	0.3			0	52		
1/10/1979	5.05				3.88		73	0.5	0.3			0	45		
1/18/1979	1.91				3.82		68	0.6	0.4			0	47		
1/23/1979	2.32				3.8		74	0.6	0.5			0	55		
1/31/1979	3.05				4.28		63	0.5	0.5			0	45		
2/7/1979	1.7				3.84		74	0.1	0.1			0	47		
2/15/1979	1.28				3.75		81					0	71		
2/23/1979	1.06				3.82		96	0.5	0.4			0	49		
3/1/1979	2.87				3.84		50	0.8	0.7			0	42		
3/8/1979	1.91				3.88		62	0.4	0.4			0	48		
3/14/1979	2.95				3.88		108	0.5	0.4			0	52		
3/21/1979	2.14				3.88		63	0.5	0.5			0	50		
3/28/1979	1.98				3.81		86	0.5	0.4			0	50		
4/4/1979	1.76				3.9		75	0.5	0.2			0	55		
4/11/1979	2.84				3.92		74	0.5	0.4			0	46		
4/18/1979	2.06				3.87		82	0.6	0.5			0	40		
4/25/1979	1.63				3.85		81	0.5	0.3			0	48		
5/2/1979	1.84				3.83		73	0.5	0.4			0	41		
5/17/1979	1.63				3.88		75	0.4	0.2			0	39		
5/23/1979	1.39				3.82		78	0.5	0.2			0	39		
6/1/1979	2.95				3.87		71	0.7	0.6			0	32		
6/6/1979	2.23				3.9		89	0.8	0.6			0	99		
6/21/1979	1.24				3.81		78	0.4	0.3			0	45		
6/27/1979	1.1				3.76		105	0.5	0.3			0	83		
11/7/1991	0.5	8.5	269		3.6	10.5	95	0.51		1.3			50		
7/25/1996					4		44	0.28		0.58	2.68	2.2	28		
8/28/1996	1.24				4		42	1.17		0.64	3.04	2.8	32		
9/30/1996	1.67				3.9		45	0.29		0.68	8.71	0	32		
11/26/1996	2.83				4.2		50	0.38		0.53	2.58	6.8	28		
12/27/1996	4.36				4.2		26	0.38		0.44	2.28	5.6	22		
3/29/1997	2.51				4.1		25	0.39		0.61	2.76	4.4	30		
4/29/1997	2.93				4.1		34	0.31		0.51	2.28	4.8	26		

Sample Date	Flow	Water Temp	Spec Cond	Field pH	Lab pH	DO	SO4	Fe	Ferrous Fe	Mn	Al	Alk	Acid	TSS	TDS
	CFS	ºC	uS/cm	SU	SU	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
5/31/1997	1.29				4.1		22	0.27		0.52	2.22	5	24		
6/28/1997	1.47				4.1		20	0.29		0.59	2.49	3.6	30		
7/19/1997	1.41				4.1		35	0.26		0.72	2.78	3.2	26		
9/13/1997	1.22				4		40	0.3		0.98	3.97	2.2	34		
10/25/1997	0.88				4.1		20	0.22		0.88	3.25	4.4	32		
11/15/1997	0.79				4		39	0.22		0.81	3.17	3.2	30		
12/20/1997	1.62				4		31	0.21		0.56	2.32	2.2	28		
2/21/1998	5.02				4.1		29	0.36		0.53	2.8	3.2	26		
3/21/1998	5.16				3.6		29	0.39		0.53	2.82	3.6	26		
4/25/1998	3.84				4.1		32	0.4		0.49	2.5	3.8	26		
4/25/1998	3.84				4.1		32	0.4		0.49	2.5	3.8	26		
5/16/1998	5.82				4.1		39	0.34		0.5	2.54	4.6	26		
6/20/1998	1.29				4		39	0.33		0.67	3.05	2	30		
7/19/1998	1.66				4		110	0.34		0.68	2.97	2.4	28		
8/15/1998					4		39	0.45		0.72	2.84	2.2	30		
9/19/1998	0.68				4		46	0.31		0.83	3.57	1.8	32		
10/31/1998	1.3				4.1		53	0.31		0.69	2.96	3.2	24		
11/21/1998	0.81				4.1		47	0.3		0.77	3.11	2.8	28		
12/19/1998	1.05				4.1		49.7	0.24		0.79	2.78	3.4	32		
1/30/1999	3.6				4.1		29	0.24		0.5	2.72	3.8	24		
3/6/1999	2.29				4.1		38	3.68		0.58	2.8	3.6	36		
4/3/1999	1.9				4.1		25	0.32		0.56	2.7	3.2	26		
4/25/1999	1.27				4		30	0.28		0.52	2.33	2.8	24		
6/5/1999					4.1		38	0.28		0.63	2.52	3.4	24		
7/29/1999					4		41	0.26	0.02	0.86	3.18		28	2	
7/31/1999	1.03				4		63	0.25		0.86	3.09	1.4	28		
2/19/2004					4		49.9	0.3	0.07	0.68	2.58	0	68	2	
5/25/2004					4.1		44.4	0.32	0.1	0.57	2.44	0	89.8	2	
7/10/2018	2.292		266.2	3.66	4.1	11.81	33.3	0.3	0.17	0.68	1.82		20.6	5	190
8/27/2018	8.08	13	224	3.8	4.2	10.82	30.3	0.3	0.08	0.47	1.3		16	5	154
9/24/2018	7.83	12.4	203.4	3.89	4.3	10.86	25.5	0.3	0.08	0.39	1.14		13.6	5	140
10/17/2018		12	188.5	4.01	4.2	10.78	28	0.3	0.08	0.39	1.2		8.2	8	142

Sample Date	Flow	Water Temp	Spec Cond	Field pH	Lab pH	DO	SO4	Fe	Ferrous Fe	Mn	Al	Alk	Acid	TSS	TDS
	CFS	ºC	uS/cm	SU	SU	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
11/14/2018	10.386	11.1	175.4	4.17	4.2	10.63	27.8	0.3	0.07	0.36	1.18		18.6	5	154
12/11/2018	6.574	9.16	241.5	4.44	4.33	10.8	25	0.298		0.356	1.018	0	14	5	98
12/13/2018	6.322	10	174.6	4.22	4.4	10.58	30.2	0.3	0.07	0.42	1.24		23.8	5	122
1/17/2019	4.777	9.4	170.8	4.2	4.2	11.13	27	0.3	0.08	0.41	1.28		21.8	5	138
2/13/2019		8.9	175.5	4.27	4.4	11.01	28	0.3	0.06	0.38	1.19		19.4	5	148
3/18/2019	5.176	8.8	200.2	4.33	4.2	10.85	25.2	0.3	0.08	0.4	1.3		26.6	5	534
3/28/2019	5.528	9.1	264.6	4.3	4.34	11.07	23.9	0.2		0.39	1.2	0	10.03	5	126
4/17/2019		9.9	202.7	3.77	4.1	10.6	25.9	0.3	0.09	0.44	1.51		15.2	5	178
6/13/2019	3.278	10.8	187.8	4.13	4.3	10.51	25.4	0.3	0.1	0.471	1.2		8.8	8	166
7/17/2019	5.336	11.3	221.8	3.99	4.4	10.73	28.9	0.3	0.1	0.44	1.23		19.8	5	144
8/15/2019		11.1	223.1	4.01	4.4	10.67	29.4	0.3	0.09	0.54	1.27		15.6	5	174
9/17/2019	1.416	10.78	294.6	4.08	4.18	10.57	30.7	0.15		0.53	1.05		27	5	146
9/19/2019	1.48	10.7	221.1	4.07	4.1	10.82	31.9	0.3	0.08	0.64	1.46		20	5	166
10/16/2019	1.156	10.7	218.2	4.13	4.1	10.05	33.2	0.3	0.02	0.59	1.23		15.2	5	174
1/16/2020	4.013	9.1	226.9	4.52	4.2	9.84	26.3	0.3	0.09	0.44	1.18		15.2	5	176

APPENDIX E

Catawissa Tunnel Outfall Data

Sample Date	Flow	Water Temp	Spec Cond	Field pH	Lab pH	DO	SO4	Fe	Ferrous Fe	Mn	Al	Alk	Acid	TSS	TDS
	CFS	ºC	uS/cm	SU	SU	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
12/12/2018	0.032	7	273.7	3.82	3.76	8.65	59.5	0.819		0.684	3.938	0	37	5	120
4/15/1975	0.8	7	175		3.9		58	3				0	60		
7/25/1996					4.2			0.92		0.3	1.35	4	22		
8/28/1996	0.35				4			1.83		0.43	1.89	2.8	32		
9/30/1996	0.59				3.8			1.92		0.46	1.39	0	30		
11/26/1996	1.18				4.4			1.01		0.29	1.46	7.8	20		
3/29/1997	0.92				4.2			0.82		0.26	1.31	5.8	18.4		
4/29/1997	1.04				4.3			0.91		0.28	1.24	6.8	22		
5/31/1997	0.92				4.4			0.75		0.23	1.12	7.4	18.2		
6/28/1997	0.37				4.1			1.34		0.39	1.61	3.4	28		
7/19/1997	0.11				4			2.03		0.49	1.78	1.8	24		
9/13/1997	0.35				4.2			0.82		0.28	0.92	3.8	16.4		
10/25/1997	2.03				4			1.71		0.55	1.51	2.8	30		
11/15/1997												0	0		
12/20/1997	0.63				4.2			0.92		0.28	0.95	4.2	15		
2/21/1998	2.25				4.4			0.58		0.17	1.14	6.4	13.4		
3/31/1998	3.15				4.3			0.68		0.21	1.11	5.8	14.6		
4/25/1998	5.29				4.4			0.64		0.19	1.21	7.2	15		
5/16/1998	6.05				4.4			0.53		0.18	1	7.2	13.4		
6/20/1998	0.63				4.1			0.98		0.32	1.3	3.4	18		
7/19/1998	0.55				4.1			1.09		0.37	1.58	3.4	18		
8/15/1998					4			1.36		0.44	1.52	2.2	22		
9/19/1998	0.24				3.9			1.55		0.53	1.83	0	18.8		
10/31/1998	0.42				4.2			0.9		0.32	1.31	5	13.6		
11/21/1998	0.37				4.1			1.17		0.38	1.49	3.4	18.6		
12/19/1998	0.28				4.1			0.91		0.36	1.07	4.2	17		
1/30/1999	2.23				4.5			0.45		0.17	1.1	6.6	13		
3/6/1999	1.89				4.4			0.54		0.19	0.98	6.4	18.4		
4/3/1999	1.37				4.2			0.72		0.23	1.23	4	13.2		
4/25/1999	0.93				4.1			0.7		0.22	1.03	3.8	14		
6/5/1999					4.1			1.02		0.31	1.33	3.8	16.2		
7/31/1999	0.25				3.9			1.58		0.42		0	20		

Sample Date	Flow	Water Temp	Spec Cond	Field pH	Lab pH	DO	SO4	Fe	Ferrous Fe	Mn	Al	Alk	Acid	TSS	TDS
	CFS	ºC	uS/cm	SU	SU	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
6/8/1978	0.2				3.8		51	1.6	0.8			0	42		
6/16/1978	0.56				3.84		43	0.7	0.7			0	40		
6/20/1978	0.47				4		58	2.3	2.1			0	46		
6/25/1978	0.43				3.68		67	1.8	1.3			0	45		
7/5/1978	0.63				3.9		54	1.5	1.5			0	38		
7/11/1978	0.27				3.64		71	2.5	2.4			0	58		
7/18/1978	0.27				3.72		64	2.9	2.4			0	44		
7/25/1978	0.17				3.7		67	3.3	2.6			0	44		
8/1/1978	0.13				3.6		68	4.5	2.9			0	48		
8/8/1978	0.69				3.82		58	2.9	2.7			0	35		
8/15/1978	0.38				3.93		59	2.6	2			0	46		
8/22/1978	0.38				4.27		74	3.3	2.8			0	51		
8/29/1978	0.35				4.21		71	3.2	2.5			0	59		
9/6/1978	0.24				3.59		66	3.3	2.8			0	50		
9/12/1978	0.24				3.39		69	3.6	3			0	55		
9/19/1978	0.24				3.66		70	4.4	2.5			0	59		
9/26/1978	0.27				3.72		94	3.3	3.3			0	61		
10/3/1978	0.2				3.89		67	3.1	3			0	56		
10/11/1978	0.27				3.82		68	2.8	2.7			0	48		
10/13/1978	0.27				3.9		56	3.2	2.9			0	46		
10/17/1978	1.85				4		42	1.1	1.1			0	22		
10/24/1978	0.9				3.7		49	1.9	1.9			0	31		
10/31/1978	0.95				4.05		48	1.9	1.7			0	32		
11/8/1978	0.58				3.89		44	1.5	1.3			0	37		
11/14/1978	0.54				3.61		52	2	1.7			0	56		
11/21/1978	0.77				3.8		42	1.5	1.3			0	25		
12/1/1978	1.53				4.04		40	1.3	1.1			0	25		
12/5/1978	1.25				4.11		31	1.4	0.8			0	21		
12/6/1978	1.43				4.16		32	1.2				0	18		
12/12/1978	2.53				4.19		35	1.1	0.7			0	25		
12/19/1978	1.37				4.05		40	1.3	0.8			0	30		
12/27/1978	1.28				4.06		55	1.3	0.9			0	19		

Sample Date	Flow	Water Temp	Spec Cond	Field pH	Lab pH	DO	SO4	Fe	Ferrous Fe	Mn	Al	Alk	Acid	TSS	TDS
	CFS	ºC	uS/cm	SU	SU	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
1/3/1979	4.32				3.96		45	1.6	0.8			0	32		
1/9/1979	3.88				4.06		35	0.9	0.9			0	17		
1/17/1979	1.75				3.99		40	1.2	1			0	18		
1/26/1979	5.25				4.15		27	0.9	0.8			4	26		
1/30/1979	2.9				4.43		34	0.9	0.8			0	26		
2/6/1979	1.71				4.08		31	0.7	0.7			0	15		
2/14/1979	0.4				3.95		53	1.7	1.7			0	39		
3/2/1979	3.1				4.12		32	0.8	0.8			0	28		
3/6/1979	5.65				3.97		58	1	0.9			0	34		
3/13/1979	2.75				4.1		39	1.1	1			0	32		
3/20/1979	1.6				3.99		48	1.3	1.3			0	31		
3/27/1979	1.5				3.93		59	1.5	1.2			0	32		
4/3/1979	1.35				3.92		43	2.2	1.5			0	33		
4/10/1979	1.65				4.02		39	1.4	0.9			0	36		
4/17/1979	1.85				3.99		39	1.2	1			0	8		
4/23/1979	1.35				3.89		38	1.1	0.8			0	16		
5/1/1979	1.85				4		40	1.1	1			0	37		
5/16/1979	1.95				4.01		47	1.5	0.6			0	40		
5/22/1979	1.4				3.94		45	1.3	1			0	43		
5/30/1979	2.82				4.04		49	1.7	0.5			0	36		
6/5/1979	1.85				4.01		51	0.7	0.6			0	66		
6/12/1979	1.25				3.88		62	0.8	0.5			0	100		
6/20/1979	0.7				3.76		59	1.9	1.5			0	69		
6/26/1979	0.31				3.72		95	2.1	1.1			0	46		
3/29/1997					4.2		20	0.82		0.26	1.31	5.8	18.4	2	
4/29/1997					4.3		20	0.91		0.28	1.24	6.8	22	2	
5/31/1997					4.4		20	0.75		0.23	1.12	7.4	18.2	2	
6/28/1997					4.1		20	1.34		0.39	1.61	3.4	28	4	
7/19/1997					4		39	2.03		0.49	1.78	1.8	24	2	
9/13/1997					4.2		20	0.82		0.28	0.92	3.8	16.4	6	
10/25/1997					4		23	1.71		0.55	1.51	2.8	30	14	
12/20/1997					4.2		20	0.92		0.28	0.95	4.2	15	6	

Sample Date	Flow	Water Temp	Spec Cond	Field pH	Lab pH	DO	SO4	Fe	Ferrous Fe	Mn	Al	Alk	Acid	TSS	TDS
	CFS	ºC	uS/cm	SU	SU	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
2/21/1998					4.4		20	0.58		0.17	1.14	6.4	13.4	10	
3/21/1998					4.3		20	0.68		0.21	1.11	5.8	14.6	10	
4/25/1998					4.4		20	0.64		0.19	1.21	7.2	15	6	
5/16/1998					4.4		20	0.53		0.18	1	7.2	13.4	2	
6/20/1998					4.1		20	0.98		0.32	1.3	3.4	18	2	
7/19/1998					4.1		42	1.09		0.37	1.58	3.4	18	12	
8/15/1998					4		30	1.36		0.44	1.52	2.2	22	4	
9/19/1998					3.9		23	1.55		0.53	1.83	0	18.8	8	
10/31/1998					4.2		65	0.9		0.32	1.31	5	13.6	2	
11/21/1998					4.1		23	1.17		0.38	1.49	3.4	18.6	2	
12/19/1998					4.1		20	0.91		0.34	1.07	4.2	17	6	
1/30/1999					4.5		20	0.45		0.17	1.1	6.6	13	4	
3/6/1999					4.4		20	0.54		0.19	0.98	6.4	18.4	2	
4/3/1999					4.2		20	0.72		0.23	1.23	4	13.2	4	
4/25/1999					4.1		20	0.7		0.22	1.03	3.8	14	4	
6/5/1999					4.1		22	1.02		0.31	1.33	3.8	16.2	22	
7/31/1999					3.9		41	1.58		0.44	1.47	0	20	16	

APPENDIX F

Catawissa Creek Macroinvertebrate Data

Location	**US Audenried**	**DS Green Mountain**	**Girard Manor Road**	**US Tomhicken**	**DS Tomhicken**
Agency	**SRBC**	**SRBC**	**SRBC**	**SRBC**	**SRBC**
Latitude	**40.8978**	**40.8959**	**40.8801**	**40.9035**	**40.9212**
Longitude	**-76.0686**	**-76.0773**	**-76.1063**	**-76.2097**	**-76.2261**
Date	**3/28/2019**	**3/28/2019**	**3/28/2019**	**3/28/2019**	**3/28/2019**
Baetis				3	
Diphetor	1				
Ephemerella	2		1		1
Ephemeridae	1				
Cinygmula				1	
Epeorus			3		1
Nixe		1			
Allocapnia					1
Haploperla	2				2
Sweltsa	5				1
Leuctra	30		63	13	
Nemouridae		22			
Amphinemura	43		93	3	1
Podmosta		97			
Prostoia	1		1		
Shipsa		1			
Tallaperla			1	1	
Acroneuria	1				
Agetina		1			
Eccoptura	2				
Perlesta		1			
Pteronarcys	2				
Diplectrona	11		21	17	
Parapsyche		15			
Mystacides		3			
Polycentropus	1			3	1
Rhyacophila					1
Neophylax					1
Lanthus				1	
Nigronia				1	
Sialis			1		
Optioservus					1
Oulimnius	18			1	6
Stenelmis					4
Psephenus				1	
Ceratopogonidae				2	1
Brachypogon		2			
Chironomidae	31		14	21	16
Culex		67			
Hemerodromia	1	2	2	1	
Prosimulium	5			5	1

Location	**US Audenried**	**DS Green Mountain**	**Girard Manor Road**	**US Tomhicken**	**DS Tomhicken**
Agency	**SRBC**	**SRBC**	**SRBC**	**SRBC**	**SRBC**
Latitude	**40.8978**	**40.8959**	**40.8801**	**40.9035**	**40.9212**
Longitude	**-76.0686**	**-76.0773**	**-76.1063**	**-76.2097**	**-76.2261**
Date	**3/28/2019**	**3/28/2019**	**3/28/2019**	**3/28/2019**	**3/28/2019**
Stegopterna			1		
Stratiomyidae		1			
Dicranota	1			1	
Helius		1			
Hexatoma	6				
Nematoda				1	
Physidae				2	
Oligochaeta	3		3	23	12
Amphipoda		1			
Hydracarina			1		
Total Ind.	**167**	**215**	**205**	**101**	**51**
Taxa Richness	**20**	**14**	**13**	**19**	**16**
EPT Taxa	**11**	**8**	**7**	**5**	**8**
Beck’s	**24**	**17**	**15**	**13**	**14**
Hilsenhoff	**2.93**	**3.44**	**2.08**	**4.69**	**5.78**
Shannon	**2.22**	**1.46**	**1.46**	**2.26**	**2.13**
% Sensitive	**66.47**	**66.51**	**89.27**	**41.58**	**19.61**
IBI Score	**70.8**	**56.7**	**60.7**	**61.5**	**55.0**
EPT Absent	**No**	**No**	**No**	**No**	**No**
Becks < 33% % Sensitive <25%	**No**	**No**	**No**	**No**	**No**
BCG Ratio	**No**	**No**	**No**	**No**	**No**
Acidification?	**No**	**Yes**	**Yes**	**No**	**No**

APPENDIX G

Catawissa Creek Fish Data

Location	**US Audenried**	**Girard Manor Road**	**US Tomhicken**	**DS Tomhicken**
Agency	**SRBC**	**SRBC**	**SRBC**	**SRBC**
Latitude	**40.8978**	**40.8801**	**40.9035**	**40.9212**
Longitude	**-76.0686**	**-76.1063**	**-76.2097**	**-76.2261**
Date	**3/28/2019**	**3/28/2019**	**3/28/2019**	**3/28/2019**
Green Sunfish				61
White Sucker				54
Eastern Blacknose Dace	20			52
Pumpkinseed				17
Brown Trout (wild)			1	7
Creek Chub			15	6
Fallfish				4
Creek Chubsucker				1
Cutlip Minnow				1
River Chub				1
Bluegill			1	1
Largemouth Bass				1
Brook Trout (wild)	20			1
Total	**40**	**0**	**17**	**207**

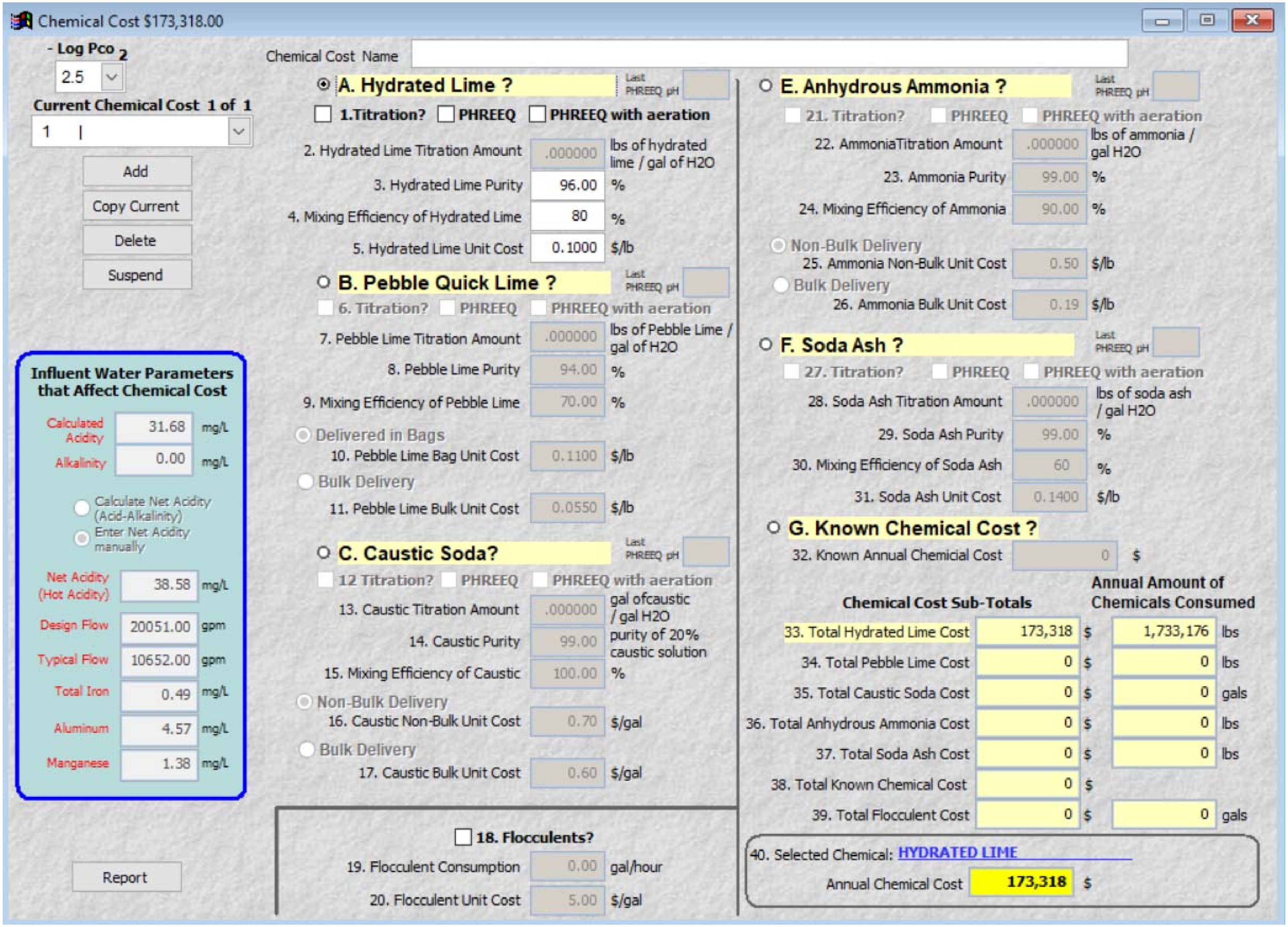
APPENDIX H

Catawissa Creek Habitat Data

Location	DS Tomhicken	US Tomhicken	Girard Manor Road	US Audenried
Agency	**SRBC**	**SRBC**	**SRBC**	**SRBC**
Latitude	**40.9212**	**40.9035**	**40.8801**	**40.8978**
Longitude	**-76.2261**	**-76.2097**	**-76.1063**	**-76.0686**
Date	**3/28/2019**	**3/28/2019**	**3/28/2019**	**3/28/2019**
Habitat parameter	**Score**	**Score**	**Score**	**Score**
Epifaunal Substrate	15	9	19	15
Instream Cover	15	12	19	14
Embeddedness	14	8	17	14
Velocity/Depth Regimes	17	13	19	13
Sediment Deposition	15	12	18	14
Channel Flow Status	18	16	18	16
Channel Alteration	15	15	19	14
Frequency of Riffles	16	11	19	15
Condition of Banks	15	14	20	14
Left Bank	8	7	10	7
Right Bank	7	7	10	7
Vegetative Protective Cover	14	13	20	15
Left Bank	6	6	10	8
Right Bank	8	7	10	7
Riparian Vegetative Zone Width	13	11	20	14
Left Bank	6	5	10	8
Right Bank	7	6	10	6
Total Habitat Score	**167**	**134**	**208**	**158**

APPENDIX I

AMDTreat Estimation of Annual Hydrated Lime Amounts and Costs for the Audenried ATP



Chemical Cost $173,318.00

- Log Pco 2: 2.5

Current Chemical Cost 1 of 1: 1

Influent Water Parameters that Affect Chemical Cost

Calculated Acidity 31.68 mg/L
Alkalinity 0.00 mg/L
○ Calculate Net Acidity (Acid-Alkalinity)
○ Enter Net Acidity manually
Net Acidity (Hot Acidity) 38.58 mg/L
Design Flow 20051.00 gpm
Typical Flow 10652.00 gpm
Total Iron 0.49 mg/L
Aluminum 4.57 mg/L
Manganese 1.38 mg/L

Chemical Cost Name

● **A. Hydrated Lime ?** Last PHREEQ pH
☐ 1.Titration? ☐ PHREEQ ☐ PHREEQ with aeration
2. Hydrated Lime Titration Amount .000000 lbs of hydrated lime / gal of H2O
3. Hydrated Lime Purity 96.00 %
4. Mixing Efficiency of Hydrated Lime 80 %
5. Hydrated Lime Unit Cost 0.1000 $/lb

○ **B. Pebble Quick Lime ?** Last PHREEQ pH
☐ 6. Titration? ☐ PHREEQ ☐ PHREEQ with aeration
7. Pebble Lime Titration Amount .000000 lbs of Pebble Lime / gal of H2O
8. Pebble Lime Purity 94.00 %
9. Mixing Efficiency of Pebble Lime 70.00 %
○ Delivered in Bags
10. Pebble Lime Bag Unit Cost 0.1100 $/lb
○ Bulk Delivery
11. Pebble Lime Bulk Unit Cost 0.0550 $/lb

○ **C. Caustic Soda?** Last PHREEQ pH
☐ 12 Titration? ☐ PHREEQ ☐ PHREEQ with aeration
13. Caustic Titration Amount .000000 gal ofcaustic / gal H2O
14. Caustic Purity 99.00 purity of 20% caustic solution
15. Mixing Efficiency of Caustic 100.00 %
○ Non-Bulk Delivery
16. Caustic Non-Bulk Unit Cost 0.70 $/gal
○ Bulk Delivery
17. Caustic Bulk Unit Cost 0.60 $/gal

☐ **18. Flocculents?**
19. Flocculent Consumption 0.00 gal/hour
20. Flocculent Unit Cost 5.00 $/gal

○ **E. Anhydrous Ammonia ?** Last PHREEQ pH
☐ 21. Titration? ☐ PHREEQ ☐ PHREEQ with aeration
22. AmmoniaTitration Amount .000000 lbs of ammonia / gal H2O
23. Ammonia Purity 99.00 %
24. Mixing Efficiency of Ammonia 90.00 %
○ Non-Bulk Delivery
25. Ammonia Non-Bulk Unit Cost 0.50 $/lb
○ Bulk Delivery
26. Ammonia Bulk Unit Cost 0.19 $/lb

○ **F. Soda Ash ?** Last PHREEQ pH
☐ 27. Titration? ☐ PHREEQ ☐ PHREEQ with aeration
28. Soda Ash Titration Amount .000000 lbs of soda ash / gal H2O
29. Soda Ash Purity 99.00 %
30. Mixing Efficiency of Soda Ash 60 %
31. Soda Ash Unit Cost 0.1400 $/lb

○ **G. Known Chemical Cost ?**
32. Known Annual Chemical Cost 0 $

Chemical Cost Sub-Totals			Annual Amount of Chemicals Consumed	
33. Total Hydrated Lime Cost	173,318	$	1,733,176	lbs
34. Total Pebble Lime Cost	0	$	0	lbs
35. Total Caustic Soda Cost	0	$	0	gals
36. Total Anhydrous Ammonia Cost	0	$	0	lbs
37. Total Soda Ash Cost	0	$	0	lbs
38. Total Known Chemical Cost	0	$		
39. Total Flocculent Cost	0	$	0	gals

40. Selected Chemical: HYDRATED LIME
Annual Chemical Cost 173,318 $