Moshannon Creek Hale to Whiteside Run Assessment
Moshannon Creek, Clearfield and Centre Counties

Technical Report Provided by Hedin Environmental through the Trout Unlimited AMD Technical Assistance Program

November 2022

Background

The Moshannon Creek Watershed Association (MCWA) requested technical assistance in the form of a watershed assessment for the segment of Moshannon Creek between Hale Road and Whiteside Run. MCWA is currently working to implement AMD remediation projects in the segment above Hale Road so the group is turning its attention to the next segment downstream. The AMD problems in this segment are complex and the goal of this assessment is to improve the understanding of impairment sources to guide future assessment and remediation efforts.

Site Description

Moshannon Creek meanders 1.9 miles through a broad floodplain as it flows from the crossing of Hale Road to the input of Whiteside Run. Coal was mined from several seams on both sides of the stream by both surface and underground methods. Underground mining was extensive but most surface traces such as entries or drains have been destroyed by subsequent surface mining. As a result, there are few point-sources of AMD despite extensive mining disturbance in the watershed. At the downstream end of the segment, mine maps indicate that underground workings extend under the stream and a borehole that penetrates these workings represents one of the few point-sources of AMD in the study area.

Map 1 is a geologic map of the study area that is excerpted from the *Geologic map of the Ramey and Houtzdale 7 1/2-minute quadrangles, Clearfield and Centre Counties, Pennsylvania* by Glass, Edmunds, and Shepps (1977). Different rock units are indicated by the color. Red dashed lines are structure contours of the Lower Kittanning no. 3 coal and heavy black lines are faults with solid, dashed, and dotted segments indicating the confidence of the mapmakers in the location of the fault. Regional dip is toward the north-northeast or roughly parallel to streamflow direction, but local structure is complex with numerous faults that cut through the study area and dip varies within and between each fault block.

Previous Assessments

Several assessments of Moshannon Creek have been conducted over the years that include this segment as part of an assessment of the larger watershed. Early monitoring was conducted as part of Operation Scarlift in the 1970s. In 2009 New Miles of Blue Streams produced the Moshannon Creek Headwaters Mine Drainage Assessment and Restoration Plan. Most recently, MCWA and partners prepared the Coldwater Conservation Plan for the Moshannon Creek Watershed in Central Pennsylvania in 2021. While none of these studies focused exclusively on the segment investigated here, they provide useful data and observations that served as a guide for the current work.

Mass Balance
A sampling round was conducted on June 2, 2022 by a team with representatives from Office of Surface Mining, MCWA, and Hedin Environmental. Eight AMD discharges were sampled and in-stream samples were collected upstream at Hale road and just upstream of the furthest downstream discharge. Sampling locations are shown in Map 2. Flow from discharges was measured using either a bucket and stopwatch or flume and stream flows were measured using a Swoffer velocity meter.

Previous investigations identified 7 AMD sources in the segment as MC10 through MC16. MC13 was inundated by a beaver dam and was not sampled. A new monitoring point, identified as "Powerline", was sampled. The results of the sampling are shown in Table 1.

Table 1. June 2, 2022 sampling results

Location	Flow (gpm)	pH (SU)	Alk. (mg/L)	Acidity (mg/L)	Fe (mg/L)	Mn (mg/L)	Al (mg/L)	SO_4 (mg/L)
MC Hale	**4,137.9**	**4.5**	**0**	**15**	**3.3**	**2.4**	**0.4**	**92**
UNT-1	**9.0**	**3.2**	**0**	**77**	**5.9**	**3.6**	**2.4**	**260**
Powerline	0.1	2.7	0	310	118.0	8.4	2.4	636
MC10	2.3	5.5	0	18	1.5	0.8	0.3	151
MC11	0.1	3.2	0	84	3.9	7.4	4.9	289
MC12	22.5	2.8	0	320	11.3	8.3	36.9	855
MC13*	--	--	--	--	--	--	--	--
MC14	11.3	2.9	0	460	80.9	23.9	44.0	1,370
MC15	1.0	2.8	0	230	110.0	7.5	0.4	583
QMC-6R	**4,586.7**	**3.9**	**0**	**27**	**4.7**	**2.7**	**1.0**	**128**
MC16	35.0	2.9	0	150	44.2	2.8	7.9	365

Bold indicates in-stream locations
**MC13 not collected due to inundation by beaver dam*

The June 2nd sampling event shows that Moshannon Creek at the upstream end of the study reach (MC Hale site) is net acidic with elevated iron, manganese, and aluminum concentrations. By the time Moshannon Creek reaches the QMC-6R station, the pH has fallen from 4.5 to 3.9 and metals concentrations have increased. The degradation in water quality is unsurprising since the sampling round included 8 sources of AMD, all of which are strongly acidic with elevated metals concentrations.

To quantify the impact on water quality in Moshannon Creek that can be attributed to each of these AMD sources requires the calculation of their respective contaminant loads. Loading is the mass of a constituent per unit of time (typically pounds per day (ppd)) and is calculated from laboratory measured concentrations and flow rate. By adding the loading from the measured upstream sources and comparing the sum to the measured loading in the stream, an accounting of pollution inputs can be performed. Iron and aluminum readily precipitate and settle as solids in streams so the loading of these constituents is generally not useful for pollution accounting. Sulfate and manganese typically stay in solution in surface waters so their loading can be used to perform amass balances to assess the completeness of AMD capture. Acidity is useful for identifying sources of impairment and for predicting the outcome of remediation efforts. Loadings are shown in Table 2.

Table 2. June 2, 2022 flow and loading

Location	Flow (gpm)	SO4 (ppd)	Acid (ppd)	Fe (ppd)	Mn (ppd)	Al (ppd)
MC Hale	**4,137.9**	**4,568.3**	**744.8**	**162.9**	**120.7**	**19.9**
UNT-1	**9.0**	**28.1**	**8.3**	**0.6**	**0.4**	**0.3**
Powerline	0.1	0.8	0.4	0.1	0.0	0.0
MC10	2.3	4.1	0.5	0.0	0.0	0.0
MC11	0.1	0.3	0.1	0.0	0.0	0.0
MC12	22.5	230.9	86.4	3.1	2.2	10.0
MC14	11.3	185.0	62.1	10.9	3.2	5.9
MC15	1.0	7.0	2.8	1.3	0.1	0.0
Sum of AMD sources above QMC-6R	37.3	428.1	152.3	15.4	5.5	15.9
QMC-6R	**4,586.7**	**7,045.2**	**1,486.1**	**259.8**	**148.1**	**55.0**
MC16	35.0	153.3	63.0	18.6	1.2	3.3
QMC-6R+ MC16	**4,621.7**	**7,198.5**	**1,549.1**	**278.4**	**149.2**	**58.4**
Sum of all AMD sources	81.2	609.4	223.5	34.7	7.1	19.5

Bold indicates in-stream stations, sites are organized from upstream to downstream

Total sulfate loading measured from the identified AMD sources between MC Hale and QMC-6R is 428 ppd but the in-stream loading increased by 2,477 ppd leaving 83% of the sulfate loading unaccounted for. Acidity loading for those same discharges totals 152 ppd while in-stream acidity loading increases by 741 ppd leaving 79% unaccounted for. If the UNT-1 and MC16 samples are included, then the unaccounted for acidity loading decreases to 72%.

Figure 1 shows the acidity loading contributions in this section of Moshannon Creek. About half of the acidity loading at QMC-6R (downstream station) was present at MC-Hale (upstream station). The discharges (including MC16 and UNT-1) account for only 14% of the acidity at MC-6R. The missing 38% of the acidity is likely due to polluted baseflow entering the stream.

The loading analysis indicates that the AMD discharges identified and sampled for this report represent only a small portion of the AMD entering this section of Moshannon Creek. The largest source of acidity is from upstream Moshannon Creek and the second largest source is unaccounted for.

It is a common practice in AMD remediation work to rely on excess alkalinity generated by treatment systems to neutralize inputs of acidity that have not or cannot be treated. Neutralizing the unaccounted loading in this reach by making the discharges net alkaline would require about 600 mg/L alkalinity from all of the discharges. Typical treatment system effluent alkalinity is 50-

100 mg/L. Treating all the discharges in this section of Moshannon Creek would not clean up the creek.

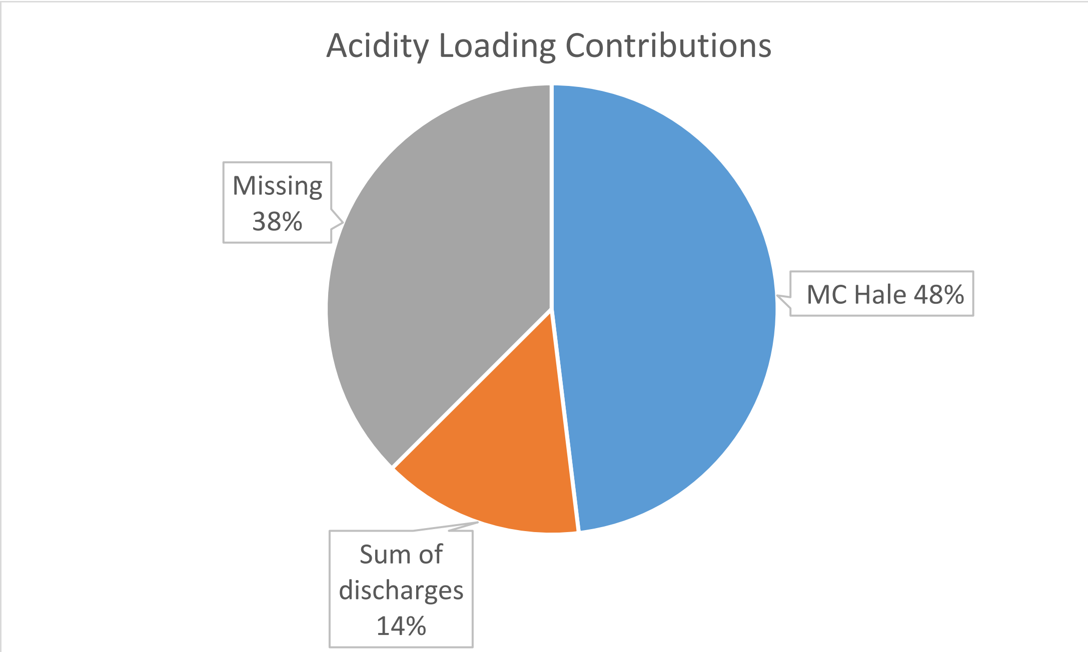


Figure 1. Acidity loading contribution in Moshannon Creek between Hale Road and Whiteside Run.

If all pollution was eliminated (0 net acidity) at MC Hale and also all of the AMD sources sampled here (except MC13 because loading cannot be calculated), the water quality at QMC-6R would still be impaired. Under the observed conditions, a net acidity of -12 mg/L would be required at MC Hale to neutralize the unaccounted-for acidity at QMC-6R. Neutralizing all of the acidity observed at QMC-6R plus MC16 using excess alkalinity at MC Hale would require a net acidity at MC Hale of -31 mg/L. Annual flow at MC Hale was estimated using Streamstats to be 5,969 gpm or 44% greater than what was measured on Jun 2nd. If loading increases proportionally to the flow at MC Hale, annual alkalinity requirements to neutralize this reach of Moshannon Creek would be about 1.1 tons $CaCO_3$ per day. More sampling under a wider range of flow conditions is needed.

Stream Flow Loss Investigation

An interesting observation made in both the Moshannon Creek Headwaters Mine Drainage Assessment and the Coldwater Conservation Plan is that while Moshannon Creek gains pollution loading in the study area, likely due to inputs of contaminated baseflow directly to the stream, the stream *loses* flow in a short section of the stream. To verify these findings an additional sampling round was conducted on October 6, 2022 which focused on in-stream sampling of the segment where leakages is suspected to occur (in the vicinity of MC14 and 15). To provide a reference for comparison to other rounds, the Hale monitoring point was sampled. The MC13 station was flooded by a beaver dam so samples were collected above and below this station to quantify the impact of this discharge. Map 3 shows the location of the sampling points.

Flow conditions were approximately five times higher during the June sampling round than during the October sampling round. Table 3 shows the results of the sampling round.

Table 3. October 6, 2022 sampling results

Location	**Flow (gpm)**	**pH (SU)**	**Alk. (mg/L)**	**Acidity (mg/L)**	**Fe (mg/L)**	**Mn (mg/L)**	**Al (mg/L)**	**SO_4 (mg/L)**
60 (Hale)	780.9	6.2	0	10	2.4	1.1	0.2	54
MC above MC13	*	4.1	0	19	4.4	1.4	0.6	75
MC below MC13	933.5	4.1	0	21	5.2	1.5	0.7	81
MC above MC14	884.1	4.0	0	32	6.6	1.6	0.9	94
MC above MC15	866.2	4.0	0	24	6.8	1.7	0.9	93
MC16	44.7	2.9	0	150	63.0	3.1	8.3	305

**Could not be measured due to inundation by beaver dam*

The impact of the MC13 discharge on Moshannon Creek was negligible on this day. Iron increased by 0.8 mg/L but all other parameters showed minor increases. Unfortunately, the MC above MC13 station was inundated by a beaver dam and the flow could not be measured. Without a flow rate, the loading contribution of MC13 cannot be calculated.

Stream flow increased between Hale and MC below MC13 stations then decreased at the subsequent stations. Flow and loading values are shown in Table 4. In-stream acidity loading increased by 250% between Hale and MC below MC13 which is unsurprising given the contributions of known and unknown discharges within the reach. What is surprising is what happened between MC below MC13 and MC above MC14. Paradoxically, the in-stream flow decreased while the loading increased.

One explanation is that the stream lost water due to mine infiltration and the water that remained in the stream is further degraded by the refuse piles along the bank of the stream. Some of these piles were partially inundated by beaver activity.

Between MC above 14 and MC above 15, both flow and loading decreased which suggests stream loss without significant unknown contributions.

Table 4. October 6, 2022 flow and loading

Location	**Flow (gpm)**	**SO4 (ppd)**	**Acid (ppd)**	**Fe (ppd)**	**Mn (ppd)**	**Al (ppd)**
60 (Hale)	780.9	506	94	22	10	2
MC above MC13*	-	-	-	-	-	-
MC below MC13	933.5	911	235	58	17	8
MC above MC14	884.1	999	340	69	17	10
MC above MC15	866.2	965	249	71	18	9
MC16	44.7	164	80	34	2	4

Map 4 shows the sampling locations overlain onto a mine map of the Mountain Branch Mine. Workings extend under the stream and it is highly likely that a borehole shown on the mine map is the source of the MC16 discharge. If the MC16 discharge is indeed a borehole into the mine workings then those workings are flooded at least to the level of the water surface of the MC16 discharge pool which has an elevation of 1513.7 according to lidar mapping. Stream leakage into the mine workings could occur above that elevation and the mine could leak water to the stream below that elevation. The 1514 contour is highlighted on Map 4 and falls downstream of the zone of observed stream flow loss. (Note: elevations shown in the mine map are approximately 10 feet lower than the lidar elevations).

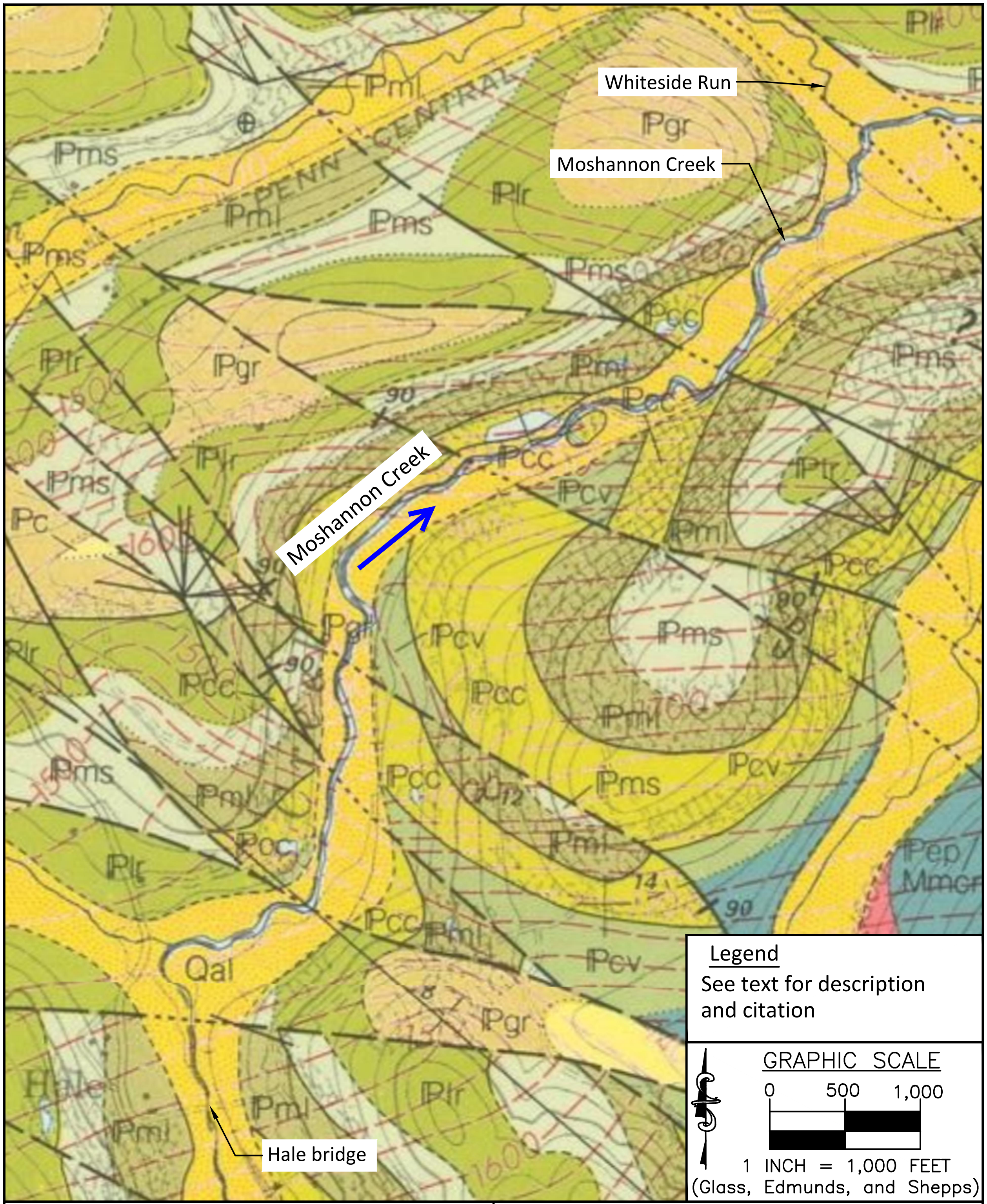
Map 4 also shows a fault crossing the stream near the MC above MC14 sampling point. The fault and associated fracturing could provide a conduit for flow to the mine workings that then returns to the stream as contaminated baseflow downstream.

Recommendations

This section of Moshannon Creek contains several surface flows of AMD. However, the mass balance analysis suggests that substantially more pollution is entering Moshannon creek as polluted subsurface flows (contaminated base flow). In addition, the downstream portion of this segment loses flow but gains pollution loading. The fate of the water lost in the stream is unknown. The lost flow may be entering mine workings and reemerging elsewhere as AMD. The complexity of the hydrology in this section of Moshannon Creek makes it unlikely that a restoration approach based on treating identified surface flows will be successful.

To understand the complex groundwater system of the study area will require investigation of the mines that are the source of the pollution. Of specific concern is the impact of deep mines that extend under Moshannon Creek. The following tasks are recommended for further assessment of this segment:

- Additional sampling to capture loading rates and accounting under a variety of conditions.
- Further research into existing documents such as mining permits or other reports.
- Drilling to identify mine pools should be considered. Geophysical methods could be utilized to identify fracturing and/or voids beneath Moshannon Creek.
- Installation of a monitoring well within the mine workings near MC16. The well should be located upslope of MC16 to avoid the creation of a new discharge.
- Survey work to ascertain the elevation of key features.
- Continuous monitoring of groundwater levels, flows, and water quality to determine the link between the mine pool and in-stream conditions.



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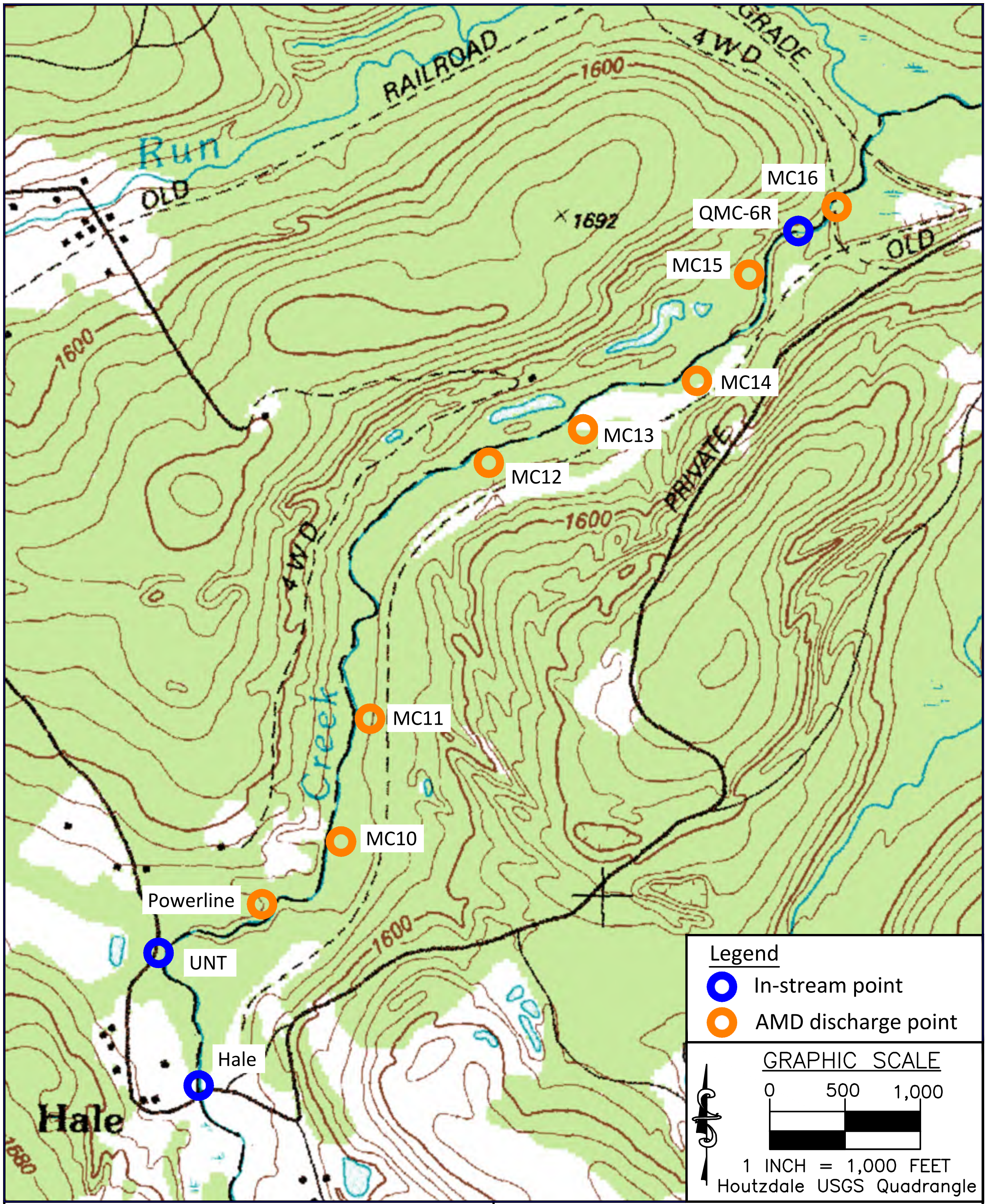
Map 1
Geologic Map

Municipality:
Rush & Woodward townships

County:
Centre & Clearfield



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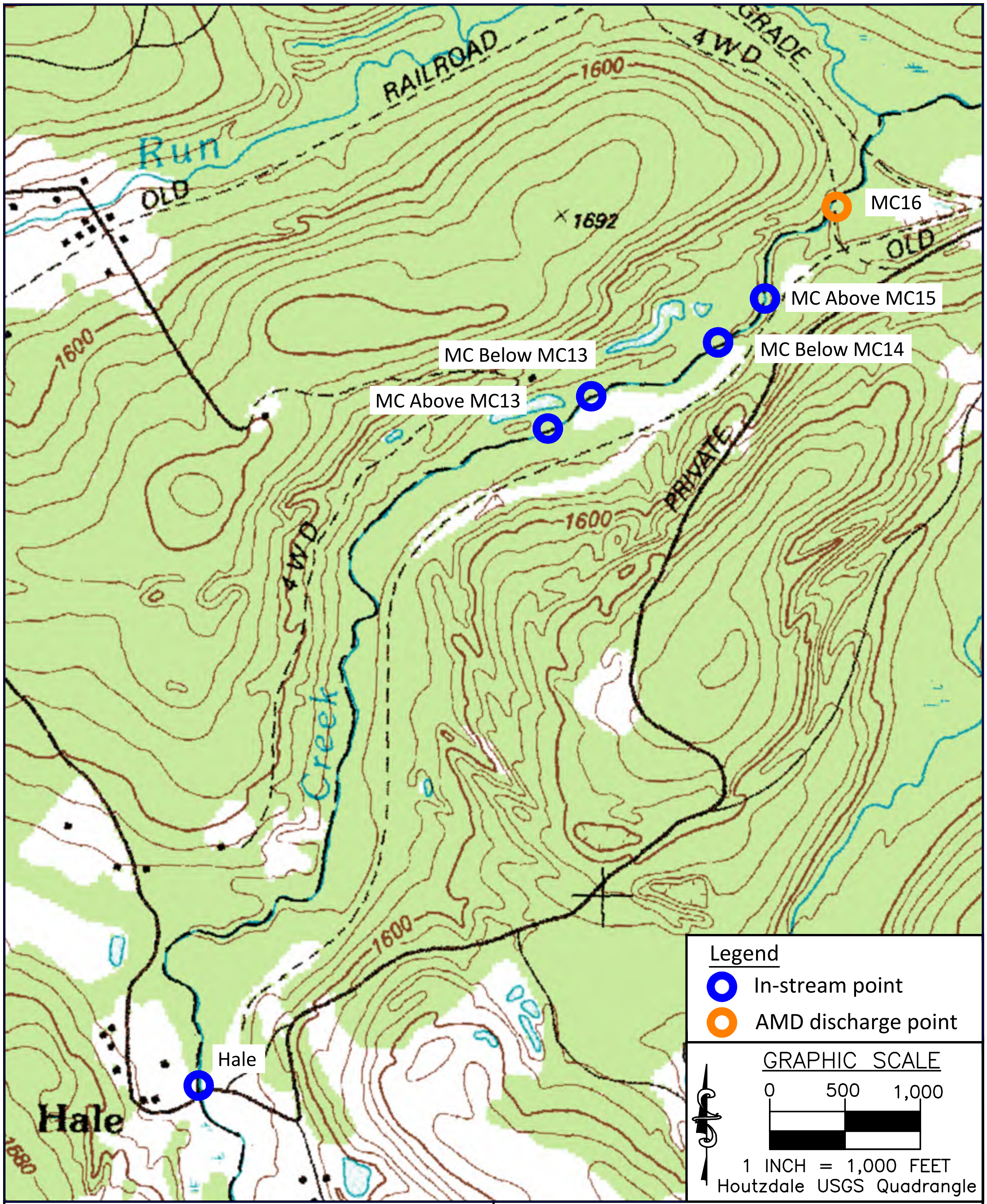
Map 2
Round 1 Sample Location Map

Municipality:
Rush & Woodward townships

County:
Centre & Clearfield



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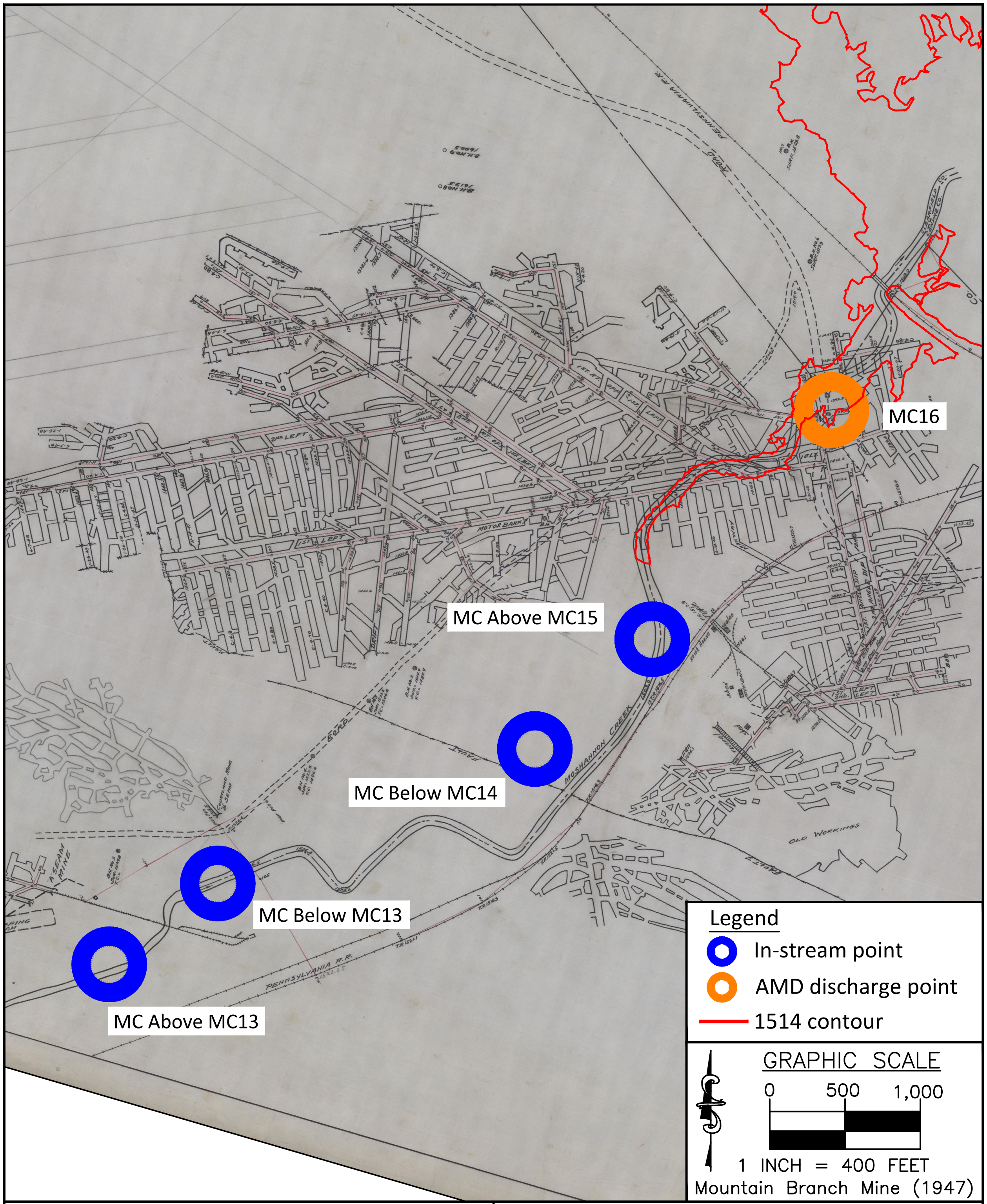
Map 3
Round 2 Sample Location Map

Municipality:
Rush & Woodward townships

County:
Centre & Clearfield



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Map 4
Underground Mine Workings

Municipality:
Rush & Woodward townships

County:
Centre & Clearfield