Loop Run Watershed Mine Drainage Assessment and Restoration Plan

Located on the Kelley Estate and SGL-321

Prepared for the Rocky Mountain Elk Foundation

By NMBS (New Miles of Blue Stream)

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Document drafted by NMBS
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Executive Summary

This project was undertaken to develop a plan to restore Loop Run to a habitable stream as well as to identify areas within SGL-321 which should be remediated in order to reduce safety hazards. The Pennsylvania Game Commission (PGC), the Rocky Mountain Elk Foundation (RMEF), and NMBS worked cooperatively to complete the tasks necessary for this document.

Loop Run and the Kelley Estate (SGL-321) are located in West Keating Township, Clinton County. The main branch of Loop Run flows 3.6 miles, with approximately 2.0 miles of tributaries in the watershed.

The PGC and NMBS worked together to assess the quality of Loop Run. A stream walk was conducted along the entire course of Loop Run and fifteen sampling locations were established; twelve discharge points and three main stem or tributary locations were selected for sampling. These fifteen sites were sampled monthly for one year for chemical parameters and flow rates. The discharges are high in acidity with most having moderate iron and aluminum concentrations and high manganese concentrations. Two of the discharges, which form a tributary to Loop Run, are high in aluminum.

Six pollution areas of note exist along Loop Run; four of these are significant. The first two of these pollution areas are characterized as large laminar flows along the edge of reclaimed surface mining. The third emanates from abandoned highwalls and ponds. The fourth originates from abandoned spoil. Two additional discharges down stream seep from the hillside. These two additional treatment areas may need to be addressed, but they are not as significant pollution contributors and are likely to be difficult to treat due to topographical issues.

The primary goal of the project partners is to restore Loop Run from the headwaters to the mouth where it enters the West Branch of the Susquehanna River. The ultimate goal is to reestablish a cold water fishery within the Loop Run Watershed that will compliment the recreational opportunities that already exist in the watershed such as hiking and hunting. This will be accomplished through four priority passive treatment projects. The secondary goal is to reclaim abandoned mine lands on Game Lands which pose public safety hazards as well as make the land less habitable for wildlife.

The recommended treatment systems for Loop Run are all passive systems. These passive treatment systems will use the most appropriate of the technologies available at the time of design and construction. The systems will consist of a combination of aerobic wetlands, vertical flow wetlands, and manganese limestone beds. The four priority projects should cost approximately $813,500.

If the four priority treatment projects are complete, Loop Run will be greatly improved. An aquatic community exists in the headwaters and tributary and treatment of the stream should allow these species to expand to the main stem. Eventually we look forward to reestablishing Loop Run as a fishery.

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Watershed Vision

It is the vision of the partnership of the RMEF and the PGC to restore the Kelley Estate with the goal of improving land quality for wildlife and human use. They also want to restore Loop Run to a stream able to support an aquatic community, including fish.

It is the long term goals of the project partners to reclaim abandoned highwalls and spoil areas, plant additional food plots, increase wildlife habitat for elk, roughed grouse, turkeys, rabbits and all other wildlife using the Game Lands. They will restore Loop Run for fishing and recreation; this effort will also improve the water quality in the West Branch of the Susquehanna River.

Introduction

In 2001 the RMEF sold the Kelley Estate Property to the Commonwealth of Pennsylvania. Of the 4,400 acres of the Kelley Estate, approximately 3,300 acres were purchased by the Pennsylvania Game Commission and are being managed as State Game Lands #321. The remaining 1,100 acres, which includes over one mile of river frontage along the West Branch of the Susquehanna River, is being managed as "Old Growth Forest" in the Sproul State Forest by the Department of Conservation and Natural Resources, Bureau of Forestry. Both parcels are open to the public for recreational activities.

The Kelley Estate was initially impacted by several deep mines located throughout the property. Additional damage caused by Pre Act surface mining in the 1940s and 1950s left the area in total devastation. Subsequent remining under stricter environmental regulations brought improvements to the area but unfortunately, the entire area was not remined and restored due to economically irretrievable coal in some areas. Thus, over 250 acres of spoil still exist along with 8,900 feet of highwall.

A Growing Greener Grant was awarded to the Rocky Mountain Elk Foundation in 2002 to develop a restoration plan for the Kelley Estate, including a watershed assessment on Loop Run and a prioritization of the highwall and spoil areas throughout the site.

The Kelley Estate was originally purchased by the Rocky Mountain Elk Foundation in order to protect over 4,000 acres of natural resources for the benefit of wildlife and humans alike. Through the continued restoration efforts of the Kelley Estate, increased benefits will be reached. Reclamation of the highwall and spoil areas will allow for additional food plots and habitat areas to be developed, while at the same time making the area safer for both humans and wildlife. These areas will be managed to have the greatest benefit to all wildlife in the area, but especially to the growing elk population. Through a partnership with the Pennsylvania Game Commission, this site was used as an elk herd release site in 2000, and the herd is beginning to establish a resident population. The Kelley Estate will be managed to offer an alternative to viewing elk in a setting like Winslow Hill near Benezette, PA. In the latter, the elk are viewed in yards, campgrounds, and roadways which are in close proximity to people. A restored Kelley Estate would offer an opportunity to experience remote wildlife viewing in a setting that resembles that of a mountain meadow in a western state. State Game Lands #321 is mentioned in the *Plan for Promoting Elk Watching and Other Nature Tourism in Northcentral Pennsylvania* as an area not to be commercialized in the promotion of elk viewing. The remote location, with easy access, should remain an asset to alternative elk viewing. The consulting firm of Fermata, Inc. has compiled this report which can be found at http://www.fermatainc.com/pennelk/index.html.

Watershed Background

Site Location:

The Loop Run Watershed is located in West Keating Township, Clinton County and can be found on the Pottersdale 7.5 minute USGS quadrangle map (pages A-2, A-3). The stream originates near New Garden and flows in a south eastern direction until its confluence with the West Branch of the Susquehanna River. It is near the Quehanna Wildlife area and approximately 30 miles from Benezette, the central location of elk viewing in the state. The nearest towns are Pottersdale, Karthaus and a small camp community known as New Garden. This watershed is comprised of approximately eight square miles. The main stem of Loop Run is 3.6 miles long and approximately 2.0 miles of tributaries contribute to its flow. The stream is contained within SGL-321.

Watershed History:

Generations of area residents have made their living and enjoyed recreation on the Kelley Estate, also known as the New Garden property. The Kelley family leased land to coal mining and timber operations that were major industries here until the 1950s. Small villages were once erected along the rail tracks in what is now deeply wooded property. Although privately owned, Kelley's land was open to hunting and recreation. The land is the only river access for communities on the western shore of the West Branch of the Susquehanna River where Pottersdale is located. It's where fathers taught their children how to hunt and where families would picnic along the banks of the river.

Extensive deep mining occurred throughout this property, impacting both the landscape and water quality prior to the 1940s. In the 1940s and 1950s, surface mining began in the area, but due to the lack of regulations, only more problems arose. Abandoned highwalls and spoil areas are located throughout the property; some are more severe than others. In the 1970s and 1980s, River Hill Coal Company went into the area and began remining. Our permit research indicates that they were mining and remining the Kittanning coal seams on the property. However, not all of the impacted areas provided an economically feasible opportunity for remining; so, extensive highwall and spoil areas remain on the site.

Appendix B contains historical water quality data and its relationship with our sample locations. Included in this appendix is a table of historical mining which includes the following information for each permit: mining permit, date issued, mining company, mine name and mining type. The historical data aids in completing the picture of mining activities and the subsequent affect on water quality. This historical data was used to develop the sampling plan and in the overall development of the restoration plan and treatment areas.

Residents have used the Kelley land for generations. Old-timers recall the tired horses that pulled train cars full of Kelley coal all week providing Sunday recreation. After church, children would line up at the "pony barn" for rides. The watershed history provides a picture of what life has been like on the Kelley Estate for the past 60+ years. It gives today’s generation knowledge of life within the area, and aids in developing the restoration efforts.

Article from the following website: http://conserveland.org/stories/npc_elk

To conserve or not?

Pottersdale, West Keating and the other communities near the Kelley property are ensconced by 700,000 acres of state forest and game lands including Sproul State Forest.

The Northcentral Pennsylvania Conservancy was willing to buy and hold the land until the state agencies could secure the money to repurchase it for state forest and game land. However, first the Conservancy wanted to know how the community felt about potential state ownership of the land.

The Conservancy held three well-attended public meetings, said Renee Carey, executive director of the Conservancy.

"The people were very concerned about the future of their home," she said. "Their questions were sharp and plentiful. Their main concern was, once in state hands, what kind of restrictions would be put on their use. Traditionally it was an area where people go hunting and picnicking. We talked about it at every meeting. With their questions answered, the support was overwhelming."

With the communities in favor of the project, the Northcentral Pennsylvania Conservancy and Rocky Mountain Elk Foundation set out to make it happen.

The Conservancy and the Elk Foundation embarked on the tricky business of negotiating a land purchase satisfactory to all of the Kelley heirs. They also had to find a lot of money.

They succeeded on both counts. A deal was struck with the heirs. Major contributions were secured from the R. K. Mellon Foundation, the National Turkey Federation, The Great Outdoors Conservancy and the Roy A. Hunt Foundation, as well as many sportsmen's groups and hundreds of individuals. The Pennsylvania Department of Conservation and Natural Resources helped with a $350,000 land trust grant from the Keystone Recreation, Park and Conservation Fund.*

The land was purchased by the two organizations in 1998. They paid off the back taxes, cleaned the property up and took other steps to ready it for the state. A couple of years later, when the state agencies were ready, they sold it at a loss to them. The Bureau of Forestry established 1,110 acres of new state forest with public access to the river. The Game Commission created 3,330 acres of new elk habitat and hunting grounds. "They couldn't have done it without us and we couldn't have done it without them," summed up Thom Woodruff, the National Lands Program Manager for the Rocky Mountain Elk Foundation.

Watershed Geology/Topography/Soils:

The description of Geology of Clinton County can be found at the Penn State University libraries and a map can be found on page A-14. Clinton County is 860 square miles. Two thirds of this county spreads itself over the Allegheny Mountain Plateau and is profoundly trenched by winding gorges of the Susquehanna River and its branches. Only small isolated patches of the coal measure beds, which are located on the very highest mountain divides, a thousand feet above the river beds, have escaped destruction.

Specifically, the Kelley Estate is located on the South Flank of the Clearfield-McIntyre Syncline. It has a strike of N 60^{o}E and the dip is SW at 1%. There is an axis that lies 1000 feet northwest through the site. The strike of the bedrock and coal is N 35^{o}E and N 55^{o}W at 3.2%. The topography shows numerous faults throughout the property, making it difficult to determine groundwater flow. The topography is comprised of moderately steep hillsides through the stream valley, with the headwaters being relatively flat. The soils on site are dominantly sandy loams and spoil material from extensive unrestored mining. Geological factors on site, along with the coal seams mined, are prime conditions for the formation of acid mine drainage. The reclamation of these abandoned areas is vital to the improvement of water quality in the surrounding streams.

A soil name map can be seen on page A-15. The size and composition of this map makes it of minimal value, but we included it for those who would like an overview of the data. For those requiring a more explicit view of the data, the source is referenced on the map.

Land Use:

The Kelley Estate has been extensively mined since the 1940s. It was also timbered in the past. It is now open reclaimed fields managed by the PGC as wildlife food plots and wildlife habitat. Limited forested areas with minimal ground cover are also present. The PGC manages the property by mowing, planting and timbering.

Cultural:

Few people live in the nearby towns or township itself. Pottersdale has a population of 70 residents with an average household of 2.27 persons. Karthaus has a population of 707 with an average household of 2.47 persons. This property is a remote area used extensively by outdoorsmen for hiking and hunting; the PGC and RMEF would like to see this area also be able to be used for fishing. It is an area to be included in the elk viewing for those who want to hike in for a natural viewing, unlike the “tamed” areas elsewhere in the state.

The area is surrounded by State Forests and the Quehanna Wildlife Area. Outdoorsmen have camps and otherwise use the area on the outskirts of the property. A few local businesses are nearby. A local hotel and restaurant is used extensively during hunting season. A new information center has been developed due to the increased tourism associated with elk viewing. Nearby is the Quehanna Wildlife Area with the Boot Camp and a few industries. No industry or other cultural activities impact Loop Run or the entire Kelley Estate as it is protected within State Game Lands #321.

Mining

Mining History:

Extensive deep mining and Pre Act surface mining occurred on the Kelley Estate leaving discharges, highwalls, and spoil areas. Remining efforts took place in the 1980s, but did not impact all of the property. See Appendix B for tables of historical mining and page A-5 for mapping of the mining activities. These historical mining permits were researched for water quality to include in the database and can be found in Appendix B.

Historical mining in the area removed the Lower Freeport, Upper, Middle, and Lower Kittanning coal seams using both deep and surface mining techniques. The first permitted mine found in the data was opened in 1940 by Frank Albert. Fifteen to twenty acres were stripped and backfilled on the Lower and Middle Kittanning coal seams at this time. Historical permits were researched back to the 1950s when a series of deep and surface mines were permitted. Loop Run was a clean stream until 1953 when it was impacted by these mines. In the 1970's, Garden Hill Coal Company was mining on the Kelley Estate and ultimately their Garden #3 job was transferred to River Hill. River Hill Coal Company completed this job and continued with remining activities on the Kelley Estate. The Cody's Hill job mined the Upper, Middle, and Lower Kittanning, as did the Stone Bridge job. All of this historical mining impacted Loop Run as the data in Appendix B shows.

The Department of the Interior, Office of Surface Mining Reclamation and Enforcement, was contacted to conduct a search of the deep mining that occurred within the watershed. They sent a Works Progress Administration (WPA) map showing the extent of one deep mine area on the property and indicated there are no detailed mine maps for the area. We also reviewed existing permit maps and the resulting permitted areas are displayed on page A-5.

AML:

Pages A-12 and A-13 show the extent of the remaining highwalls and spoil areas on the Kelley Estate. Most of the original abandoned areas have been reclaimed by remining, but three priority areas remain. Two are highwall areas. These are deep highwalls with exposed rock faces. The third priority is what appears to be a low wall area, with rolling spoil and three impoundments remaining. There is a slight safety hazard with the third priority, but extensive land would be reclaimed to be used for habitat or food plots. This area has also been undermined (page A-5) and a discharge flows during wet seasons. The discharge does not, however, impact the water quality of Loop Run.

Our top reclamation priority has already been added to the BAMR list for reclamation. This is the most dangerous highwall on the property. We will be working closely with BAMR to insure all project partners are involved with all aspects of the reclamation process.

Current Mining:

Mining is not currently occurring within the Loop Run Watershed.

Reclamation Efforts:

The highwall and spoil areas are mapped (Pages A-12 and A-13) and prioritized based on hazards and effect on water quality, along with economic feasibility. Many of the reclamation areas chosen by the PGC were for creation of food plots and wildlife habitat, not necessarily an environmental impact. NMBS tried to weigh the concerns of all parties in the prioritization process.

Three areas for reclamation have been identified. The first priority is a highwall area with exposed rock faces. It is over 2000' long and approximately 100' deep. It has been added to the BAMR reclamation list. The second priority is another highwall area which appears to extend from the first; rolling spoil areas separate the two. The third area appears to be a low wall area, with rolling spoil and three impoundment areas remaining. The reclamation efforts will be further addressed later in the document.

Remining Potential:

Remining is not a feasible option on the property. Remining did occur in the 1980s by River Hill Coal Company and they would have removed any and all remaining coal seams that were economically feasible. Evidence shows that remining efforts would not positively impact the water quality.

Data Collection

Field Reconnaissance:

PGC and NMBS representatives initially walked the stream in October 2002 in preparation for the assessment. They used a map created by BAMR interns who did a pre-survey of the site in the summer and winter of 2001. Discharges were located, flagged and inspected for flow devices, and field measurements, such as pH and conductivity, were collected. Of the 22 flagged areas, 15 were chosen for monthly sampling (page A-7 and A-8). Four of the remaining sites had field measurements taken on a quarterly basis (pages A-9), and others that were flagged were considered non-significant and no samples were collected. Weirs were installed through the winter of 2002 and sampling began in March 2003. PGC employees collected the monthly samples after being trained by NMBS.

Historical Data:

All historical mining permits were obtained and researched for water quality data (see Appendix B). The water quality data was included in the database and used to evaluate discharges over time. BAMR did a preliminary study in 2001 and this data has also been compiled and included. No other information was found pertaining to the Loop Run watershed.

Documentation of Problem Areas:

1. Water Samples: Table 1 represents the sampling locations on Loop Run. The sampling period is M for monthly and Q for quarterly. The table contains the monitoring point, sample description and latitude and longitude. Pages A-7, A-8, A-9 are maps of the sample locations

Table 1: Sampling Plan

Monitoring Point	Description	Latitude	Longitude	Sampling Period
LR-1	headwaters of Loop Run	41 11 31.920	78 02 3.120	M
LR-2	UT to LR	41 11 18.888	78 01 57.288	M
LR-3	Loop Run where crosses the road	41 11 14.280	78 01 54.372	Q
LR-4	spring fed UT to Loop Run at 4-wheeler path	41 11 8.772	78 01 53.760	Q
LR-5	two pits flow together	41 11 13.020	78 00 56.988	M
LR-6	impoundment near gate, old highwall	41 11 11.040	78 00 57.240	M
LR-10	channel from spoil area	41 10 52.248	78 01 44.112	M
LR-11	channel from moss seepage	41 10 49.440	78 01 49.908	M
LR-12	seepage area	41 10 53.148	78 01 50.988	M
LR-13	large iron mat seep area	41 10 44.328	78 01 49.296	M
LR-14	seep area	41 10 41.232	78 01 54.048	M
LR-15	seep area	41 10 39.828	78 01 56.172	M
LR-16	seep area	41 10 37.200	78 01 59.448	M
LR-17	wet seepage area along hillside	41 10 29.388	78 02 2.112	M
LR-18	channel collecting wet area	41 10 18.192	78 01 57.072	M
LR-19	UT	41 10 19.632	78 01 58.440	M
LR-20	large impoundment, water doesn't leave	41 10 34.392	78 00 48.888	Q

Monitoring Point	Description	Latitude	Longitude	Sampling Period
LR-21	small impoundment, water doesn't leave	41 10 29.280	78 00 43.560	Q
LR-22	pit area, no water	41 10 37.380	78 00 39.888	Q
LR-23	Loop Run below all discharges	41 10 10.164	78 01 57.792	M

2. Abandoned Mine Lands: See page A-5 for a map of the historical mining in the area and page A-13 for the prioritization of the reclamation areas.
3. Coal refuse areas: On the Kelley Estate, only one coal refuse area exists. It is located along the railroad tracks that that traverse the West Branch of the Susquehanna River and negotiations are in progress to have it removed. The pile would be affecting water quality in the West Branch of the Susquehanna River. Additional spoil material on the property is limited to unreclaimed areas of rolling material. It consists of overburden material, and no valuable coal refuse.

Permission:

Twelve of the fifteen sample locations were on State Game Lands, thus access was not a problem. NMBS obtained permission to access the three sample locations that were on private property. Each landowner was contacted by phone, and permission was obtained for the installation of the weirs and for the monthly sampling. All of the treatment areas are located on State Game Lands and the cooperative effort will continue through the construction and maintenance phase of the systems.

Property Ownership:

Although the PGC and DCNR own the bulk of the property, there appear to be two additional property owners. The following parcels were located at the Clinton County GIS website:

- The PGC owns multiple parcels of land that constitute SGL-321.
- DCNR owns multiple parcels that total 1,000 acres within the Kelley Estate and Loop Run Watershed.
- Parcel ID#16-20179-34 is a private landowner near the headwaters of Loop Run.
- Parcel ID#16-7086-35 is a private landowner in the Loop Run Watershed.

Development of Monitoring Plan:

A monitoring plan was developed after the initial reconnaissance. The sampling plan focused on the mine drainage discharges and appropriate stream samples. The sites chosen for quarterly field monitoring were impoundments and a tributary with marginal quality where the landowner could not be reached. The natural springs in the area have pH 4.5 to 5.0, with low conductivity. Monitoring these locations were not necessary for the overall development of the restoration plan. The impoundments are located in spoil material, but they do not discharge or find their way to Loop Run. See Table 1 for the list of sampling points.

Sampling Methods:

NMBS trained the PGC to conduct the monthly sampling. They were trained to properly conduct field chemistry tests, collect water samples, and measure flow rates.

Samplers were trained to collect pH, conductivity, and temperature measurements in the field. A NMBS representative reviewed proper use and care of each of the pieces of equipment required for these measurements.

A NMBS representative took samplers into the field and identified the points that were selected for monitoring and reviewed proper sampling methods with samplers at each of these sites.

The sampling methods used require that samples be taken as close to the source as possible. Samplers were directed to take samples in a section of the stream or discharge where flow is concentrated to provide the best representation of the chemical properties and to avoid sampling in pooled backwater areas or areas that are littered with decaying organic matter. Samplers were also directed to avoid areas that contain heavy concentrations of aquatic vegetation.

Samplers were taught to collect water samples in a manner that would prevent contamination. These steps included the exclusive use of bottles supplied by the lab, and the technique of field rinsing equipment. Field rinsing was used to equilibrate the equipment to the sample environment; this was also done to ensure that all cleaning solution residues have been removed before sampling began.

Samplers were taught to rinse and then fill bottles in a manner that minimizes contact with the air. The exposure of the sample to the atmosphere can increase the DO concentration, causing reduced metal ions to oxidize and precipitate as hydroxides. The precipitation of iron and other metal hydroxides can result in lower concentrations of iron and co-precipitating metals in the analyzed sample.

Samplers were instructed to keep bottles cool as soon as possible. Provisions were made as part of the sampling plan to ensure prompt delivery of samples to the lab.

Samplers were taught to use a water resistant field book to record sampling information in the field. The sampling information should include date, sample name, field pH, field conductivity, flow, temperature, weather conditions. Samplers were also directed to always be aware of and record potential sources of contamination at any field site.

Samplers were instructed to properly label bottles. These labels were the same as those recorded on the chain of custody that was sent with the bottles to the lab. A NMBS representative maintained responsibility for filling out the chain of custody and any additional lab paperwork that was required.

Water Quality Measurements:

Water samples were analyzed for mine drainage parameters. The pH, conductivity, and temperature were measured in the field. The pH and conductivity were measured using hand held Testr's by Oakton and temperature was measured with a thermometer. The meters were calibrated with buffer solutions prior to each use.

Iron, aluminum, manganese, acidity, alkalinity, lab pH, lab conductivity, TSS, TDS, and sulfates were measured in the laboratory. Mahaffey Lab performed the analyses using standard methods. Samples for metals were preserved in the field by adding five drops of nitric acid. None of the samples were filtered, so they represent total metal concentrations.

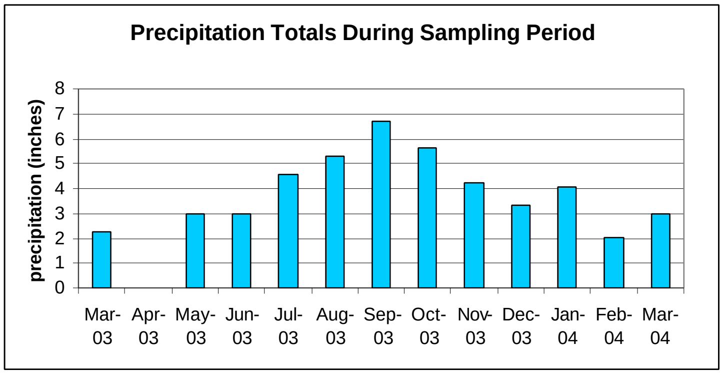
Flow Rate:

V-notch weirs were installed at sampling locations. The water flow height over the weir was measured and gallons per minute (gpm) were calculated. Three pipes were installed at one location and a bucket and stopwatch were used for the "timed volume" method. The bottom stream sample flow was calculated using the "bobber" method, where a cross section is determined and a bobber is floated numerous times over a distance and the duration is measured.

Precipitation During Sampling Period:

As part of the sampling event, temperature and weather conditions were recorded in the field books. Precipitation events can affect the chemistry of the samples either by dilution or causing flush events. These recorded conditions were considered in the final site evaluations.

Total rainfall during the 12-month sampling period is also important in the overall evaluation of the remediation efforts. Drought years versus high water years can affect flow rates and may change the overall design of the treatment systems. March 2003 through March 2004, the 12-months of sampling for the restoration plan, was considered an average or above average year for rainfall, after experiencing multiple drought years. This data will therefore best represent the conditions of the discharges.



This graph represents the precipitation totals as collecting during the 12-month sampling for the development of the restoration plan. Data could not be found for the month of April. Daily precipitation was added to produce this graph. Data was obtained from www.pasc.met.psu.edu/IA.

Mapping

Location maps

The location of the Loop Run watershed can be found on page A-2. This displays a map of Pennsylvania and the location of the Loop Run Watershed within the Commonwealth. Page A-3 is a map that displays the Kelley Estate and the Loop Run Watershed in the context of surrounding municipalities.

Stream Quality

Page A-4 displays a color coded version of Loop Run. The variation in color describes the quality of the stream as it runs from headwaters to mouth (based upon the sampling which was done).

Mine Areas

Page A-5 is a map displaying the Kelley Estate and the Loop Run Watershed and the position of underground and other permitted mining operations within or near the two boundaries. Permitted areas include both areas for strip mining and areas permitted for refuse storage.

Monitoring Program

Pages A-6, A-7, A-8, and A-9 represent the historical and present sampling plan on the Kelley Estate. A-6 displays the Loop Run watershed, parts of the surrounding streams, and the position of historical sampling points. A-7 displays the Loop Run watershed, parts of the surrounding streams, and the position of monthly sampling points. A-8 displays the Loop Run watershed, parts of the surrounding streams and the position of monthly sampling points. A backdrop is added to this map which displays the appropriate portions of the USGS quadrangle maps of the area. A-9 displays the Loop Run watershed, parts of the surrounding streams, and the position of quarterly sampling points.

Treatment Areas

Pages A-10 and A-11 represent the proposed treatment areas on Loop Run. A-10 displays the proposed treatment areas against the boundary of the Loop Run watershed. A-11 displays the proposed treatment areas against the boundary of the Loop Run watershed; this map also displays the appropriate portions of the USGS quad maps for the area.

The design and layout of treatment areas 1 through 4 can be seen in Appendix C. These are detailed on pages C-1 through C-4.

Reclamation Areas

Pages A-12 and A-13 represent the proposed reclamation areas on the Kelley Estate. A-12 displays the Kelley Estate and the Loop Run watershed and the position of reclamation areas within the Kelley Estate. A-13 displays the Kelley Estate and the Loop Run watershed and the position of reclamation areas within the Kelley Estate; this map also displays the appropriate portions of the USGS quad maps for the area.

Data Analysis

The sampling data for each sample location can be found in the following sections. Flow was collected at point and samples were analyzed for pH, conductivity, acidity, aluminum, iron, manganese, and sulfate. The loadings for acidity, aluminum, and iron are calculated and included as columns in each table. Each table contains not only the raw water data, but also an average value for each parameter, the maximum value, the minimum value, and the 75% and 90% confidence intervals for each parameter.

Discharge Areas/Descriptions of Sample Locations

LR1

LR1 is the headwaters of Loop Run. A basic aquatic survey showed caddisflies, mayflies, and water beetles. This aquatic population will be used to repopulate the restored stream. Flow is relatively small in the summer and would probably not support a fish community.

Table 2: Water Chemistry of LR1

Date	gpm Flow	pH	Umhos /cm Cond	mg/L Acidity	lbs/day Acid Load	mg/L Alk	mg/l Fe	lbs/day Fe Load	mg/L Al	mg/L Mn	mg/L SO4
3/13/2003		6.6	65	0		14	2		1.26	0.11	16
4/24/2003		6.3	101	0		14	0.19		0.13	0.08	16
5/13/2003	38.8	6.4	69	0	0	22	0.17	0.0795	0.14	0.01	26
6/26/2003		6.6	74	0		26	1.54		1.21	0.23	19
7/28/2003	12	6.2	80	0	0	29	0.38	0.0550	0.31	0.02	16
8/26/2003	5.5	6.6	86	0	0	32	0.72	0.0477	0.48	0.35	13
9/16/2003	6.25	6.5	89	0	0	35	0.37	0.0279	0.2	0.05	14
10/23/2003	15.5	6.4	88	0	0	26	0.11	0.0206	0.08	0.03	9
12/4/2003	47.1	6.9	101	0	0	20	0.53	0.3009	0.22	0.04	11
12/30/2003	103.5	6.3	68	10	12.477	17	0.32	0.3993	0.19	0.03	11
3/4/2004	72	6.6	65	0	0.000	16	0.55	0.4774	0.32	0.03	10
Average	37.581	6.491	80.545	0.909	1.560	22.818	0.625	0.176	0.413	0.089	14.636
Max	103.500	6.900	101.000	10.000	12.477	35.000	2.000	0.477	1.260	0.350	26.000
Min	5.500	6.200	65.000	0.000	0.000	14.000	0.110	0.021	0.080	0.010	9.000
75% Con	51.981	6.559	85.213	1.955	3.354	25.357	0.834	0.252	0.559	0.126	16.323
90% Con	58.171	6.597	87.360	2.554	4.125	26.497	0.842	0.284	0.585	0.147	17.291

LR2

LR2 is a sample point on a tributary entering Loop Run near the headwaters. A few seepage areas enter this tributary, but nothing significant. It begins as a spring behind camps. There is no discrete acid discharge entering the tributary. It appears that the geology of the area creates acidic conditions in the groundwater. Lime sand addition may be useful in this area.

Table 3: Water Chemistry of LR2

Date	gpm Flow	pH	Umhos /cm Cond	mg/L Acidity	lbs/day Acid Load	mg/L Alk	mg/l Fe	lbs/day Fe Load	mg/L Al	mg/L Mn	mg/L SO4
3/13/2003	17.1	4.3	328	26	5.360	4	0.33	0.0680	3.85	2.01	145
4/24/2003		4.3	352	10		6	0.09		4.47	2.87	157
5/13/2003	56.3	4.4	322	30	20.361	4	0.06	0.0407	2.83	1.96	116
6/26/2003	17.1	4.3	327	35	7.215	4	0.15	0.0309	3.62	2.35	142
7/28/2003	35.1	4.2	263	28	11.847	3	0.36	0.1523	2.56	2.31	109
8/26/2003	51.6	4.2	366	33	20.527	2	0.49	0.3048	3.62	3.19	146
9/16/2003	42.8	4.2	315	31	15.994	3	0.44	0.2270	3.07	3.02	124
10/23/2003	51.6	4.2	347	36	22.393	3	0.17	0.1057	3.52	2.79	135
12/4/2003	61.3	4.4	500	26	19.213	6	1	0.7390	3.76	2.57	114

Date	gpm Flow	pH	Umhos /cm Cond	mg/L Acidity	lbs/day Acid Load	mg/L Alk	mg/l Fe	lbs/day Fe Load	mg/L Al	mg/L Mn	mg/L SO4
12/30/2003	159.6	4.4	302	49	94.273	4	0.07	0.1347	3.25	2.07	105
1/29/2004		4.5	366	47		6	0.43		4.06	2.47	122
3/4/2004	110.6	4.4	254	18	23.999	4	0.16	0.2133	1.96	1.65	82
Average	60.310	4.317	336.833	30.750	24.118	4.083	0.313	0.202	3.381	2.438	124.750
Max	159.600	4.500	500.000	49.000	94.273	6.000	1.000	0.739	4.470	3.190	157.000
Min	17.100	4.200	254.000	10.000	5.360	2.000	0.060	0.031	1.960	1.650	82.000
75% Con	76.228	4.351	357.609	34.352	33.377	4.519	0.401	0.277	3.610	2.594	131.809
90% Con	83.071	4.366	366.540	35.900	37.357	4.706	0.439	0.310	3.709	2.661	134.843

LR3

LR3 is a quarterly field sample collected where LR1 and LR2 mix.

LR4

LR4 is a small tributary flowing off of a reclaimed mine area. Chemistry is marginal and aquatic insects are present. The flow has ranged from 10 to 25 gpm. Quarterly field samples were collected at this location.

LR5

LR5 is a discharge formed in an abandoned highwall area. It flows along the bottom of a highwall and enters two settling ponds before crossing under the access road to SGL-321. The discharge then flows through a natural wetland and forms a tributary, after mixing with LR6, to Loop Run. This tributary is the first major polluter to Loop Run. Investigation showed that reclaiming this area would have no impact on the discharge and it would be most cost effective to build the treatment cells in the highwall/ponded area.

Table 4: Water Chemistry of LR5

Date	gpm Flow	pH	Umhos /cm Cond	mg/L Acidity	lbs/day Acid Load	mg/ L Alk	mg/l Fe	lbs/day Fe Load	mg/L Al	mg/L Mn	mg/L SO4
3/13/2003	6.2	4	1660	130	9.716	0	2.16	0.1614	14.2	19.8	1091
4/24/2003	49.3	3.7	1900	162	96.277	0	0.77	0.4576	18.9	25.4	24
5/13/2003	19.6	3.8	2030	198	46.782	0	1.23	0.2906	14.7	23.2	1319
6/26/2003	51.6	3.7	1980	146	90.816	0	1.36	0.8460	21.1	24.4	1301
7/28/2003	25	3.7	1560	140	42.192	0	2.16	0.6510	13	20.9	1038
8/26/2003	20	3.6	2030	142	34.236	0	2.71	0.6534	15.8	23.8	1092
9/16/2003	27.5	3.6	1820	160	53.041	0	2.77	0.9183	13.6	23.1	1027
10/23/2003		3.7	1970	165		0	1.61		16.4	23.5	1121
12/4/2003		3.7	2000	150		0	2.1		17.2	24	1118
12/30/2003	110.6	3.9	1830	140	186.656	0	1.18	1.5732	13.9	19.4	893
1/29/2004		3.9	2290	132		0	8.56		12.9	21.2	1174
3/4/2004	38.8	3.8	1910	124	57.998	0	2.19	1.0243	12.2	21.5	901
Average	38.733	3.758	1915.000	149.083	68.635	0	2.400	0.731	15.325	22.517	1008.25
Max	110.600	4.000	2290.000	198.000	186.656	0	8.560	1.573	21.100	25.400	1319.00
Min	6.200	3.600	1560.000	124.000	9.716	0	0.770	0.1614	12.200	19.400	24
75% Con	50.499	3.800	1977.456	155.757	88.455	0	3.076	0.894	16.213	23.150	1119.89
90% Con	55.557	3.817	2004.304	158.626	96.974	0	3.367	0.964	16.595	23.422	1167.87

LR6

LR6 is a discharge that seeps out from a rock outcrop area and forms an impoundment before mixing with LR5. Through investigations, it is believed that reclamation will not stop the discharge, but would force it to come out somewhere else. It is most cost effective to treat the discharge in the existing impoundment and mix it with LR5.

Table 5: Water Chemistry of LR6

Date	gpm Flow	pH	Umhos /cm Cond	mg/L Acidity	lbs/day Acid Load	mg/L Alk	mg/l Fe	lbs/day Fe Load	mg/L Al	mg/L Mn	mg/L SO4
3/13/2003	2.2	3.5	2330	352	9.335	0	2.54	0.0674	43.7	37.5	1590
4/24/2003	12.7	3.5	3000	348	53.277	0	1.92	0.2939	42.3	45.7	2025
5/13/2003	12.7	3.5	2890	424	64.913	0	1.86	0.2848	36.1	41.7	1885
6/26/2003	19.6	3.5	2550	286	67.574	0	2.82	0.6663	42.6	40.2	1767
7/28/2003	22.5	3.4	2200	244	66.181	0	3	0.8137	30.4	32.4	1384
8/26/2003	12.5	3.3	2580	281	42.342	0	4.12	0.6208	31.1	37.6	1464
9/16/2003	7.5	3.4	2310	301	27.214	0	4.12	0.3725	27.7	38.2	1447
10/23/2003	19.6	3.5	2560	287	67.811	0	3.01	0.7112	30.7	38.4	1547
12/4/2003	14.8	3.5	2620	322	57.448	0	2.39	0.4264	32.4	38.2	1645
12/30/2003	28.2	3.6	2450	281	95.525	0	1.56	0.5303	29.1	35.1	963
1/29/2004		3.7	2760	266		0	3.94		40.9	44.6	1683
3/4/2004	10.8	3.6	2560	254	33.069	0	2.59	0.3372	29.5	36.4	1413
Average	14.827	3.500	2567.500	303.833	53.154	0.000	2.823	0.466	34.708	38.833	1567.750
Max	28.200	3.700	3000.000	424.000	95.525	0.000	4.120	0.814	43.700	45.700	2025.000
Min	2.200	3.300	2200.000	244.000	9.335	0.000	1.560	0.0674	27.700	32.400	963.000
75% Con	17.345	3.535	2645.252	320.644	61.404	0.000	3.112	0.543	36.715	40.084	1658.328
90% Con	18.428	3.550	2678.675	327.870	64.950	0.000	3.236	0.576	37.578	40.622	1697.264

LR10

LR10 is a tributary to Loop Run formed by seepage from the edge of an unreclaimed spoil area. At the point of discharge, it is flowing at approximately 10 gpm. The sample was collected near the confluence with Loop Run after numerous seeps/wet areas are collected into the channel. Walking down the channel, large iron seepage areas enter on the right side creating dead zones through the entire length, approximately 3000 ft. The discharges are laminar flow sheets with no distinct point of discharge. Two possibilities exist for treatment of this channel. The first would be to treat within the channel itself starting near the top. An alternating plan of settling ponds/limestone beds would be used through the valley. Another approach would be to construct treatment cells at the bottom of the channel in the flattened area. The channel enters a flat bottom of hemlocks and no further seepage enters. It is not the goal to restore the channel, but to treat it before it enters Loop Run.

Table 6: Water Chemistry of LR10

Date	gpm Flow	pH	Umhos /cm Cond	mg/L Acidity	lbs/day Acid Load	mg/ L Alk	mg/l Fe	lbs/day Fe Load	mg/L Al	mg/L Mn	mg/L SO4
3/13/2003	6.2	3.3	2610	200	14.948	0	7.5	0.5605	9.3	36.4	1641
4/24/2003	110.6	3.3	2710	190	253.319	0	7.57	10.0928	10.7	42.1	1928
5/13/2003	150.7	3.2	2680	206	374.231	0	5.32	9.6646	7.87	33.9	1509
6/26/2003	198.4	3.1	2750	177	423.326	0	5.7	13.6325	8.73	40.7	1686
7/28/2003		3.2	2300	167		0	5.95		7.82	31.4	1387
8/26/2003		3.1	4200	209		0	8.26		8.06	41	1827
9/16/2003		3.2	2630	208		0	7.08		6.9	37.3	1456
10/23/2003		3.3	2730	181		0	8.1		8.68	35.5	1559
12/4/2003		3.4	2620	198		0	9.66		9.3	34.9	1435
12/30/2003		3.5	2090	129		0	4.83		7.03	23.9	1001
1/29/2004		3.5	2580	163		0	7.86		10.1	35.7	1400
3/4/2004		3.4	1890	116		0	4.06		5.41	22	825
Average	116.475	3.292	2649.167	178.667	266.456	0.000	6.824	8.488	8.325	34.567	1471.167
Max	198.400	3.500	4200.000	209.000	423.326	0.000	9.660	13.633	10.700	42.100	1928.000
Min	150.700	3.100	1890.000	116.000	374.231	0.000	4.060	9.665	5.410	22.000	825.000
75% Con	163.529	3.337	2835.003	188.813	371.286	0.000	7.371	11.695	8.813	36.645	1574.821
90% Con	183.757	3.357	2914.889	193.174	416.349	0.000	7.606	13.073	9.022	37.539	1619.379

LR11

LR11 is a channel that forms from seepage flowing through a moss/wetland area. The flow is less than 10 gpm and could be diverted into the systems treating LR10.

Table 7: Water Chemistry of LR11

Date	gpm Flow	pH	Umhos /cm Cond	mg/L Acidity	lbs/day Acid Load	mg/L Alk	mg/l Fe	lbs/day Fe Load	mg/L Al	mg/L Mn	mg/L SO4
3/13/2003	7.6	3.6	2370	110	10.078	0	2.15	0.1970	3.51	31.2	1558
4/24/2003	5	3.8	2220	78	4.701	0	1.54	0.0928	2.89	26.9	1549
5/13/2003	7.6	3.7	2300	98	8.978	0	1.11	0.1017	2.12	26.9	1373
6/26/2003	22.2	3.74	2270	67	17.930	0	1.33	0.3559	2.63	27.5	1461
7/28/2003	12.7	3.6	1580	66	10.104	0	1.3	0.1990	1.15	18.7	916
8/26/2003	7.6	3.5	2490	85	7.787	0	3.69	0.3381	2.23	32.3	1405
9/16/2003	19.6	3.5	2080	100	23.627	0	2.66	0.6285	1.59	28.6	1112
10/23/2003	14.8	3.3	2360	80	14.273	0	1.8	0.3211	2.51	26.1	1290
12/4/2003	14.8	3.7	2520	100	17.841	0	1.36	0.2426	3.04	26.8	1344
12/30/2003	25.1	4.2	2700	35	10.590	2	0.95	0.2874	2.36	22.3	1044
1/29/2004											
3/4/2004		3.8	2040	73		0	0.97		2.09	23.1	985
Average	13.700	3.676	2266.364	81.091	12.591	0.182	1.715	0.276	2.375	26.400	1276.091
Max	25.100	4.200	2700.000	110.000	23.627	2.000	3.690	0.628	3.510	32.300	1558.000
Min	5	3.300	1580.000	35.000	4.701	0.000	0.950	0.0928	1.150	18.700	916.000
75% Con	16.208	3.756	2369.386	88.431	14.676	0.391	2.004	0.333	2.604	27.751	1354.737
90% Con	17.286	3.790	2413.672	91.587	15.572	0.481	2.129	0.357	2.702	28.331	1388.545

LR12

LR12 is a discrete channel that forms on the edge of a large iron mat area. This channel is created by a spring/seep that surfaces in an area of moss. The channel flows down the hillside collecting some of the seepage from the nearby iron mat.

Table 8: Water Chemistry LR12

Date	gpm Flow	pH	Umhos /cm Cond	mg/L Acidity	lbs/day Acid Load	mg/L Alk	mg/l Fe	lbs/day Fe Load	mg/L Al	mg/L Mn	mg/L SO4
3/13/2003		3.5	2400	98		0	2.6		2.7	26.6	1529
4/24/2003	17.1	3.5	2280	80	16.491	0	2.31	0.4762	2.52	28	1578
5/13/2003	35.1	3.5	2410	114	48.236	0	1.56	0.6601	1.96	25	1393
6/26/2003	28.2	3.4	2350	80	27.196	0	2.24	0.7615	1.96	26.1	1527
7/28/2003	35.1	3.4	1850	83	35.119	0	2.66	1.1255	1.49	20.1	1177
8/26/2003	35.1	3.3	2540	90	38.081	0	3.37	1.4259	2.07	29.4	1345
9/16/2003	35.1	3.4	2320	112	47.390	0	3.15	1.3328	1.77	26.6	1301
10/23/2003	29.5	3.5	2450	87	30.939	0	3.88	1.3798	2.29	27.3	1317
12/4/2003	31.5	3.6	2350	96	36.454	0	3.31	1.2569	2.69	29.5	1298
12/30/2003	47.1	3.7	2010	72	40.880	0	1.93	1.0958	1.88	17.5	985
1/29/2004											
3/4/2004	51.6	3.6	2090	71	44.164	0	1.68	1.0450	1.91	20.6	1004
Average	34.540	3.491	2277.273	89.364	36.495	0.000	2.608	1.056	2.113	25.155	1314.000
Max	51.600	3.700	2540.000	114.000	48.236	0.000	3.880	1.426	2.700	29.500	1578.000
Min	17.1	3.300	1850.000	71.000	16.491	0.000	1.560	0.4762	1.490	17.500	985.000
75% Con	38.031	3.530	2349.448	94.388	40.044	0.000	2.868	1.174	2.248	26.540	1382.675
90% Con	39.532	3.547	2380.474	96.548	41.569	0.000	2.980	1.224	2.306	27.136	1412.196

LR13

LR13 is a weir and a series of pipes used to collect flow from a large iron mat/seepage area. LR12 is on the upstream side of this area. The contour for this site is at an approximate 3-4% slope. It would be possible to ditch at the top of the contour to capture flow before it flows as sheets down the hillside creating a dead zone. The area is approximately 135 yards across and 110 yards from the top tree line to the bottom of the dead zone. There is a terrace area at this mark above the stream. It would be possible to build the treatment system horizontally across the hillside, terrace a middle stabilizing section, and then build another horizontal series of cells. There is an old logging road above this area that could be modified for access. As part of the restoration plan, the road to this site is being surveyed.

Table 9: Water Chemistry of LR13

Date	gpm Flow	pH	Umhos /cm Cond	mg/L Acidity	lbs/day Acid Load	mg/L Alk	mg/l Fe	lbs/day Fe Load	mg/L Al	mg/L Mn	mg/L SO4
3/13/2003	9.1	3.4	2120	90	9.873	0	5.92	0.6494	4.74	19	1298
4/24/2003	17.88	3.2	2510	102	21.985	0	2.47	0.5324	3.56	25.2	1691
5/13/2003	19.99	3.2	2360	126	30.363	0	1.89	0.4554	2.67	21.7	1302
6/26/2003	13.2	3.1	2370	107	17.026	0	5.34	0.8497	2.26	20.4	1475
7/28/2003	14.1	3.2	1960	103	17.507	0	3.49	0.5932	2.06	16.5	1116
8/26/2003	27.1	3.1	2670	125	40.836	0	6.74	2.2019	2.93	26.7	1478
9/16/2003	12.7	3.2	2190	124	18.984	0	4.13	0.6323	2.27	19.9	1071
10/23/2003	10.8	3.3	2450	103	13.410	0	2.77	0.3606	3.06	21.1	1207
12/4/2003	10.8	3.4	2510	104	13.540	0	2.86	0.3723	4.01	21.6	1370
12/30/2003	25.1	3.5	2230	85	25.719	0	1.25	0.3782	2.77	16.2	1111
1/29/2004											
3/4/2004		3.9	1050	51		0	1.23		4.48	10.2	395
Average	16.077	3.318	2220.000	101.818	20.924	0.000	3.463	0.703	3.165	19.864	1228.545
Max	27.100	3.900	2670.000	126.000	40.836	0.000	6.740	2.202	4.740	26.700	1691.000
Min	9.1	3.100	1050.000	51.000	9.873	0.000	1.230	0.361	2.060	10.200	395.000
75% Con	18.344	3.399	2371.710	109.300	24.296	0.000	4.111	0.902	3.482	21.424	1344.291
90% Con	19.318	3.433	2436.926	112.517	25.746	0.000	4.390	0.988	3.619	22.094	1394.046

LR14

LR14 is another large laminar seepage area down the hillside. It is related to LR15 and LR16. Again a ditch along the top contour could be used to capture the seepage into one series of treatment cells. It appears to be only slightly steeper than the area for LR13 and the same idea of treatment could be used. A horizontal series of treatment cells, a stabilizing bench, and another series of horizontal cells could be used for treatment.

Table 10: Water Chemistry for LR14

Date	gpm Flow	pH	Umhos /cm Cond	mg/L Acidity	lbs/day Acid Load	mg/L Alk	mg/l Fe	lbs/day Fe Load	mg/L Al	mg/L Mn	mg/L SO4
3/13/2003	44.4	3.7	2060	74	39.607	0	1.32	0.7065	3.96	21.3	1308
4/24/2003	60.2	3.7	2540	84	60.959	0	1.42	1.0305	4.55	25.9	1800
5/13/2003	14.8	3.6	2510	100	17.841	0	1.34	0.2391	3.36	21.4	1549
6/26/2003	47.3	3.3	2670	118	67.283	0	4.23	2.4119	5.03	25.5	1784
7/28/2003	47.8	3.5	1970	71	40.912	0	1.55	0.8931	2.22	17.6	1218
8/26/2003	41.8	3.4	2480	80	40.311	0	3.49	1.7586	3.14	25.7	1503
9/16/2003	50.4	3.5	2350	93	56.503	0	2.27	1.3792	2.41	21.9	1309
10/23/2003	56.6	3.6	2520	78	53.220	0	1.97	1.3441	3.55	22.9	1364
12/4/2003	50.4	3.7	2410	84	51.035	0	1.67	1.0146	3.99	22.7	1361
12/30/2003	81.4	3.8	2200	75	73.595	0	1.29	1.2658	3.54	17.7	1193
1/29/2004		3.9	2470	82		0	2.05		4.37	20.5	1378
3/4/2004	51.6	3.8	2180	60	37.322	0	0.95	0.5909	3.09	17.4	1074
Average	49.700	3.625	2363.333	83.250	48.962	0.000	1.963	1.149	3.601	21.708	1403.417
Max	81.400	3.900	2670.000	118.000	73.595	0.000	4.230	2.412	5.030	25.900	1800.000
Min	14.800	3.300	1970.000	60.000	17.841	0.000	0.950	0.239	2.220	17.400	1074.000
75% Con	55.168	3.684	2434.533	88.224	54.443	0.000	2.285	1.354	3.878	22.727	1477.158
90% Con	57.518	3.709	2465.139	90.363	56.799	0.000	2.424	1.442	3.998	23.165	1508.857

LR15

LR15 is an area related to LR14. The laminar flow runs down the hillside and does not discharge at any discrete location. The weir is on the bottom of the hillside on the floodplain of Loop Run where the seepage is collected in a discrete channel.

Table 11: Water Chemistry of LR15

Date	gpm Flow	pH	Umhos /cm Cond	mg/L Acidity	lbs/day Acid Load	mg/L Alk	mg/l Fe	lbs/day Fe Load	mg/L Al	mg/L Mn	mg/L SO4
3/13/2003	198.4	3.4	2820	170	406.584	0	4.74	11.3365	11.8	32.2	1801
4/24/2003	142.1	3.4	4290	170	291.208	0	3.96	6.7834	11.2	34.5	2005
5/13/2003	10.8	3.3	4340	224	29.163	0	4.21	0.5481	9.9	33	2712
6/26/2003	142.1	3.3	2970	150	256.948	0	3.5	5.9955	11.9	34.2	2012
7/28/2003	142.1	3.2	2670	167	286.069	0	3.87	6.6293	9.36	28.2	1763
8/26/2003	142.1	3.2	4610	163	279.217	0	5.36	9.1816	12.1	35.7	1993
9/16/2003	125.8	3.3	2880	192	291.167	0	5.34	8.0981	10.1	33.8	1953
10/23/2003	136.5	3.6	3050	159	261.631	0	6.23	10.2513	11.1	31.7	1549
12/4/2003	150.7	3.5	3030	174	316.098	0	6.05	10.9908	10.6	33	2474
12/30/2003	198.4	3.6	2750	134	320.484	0	3.99	9.5428	9.57	27.4	1522
1/29/2004	136.5	3.6	2950	142	233.658	0	4.29	7.0591	10.1	28.8	1574
3/4/2004	142.1	3.4	2780	142	243.244	0	4.28	7.3316	8.18	28.3	1432
Average	138.967	3.400	3261.667	165.583	267.956	0.000	4.652	7.812	10.493	31.733	1899.167
Max	198.400	3.600	4610.000	224.000	406.584	0.000	6.230	11.337	12.100	35.700	2712.000
Min	10.800	3.200	2670.000	134.000	29.163	0.000	3.500	0.548	8.180	27.400	1432.000
75% Con	154.434	3.449	3496.557	173.733	297.113	0.000	4.948	8.777	10.884	32.677	2027.538
90% Con	161.083	3.470	3597.530	177.236	309.646	0.000	5.075	9.191	11.052	33.083	2082.721

LR16

LR16 is a channel which forms on the bottom of the floodplain collecting the flow from the above hillside. This area is more wooded than LR14 and LR15. There is not space on the bottom floodplain to build treatment cells. Another possibility for treatment of LR14, LR15, and LR16 would be to collect flows into a conveyance system and begin treatment in the flattened area above LR16 if the hill would be considered too steep for equipment or construction. There would be more ditching needed, but an unlimited flattened area would exist. There is an old logging road near LR16, but it is fairly wet.

Table 12: Water Chemistry of LR16

Date	gpm Flow	pH	Umhos /cm Cond	mg/L Acidity	lbs/day Acid Load	mg/L Alk	mg/l Fe	lbs/day Fe Load	mg/L Al	mg/L Mn	mg/L SO4
3/13/2003	25.1	3.4	2520	186	56.279	0	4.31	1.3041	13.6	36.6	1548
4/24/2003	28.2	3.3	2800	230	78.187	0	3.58	1.2170	15.9	41.3	2008
5/13/2003	103.5	3.2	2910	258	321.899	0	3.23	4.0300	11.9	33.8	1743
6/26/2003	35.1	3.2	2710	186	78.701	0	4.81	2.0352	14	38.8	1780
7/28/2003		3.2	2370	182		0	4.29		10.6	31.3	1529
8/26/2003	31.5	3.2	4070	203	77.084	0	7.84	2.9771	13.2	43	1863
9/16/2003	31.5	3.2	2510	215	81.641	0	5.13	1.9480	11	37	1486
10/23/2003	32.4	3.3	2870	190	74.209	0	3.39	1.3241	12.9	37.3	1306
12/4/2003	31.5	3.4	2740	218	82.780	0	2.94	1.1164	12.7	39.4	1821
12/30/2003	56.3	3.9	3040	56	38.006	0	2.16	1.4660	9.88	28.5	1199
1/29/2004											
3/4/2004	83.8	3.4	2330	143	144.457	0	2.21	2.2325	8.84	27	1120
Average	45.890	3.336	2806.364	187.909	103.325	0.000	3.990	1.965	12.229	35.818	1582.091
Max	103.500	3.900	4070.000	258.000	321.899	0.000	7.840	4.030	15.900	43.000	2008.000
Min	25.1	3.200	2330.000	56.000	38.006	0.000	2.160	1.116	8.840	27.000	1120.000
75% Con	55.688	3.408	2971.508	206.267	132.931	0.000	4.546	2.302	12.935	37.598	1682.146
90% Con	59.900	3.439	3042.499	214.159	145.657	0.000	4.785	2.447	13.238	38.363	1725.157

LR17

LR17 is a channel formed by seepage along the bottom toe of spoil in the floodplain area. Bright iron water meanders through a natural wetland area before entering Loop Run. There is approximately 25 yards of space between the hillside and Loop Run for treatment. A main concern would be access and flooding of Loop Run. The area for treatment narrows near the weir. There is a wetland area downstream of the channel, where settling basins could be built, but again it is in the floodplain.

Table 13: Water Chemistry of LR17

Date	gpm Flow	pH	Umhos /cm Cond	mg/L Acidity	lbs/day Acid Load	mg/L Alk	mg/l Fe	lbs/day Fe Load	mg/L Al	mg/L Mn	mg/L SO4
3/13/2003	42.8	4.5	1540	62	31.989	8	3.06	1.5788	4.79	20.4	948
4/24/2003		4.2	2030	58		4	5.42		3.38	24.3	1341
5/13/2003	31.5	4	1970	90	34.175	0	4.64	1.7619	3.48	20.1	1144
6/26/2003	19.6	3.8	1960	50	11.814	0	4.24	1.0018	2.36	20.4	1255
7/28/2003	56.3	3.9	1540	57	38.685	0	4.89	3.3188	2.78	17.7	1029
8/26/2003		3.7	2390	89		0	4.58		3.19	30.1	1511
9/16/2003		3.9	1690	77		0	3.98		2.76	22.4	838
10/23/2003		3.9	2080	65		0	5.26		1.95	21.6	1097
12/4/2003		4.9	2130	70		10	8.74		2.02	20.7	1284
12/30/2003		5	3160	34		6	7.26		2.73	16.9	876
1/29/2004											
3/4/2004		4.6	1460	47		6	3.89		3.17	14.3	653
Average	37.550	4.218	1995.455	63.545	29.166	3.091	5.087	1.915	2.965	20.809	1088.727
Max	56.300	5.000	3160.000	90.000	38.685	10.000	8.740	3.319	4.790	30.100	1511.000
Min	19.600	3.700	1460.000	34.000	11.814	0.000	3.06	1.002	1.950	14.300	653.000
75% Con	46.571	4.377	2163.058	69.532	36.010	4.420	5.649	2.485	3.239	22.238	1175.936
90% Con	50.449	4.445	2235.107	72.105	38.952	4.992	5.890	2.730	3.358	22.853	1213.425

LR18

LR18 is a point similar to LR17, but further downstream. There is seepage along the bottom of the floodplain area with about 25 yards between the hillside and stream. Above is an old road which could potentially be dug out for additional space.

Table 14: Water Chemistry for LR18

Date	gpm Flow	pH	Umhos /cm Cond	mg/L Acidity	lbs/day Acid Load	mg/L Alk	mg/l Fe	lbs/day Fe Load	mg/L Al	mg/L Mn	mg/L SO4
3/13/2003	72	4.8	1220	16	13.887	8	0.35	0.3038	2.06	8.22	710
4/24/2003	38.8	4.6	1540	28	13.096	6	0.77	0.3601	3.48	9.8	999
5/13/2003	19.6	4.5	1550	40	9.451	8	0.91	0.2150	2.64	8.08	862
6/26/2003	22.2	4.5	1510	27	7.226	6	0.9	0.2409	2.73	8.59	881
7/28/2003	35.1	4.4	1370	38	16.079	5	0.78	0.3300	2.46	9.78	873
8/26/2003	14.8	4.2	1780	32	5.709	4	3.64	0.6494	3.4	12.4	1015
9/16/2003	28.2	4.4	1490	49	16.657	6	1.01	0.3433	2.08	13.7	738
10/23/2003	31.5	4.5	1650	34	12.911	7	0.84	0.3190	2.71	10.2	792
12/4/2003	35.1	4.7	1550	28	11.847	8	1.11	0.4697	2.55	8.12	796
12/30/2003	66.5	5	2610	25	20.041	6	0.52	0.4169	1.96	6.7	387
1/29/2004											
3/4/2004	96.6	4.6	110	17	19.796	5	0.28	0.3261	1.41	5.52	440
Average	41.855	4.564	1489.091	30.364	13.336	6.273	1.010	0.361	2.498	9.192	772.091
Max	96.600	5.000	2610.000	49.000	20.041	8.000	3.640	0.649	3.480	13.700	1015.000
Min	14.800	4.200	110.000	16.000	5.709	4.000	0.280	0.215	1.410	5.520	387.000
75% Con	50.712	4.638	1690.317	33.745	14.958	6.740	1.326	0.403	2.710	10.011	841.908
90% Con	54.519	4.671	1776.818	35.199	15.655	6.941	1.462	0.420	2.802	10.363	871.920

LR19

LR19 is a tributary to Loop Run. A quick aquatic assessment was conducted. Caddisflies and mayflies were found on all overturned rocks. This tributary is marginal in quality and contains an aquatic community to repopulate Loop Run.

Table 15: Water Chemistry of LR19

Date	gpm Flow	pH	Umhos /cm Cond	mg/L Acidity	lbs/day Acid Load	mg/L Alk	mg/l Fe	lbs/day Fe Load	mg/L Al	mg/L Mn	mg/L SO4
3/13/2003		5.2	300	8		6	0.16		0.36	0.55	130
4/24/2003		5.5	484	2		8	0.4		0.33	0.43	238
5/13/2003	28.2	5.2	435	8	2.720	8	0.12	0.0408	0.33	0.41	187
6/26/2003		4.1	486	8		1	0.27		0.28	0.47	229
7/28/2003		5.5	397	16		7	0.12		0.3	0.54	180
8/26/2003		5.7	671	7		8	0.44		0.29	0.86	344
9/16/2003		5.6	503	19		7	0.27		0.18	0.58	225
10/23/2003		5.7	519	13		8	0.14		0.16	0.54	201
12/4/2003		5.6	482	2		8	0.23		0.22	0.43	203
12/30/2003		5.1	388	27		7	0.18		0.46	0.51	146
1/29/2004		5.6	526	23		8	0.27		0.26	0.36	221
3/4/2004		4.9	331	9		5	0.06		0.41	0.53	111
Average	28.200	5.308	460.167	11.833	2.720	6.750	0.222	0.041	0.298	0.518	201.250
Max	28.200	5.700	671.000	27.000	2.720	8.000	0.440	0.041	0.460	0.860	344.000
Min	28.200	4.100	300.000	2.000	2.720	1.000	0.060	0.041	0.160	0.360	111.000
75% Con		5.461	493.065	14.470	0.000	7.431	0.260	0.000	0.328	0.560	221.371
90% Con		5.527	507.208	15.604	0.000	7.724	0.276	0.000	0.340	0.578	230.020

LR23

LR23 is the downstream sample location on the main stem of Loop Run below all discharges.

Table 16: Water Chemistry of LR23

Date	gpm Flow	pH	Umhos /cm Cond	mg/L Acidity	lbs/day Acid Load	mg/L Alk	mg/l Fe	mg/L Al	mg/L Mn	mg/L SO4
3/13/2003		4	970	44		0	1.04	3.74	10.3	495
4/24/2003	1827.71	3.6	1870	110	2423.594	0	1.77	9.67	22.4	1368
5/13/2003	2108	3.6	1550	100	2541.151	0	1.3	5.72	16.4	884
6/26/2003	937	3.5	190	97	1095.648	0	1.92	8.51	22.5	1115
7/28/2003	1935	3.6	1330	78	1819.430	0	2.15	5.63	15.1	793
8/26/2003	1110	3.4	2270	115	1538.795	0	2.91	9.18	27.9	1184
9/16/2003	1777	3.5	1590	113	2420.615	0	1.99	5.55	19	787
10/23/2003	1444	3.7	1760	97	1688.491	0	2.32	7.41	20.3	877
12/4/2003	1379	3.7	1710	100	1662.356	0	4.55	7.47	18.7	881
12/30/2003	2962	4.3	2370	37	1321.133	3	1.42	6.17	13.5	568
1/29/2004		4	1900	95		0	2.67	9.34	19.5	1033
3/4/2004	2777	3.9	1040	43	1439.475	0	1	3.72	9.87	402
Average	1825.671	3.733	1545.833	85.750	1795.069	0.250	2.087	6.843	17.956	865.583
Max	2962.000	4.300	2370.000	115.000	2541.151	3.000	4.550	9.670	27.900	1368.000
Min	937.000	3.400	190.000	37.000	1095.648	0.000	1.000	3.720	9.870	402.000
75% Con	2066.281	3.821	1745.615	95.216	1978.103	0.538	2.413	7.532	19.699	960.412
90% Con	2169.713	3.859	1831.495	99.285	2056.784	0.661	2.553	7.828	20.449	1001.176

Field Quarterly Sample Locations

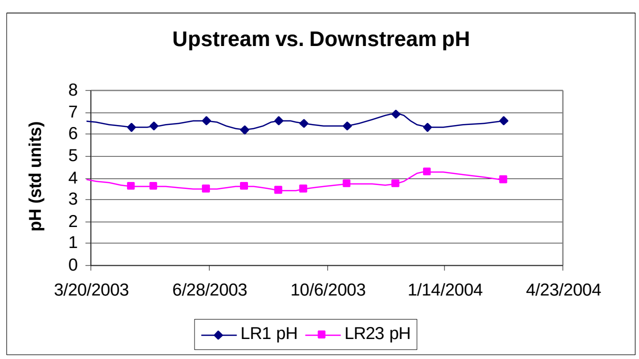
Upon initial reconnaissance, points were chosen in the watershed as being non significant. These sites were sampled and tested in the field quarterly. These are sites such as impoundments, stream mixing, and non-polluted tributaries.

Table 17: Average Chemistry of Quarterly Sampling Points

Sample Location	Description	pH	Cond	Total Acidity	Alkalinity	Iron
LR3	Mixing of LR1 and LR2	5.11	220	34.2	13.68	0.1
LR4	UT to Loop Run near headwaters	4.84	278	41.04	13.68	0.1
LR20	Impoundment, no water leaves	4.43	198	54.72	0	0.1
LR21	Impoundment, no water leaves	3.96	372	118.32	0	0.1
LR22a	Impoundment, no water leaves	3.76	440	157.32	0	1.5

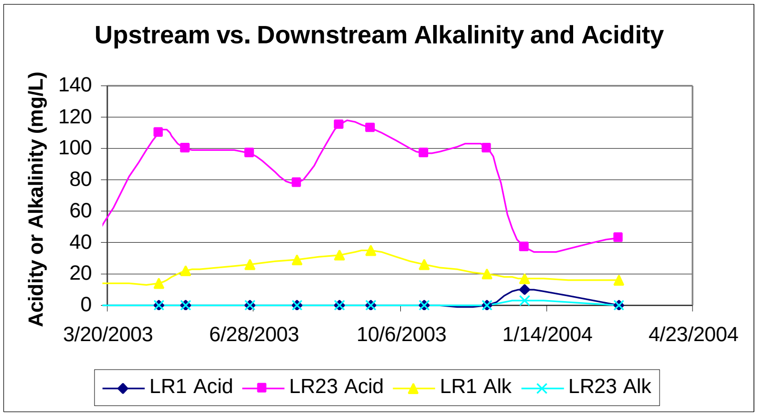
Comparison of Upstream (LR1) vs. Downstream (LR23)

The following graphs represent the change in water quality from the upstream to the downstream sample location. LR23 clearly shows degradation from the mine discharges entering along the middle section of Loop Run.

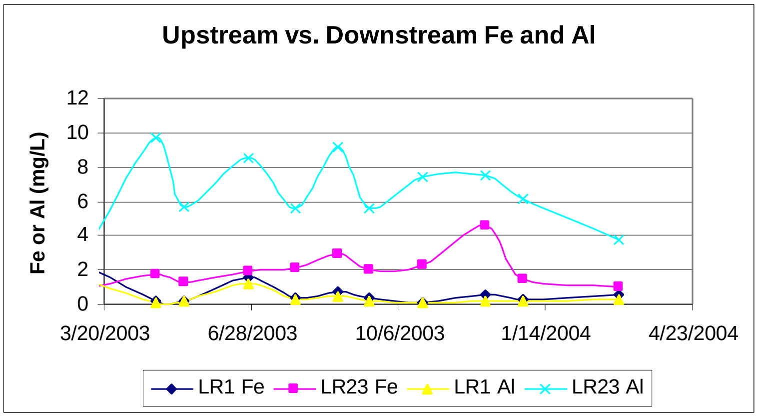


This graph shows the average upstream pH to be between 6 and 7, while the downstream pH ranges between 3 and 4. This shows the impact of the mine drainage discharges entering Loop Run.

This graph represents the comparison of alkalinity and acidity on the upstream versus downstream sample. The trends are reversed as would be expected from the mine drainage impact. The upstream sample has alkalinity present with minimal acidity, while the downstream sample has no alkalinity and acidity levels ranging from 40 to 120 mg/L.

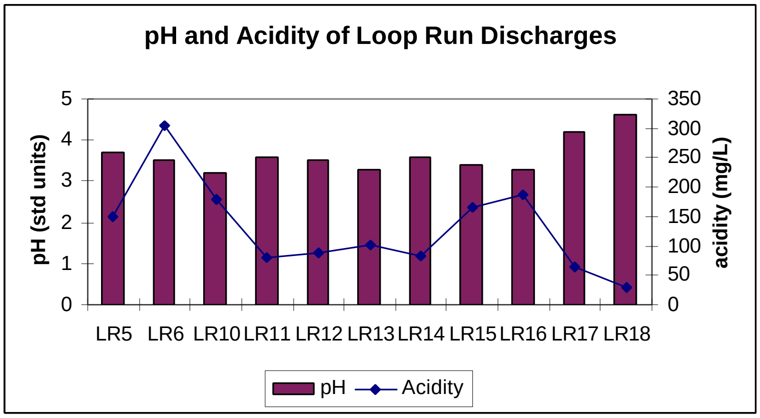


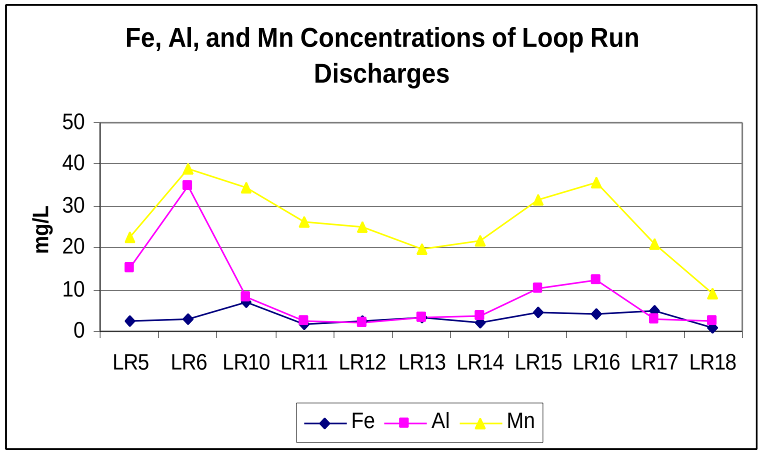
This graph represents the changing quality of iron and aluminum from the upstream to downstream sample. The metal concentrations in the headwaters are minimal. The downstream sample is impacted by metals from the mine drainage discharges entering along its length.



Comparison of Discharges

This graph represents the pH and acidity of the Loop Run discharges moving downstream. The pH of the discharges remains fairly consistent ranging from pH 3.0 to 4.0. The acidity varies slightly more with LR6 having the greatest contamination. This graph clearly shows that all discharges are of poor quality and therefore have an adverse affect on the water quality of Loop Run. Treatment is necessary for the overall restoration of the stream.





This graph represents the Fe, Al, and Mn of the Loop Run discharges moving downstream. The most significant pollution comes from the high manganese concentrations. Manganese does not directly impact the aquatic life in the stream, but adds to the acidity concentrations. It will be treated using limestone beds. Both iron and aluminum are of moderate levels, and can be treated using passive technology. The worst site is LR6, with high aluminum levels. This will be taken into consideration with both the design and O&M of this treatment system. Again, it is clear that all discharges are adding to the pollution loading of Loop Run and treatment is necessary for restoration efforts.

AMD Treatment Methods:

Through the years, many treatments have been developed for AMD remediation and currently there are a number of organized efforts in Pennsylvania using both active and passive treatment methods on a watershed scale. Active treatment methods incorporate the use of mechanized procedures for the addition of alkaline materials and require constant monitoring and maintenance. Basic chemicals are used as additives to increase the pH and cause the precipitation of metals, such as Fe, Mn, and Al. The chemicals commonly used are Ca(OH)2 (hydrated lime), NaOH (caustic soda), NH_3 (ammonia), CaO (pebble quicklime) and Na_2CO_3 (soda ash) (Robb and Robinson, 1995). The chemicals used on a particular site depend on mine drainage characteristics and site accessibility. Hydrated lime is commonly used, but is hydrophobic and requires mixing. Pebble quicklime (CaO) is utilized at sites where it is usually dissolved by a water wheel arrangement. Soda ash, in the form of briquettes, is used in remote areas with low flows and low acidity. Caustic soda is also used in remote areas with low flows. Liquid caustic soda is capable of treating high acidity and high Mn because it raises the pH quickly, but it is expensive and dangerous to handle. Another potentially dangerous chemical used less frequently is ammonia. It must be handled carefully and is stored as a liquid. Ammonia can raise the pH above 9.2, but may have direct negative impacts on the biota of the receiving streams (Skousen and Ziemkiewicz, 1995).

Other active treatment methods include dissolved air flotation and ion exchange devices, flocculants, coagulants, and oxidants (Skousen and Ziemkiewicz, 1995). Active methods are successful, but expensive. It is not uncommon for water treatment costs to exceed $200,000 per year at AMD sites using active treatment. Another concern is the large volume of sludge produced from the precipitation of metals. Disposal costs for the sludge add to the cost of chemical treatment. Active methods may also cause environmental damage because potentially harmful chemicals are used. The high cost and possible side effects of active treatment can be avoided by the use of passive treatment systems.

Passive treatment systems, which require only limited maintenance, are the alternative approach to active treatment methods. They require no input of manufactured chemicals and have a lower operation and maintenance cost. A downside is that they do require longer retention times and larger treatment areas (Hedin et al., 1994). Page C5 shows the evolution of passive treatment technology since the early 1980s. Passive treatment systems were first designed after it was observed that natural wetland systems in the path of AMD had some positive effects. The first passive systems described were natural *Sphagnum* wetlands that were improving AMD as discharges flowed through them. The first constructed wetlands were small and planted with cattails (*Typha latifolia)*. They were designed to encourage oxidation processes to precipitate unwanted metals and in turn increase the pH (Robb and Robinson, 1995).

Constructed wetlands function by precipitating metal hydroxides, forming metal sulfides, and adsorbing small amounts of metals to the plant community (Skousen and Ziemkiewicz, 1995).

Two types of wetlands are constructed, aerobic and anaerobic. Aerobic wetland systems are designed to encourage metal precipitation through oxidation processes and are therefore normally shallow, vegetated, and have surface flow predominating (Robb and Robinson, 1995). Anaerobic wetland systems require that the mine water flow through an organic layer under anaerobic conditions. The organic material most commonly used is spent mushroom compost. This organic material must contain sulfate-reducing bacteria for metal sulfide precipitates to form (Robb and Robinson, 1995).

Both vegetation and bacteria are vital to wetland treatment success. Wetland plant species have many roles in mine drainage treatment. They include substrate consolidation, metal accumulation, stimulation of microbial activity and improve the aesthetics of the site. Constructed wetlands can also provide valuable wildlife habitat, for animals such as reptiles and amphibians. Plants may also serve as a food source. Sulfate reducing bacteria, such as *Desulfovibrio* and *Desulfotomaculum*, play a major role by increasing the pH and encouraging metal precipitation. It has been shown that *Desulfovibrio* are most effective at a pH > 4.5 so an important aspect of anaerobic wetland treatment is maintaining the pH within the organic layer (Nawrot and Klimstra, 1990). Sulfate reducers exist in the absence of oxygen and are only found in the deeper parts of the organic layer where they are able to perform their function of sulfate reduction and alkalinity production. Treatment efficiencies of these microbial dependent wetlands show trends of seasonal variation. The decrease in treatment efficiency may be due to biological functions slowing with decreasing temperatures (Kepler, 1990).

These bacteria utilize the organic substrate as a carbon source and use sulfate as an electron acceptor in the following reactions:

$$SO_4^{2-} + 2\ CH_2CHOHCOO^- + 4\ H^+ \rightarrow H_2S + 2\ CH_3COOH + 2\ H_2CO_3 \quad (1)$$

SO42- + CH3OO- + 3 H+ → H2S + 2 H2CO3 (2)

SO42- + 2 CH3CHOHCOO- +3 H+ → 3H2S + 6 H2CO3 (3)

Sulfate reducing bacteria cannot break down complex organic substrates so they rely mainly on fermenting bacteria to provide substrates like acetate and lactate from larger organic molecules (Cork and Cusanovich, 1979). Plants aid in maintaining these bacterial communities by providing attachment sites and a continual supply of organic matter (Skousen and Ziemkiewicz, 1995).

Another type of passive treatment technology is an anoxic limestone drain (ALD). The Tennessee Division of Water Pollution Control in 1988 first built prototype ALDs. At the same time, the Tennessee Valley Authority (TVA) personnel found that AMD from a coal refuse dam was being neutralized by calcium carbonate limestone in an old road buried beneath the dam (Brodie et al., 1993). In an ALD, alkalinity is produced when AMD contacts limestone in an anoxic environment producing bicarbonate alkalinity. ALDs consist of a shallow limestone filled trench, sealed from the atmosphere, through which the AMD is channeled. Limestone with greater than 90% $CaCO_3$ is used to produce the greatest amount of alkalinity (Brodie et al., 1993). The limestone layer is often covered with plastic or geotextile fabric. Clay soil is then placed over the plastic or fabric followed by a covering of a heavy soil, and then vegetated. The amount of limestone used is determined by the flow and loading of the AMD and desired longevity for the system. Usually, extra limestone is employed to ensure a comfortable safety factor for longevity. The use of an oxidation basin immediately after the ALD allows for precipitation of the metals (Brodie et al., 1993).

Three other criteria are followed when constructing ALDs. The first is to keep out any organic matter that may allow microorganisms to grow and coat the limestone. The second is that larger limestone (1"-6") should be used to maintain flow in case plugging occurs due to metal precipitation. Finally, oxygen should be kept out of the drain to deter metal precipitates from forming (Skousen and Ziemkiewicz, 1995). ALDs have been found to raise pH and introduce as much as 300 mg/l of bicarbonate alkalinity as shown by the following equations:

CaCO3 (s) + 2 H+ ←→ Ca2+ + H2CO3- (1)

CaCO3 (s) + H2CO3- ←→ Ca2+ + 2 HCO3- (2)

CaCO3 (s) + H2O ←→ Ca2+ + HCO3- + OH- (3)

The rate of calcium dissolution is dependent on carbon dioxide partial pressure. Generally, the rate of calcium dissolution will increase as the partial pressure increases (Plummer et al., 1979).

As the water leaves the ALD and is exposed to oxygen, the increased pH promotes metal precipitation and the bicarbonate alkalinity neutralizes the acidity produced by metal hydrolysis (Hedin and Watzlaf, 1994). Dissolved oxygen (DO) concentration is a limiting factor in the utility of ALDs. A DO level of less than 1.0 mg/l is recommended to ensure that Fe^{3+} will not precipitate, coating the limestone or clogging the system (Kepler and McCleary, 1994). Al^{3+}, however, can precipitate at a pH > 4.5 in the absence of oxygen, therefore clogging the system even in the absence of oxygen (Kepler and McCleary, 1994). ALDs are often used in combination with anaerobic constructed wetlands and vertical flow wetlands, which are also called successive alkalinity producing systems (SAPS) in the literature.

Vertical flow wetlands are being used on mine sites for the treatment of AMD (page C6 and C7). It is a newer technology that has shown great success. Vertical flow wetlands combine ALDs and anaerobic wetlands into one integrated system. Vertical flow is promoted through rich organic wetland substrates followed by a limestone bed (Kepler and McCleary, 1994). Most systems are constructed as ponds lined with 65-85 cm of limestone on which approximately 65 cm of spent mushroom compost is spread. To maintain reducing conditions within the organic layer, at least 85 cm of compost is recommended (Demchak, et al. 2001). On top of the compost layer is freestanding water with a depth of 40-255 cm (Skousen and Ziemkiewicz, 1995). Perforated pipes under the limestone layer collect the flow. Various piping patterns are used from a minimal approach where only 2-3 pipes are placed lengthwise through the system, to a maximal approach where piping is placed in a grid-like pattern on 5' or 10' centers. Demchak et al. recommends the use of increased piping to insure preferential flow does not occur.

Vertical flow wetlands add alkalinity both through bacterial sulfate reduction and limestone dissolution. Bacterial-mediated sulfate reduction occurs in the organic layer. Bacteria oxidize organic compounds using sulfate and release hydrogen sulfide and bicarbonate. The sulfate reduction directly affects concentrations of dissolved metals by raising alkalinity and providing the conditions necessary for precipitating them as metal sulfides (Skousen and Ziemkiewicz, 1995). Metals precipitating in the system may decrease the lifespan. Flushing the wetlands may be a solution to increasing the treatment success and may aid in the prevention of clogging. Acidic conditions may also be created from reactions involving H_2S, including $H_2S \rightarrow H^+ + HS^-$ and $Fe^{2+} + HS^- \rightarrow FeS + H^+$. When the mine water enters the organic layer containing dissolved Fe^{3+}, dissolved O_2, or precipitated Fe and Mn oxides, the H_2S is oxidized and mineral acidity is affected (Hedin et al., 1994). As the H_2S levels increase, the acidity decreases raising pH levels. The amount of H_2S produced can be qualitatively detected by both the odor of the gas and the rich black color of the organic layer which can be an indicator of successful treatment within the wetland (Nawrot and Klimstra, 1990).

Another source of bicarbonate in vertical flow wetlands is attributed to dissolution of the limestone, $CaCO_3 + H^+ \rightarrow Ca^{2+} + HCO_3^-$. The dissolution rate and concomitant alkalinity generation are greatly affected by the partial pressure of CO_2. Anaerobic mine water increases CO_2 partial pressures due to decomposing organic matter and precipitation of metal sulfides. The dissolved CO_2 is a weak diprotic acid and continues to react with limestone, producing more Ca^{2+} and HCO_3^-. When highly acidic water contacts limestone, the first reaction is neutralization of proton acidity. The reaction increases pH and decreases metal solubility. As pH rises above 4.5, bicarbonate accumulates, decreasing the solubility of metals (Hedin et al., 1994a). It has been stated that limestone dissolution requires a 12-hour contact time for maximum alkalinity production (Kepler and McCleary, 1994). In vertical flow wetlands, through a combination of bacterial mediated sulfate reduction and limestone dissolution, alkalinity is produced. The increased pH results in the precipitation of metals when the discharged water is exposed to oxygen.

Passive treatment technology is undergoing rapid development because of the importance of developing remediation methods for AMD at a low cost. Other systems are being studied to determine if they can be successfully used as cost-efficient systems, either alone or in combination with other systems. One such system is a limestone pond. The pond is constructed on an upwelling of an AMD seep or underground discharge point. Limestone is placed on the bottom of the pond and water flows up through it. They are normally constructed with 1-3 m of water, 0.3-1.0 m of limestone, and have a retention time of 1-2 days. The drainage requires a low DO, and should contain minimal Fe^{3+} and Al^{3+}, so clogging does not occur (Skousen and Ziemkiewicz, 1995). If higher concentrations of metals are present, a flushing system can be added.

Another technique involves the use of open limestone channels. They add alkalinity to acidic water in open channels or ditches lined with limestone. The channel should contain a slope greater than 20% to maintain flow velocities that keep precipitates in suspension (Skousen and Ziemkiewicz, 1995). Direct addition of limestone sand to streams is another technique being used. The sand is placed in the headwaters of a stream and during high flows the sand moves downstream and mixes with natural sediments. No harmful effects have been seen. An increase in pH and calcium levels have been observed along with a decrease in toxic aluminum species. A careful selection of particle size, purity and mass of the limestone is important for treatment success (Downey et al., 1994).

Diversion wells have been used in Scandinavia to treat small acidic streams since the late 1970's (Sverdrup, 1983). The first full-sized wells were implemented in Sweden in 1980 and were first used in Lebanon County, Pennsylvania in 1986. Diversion wells are constructed from a cylinder or vertical tank made of either concrete or metal. They are 1.5-1.8 m in diameter, 2.0-2.5 m deep and filled with limestone. They contain a large pipe that extends vertically down the center of the well. Water is fed from the stream into the pipe that exits near the bottom through a nozzle. Water then flows up through the limestone, fluidizing it. Grinding and dissolution of the limestone occurs creating alkalinity. Due to the high pressure created within the wells, floc is removed at a consistent rate, so limestone coating is not a concern. Diversion wells are not entirely passive in that limestone must be added on a monthly basis and sometimes even daily. They work best where metal concentrations are low since there are no settling ponds employed.

Bioremediation is another passive treatment technique being used. Seeded microbes are used to convert metals to their less harmful species. Metal oxidation and precipitation are promoted through hydroxide formation, as is metal reduction and precipitation through sulfide formation. One example is the use of metal oxidizing beds for the treatment of both Mn and Fe (Skousen and Ziemkiewicz, 1995). Mn is difficult to remove because of the high pH required to precipitate it (> 9.0) and competition with Fe precipitation when Fe is present in high concentration. Researchers in Maryland have established a combination of microbes that have been shown to precipitate Mn to effluent standards. These beds have been in use for approximately 10 years, with the first being constructed in Pennsylvania in 1994.

Maintenance

Through discussions with the PGC, long term maintenance of the constructed treatment systems will be conducted by them. They are willing to do the field work associated with maintenance of the treatment cells. An operation and maintenance plan will be developed for each treatment project as it enters final design. Potential problems are as follows:

Wetlands require minimal maintenance. Visual inspections are necessary to insure muskrats and beavers are not impacting inlet/outlet structures or destroying vegetation. VFWs require regular flushing to insure plugging does not occur. This flushing frequency will vary depending on the size of the system and metal loading entering the system. The primary maintenance issue is with solids removal in the settling ponds. The purpose of the settling pond is to collect precipitated metals. These solids accumulate over time and will eventually need to be removed. Ponds are typically designed to operate for 15 to 25 years before needing to be cleaned out.

Prioritization of Treatment Areas

The prioritization of treatment areas were based on a variety of criteria. All treatment sites are on State Game Lands #321, so landowner access and permission has been obtained. The water quality is conducive to using passive treatment technology due to moderate acidity and metal loadings. Four primary treatment sites have been identified as necessary for restoring Loop Run, with two additional as possibilities. The cost is reasonable for the restoration of approximately four miles of stream. Two of the sites have a slight topographic concern, but it was decided that the area is large enough and not excessively steep for treatment. Systems will be built horizontally along the contour with a terraced stabilization in the center and another horizontal series of systems. No other major site constraints exist. Operation and maintenance plans for the systems will be developed upon final design. The systems will need to be flushed, most likely on a quarterly basis. The PGC will be conducting monthly visual inspections of the treatment sites to insure functionality is continuing and report any changes to the treatment so appropriate measures can be taken.

Priority #1: LR5 and LR6

A schematic of the treatment system proposed for this priority can be found on page C-1 in Appendix C.

Site Description:

LR5 is a discharge from the bottom of a highwall area. Further investigation showed that reclamation of the area would not impact the discharge and would cause it to discharge at another location; therefore, this site is a target for treatment rather than reclamation. The discharge forms a flow through the bottom of the highwall area where it enters two ponds. The ponds discharge to a pipe which carries the flow under the entry road to SGL-321and through a naturally occurring wetland where it combines with the flow from LR6 and forms a tributary to Loop Run.

LR6 emanates from a collapsed rock area where it forms a large impoundment. The impoundment discharges under the Game Lands road where it joins with LR5. The areas where the discharges flow are conducive to construction. They are already being ponded, so it was decided that construction can occur in the existing area of flow. This will greatly reduce excavation and construction costs. The existing ponded areas will be turned into treatment cells, and the effluent can be collected into one large polishing wetland before being discharged into the tributary.

Table 18: Summary of Chemistry for LR5

Date	gpm Flow	pH	Umhos /cm Cond	mg/L Acidity	lbs/day Acid Load	mg/ L Alk	mg/l Fe	lbs/day Fe Load	mg/L Al	mg/L Mn	mg/L SO4
Average	38.733	3.758	1915.000	149.083	68.635	0	2.400	0.731	15.325	22.517	1008.25
Max	110.600	4.000	2290.000	198.000	186.656	0	8.560	1.573	21.100	25.400	1319.00
Min	6.200	3.600	1560.000	124.000	9.716	0	0.770	0.1614	12.200	19.400	24
75% Con	50.499	3.800	1977.456	155.757	88.455	0	3.076	0.894	16.213	23.150	1119.89
90% Con	55.557	3.817	2004.304	158.626	96.974	0	3.367	0.964	16.595	23.422	1167.87

Table 19: Summary of Chemistry for LR6

	gpm Flow	pH	Umhos /cm Cond	mg/L Acidity	lbs/day Acid Load	mg/L Alk	mg/l Fe	lbs/day Fe Load	mg/L Al	mg/L Mn	mg/L SO4
Average	14.827	3.500	2567.500	303.833	53.154	0.000	2.823	0.466	34.708	38.833	1567.750
Max	28.200	3.700	3000.000	424.000	95.525	0.000	4.120	0.814	43.700	45.700	2025.000
Min	2.2	3.300	2200.000	244.000	9.335	0.000	1.560	0.067	27.700	32.400	963.000
75% Con	17.345	3.535	2645.252	320.644	61.404	0.000	3.112	0.543	36.715	40.084	1658.328
90% Con	18.428	3.550	2678.675	327.870	64.950	0.000	3.236	0.576	37.578	40.622	1697.264

Recommendations:

Both treatment systems will be of comparable design because of the similar chemical loadings. LR5 is larger in flow at 28.5 gpm, but has an average iron concentration of 1.8 mg/L and an average aluminum concentration of 16.1 mg/L. On the other hand, LR6 has an average flow of 13.6 gpm, but the iron is 2.86 mg/L and the aluminum is 35.2 mg/L. Both sites average out to the same loadings entering the tributary, therefore, similar treatment designs will be used for both.

Both systems will consist of an initial settling/holding pond to regulate flow into the treatment cells. Both systems will have two limestone treatment cells. LR5 will be designed for a 50 gpm flow and the cells will be 120’ by 75’, with each containing a minimum of 600 tons of limestone. LR6 will be designed for a flow of 25 gpm, and will again be sized at 120’ by 75’ (due to increased concentrations of metals). All limestone cells will have flushing systems due to the higher levels of aluminum. The effluent from the treatment cells will enter settling ponds, before coming together in a final polishing wetland. The wetland will be long and narrow to fit the topography of the area. It will contain a mixture of mushroom compost and limestone in the substrate, to help maintain pH levels as the metals precipitate. The effluent will then reenter the existing tributary to Loop Run.

The approximate cost of constructing each limestone cell is $15,000 because of the limited excavation requirement. Four of these cells would total $60,000. The wetland will cost approximately $20,000 to insure a mixture of limestone and mushroom compost. Holding ponds and settling ponds will be approximately $12,500, again due to minimal excavation costs. An additional $10,000 will be added to construction costs for project oversight. The overall treatment system cost would be $92,500 for construction costs. Additional costs are design and permitting. The typical costs can be broken down to surveying costs at $4,500, permitting costs at $3,900, E&S Controls at $1,560, Design and Engineering costs at $16,950, Bid Packages at $2,600, and Other/Project Management at $2,600. These are typical costs to design and permit a treatment site. They vary slightly depending on the size of the project. The total costs for design and permitting are therefore, $32,110. The overall design and construction cost of Treatment Area #1 is $134,610.

Predicted Effect of System on Receiving Stream:

The water discharging from the polishing wetland should be alkaline in nature with minimal iron and aluminum concentrations. The metals will be retained in the settling pond and wetland. The treated water will be able to support an aquatic community and will begin the neutralization of the main stem of Loop Run.

Other:

The high aluminum concentrations at this site will increase the rate of flushing. A final O&M plan will be developed with the final design, but monthly flushing will most likely be necessary. Additional maintenance will include the removal of precipitated metals from the settling pond. The pond will be designed for a 15+ year lifespan. Visual checks of the system will be made monthly to insure that wildlife is not affecting the integrity of the system. A field monitoring plan will be established to determine the overall effects of the treatment system on water quality. The PGC has agreed to assume the long term O&M of the treatment system. They will be conducting the monthly checks and reporting to NMBS if any corrections need to be made.

Permits will need to be obtained for the construction of the system. A field meeting with PADEP, PGC, PFBC, Army Corp of Engineers, Conservation District, and NMBS will occur to insure all permitting issues are addressed.

This site has been submitted to both the Growing Greener Program and the Chesapeake Bay Small Watershed Grants Program for design and permitting monies. The construction phase will be submitted to Growing Greener and potentially OSM for funding. Other potential grant sources will continue to be identified.

Priority #2: LR10

A schematic of the treatment system proposed for this priority can be found on page C-2 in Appendix C.

Site Description:

LR10 is a channel discharge that flows from a spoil area. The channel collects seepage from two large dead zones of laminar water flow that have created iron mats. We are concerned with treating only the channel before entering Loop Run to eliminate the pollution. We are not concerned with restoring the channel itself, so we will be treating at the bottom of the channel.

Table 20: Summary of Chemistry for LR10

	Gpm Flow	pH	Umhos /cm Cond	mg/L Acidity	lbs/day Acid Load	mg/L Alk	mg/l Fe	lbs/day Fe Load	mg/L Al	mg/L Mn	mg/L SO4
Average	116.475	3.292	2649.167	178.667	266.456	0.000	6.824	8.488	8.325	34.567	1471.167
Max	198.400	3.500	4200.000	209.000	423.326	0.000	9.660	13.633	10.700	42.100	1928.000
Min	150.700	3.100	1890.000	116.000	374.231	0.000	4.060	9.665	5.410	22.000	825.000
75% Con	163.529	3.337	2835.003	188.813	371.286	0.000	7.371	11.695	8.813	36.645	1574.821
90% Con	183.757	3.357	2914.889	193.174	416.349	0.000	7.606	13.073	9.022	37.539	1619.379

Recommendations:

LR10 has an average flow of 116 gpm and will be designed for a 200 gpm flow. The average iron concentration is 6.82 mg/L and average aluminum is 8.32 gm/L. We will be treating manganese at these sites through the use of limestone removal beds. These will not only aid in the removal of manganese, but will add alkalinity to the discharge channel. The average manganese at this site is 34.5 mg/L. We will be using a combination of treatment cells at this site.

We considered two options for treatment. The first was building a series of limestone cells through the existing channel, with a settling pond and wetland at the bottom of the channel. We decided instead to treat at the bottom of the channel after collection of all seeps. The system will consist of an initial holding pond to regulate flow into the treatment system. It will be followed by a 200’ by 100’ aerobic wetland to allow for iron and aluminum to precipitate. We will be mixing a 2:1 combination of organic matter and limestone in this cell. The aerobic wetland will then enter a vertical flow wetland. It will be size at 240’ by 130’. The short side of these systems will be vertical to the existing channel and the long side will be horizontal. This system will consist of 3’ of limestone and 2’ of organic matter. It will have a grid like piping system which will also be used as a flushing system. This will be followed by a large settling pond. The discharge of the settling pond will enter a large limestone manganese removal bed that will be 300’ by 100’ with baffles to insure maximum contact with the limestone. A final polishing wetland will be at the bottom of the cells before the treated water enters Loop Run.

The approximate cost of constructing the treatment system is $168,850 as a total for each of the components. The initial holding pond will be $5,000 followed by $18,350 for the aerobic wetland. The VFW will cost $96,000 followed by $20,000 for the settling pond. The manganese removal bed will cost another $20,000 and finally the polishing wetland will be $8,500. An additional $10,000 will be added to construction costs for project oversight. These are estimated costs and could change at time of construction. Additional costs are design and permitting. The typical costs can be broken down to surveying costs at $4,500, permitting costs at $3,900, E&S Controls at $1,560, Design and Engineering costs at $16,950, Bid Packages at $2,600, and Other/Project Management at $2,600. These are typical costs to design and permit a treatment site. They vary slightly depending on the size of the project. The total costs for design and permitting are therefore, $32,110. The overall design and construction cost of Treatment Area #2 is $210,960.

Predicted Effect of System on Receiving Stream:

The water discharging from the polishing wetland should be alkaline in nature with minimal iron and aluminum concentrations. The metals will be retained in the settling pond and wetland. The water discharging into Loop Run will be able to support an aquatic community and will continue the neutralization of the main stem of Loop Run.

Other:

A final O&M plan will be developed with the final design. Quarterly flushing will most likely be necessary due to the moderate aluminum concentrations. Additional maintenance will be removing precipitated metals from the settling pond. The pond will be designed for a 15+ year lifespan. Visual checks of the system will be made monthly to insure that wildlife is not affecting the integrity of the system. A field monitoring plan will be established to determine the overall effects of the treatment system on water quality. The PGC has agreed to long term O&M of the treatment system. They will be conducting the monthly checks and reporting to NMBS if any corrections need to be made.

Permits will need to be obtained for the construction of the system. A field meeting with PADEP, PGC, PFBC, Army Corp of Engineers, Conservation District, and NMBS will be conducted to insure all permitting issues are addressed.

This site will be submitted to both the Growing Greener Program and the Chesapeake Bay Small Watershed Grants Program for design and permitting monies in the spring of 2005. The construction phase will be submitted to Growing Greener and potentially OSM for funding. Other potential grant sources will continue to be identified.

Priority #3: LR12 and LR13

A schematic of the treatment system proposed for this priority can be found on page C-3 in Appendix C.

Site Description:

LR12 is a discrete channel formed by a spring on the edge of a large iron mat area, LR13. This channel is created by a spring/seep that surfaces in an area of moss. The channel flows down the hillside collecting some of the seepage from the nearby iron mat before entering Loop Run.

LR 13 is a large laminar flow area that creates an iron mat/seepage area. LR12 is on the upstream side of this area. The contour for this site is at an approximate 3-4% slope. It would be possible to ditch at the top of the contour to capture flow before it flows as sheets down the hillside creating a dead zone. The area is approximately 135 yards across and 110 yards from the top tree line to the bottom of the dead zone. There is a terrace area at this mark above the stream. It would be possible to build the treatment system horizontally across the hillside, terrace a middle stabilizing section, and then build another horizontal series of cells. There is an old logging road above this area that could be modified for access. As part of the restoration plan, the roads are being surveyed for Treatment Areas 2-4.

Table 21: Summary of Chemistry for LR12

	gpm Flow	pH	Umhos /cm Cond	mg/L Acidity	lbs/day Acid Load	mg/L Alk	mg/l Fe	lbs/day Fe Load	mg/L Al	mg/L Mn	mg/L SO4
Average	34.540	3.491	2277.273	89.364	36.495	0.000	2.608	1.056	2.113	25.155	1314.000
Max	51.600	3.700	2540.000	114.000	48.236	0.000	3.880	1.426	2.700	29.500	1578.000
Min	17.1	3.300	1850.000	71.000	16.49	0.000	1.560	0.476	1.490	17.500	985.000
75% Con	38.031	3.530	2349.448	94.388	40.044	0.000	2.868	1.174	2.248	26.540	1382.675
90% Con	39.532	3.547	2380.474	96.548	41.569	0.000	2.980	1.224	2.306	27.136	1412.196

Table 22: Summary of Chemistry for LR13

	gpm Flow	pH	Umhos /cm Cond	mg/L Acidity	lbs/day Acid Load	mg/L Alk	mg/l Fe	lbs/day Fe Load	mg/L Al	mg/L Mn	mg/L SO4
Average	16.077	3.318	2220.000	101.818	20.924	0.000	3.463	0.703	3.165	19.864	1228.545
Max	27.100	3.900	2670.000	126.000	40.836	0.000	6.740	2.202	4.740	26.700	1691.000
Min	9.1	3.100	1050.000	51.000	9.873	0.000	1.230	0.361	2.060	10.200	395.000
75% Con	18.344	3.399	2371.710	109.300	24.296	0.000	4.111	0.902	3.482	21.424	1344.291
90% Con	19.318	3.433	2436.926	112.517	25.746	0.000	4.390	0.988	3.619	22.094	1394.046

Recommendations:

Treatment Area #3 for LR12/13 has a design flow of 100 gpm. The average iron concentration is 4.79 mg/L and average aluminum is 3.38 gm/L. We will be treating manganese at this site through the use of limestone removal beds. These will not only aid in the removal of manganese, but will add alkalinity to the discharge channel. The average manganese at this site is 28.21 mg/L. We will be using a combination of treatment cells at this site.

The first step in system design and construction is constructing a conveyance ditch at the top of the contour to capture the flow. We will divert flow from LR12 and LR13 into the same series of treatment cells. We will dig the conveyance 10+ feet below the surface to capture all subsurface flow. This will dry up the site for construction. We may need to remove the iron precipitate on the site or, at a minimum, move it to the sides of the treatment area.

The system will consist of an initial holding pond to regulate flow into the treatment system. It will be followed by a 200’ by 100’ aerobic wetland to allow for iron and aluminum to precipitate. We will be mixing a 2:1 combination of organic matter and limestone in this cell. The aerobic wetland will then enter a vertical flow wetland. It will be sized at 190’ by 110’. This first series of cells will be on the top contour. This system will consist of 3’ of limestone and 2’ of organic matter. It will have a grid like piping system which will also be used as a flushing system. We will then terrace a stability area and construct the next series of cells. The VFW will be followed by a large settling pond, which will also act as a flush pond. The discharge of the settling pond will enter a limestone manganese removal bed that will be 200’ by 100’ with baffles to insure maximum contact with the limestone. A final polishing wetland will be at the end of the cells before the treated water enters Loop Run.

The approximate cost of constructing the treatment system is $112,050 as a total for each of the components. The initial holding pond will be $5,000 followed by $18,350 for the aerobic wetland. The VFW will cost $58,000 followed by $9,200 for the settling pond. The manganese removal bed will cost another $13,000 and finally the polishing wetland will be $8,500. An additional $10,000 will be added to construction costs for project oversight. These are estimated costs and could change at time of construction. Additional costs are design and permitting. The typical costs can be broken down to surveying costs at $4,500, permitting costs at $3,900, E&S Controls at $1,560, Design and Engineering costs at $16,950, Bid Packages at $2,600, and Other/Project Management at $2,600. These are typical costs to design and permit a treatment site. They vary slightly depending on the size of the project. The total costs for design and permitting are therefore, $32,110. The overall design and construction cost of Treatment Area #3 is $154,160.

Predicted Effect of System on Receiving Stream:

The water discharging from the polishing wetland should be alkaline in nature with minimal iron and aluminum concentrations. The metals will be retained in the settling pond and wetland. The water discharging into Loop Run will be able to support an aquatic community and will continue the neutralization of the main stem of Loop Run.

Other:

A final O&M plan will be developed with the final design. Quarterly flushing will most likely be necessary due to the moderate aluminum concentrations. Additional maintenance will be removing precipitated metals from the settling pond. The pond will be designed for a 15+ year lifespan. Visual checks of the system will be made monthly to insure that wildlife is not affecting the integrity of the system. A field monitoring plan will be established to determine the overall effects of the treatment system on water quality. The PGC has agreed to long term O&M of the treatment system. They will be conducting the monthly checks and reporting to NMBS if any corrections need to be made.

Permits will need to be obtained for the construction of the system. A field meeting with PADEP, PGC, PFBC, Army Corp of Engineers, Conservation District, and NMBS will be conducted to insure all permitting issues are addressed.

This site will be submitted to both the Growing Greener Program and the Chesapeake Bay Small Watershed Grants Program for design and permitting monies in the spring of 2006. The construction phase will be submitted to Growing Greener and potentially OSM for funding. Other potential grant sources will continue to be identified.

Priority #4: LR14, LR15 and LR16

A schematic of the treatment system proposed for this priority can be found on page C-4 in Appendix C.

Site Description:

LR14 is similar in description to LR13, but further downstream. It is an area formed by seepage along the top contour forming laminar flow that has created a large dead zone of iron precipitation. It is related to LR15 and LR16. Similar to Treatment Area #3, this area can be ditched along the top contour to capture the seepage into one series of treatment cells. It appears to be only slightly steeper than the area for LR13 and the same idea of treatment could be used. A horizontal series of treatment cells, a stabilizing bench, and another series of horizontal cells. LR15 is a channel that collects seepage off of the hillside above. It captures the laminar flow as it seeps off the edge of the bank and enters Loop Run. The flow can be captured in the conveyance associated with LR14. LR16 is another channel as you continue along the hillside collecting flow from above. This area is more wooded. Again, the flow can be captured above.

There is not space on the bottom floodplain to build treatment cells. A conveyance ditch will be constructed at the top of the contour for LR14, LR15, and LR16 and a series of treatment cells will be used. Another possibility for treatment of LR14, LR15, and LR16 would be to collect flows into a conveyance system and begin treatment in the flattened area above LR16 if the hill would be considered too steep for equipment or construction. There would be more ditching needed, but a sufficiently unlimited flattened area would exist. There is an old logging road near LR16, but it is fairly wet. As part of the restoration plan, the roads are being surveyed in Treatment Areas 2-4.

Table 23: Summary of Chemistry for LR14

	gpm Flow	pH	Umhos /cm Cond	mg/L Acidity	lbs/day Acid Load	mg/L Alk	mg/l Fe	lbs/day Fe Load	mg/L Al	mg/L Mn	mg/L SO4
Average	49.700	3.625	2363.333	83.250	48.962	0.000	1.963	1.149	3.601	21.708	1403.417
Max	81.400	3.900	2670.000	118.000	73.595	0.000	4.230	2.412	5.030	25.900	1800.000
Min	14.800	3.300	1970.000	60.000	17.841	0.000	0.950	0.239	2.220	17.400	1074.000
75% Con	55.168	3.684	2434.533	88.224	54.443	0.000	2.285	1.354	3.878	22.727	1477.158
90% Con	57.518	3.709	2465.139	90.363	56.799	0.000	2.424	1.442	3.998	23.165	1508.857

Table 24: Summary of Chemistry for LR15

	gpm Flow	pH	Umhos /cm Cond	mg/L Acidity	lbs/day Acid Load	mg/L Alk	mg/l Fe	lbs/day Fe Load	mg/L Al	mg/L Mn	mg/L SO4
Average	138.967	3.400	3261.667	165.583	267.956	0.000	4.652	7.812	10.493	31.733	1899.167
Max	198.400	3.600	4610.000	224.000	406.584	0.000	6.230	11.337	12.100	35.700	2712.000
Min	10.800	3.200	2670.000	134.000	29.163	0.000	3.500	0.548	8.180	27.400	1432.000
75% Con	154.434	3.449	3496.557	173.733	297.113	0.000	4.948	8.777	10.884	32.677	2027.538
90% Con	161.083	3.470	3597.530	177.236	309.646	0.000	5.075	9.191	11.052	33.083	2082.721

Table 25: Summary of Chemistry on LR16

	gpm Flow	pH	Umhos /cm Cond	mg/L Acidity	lbs/day Acid Load	mg/L Alk	mg/l Fe	lbs/day Fe Load	mg/L Al	mg/L Mn	mg/L SO4
Average	45.890	3.336	2577.273	187.909	103.325	0.000	3.990	1.965	12.229	35.818	1582.091
Max	103.500	3.900	4070.000	258.000	321.899	0.000	7.840	4.030	15.900	43.000	2008.000
Min	25.1	3.200	280	56.000	38.006	0.000	2.160	1.116	8.840	27.000	1120.000
75% Con	55.688	3.408	2888.896	206.267	132.931	0.000	4.546	2.302	12.935	37.598	1682.146
90% Con	59.900	3.439	3022.854	214.159	145.657	0.000	4.785	2.447	13.238	38.363	1725.157

Recommendations:

Treatment Area #4 for LR14/15/16 has a design flow of 250gpm. The average iron concentration is 7.81 mg/L and average aluminum is 15.9 mg/L. We will be treating manganese at this site through the use of limestone removal beds. These will not only aid in the removal of manganese, but will add alkalinity to the discharge channel. The average manganese at this site is 43.2 mg/L. We will be using a combination of treatment cells at this site.

The first step in system design and construction is constructing a conveyance ditch at the top of the contour to capture the flow. We will divert flow from LR14, LR15 and LR16 into the same series of treatment cells. We will dig the conveyance 10+ feet below the surface to capture all subsurface flow. This will dry up the site for construction. We may need to remove the iron precipitate on the site or, at a minimum, move it to the sides of the treatment area.

The system will consist of an initial holding pond to regulate flow into the treatment system. It will be followed by a 200’ by 200’ aerobic wetland to allow for iron and aluminum to precipitate. We will be mixing a 2:1 combination of organic matter and limestone in this cell. The aerobic wetland will then enter a vertical flow wetland. It will be sized at 280’ by 150’. This first series of cells will be on the top contour. This system will consist of 3’ of limestone and 2’ of organic matter. It will have a grid like piping system which will also be used as a flushing system. We will then terrace a stability area and construct the next series of cells. The VFW will be followed by a large settling pond, which will also act as a flush pond. The discharge of the settling pond will enter a limestone manganese removal bed that will be 380' x 200' with baffles to insure maximum contact with the limestone. A final polishing wetland will be at the end of the cells before the treated water enters Loop Run.

The approximate cost of constructing the treatment system is $271,660 as a total for each of the components. The initial holding pond will be $5,000 followed by $38,500 for the aerobic wetland. The VFW will cost $138,000 followed by $28,660 for the settling pond. The manganese removal bed will cost another $53,000 and finally the polishing wetland will be $8,500. An additional $10,000 will be added to construction costs for project oversight. These are estimated costs and could change at time of construction. Additional costs are design and permitting. The typical costs can be broken down to surveying costs at $4,500, permitting costs at $3,900, E&S Controls at $1,560, Design and Engineering costs at $16,950, Bid Packages at $2,600, and Other/Project Management at $2,600. These are typical costs to design and permit a treatment site. They vary slightly depending on the size of the project. The total costs for design and permitting are therefore, $32,110. The overall design and construction cost of Treatment Area #3 is $313,770.

Predicted Effect of System on Receiving Stream:

The water discharging from the polishing wetland should be alkaline in nature with minimal iron and aluminum concentrations. The metals will be retained in the settling pond and wetland. The water discharging into Loop Run will be able to support an aquatic community and will continue the neutralization of the main stem of Loop Run.

Other:

A final O&M plan will be developed with the final design. Quarterly flushing or possibly monthly flushing will be necessary due to the elevated aluminum concentrations. Additional maintenance will be removing precipitated metals from the settling pond. The pond will be designed for a 15+ year lifespan. Visual checks of the system will be made monthly to insure that wildlife is not affecting the integrity of the system. A field monitoring plan will be established to determine the overall effects of the treatment system on water quality. The PGC has agreed to long term O&M of the treatment system. They will be conducting the monthly checks and reporting to NMBS if any corrections need to be made.

Permits will need to be obtained for the construction of the system. A field meeting with PADEP, PGC, PFBC, Army Corp of Engineers, Conservation District, and NMBS will be conducted to insure all permitting issues are addressed.

This site will be submitted to both the Growing Greener Program and the Chesapeake Bay Small Watershed Grants Program for design and permitting monies in the spring of 2007. The construction phase will be submitted to Growing Greener and potentially OSM for funding. Other potential grant sources will continue to be identified.

Priority #5/#6: LR7 and LR8

These are seepage areas located on the floodplain downstream on Loop Run. The area is limited for construction purposes. They are seeps that emanate along the bottom of the hillside and meander through moss/wetland areas on the floodplain before entering Loop Run. There is iron precipitate throughout the floodplain.

The treatment strategy for these areas would be to build large wetlands to allow the metals to precipitate. The wetlands would have a 2:1 mixture of organic matter and limestone to maintain pH levels as the metals precipitate. The above treatment areas will neutralize Loop Run enough that these discharges are no longer significant. It is suggested that the stream continue to be monitored after above treatment systems are constructed to make the final determination if these areas do need a treatment solution.

The difficulties in treating in these areas are that they are flat and located on the floodplain. It would be difficult to get construction equipment into this area. We will further analyze the feasibility of treating these discharges as successful treatment occurs upstream.

Table 26: Summary of Chemistry LR17

	gpm Flow	pH	Umhos /cm Cond	mg/L Acidity	lbs/day Acid Load	mg/L Alk	mg/l Fe	lbs/day Fe Load	mg/L Al	mg/L Mn	mg/L SO4
Average	37.550	4.218	1995.455	63.545	29.166	3.091	5.087	1.915	2.965	20.809	1088.727
Max	56.300	5.000	3160.000	90.000	38.685	10.000	8.740	3.319	4.790	30.100	1511.000
Min	19.600	3.700	1460.000	34.000	11.814	0.000	3.06	1.002	1.950	14.300	653.000
75% Con	46.571	4.377	2163.058	69.532	36.010	4.420	5.649	2.485	3.239	22.238	1175.936
90% Con	50.449	4.445	2235.107	72.105	38.952	4.992	5.890	2.730	3.358	22.853	1213.425

Table 27: Summary of Chemistry LR18

	gpm Flow	pH	Umhos /cm Cond	mg/L Acidity	lbs/day Acid Load	mg/L Alk	mg/l Fe	lbs/day Fe Load	mg/L Al	mg/L Mn	mg/L SO4
Average	41.855	4.564	1489.091	30.364	13.336	6.273	1.010	0.361	2.498	9.192	772.091
Max	96.600	5.000	2610.000	49.000	20.041	8.000	3.640	0.649	3.480	13.700	1015.000
Min	14.800	4.200	110.000	16.000	5.709	4.000	0.280	0.215	1.410	5.520	387.000
75% Con	50.712	4.638	1690.317	33.745	14.958	6.740	1.326	0.403	2.710	10.011	841.908
90% Con	54.519	4.671	1776.818	35.199	15.655	6.941	1.462	0.420	2.802	10.363	871.920

Summary Treatment Areas

The following table summarizes the treatment necessary for the restoration of Loop Run. Four priority treatment areas are needed; an additional two small treatment areas have also been identified as ones that are worth reviewing after the initial four have been constructed. The table lists the type of treatment to be used and the cost associated with each area. The best available technology at the time will be used and treatment designs may be changed upon further site investigation. These are conceptual designs only.

Considerations will be taken into all final designs. Flushing systems will be a priority and concern, especially at Treatment Area #1 due to the high aluminum levels. We may be incorporating new designs being developed by BAMR for upflow limestone ponds using a water level activated flushing system. Our vertical flow systems may incorporate the two-tiered approach to flushing to insure the top 6” of limestone does not become plugged with aluminum. By-pass systems will be used in all treatment areas to allow excess flow to by-pass the system, instead of short circuiting or decreasing the longevity of the system. The by-pass system will consist of limestone channels to provide some treatment to the excess flow. The VFW will incorporate at least 24 inches of organic matter to insure the long-term viability of a bacterial community which should act to reduce iron and add alkalinity to the system. The piping system will be designed in a grid like pattern to insure flow throughout the system and decrease the chance of preferential flow. In-flow will be distributed through a perforated pipe on the horizontal surface of the VFW to insure flow throughout the system. The aerobic wetlands will be constructed with a combination of organic material and limestone to increase alkalinity production and longevity of the compost layer. This will insure the bacterial community is able to thrive and act as sulfate reducers through the lifetime of the system.

Table 28: Summary of Treatment Areas

Priority	Sites	Treatment	Cost
#1	LR5 and LR6	Limestone cells, wetland	$134,610
#2	LR10	Wetland, VFW, Mn limestone bed	$210,960
#3	LR12 and LR13	Wetland, VFW, Mn limestone bed	$154,160
#4	LR14, LR15, and LR16	Wetland, VFW, Mn limestone bed	$313,770
#5and #6	LR17 and LR18	wetlands	

Surveying of Roads to Treatment Areas #2, #3, and #4

A construction access road is needed to allow the transport of personnel, equipment, and materials from existing access roads on the Kelley Estate to the proposed acid mine drainage treatment sites. Existing access roads along the edge of the reclaimed area will allow access to within approximately 500 feet of the proposed treatment site 3. However, an elevation drop of between 60 and 100 feet occurs across a relatively short distance at the edge of the reclaimed area, making access to the proposed treatment sites at the point of shortest distance between the existing road and the treatment sites difficult.

An existing "skidder" road, likely remaining from logging or mining operations, roughly follows the toe of the slope, which lies between the proposed treatment systems and the existing access road. The toe of the slope roughly corresponds with the toe of spoil following the previous reclamation activities. The existing skidder road traverses the steep slope and connects to the existing road at the edge of the reclaimed area. The skidder road was examined for use as the proposed access down over the hillside to the treatment system, but its use was discounted because of the steepness of the grade, the need to make an immediate, sharp right or left turn at the bottom of the steep hill to avoid running into mucky, wet areas, and the need to cut down a large area of trees at the bottom of the hill to allow for sufficient turning radius for trucks.

A point of access to the existing road was selected slightly east of proposed Treatment Area #2. The area of connection to the existing road is surrounded by a fairly flat, grassy area that would allow sufficient turning room for tri-axle trucks carrying limestone and could provide a staging area for materials. This location was chosen to traverse the steep slope because the total embankment height is lower at this point than at other locations, the slope is slightly milder, and the remaining edge of spoil can be easily graded with a bulldozer to create a suitable grade for truck ingress and egress. The access road is to be cut diagonally across the slope to minimize the grade of the road. Again, because of safety concerns, this was believed to be the safest and most practical location to traverse the slope, offsetting the slightly longer distance than would be needed to traverse the slope closer to Treatment Area #3.

Once the toe of the slope is reached, the proposed road alignment follows the existing skidder road alignment described previously. This alignment was selected because the existing road is still fairly open, which minimizes the amount of trees that will need to be removed. The proposed road shifts away from the existing road alignment slightly in some locations to avoid some mature oak and hemlock trees and shifts upslope slightly in some locations to avoid wet areas.

The proposed road can be constructed in segments, with the road constructed to area 2, then subsequent connecting segments to areas 3 and 4 prior to commencing construction in those areas. The proposed access road can be left in place to be used for permanent operation and maintenance needs to the proposed treatment systems.

The centerline of the proposed access road was staked out with wooden survey stakes at approximate 100-foot intervals, changes in grade; high and low points in the proposed alignment, horizontal curves, and at proposed culvert locations. Trees that will need to be removed were marked with white paint blazes. Stakes were set so that the next stake is visible from the location of the previous stake, in all cases, and orange flagging was used on the vegetation to indicate the access road alignment in areas where vegetation may reduce visibility.

Several drainage culverts will be needed at various locations along the proposed access road. Culvert locations and sizes were determined based on existing contours, the proposed slope of the roadway, and the contributing drainage area to each culvert. Each culvert location corresponds to a centerline stake.

A design and layout package has been prepared for the proposed construction access road for future use by Pennsylvania Game Commission personnel and/or the construction contractor. This package includes a large scale location map showing the location of the proposed access road with respect to other existing roadways on the Kelley Estate and a smaller scale map showing the locations of the centerline stakes for the roadway layout with existing contours and the proposed treatment system locations. Coordinates for each of the centerline stakes have been provided in the event that stakes are inadvertently removed or vandalized. Construction details, such as a roadway cross section and rock apron detail, have also been provided.

Priority of Reclamation Areas:

Priority #1: Highwall

The first priority for reclamation is an abandoned highwall located on the far edge of the Kelley Estate away from Loop Run (pages A-12 and A-13). This highwall area is approximately 2000’ in length, with an average depth of 96’ and an average width of 159’. The minimum depth is 42’ and the maximum is 189’. The minimum width is 48’ and the maximum is 228’. In order to reclaim the highwall area, approximately 65 acres will need to be disturbed to obtain enough material to fill in the existing pit area.

Along with safety and additional acreage for wildlife management, positively affecting 65 acres of Game Lands will have a beneficial impact on the surrounding water quality. With the open highwall and pit area, rain infiltrates through the spoil material and pit floor producing acidity as it percolates. The acidity then releases metals from the surrounding soil and rock material, eventually finding its way into local waterways. In this case, due to hydrology, rock strata, and local geological faults, the water hitting this area is making its way into Little Birch Island Run, and eventually into the West Branch of the Susquehanna River. A TMDL is now being conducted on Little Birch Island Run to determine the overall impact of mine drainage and other sources of pollution. Preliminary samples show the headwaters of the stream to have alkalinity greater than acidity and undetectable metal concentrations. As the stream travels through mining areas, the acidity becomes greater than alkalinity and metal concentrations increase. The TMDL will prioritize the stream for restoration and clean up. Through the reclamation of this highwall/spoil area, benefits will be seen in the overall water quality in Little Birch Island Run. Before reclamation begins, lime will be added to the pit floor and spoil areas. This lime will begin neutralizing the acidity being produced and will decrease the metals leaching from the surrounding area.

Along with liming, biosolids are planned for the area. This will be beneficial in the success of revegetating the site. There is little to no topsoil present on site, and biosolids application will have a great benefit to the seeding and planting success of the area. This also has a benefit to the water quality. It not only acts as a filtration system for rainwater, the increased biomass of vegetation will aid in decreasing infiltration. Decreased infiltration allows less contact time with the ‘hot’ material below, in turn decreasing the amount of acidity being produced.

This project has already been submitted and rejected by the Growing Greener Program. BAMR was then contacted on the possibility that they conduct the reclamation. They agreed to do the project. The site has been flown for surveying purposes and field meetings will be set-up with PGC, RMEF, BAMR, and NMBS to make sure all project partners are involved with the reclamation project. As a first step, the PGC is submitting a biosolids permit for the entire SGL-321. The biosolids will be used as a soil amendment to increase vegetative growth throughout the property. Much of the Game Lands is rolling abandoned spoil that has trees, but no ground cover growing. This use of biosolids as a soil amendment will enhance all growth throughout the property.

As part of the original Growing Greener Grant we calculated costs associated with the project. The construction phase cost is broken down in the table below. BAMR will calculate its own costs and put the project out for bid. As part of the original plan, blasting was added to reduce costs of earthmoving activity. A local blasting company visited the site and recommended blasting the exposed rock face as a more efficient way of filling in the pit area. BAMR will, however, develop its own reclamation plan.

Table 29: Estimated Reclamation Costs of Priority #1 Highwall

Item	Cost
Site Access	$ 5,000
Clear and Grub	10,000
Erosion Sediment Control	10,000
Earthwork (456,000 cy at $0.80/yard)	364,800
Earthwork/Blasting	65,000
Alkaline Backfill Materials (240 tons at $50.00/ton)	12,000
Limestone Channels/Piping	10,000
Mobilization/Demobilization	47,680
10% Contingency	52,448
Total	$ 576,928

The following is a document submitted with the original Growing Greener Grant. It shows the cooperation from the PGC and the commitment they have made to the restoration of SGL-321. The plan outlines the planting recommendations for the reclaimed highwall area and the in-kind contributions to be made by the PGC. This plan will be provided to BAMR before final design plans are made.

TENTATIVE RECLAMATION PLAN

FOR

STATE GAME LANDS 321, CLINTON COUNTY

Prepared by Colleen M. Shannon, Land Management Group Supervisor

Below is a tentative plan for revegetating a portion of State Game Lands 321 as a result of the reclamation of abandoned surface mine high walls. This project is proposed as part of a Growing Greener Grant administered by the Rocky Mountain Elk Foundation. The dollar amounts represent the approximate value of in-kind contributions for work provided by the Pennsylvania Game Commission.

The total area to be revegetated is 65 acres. The plan is to plant trees on approximately 30 acres and plant herbaceous cover on 35 acres in order to provide a diversity of wildlife habitat, replace existing conifer cover that will be lost during the reclamation process, provide nesting cover for birds and small game, and increase the quantity of food-producing shrubs on the game lands.

Tree planting – 30 acres, PGC provides seedlings and labor to plant

15 acres – planted in conifer cover, primarily white spruce and white pine.

1300 tree seedlings per acre = 19,500 seedlings = $4200

Labor & equipment to plant trees = 234 hours = $4700

5 acres – consisting of 10 one-half acre fenced areas for apple trees

500 trees = $2500

Labor & equipment to plant trees = 250 hours = $5000

10 acres – consisting of 20 one-half acre fenced areas for planting crabapples or other fruit-producing shrubs or for aspen regeneration

1300 tree seedlings per acre = 13,000 seedling = $2800

Labor & equipment to plant trees = 160 hours = $3200

Herbaceous openings – 35 acres, PGC provides seed and labor to plant

15 acres – cool-season grasses such as PGC standard clover and trefoil mixture

Labor & equipment costs – 105 man hours and tractor hours = $6300

Seed = $500

20 acres – warm-season grasses mixture with clovers

Labor & equipment costs – 60 man hours and tractor hours = $3600

Seed = $2800

Total value of in-kind contribution by the PGC is $35,600. This figure does not include administrative costs.

Calculations for the site were conducted by the engineer working for NMBS. It was calculated that 456,000 cubic yards of material would be needed to reclaim the highwall area. This in turn would reclaim a total of 65 acres of surrounding land which is now rolling spoil area. The total construction cost of Priority Area #1 is $576,928. Engineering and surveying costs would be added for this project if it was being designed by an engineering firm.

Priority #2: Highwall

The second priority area is another highwall area. It actually is an extension of priority #1, but rolling spoil material is located in between the areas (pages A-12 and A-13). This highwall is approximately 1000' in length with an average depth of 45' and an average width of 96'. The minimum depth of the highwall is 39' with a maximum of 78'. The minimum width of the highwall is 36' and a maximum of 195'. This area appears to be less of a hazard than priority area #1 because of its smaller size, but it does have exposed rock faces, and areas that have fallen into the pit. This area is easily accessed and the pit floor can be walked.

A small impoundment is found on the side of the pit, but the water does not appear to exit. This highwall is near the center of the Game Lands and does not appear to be linked to any water body. It, however, may be hydrologically related to priority #1 and may be adding to the pollution entering Little Birch Island Run.

This highwall should be reclaimed for safety factors of both human and wildlife. Reclaiming this highwall would also add acreage for wildlife habitat and food plots. Approximately 25 acres would be reclaimed through the reclamation of this highwall area. This site would be similar to priority #1. Lime would be added to the pit floor and backfill material. The surface would have biosolids application to increase the vegetation growth. The PGC would be involved in developing the revegetation plan of the area to insure their goals of the Game Lands are met.

BAMR will be contacted concerning the potential of reclaiming this area. If this is not possible, a grant will be submitted to Growing Greener for the reclamation of this highwall, along with additional funding sources. The construction phase cost is broken down in the table below.

Table 30: Estimated Reclamation Costs of Priority #2 Highwall

Item	Cost
Site Access	$ 5,000
Clear and Grub	7,500
Erosion Sediment Control	7,500
Earthwork (80,000 cy at $0.80/yard)	64,000
Earthwork/Blasting	35,000
Alkaline Backfill Materials (120 tons at $50.00/ton)	6,000
Limestone Channels/Piping	5,000
Mobilization/Demobilization	13,000
10% Contingency	14,300
Total	$ 157,300

Additional costs will include $6,000 for surveying work and mapping, $6,000 for permitting and E&S design, $10,000 for construction oversight, and approximately $25,000 for engineering and design costs. The total cost for priority area #2 is approximately $198,300. Match monies would be obtained through the application of biosolids and partnership with the PGC for planting and seeding of the area.

Priority # 3: Spoil / Ponds

The third priority area for reclamation is a spoil area which contains three impoundments and is approximately 20 acres in size (see pages A-12 and A-13). The far side of the area does have a steep embankment with an exposed rock face and sloughing material. The area appears to be located at the portal of a large deep mine on the property and is probably material that has been brought out of the mine. A small cut appears to have been made here as well. The area appears to consist of overburden material and lacks any usable fuel material. It is a rolling area with limited growth. Trees have begun to develop on the area, but no groundcover is present. By reclaiming this area, 20 acres will be gained which can be used for wildlife habitat and food plots; a safety hazard will also be removed.

Three separate impoundments have developed on this area. None are discharging water, but may be percolating into the groundwater. Quarterly samples were taken on two of these, LR20 and LR21 (Table 17). This priority area is located near the center of the Game Lands and near the elk release area. It is difficult to determine the groundwater flow on site due to the extensive mining and rock fractures. The seepage from the bottom of the ponds may be entering groundwater and eventually making its way to Loop Run or Little Birch Island Run. The impoundments have approximately 3' to 4' of standing water all year, and now have bird boxes around them. The PGC does not, however, see a long term benefit of maintaining the ponds and see the reclaimed land as being more valuable.

Regrading costs in this area would be $4,000 per acre. Revegetation, including mulch and fertilizer, will cost $1,000 per acre. Additional lime would be added at a rate of 20 tons per acre at a cost of $520 per acre. An approximate reclamation cost for priority #3 would be $130,400. As with other areas, biosolids would be added and potentially the PGC would take on the task of seeding and planting the area. Additional costs would be $10,000 for surveying and mapping, $8,000 for permitting and E&S control design, $20,000 for engineering fees for the reclamation design itself, and $10,000 for construction oversight. Mobilization and demobilization costs would be $17,840 and adding a 10% contingency $19,624, the total cost of the project would therefore be $215,864.

Summary of Reclamation Areas

Three reclamation areas have been identified on SGL-321. Two are highwall areas creating a hazard to both wildlife and humans alike. The rock faces are sloughing off creating a safety hazard. Infiltration percolating through the pit areas may be making their way to Little Birch Island Run increasing the pollution loadings to this stream. The combination of the two highwall projects would reclaim 90 acres of land on the property to be used as wildlife habitat and additional food plots. The third area is a spoil area located near the portal of a large deep mine. Impoundments in this area have created a safety hazard, along with falling rock on a steep embankment area. Reclamation of this area would reclaim 20 acres of the property.

Table 31: Summary of Costs of Reclamation Priorities

Priority	**Cost**
Highwall #1	$ 576,928 + BAMR design
Highwall #2	$ 198,300
Spoil #3	$ 215,864

Potential Funding Sources

As we have used in the past, PADEP's Growing Greener Program is considered the largest source of funding for watershed projects. This program funded the development of this restoration plan, and a grant was submitted for the first design/permitting project on Treatment Area #1. This program provides funding for design/permitting and construction phases for remediation of mine drainage in a watershed. The grant period normally opens in early winter and closes in early spring, with announcements made in late summer. The grant length is normally two to three years to allow for completion of construction. Non-profit groups, educational institutions and municipalities may apply for grants. Through submission to the Growing Greener Grant program, projects are eligible for EPA 319 Watershed grants. To be eligible for EPA 319 monies, a TMDL needs to be completed on the watershed.

The Bureau of Abandoned Mine Reclamation (BAMR) can also provide funds for surface reclamation projects. We have already contacted BAMR for reclamation of Priority Area #1 and they have added the reclamation project to their list. BAMR can also design and construct passive treatment systems. It is the landowner's responsibility to contact BAMR to get them involved with projects.

Another source of funding is through the Chesapeake Bay Small Watershed Grants Program. The grant deadline is in February and grants are awarded in late summer. We have submitted the design and permitting of Treatment Area #1 to this program. Any watershed activity is eligible for funding, but the grants are limited to $50,000 and require up to 50% match. This program can be used successfully for design and permitting, but construction activities are normally out of this range.

A final source of funding is through the Office of Surface Mining Appalachian Clean Streams Initiative. These grants can be used for construction phases only, not for engineering or design costs. This program also requires a significant match. These grants are within the $100,000 range, but can be successfully matched with other funding to complete a project. OSM has an open grant application, so no deadlines exist.

As stated above, all grant programs rely on match money for success and funding. This match comes through community involvement, volunteers, equipment donation, or material donation. For work conducted on the Kelley Estate (SGL-321), we have the support and partnership of the PGC to be used as a match. They have committed to man hours for building of roads, ditch construction, and long term maintenance. It is these types of partnerships that make projects a success.