KLONDIKE AMD TREATMENT PROJECT
FINAL REPORT

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November 12, 2008

Prepared for

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Contents

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EXECUTIVE SUMMARY

At the Klondike Project near Ashville, PA, two passive treatment systems have been constructed in 2007 by the Clearfield Creek Watershed Association to treat two acid mine discharges. The cost of $584,387, was obtained from US EPA 319 funds, a Growing Greener grant, the Appalachian Clean Streams Program, and the Western PA Watershed Program, plus considerable in-kind contribution by US Environmental Research Services and Watershed members. The KL-2 system is generating net alkaline water and removing about 95 lb/d of acidity, 3 lb/d Fe and 1 lb/d Al. During winter and spring, the KL-1 system removed 71 lb/d of acidity, about 90% of the 30 lb/d Fe and 1 lb/d of Al, but was found to be plugging with Fe precipitate on top of the compost. The system has been modified in several ways to improve performance, including construction of additional Fe-removing ponds with a grant of $12,145 of Quick Response Funds, and is currently treating water again. The restoration of a small stream to its original channel through strip mine spoil has also been completed as part of the project.

INTRODUCTION

The Klondike project, located near Ashville in Gallitzin and Dean Townships, Cambria County, PA., is intended to passively treat two acid discharges emanating from the long-abandoned Klondike underground coal mine and related surface mines. The two Klondike discharges, 32R2 and 32R2A are being treated by treatment systems KL-1 and KL-2, respectively. The Klondike discharges (and the treatment systems) flow into Little Laurel Run, a tributary to Clearfield Creek (Figure 1). The Klondike Project is supervised by the Clearfield Creek Watershed Association with design and construction oversight by John Foreman of US Environmental Research Services.

The goal of the treatment systems is to remove the acidity and metals from the discharges so that Little Laurel Run will satisfy water quality standards for the stream, which is classed as a cold water fishery (Rose, 2005). At 32R2 (KL-1), the loads of acidity, Fe and Al are 69, 22 and 0.6 lb/d, respectively, based on data in Rose (2005). For 32R2A (KL-2), the loads of acidity, Fe and Al to be removed are 73, 8 and 2.5 lb/d, respectively, based on Rose (2005). Attainment of standards in Little Laurel Run will require treatment of three additional upstream discharges in the West Ferris Wheel area (32R3, 32R4 and 32R5), plus several downstream discharges. Design and permitting is underway for the West Ferris Wheel discharges, as discussed in the Restoration Plan for Little Laurel Run (Rose, 2005). A revegetation project, the Ferris Wheel project, is underway on a large area of spoil that has been barren for about 50 years. Revegetation of this site will decrease AMD from the site and decrease runoff during storms.

Design and permitting of the KL-1 and KL-2 systems occupied the period between 2004 and spring 2007. The two treatment systems were constructed in August through November 2007, and began treating water in November. The restoration of a small stream (the “Krug” tributary) to its original channel is also a part of this project, and was completed in July 2008. This stream had been infiltrating the strip mine and contributing to flow into KL-2. During winter and spring 2008, the KL-2 system was treating satisfactorily, and KL-1 was removing all the Fe, Al and pH acidity. However, in June 2008, sampling showed that KL-1 was only partially treating the AMD. Draining the vertical flow pond showed accumulation of about an inch of Fe precipitate on the compost, tending to plug the system. Modifications are underway to minimize this problem.

Three entities own property in the area. The Hite-Dodson heirs own a triangular slice of property that includes most of the access roads, the stream reconstruction, and part of the area for the KL-1 treatment system. The Blair County Solid Waste Authority owns land to the east that included most of the area of the two treatment systems. Cooney Bros. Coal Co owned land at the entrance to the project and along the first part of the access road. Cooney Bros also owned coal rights to some of the area. The Cooney property has since been transferred to a trust. Agreements for access, construction and maintenance were obtained from all three of these owners.

DESIGN OF THE KLONDIKE PROJECT

CCWA received announcement of a Growing Greener award of $12,855 for design and permitting in 9/03. An in-kind match of $15,120 was contributed by US Environmental Research Service, Arthur Rose, and members of CCWA.

Data on the flow and chemistry of the 32R2 (KL-1) and 32R2A (KL-2) discharges are shown in Table 1. Based on data available during design, the 32R2 discharge had an average flow of 15 gal/min with pH 3.3, acidity of 417 mg/L as $CaCO_3$, Fe of 141 mg/L, Mn 30 mg/L and Al 3.8 mg/L. The acidity load averaged 69 lb $CaCO_3$/d and the Fe load was 22 lb/d. The 32R2A discharge had an average flow of 151 gal/min, with average pH of 3.5, acidity of 50 mg/L CaCO3, Fe 5.4 mg/L, Mn 3.3 mg/L and Al 1.5 mg/L. The acidity load averaged 73 lb/day, and the Fe load was 8 lb/d. Thus, the 32R2 discharge had small flow but very high acidity and Fe, compared to high flow and relatively lower acidity and Fe in 32R2A. The acidity load of the two was similar. Both discharges had relatively low Al, and were deemed to be treatable with a vertical flow pond.

The design was largely completed by early 2005. Treatment is by two passive vertical flow ponds (VFP’s) with preceding and succeeding oxidation and settling ponds plus small wetlands. In addition, a small tributary with flow up to 400 gal/min that flowed over a highwall and seeped into the KL-2 underground mine because of spoil blocking its channel has been restored to its original channel.

Permitting consumed the period from spring 2005 through summer 2007.

Plates 1 through 5 show the design of the system. The project can be divided into four major segments:

1. Construction of access roads, culverts and associated E&S controls (Plate 1).
2. Construction of the KL-1 treatment system. (Plate 3)
3. Construction of the KL-2 treatment system (Plate 5)
4. Construction of a restored channel for the “Krug” tributary (Plate 4)

An access road to the vicinity of the proposed treatment systems already existed, in the form of a strip mine road to KL-1 and a logging road from there to KL-2. This road was upgraded to handle tri-axle trucks, and branches extended into the treatment pond areas. An improved highway access was designed to meet PENNDOT requirements.   Five culverts were designed for crossings of two upper tributaries of Little Laurel Run, the KL-1 discharge, the "Krug" Tributary, and a wet-weather flow from mine spoil near KL-2.   Two additional culverts were designed to allow access across bypass channels and into the treatment pond areas.   The disturbed ground along the access roads was designed to be vegetated immediately after improvement of the roads, and appropriately ditched to control water.

A gently sloping area just downslope from strip mine spoil was selected for the KL-1 treatment system. A 90 degree V-notch weir (designated 32R2) allows measurement of flow from the KL-1 discharge in a strip mine.   The pre-existing channel extends for about 300 feet from the origin of the discharge, through a notch in surface mine spoil, to the KL-1 site. It is crossed by the road to the KL-2 site. The final section of this flow path is lined with limestone riprap. Prior to construction, the KL-1 flow extended about 450 feet down the hill from the KL-1 site to Little Laurel Run. The treated outflow of the KL-1 system enters this old channel to Little Laurel Run

The initial settling pond and the oxidation-precipitation pond of KL-1 were designed as ponds with a 6- to 9-foot water depth and a retention time of several days for the average flow of 32R2.   The water surface dimension of the initial settling pond is 55 x 85 ft. and of the oxidation-precipitation pond is 63 x 74 ft. Inner slopes are 2:1.   The VFP was sized based on a 25-year life for the limestone consumption and acidity removal at a rate of 35 g of acidity($CaCO_3$)/m^2/d (Rose, 2004), at the average flow and chemistry. This resulted in a pond with water surface dimensions of 78 x 125 feet, and a water depth of about 4.5 ft.   Inner slopes are 2:1.   A 2-foot thick layer of limestone (AASHTO#1, about 3 inch size, >86% $CaCO_3$, 686 tons) was designed to be overlain by 1 foot of spent mushroom compost mixed with 25 vol % wood chips and 10 vol % fine limestone (498 yd^3).   The underdrain near the base of the limestone consists of 6 inch diameter perforated PVC pipe (1-inch holes at 1 spacing) at 10 ft intervals, joining a 6 inch PVC manifold pipe that leads to the outflow manhole. The position of the underdrain pipes is indicated by spray-painted markings on the liner and recorded on the as-builts. The VFP pond is lined with a plastic liner of 30 mil HD polyethylene; the other two ponds were originally designed to be lined, but linings were later removed to save money. The treated water flows into the final oxidation-precipitation pond through a "diffuser pipe", a horizontal, 10-foot length of perforated PVC pipe. Water emerging from the perforations splashes onto a series of rocks to add oxygen and then into the pond.   The outflow of the final oxidation-settling pond flows down a rip-rapped channel into a wetland 150 feet long and about 10 ft wide, to the final outflow point at the original channel.

At KL-2, the flow emerges from discharge 32R2A, a caved entry to the Klondike underground mine on the B coal.   This entry evidently served as a drainage point for the mine, which extends updip across PA 36. A 3-foot rectangular weir measures the flow from this discharge. The water flows down the slope in a limestone-lined channel for about 300 feet to the location of the first pond.

The initial settling pond and the final oxidation-precipitation pond have a 6- to 9-foot water depth and a retention time exceeding 2 days at average flow. The dimension of the initial settling pond at the water surface is 57 x 137 ft, and of the final oxidation-precipitation pond is 64 x 123 ft.   Inner slopes are 2:1.   For the VFP, calculations showed that sizing with acidity removal of 35g/d/m^2 resulted in a retention time in the 2 ft. thick limestone layer considerably less than 16 hours, the desired retention time. This VFP was sized to provide a 16-hour retention time in the limestone layer, after consumption of limestone over a 25-year design life. The limestone is again AASHTO #1 (about 3 inch, >86% $CaCO_3$, 2009 tons). The VFP pond is lined with 30 mil HD polyethylene. A 1-foot layer of spent mushroom compost mixed with wood chips and fine limestone as above overlies the limestone. Perforated underdrain pipes (1 inch perforations every foot) in the bottom of the limestone are spaced at 10-foot intervals, and lead to two outflow manifolds and separate outflows. The position of the underdrain pipes is indicated by spray-painted markings on the liner. The outflow again emerges into the final pond through numerous holes in a horizontal 6-inch PVC pipe, onto rocks just above the water level of the final oxidation-precipitation pond. From this pond, the outflow cascades down a channel lined with very coarse riprap (>1 foot diameter) into a wetland with dimension of 380 x 8 ft. The final outflow enters the original channel of the 32R2A discharge and flows about 50 feet to Little Laurel Run.

Excavation of KL-1 ponds proceeded without problems, but at KL-2, bedrock was encountered several feet above the intended bottom of the ponds. Some bedrock was removed, but to minimize this problem, the ponds were shifted a few feet uphill from the original location. Spoil from the stream restoration cut was used for part of the berms on KL-2.

Both treatment systems are protected from influx of surface water by ditches immediately uphill from the ponds. At KL-2, appreciable water was encountered in the bottom of the excavation, and now emerges as small flows between the ponds and the wetland. Some of this water is apparently shallow acidic groundwater from the mine workings up the hill; others of the small flows appear to be leakage of untreated water from the initial settling ponds and treated water from the final precipitation pond. The total of these small flows is a few gallons per minute, and is neutralized by the main flow, but may be adding Fe to the final outflow. Seepages along the uphill side of the cut for the VFP were captured in a trench of crushed stone and accessed by a well up to the surface. During installation of the liner, this well was pumped so that the liner was installed without complication from this flow. The well remains near the outflow manhole.

Restoration of the small stream ("Krug" tributary) involved excavation of 17,000 cubic yards of mine spoil that had been left across the original stream course, and construction of riprap channels at the bottom of the highwall and down the steep slope below the culvert on the KL-2 access road. The channel was planted in grass designed to handle the maximum anticipated stream flow. The stream re-enters its original channel and flows to Little Laurel Run.

PERMITS

The following permits were obtained:

1. Highway Occupancy permit
2. Erosion and Sedimentation Permit
3. Stream Encroachment and Wetland Permit (Chapter 105, Section 404)
4. NPDES Permit
5. PA Natural Diversity Inventory
6. Cultural Resource Notice

CONSTRUCTION

In February 2005, an award of $391,512 for construction was made to CCWA from EPA 319 funds administered by the PA DEP. Based on this award and the receipt of all permits, the design was incorporated into a bid package by US Environmental Research Services in 2007. The bid documents specified that PA prevailing wages and Davis-Bacon wages were not required, owing to the federal source of the funds, and the fact that this type of construction was not covered by Davis-Bacon.

On 5/25/07 the project was advertised for bids to be received by 6/22/07. Site meetings for prospective bidders were held 6/8 and 6/15/07. Bid packages were sold for $200 each. A total of 6 bid packages were distributed.

Three bids were received and opened on 6/22/07. The three total bids were Ligonier Construction, $622,763; Krieger Excavating, $646,708; and Delozier Inc, $860,023. Low bidder was Ligonier Construction. The low bid greatly exceeded the grant of $391,512 awarded from EPA 319 funds for construction. After discussion with the low bidder, Ligonier Construction, a contract was awarded for $385,844 on 7/26/07 for construction of the KL-1 and KL-2 systems. This contract did not include the stream restoration or liners in the ponds, but did include amounts for accomplishing the stream restoration and liners in the VFP's if funds were received during the project. Work on this contract started 8/6/07.

In order to proceed with the stream restoration and pond liners, an application for $100,000 was submitted to US Office of Surface Mining, Appalachian Clean Streams Foundation. These funds were received in October. An additional application for $20,000 was submitted to the Western Pennsylvania Watershed Program. A positive verbal response was received on the latter proposal, but the formal award was not announced until November 2007. After discussion with the EPA 319 office in PA DEP, we were awarded an additional $59,980 in order to place liners in the vertical flow ponds.

Thus the final funds made available for the project were as follows:

Growing Greener (design)	$12,855
EPA 319 (original)	391,512
EPA (supplemental)	59,980
Office of Surface Mining	100,000
Western PA Watershed Prog.	20,000
Total	$584,347

In-kind contributions by Watershed members and by U.S. Environmental Research Services amount to more than $20,000 during the project, and the Blair County Solid Waste Authority, Cooney Bros. Coal Co and Hit-Dodson families contributed land and access.

Construction of the KL-1 and KL-2 systems, including liners in the VFP ponds, was essentially completed in November 2007, and they started to treat water. The stream channel restoration was completed except for removal of the stream diversion, which was removed in spring 2008 after the grass had grown in the channel. The stream is now flowing very nicely in the channel, and leakage into the strip mine has ceased.

In spring and summer 2008, Ligonier did some reseeding, and furnished "as-built" drawings of the construction. A list of deficiencies in the "as builts" was returned to Ligonier, and revised drawings were received 11/13/08.

MONITORING AND PROBLEMS

Starting in December 2007, the systems have been sampled approximately monthly at the outflows and selected other sites. The results are summarized in Table 1. On most dates, a non-filtered water sample and a small acidified sample were collected at the various sample sites and sent to Mahaffey Laboratories, Curwensville, PA. Field measurements were taken of pH, conductance and (if pH exceeded 4.5) field alkalinity. On most occasions the weirs at the discharges (32R2 and 32R2A) were measured to obtain flow through the systems. On 5/20/08 a set of measurements was made for Dissolved Oxygen (DO) using a DO meter. On 6/20/08, samples were filtered in the field through 0.45 µm, acidified, and submitted for dissolved metals. A few samples in January, February, April and June were measured for acidity (EPA method 305.1) by Arthur Rose at Penn State.

At KL-2, the sampling shows outflow pH of 5.7 to 7.2, negative acidity (usually minus 20 to minus 38 mg/L), and alkalinity of 30 to 75 mg/L. The Fe in the VFP outflow (KL2-4) is very low. However, at the final outflow (KL2-5), some Fe and Al is present in the samples. The source of the Fe and Al is uncertain, but may be the small leakages along the wetland, combined with sorption to organic matter that is derived from the compost. In n any case, the acidity is negative and the pH is high enough that Al and Fe are not soluble. This organic component is diminishing as the most soluble organics are removed from the compost. The system is considered successful in view of the net alkaline nature and considerable alkalinity in the outflow. Also, the ongoing growth of wetland plants in the wetland should capture much of this suspended organic matter.

During winter and spring, outflow from KL-1 had pH 5.2 to 6.8, alkalinity of 30 to 60 mg/L but acidities of 31 to 66 mg/L. Some total Fe values in the outflow were 7 to 16 mg/L; observations showed most of this Fe was suspended Fe. Manganese was 29 to 40 mg/L, and calculations showed that essentially all the acidity was attributable to Mn.

When sampled on 6/20/08, the outflow pH had 3.6, with acidity of 137 mg/L, and 22 mg/L dissolved Fe in the outflow. This indicated a considerable problem with the system. As a result, the system was drained in early July, and about 1 inch of Fe precipitate was observed covering the compost. The rapid accumulation of this much Fe precipitate in 7 months indicated serious problems with plugging over the longer term, and probable partial plugging to cause the decrease in performance. In mid-July, flow into the system was diverted back to the bypass channel by a small dam in the inflow channel.

To remove this layer of precipitated Fe, members of the watershed association spent several half-days shoveling out the layer of Fe precipitate, adding about 6 inches of additional compost with added limestone, and tilling the compost with a rototiller to restore its permeability. A total of 30-40 man-hours of labor are estimated for this effort.

Several other modifications have been made or will be made to minimize the Fe precipitate problem.

1. The outflow channel from the final oxidation-precipitation pond was lowered about a foot to provide more of a drop and splash effect for the outflow of the VFP. This should provide more dissolved oxygen to precipitate the Fe in this pond.

2. Limestone was added to the steep outflow channel from the final pond to the wetland, to add more alkalinity to the flow.
3. During removal of Fe from the VFP, a small hose fed by a pump was used to slurry up part of the Fe layer and wash it to a sump on one edge of the pond, where the slurry could be pumped out with a second pump. This was much easier than shoveling out the precipitate, and seemed to do a thorough job with minimal disturbance of the compost.
4. In an experiment, about 30 ft^2 of the compost was covered by a 6 inch-thick perforated geowebbing overlain by a plastic sheet. The intent is that the Fe will settle on the sheet and can be easily removed, but the water can flow laterally into and through the geowebbing and down through the compost.
5. Quick Response Funds of $12,145 have been obtained to construct about 2000 square feet of elongated shallow ponds before the water flows into the first existing settling pond. The intent is to provide more area for low-pH Fe-oxidizing bacteria to remove Fe. Research by Dr. William Burgos at Penn State indicates that increased surface area is a key factor in precipitating Fe at low pH. These ponds were completed in early November and are now filling.
6. Some of the Fe in the VFP enters this pond in suspension, as indicated by the presence of 107 mg/L total Fe entering the VFP on 6/20/08, but only 95 mg/L of dissolved Fe. To capture this Fe, an experimental filter filled with "Fuzzy Filter" donated by Schreiber, Inc. has been placed between these ponds. Based on the outcome of this test, a permanent filter will be installed at this site.
7. Visual observation suggests that the water in the ponds is stratified, probably in part because of temperature differences, probably with a warm layer at the surface in summer, and a cold layer at the surface in winter. Water from rain or snowmelt may also form a surface layer. In winter the water in the ponds was relatively clear, perhaps indicating lack of oxygen transfer thru the surface layer, or low rates of Fe oxidation due to low temperature. In summer, the ponds have been orange-brown and highly turbid, indicating a different type of circulation and/or temperature. Because of this stratification, influent water probably does not circulate through the entire pond. To improve mixing in the pond, installation of fabric curtains is being investigated, with the intent of precipitating and settling more Fe in the initial pond, and more in the final pond, so that less suspended Fe enters the wetland.

Discussions and investigations are underway with Dr Rachel Brennan, Assistant Professor of Civil Engineering at Penn State, regarding the installation at KL-1 of a small experimental treatment system using chitin as the treatment material. This test would be funded by a grant from the National Science Foundation that Dr. Brennan currently holds. The treatment would probably take place in a septic tank, and would remove a part of the load at KL-1. Lab tests are planned using KL-1 water to develop the design for this field experiment.

These changes should lead to more Fe precipitation before water enters the ponds and less Fe entering the VFP, less precipitated Fe in the VFP, easier removal of Fe precipitate in the future, and less Fe precipitate carried into the wetland.

Starting about September 15, about half the discharge was allowed to flow into the KL-1 system through a pipe and valve in the dam that diverts water into the bypass system. The initial settling pond filled and as of 11/1 the VFP was nearly filled. The flow was again interrupted during construction of the additional oxidation ponds in early November, but the system is now receiving water again.

Three weirs have been installed on Little Laurel Run to evaluate the success of the Klondike treatment system. Weir 32MS1 is at the mouth, just above the PA 53 bridge. Weir 32MS2 is about 200 yards downstream from the outflow of KL-2, and 32MS3 is a short distance upstream from the outflow of KL-1 (see Figure 1). Several samples and flow measurements have been collected from these sites. Results are listed in table 1. The stream sites are still highly acid and metal-rich from the Ferris Wheel discharges, but at 32MS2 the excess alkalinity contributed by the KL-2 system is clearly precipitating part of the Fe from the upstream discharges.

LOAD REDUCTIONS

The reductions in load of acidity, iron and aluminum accomplished by the Klondike systems are summarized in Table 2.

The reduction in acidity load for KL-1 averages 71 lb/day for the 7 months that it was treating water. This is approximately equal to the load of 69 lb/d found for the average load of this discharge cited in the Little Laurel Restoration Plan (Rose, 2005), and is approximately 89% of the acidity load for the period. The remaining acidity is dominantly Mn acidity. The Fe load removal is 27 lb/day, which is 90% of the total Fe load. Most of the remaining Fe was escaping the systems as suspended precipitate. Essentially all the Al is being removed. When the modifications are completed, these removals are expected to improve.

For KL-2, the effluent is net alkaline (negative acidities), with an average load reduction of 95 lb/day, or 148% of the influent acidity. This excess alkalinity more than balances the remaining acidity from KL-1, and the situation should improve in the future. Fe emerging from the VFP is very low, with a load reduction of 3 lb/d. However, the load is higher in the final outflow. Essentially all Fe load from discharge 32R2A is apparently removed. The cause of the Fe in the final outflow is being investigated. In view of the net alkaline nature of the final effluent, all Fe is insoluble when reactions are complete. Similar considerations apply to the Al load.

CONCLUSIONS

The two passive treatment systems of the Klondike Project have been completed, and KL-2 is successfully treating water. The KL-1 system, after modifications currently underway, is expected to treat this discharge to a net alkaline condition, and remove all the dissolved Fe. The stream restoration was activated in summer 2008 and is carrying this good water to Little Laurel Run rather than into the mine and out KL-2.

Monitoring and maintenance of the system by the Watershed Association will be continued during the life of the system. The monitoring will include samples from the three weirs in Little Laurel Run. Also, design and permitting is proceeding on the West

Ferris Wheel project, which will remove nearly all the remaining acidity and metals in the upper half of Little Laurel Run.

REFERENCES

Rose, A.W., 2005, A Restoration Plan for Little Laurel Run, Cambria County, Pennsylvania. Report to PA DEP and USEPA prepared for Clearfield Creek Watershed Association, 20 pp.

KLONDIKE AMD TREATMENT PROJECT

During 2007, two passive treatment systems were constructed by the Clearfield Creek Watershed Association to treat abandoned coal mine discharges near Ashville, PA. The systems remove about 200 lb/day of acidity and 30 lb/d of iron from Little Laurel Run. The systems were funded by US EPA 319, Growing Greener, Appalachian Clean Streams and Western PA Watershed funds, plus in kind contributions from John Foreman and Watershed members..

OPERATION, MAINTENANCE AND REPLACEMENT PLAN
KLONDIKE PASSIVE TREATMENT SYSTEMS

Arthur W. Rose
November 12, 2008

Operation, maintenance and replacement of the Klondike passive treatment systems in Dean and Gallitzin Twps., Cambria County, PA is being conducted by the Clearfield Creek Watershed Association (CCWA). The location of the site is shown on Figure 1. The systems have a design life of 25 years. During this period, the CCWA will regularly monitor the systems, correct any minor problems, and arrange for remediation of any major problems.

Two treatment systems constitute the main facilities at the project. The KL-1 system treats the outflow of discharge 32R2 from strip mine spoil. The KL-1 system consists of a channel leading to two shallow Fe-precipitation ponds, then a deeper precipitation-settling pond, the vertical flow pond (VFP), an oxidation-settling pond, and a wetland (Figure 2). A 90-degree V-notch weir exists at the discharge, and a similar weir is being installed at the final outflow. Sampling sites are as follows:

1. Discharge weir 32R2
2. Inflow to deep pond 1 (KL1-2)
3. Inflow to VFP (KL-1-3)
4. Outflow of VFP (KL1-4)
5. Final outflow of system (KL1-5)

At the KL-2 system, the layout is similar. The discharge emerges from a caved portal to the underground Klondike Mine. A 3-foot rectangular weir is available to measure the flow at this point. The flow cascades down the hill for about 300 feet in a channel lined with large limestone riprap, and enters a settling pond. This pond flows into the VFP. The outflow of the VFP emerges into an oxidation-settling pond, which flows out down a rip-rapped channel to a wetland channel. At the end of this channel, the water flows down hill along the original path of the discharge and into Little Laurel Run. Sampling sites are:

1. Discharge 32R2A
2. Inflow to first pond (KL2-2)
3. Inflow to VFP (KL2-3)
3. Outflow of VFP (KL2-4)
4. Final outflow (KL2-5)

The general plan for monitoring and sampling is to visit KL-1 and KL-2 at least quarterly. The systems will be inspected for problems, such as leaks, blockage, and other potential physical problems. At least at the influent (32R2 and 32R2A) and the effluent (KL1-5 and KL2-5) we will measure flow, field pH, field alkalinity, temperature and conductance, and collect a sample for lab analysis of pH, alkalinity, hot acidity, Fe, Mn, Al, and SO_4. The samples will be submitted to Mahaffey Labs or another certified lab for analysis. The VFP outlets (KL1-4 and KL2-4) will probably also be sampled and measured. Field measurements of ORP and dissolved oxygen will also be conducted as relevant at these sites. Values for acidity and the other parameters will be entered into a spread sheet and graphed.

The main criterion for satisfactory performance will be acidity. If the non-Mn acidity of the effluent becomes positive for two successive quarters (i.e., net acid in terms of pH, Fe, Al and alkalinity), we will conduct more detailed sampling and investigations to evaluate the cause. Secondary criteria will be dissolved Fe and Al concentrations less than 1 mg/L. The goal is that the systems furnish net alkaline water to Little Laurel Run.

If minor repairs of modifications will solve the problem, we will endeavor to accomplish this with our own efforts or local partners. If the system is determined to require significant rebuilding, we will seek funding for this step from sources in the state, federal government, foundations or other sources.

We also have 3 weirs/sampling points on Little Laurel Run. Site 32MS3 is just upstream from the inflow of the KL-1 system, 32MS2 is just downstream from the KL-2 inflow, and 32MS1 is at the mouth of Little Laurel Run, just upstream from PA 53. These sites will also be sampled at the quarterly sampling dates, and studied to examine the effects of the treatment systems on Little Laurel Run.

Quality control for the field measurements will include calibration of the pH meter against pH 4 and pH 7 buffers at the beginning of field work at the sites, and check of the conductance meter with a conductance standard. The ORP measurements will be calibrated with Zobell solution.