Little Coon Run and Walley Run
Mine Drainage Assessment and Restoration Plan

Prepared for the Farmington Township Supervisors

By Hedin Environmental
With Biological Assessment by Confluence Ecological

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Opinions expressed herein are those of the authors and not necessarily those of the DEP.

Executive Summary

The purpose of this project was to provide a restoration plan for mine drainage impacts to Little Coon Run and Walley Run, tributaries of Coon Creek. Coon Creek is a tributary of Tionesta Creek, classified as watershed 16F by the DEP. The study area is located primarily in Farmington Township, Clarion County. The main branch of Walley Run flows 3.7 miles. Walley Run also has 2.3 miles of tributary streams. Little Coon Run is 4.1 miles long and has 6.5 miles of tributary. Therefore, 16.6 miles of streams and tributaries are present in the study area.

54 sampling stations were established in the study area for chemistry and flow rate measurements of discharges, tributaries and streams. Biological sampling occurred at nine stations for macroinvertebrates and five of those nine stations for fish. This sampling indicated moderate pollution to Walley Run and severe pollution to Little Coon Run. Acidity and metals from numerous mine drainage discharges impair the streams. Coon Creek is also affected, particularly by pollution from Little Coon Run. Impairments are evident in both the chemical and biological results.

In general, the discharges with the worst quality emerge in the headwaters of Little Coon Run and its tributaries and, to a lesser extent, the headwaters of Lard Run. These seeps, which are characterized by very low pH and elevated aluminum levels, originate from surface mines and mine refuse. The flows are typically dependant upon precipitation and most do not flow all year. These discharges are of concern primarily due to the highly toxic nature of aluminum.

Further from the headwaters, the mine drainage impacts are typically from ground water seeps and abandoned wells that have larger, more constant flows of water than the surface flows near the headwaters. These discharges typically contain some alkalinity, elevated concentrations of iron and low concentrations of aluminum. The primary concern from this type of discharge is the acidity present due to elevated iron concentrations.

The primary goal of this project is to improve Little Coon Run beginning at the mouth of the stream and working towards the headwaters. This stream is the most polluted in the study area and greatly impacts Coon Creek.

Six high priority projects with a total estimated cost of $763,000 are recommended. The projects include four reclamation projects covering a total of 55 acres, a project to plug two wells (grant application pending), and one anoxic limestone drain treatment system. The high priority projects affect several discharges to Little Coon Run and one discharge to Lard Run. Other medium- and low-priority projects are also detailed in this report.

If the six high-priority projects are successfully completed, Coon Creek and Little Coon Run will be greatly improved. Currently impacted segments of Coon Creek should experience chemical and biological conditions similar to un-impacted upstream stations. Little Coon Run will also experience vast improvements for at least three stream miles, with more modest improvements in tributary and headwater areas.

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I. Introduction

A. Watershed Location and Description

The purpose of this project was to assess mine drainage impacts and to provide a restoration plan for Little Coon Run and Walley Run, tributaries of Coon Creek. Coon Creek is a tributary of Tionesta Creek, classified as watershed 16F by the DEP. Figure 1 shows the study area. The study area is located primarily in Farmington Township, Clarion County. A small part of the western portion of the Little Coon Run watershed lies in Washington Township, Clarion County. In addition, the final 100 meters of Walley Run before the confluence with Coon Creek are located in Green Township, Forest County. Bull Run, a tributary of Coon Creek that lies between Little Coon Run and Walley Run, is not impacted by mine drainage.

No named settlements are located within the watershed, but the villages of Crown, Tylersburg, Frills Corners and Newmansville are located just outside the watershed boundaries. The North Clarion High School is located partially within the watershed. State Game Lands #24 encompasses most of the main stem of Little Coon Run, the area around the mouth of Walley Run, and the entire length of Coon Creek in the study area. Numerous permanent residences and camps are located within the watershed.

The main branch of Walley Run flows 3.7 miles. Walley Run also has 2.3 miles of tributary streams. Little Coon Run is 4.1 miles long and has 6.5 miles of tributary. Therefore, 16.6 miles of streams and tributaries are present in the study area. (Note: All stream lengths measured from blue-line streams on USGS 7.5' Topographic Maps.)

B. Watershed Geology and History

The study area is located in the northwestern segment of Pennsylvania known as the Allegheny Plateau Section of the Appalachian Plateau Physiographic Province. The topography is typified by broad hilltops at the headwaters of streams with steeply dissected hillsides at the confluence of major tributaries.

The regional structure is controlled by the Leeper Anticline that is located within 2,000 feet of the southeast corner of the County Landfill operations, passing through the town of Leeper, with the axis of the anticline trending in a northeast to southwestern direction. The Frills Corners Syncline accompanies the Leeper Anticline and is situated to the northwest. The axis of the syncline also trends in a northeast to southwestern direction with its axis located to the northwest of Frills Corners. Little Coon Run and Lard Run originate on the northwestern flank of the Leeper Anticline and flow towards the axis of the Frills Corner Syncline, with the main drainage of Little Coon Run following the axis of the syncline closely.

Pennsylvanian age rocks outcrop in the Allegheny and Pottsville Groups in the upper portions of the watersheds, while the Mississippian age Shenango Formation outcrops in the lower reaches of the streams at Coon Creek. Total amount of relief between headwaters of the streams and Coon Creek is approximately 340 feet.

The headwaters of the streams fall near the contact between the base of the Pennsylvania Allegheny Group and the top of the Pennsylvania Pottsville Group. The Clarion coal occurs near the base of the Allegheny group and was widely mined in the study area. The clay beneath the Clarion coal serves as the base of the Allegheny Group.

The topography of the watersheds is moderately steep at their confluence with Coon Creek, while the headwater areas are gently rolling to relatively flat. Little Coon Run and Lard Run originate near the base of the Clarion coal seam. Prior to the mining of the Clarion coal seam, discharges off the coal seam likely produced good water. During the mining of the coal, overburden was placed on the outcrop of the coal seam covering up any sign of the edge of coal. Water draining off of the coal seams currently infiltrates spoil and soil, emerging down gradient of the original location of the coal outcrop. In most instances, water discharging in close proximity to these abandoned mine sites is polluted mine drainage.

Deep mining occurred in the area and was conducted around the time of World War II. Surface mining in this area started in the 1940's and continued until the 1960's. In addition, there were small "house coal" mines that were utilized by local residents for the heating of their homes. The hilltops in the upper reaches of the watersheds contained small patches of coal that were removed using a hilltop removal pattern. Coal crops may have been left in place in some areas. These small abandoned mines and their associated spoil areas appear to be the main source of pollution to these streams. The only coal that remains in the area is at coal outcrop locations and under roadways and cemeteries.

Oil and gas exploration and production has also impacted the study area. Numerous abandoned oil and gas wells are present, some of which discharge mine drainage to the streams. The abandoned wells provide a conduit for contaminated water in lower aquifers to rise to the surface.

A landfilling operation was started on an abandoned strip mine in the headwaters of the stream in the late 1970’s. The landfill was known as the Kinnear Landfill and is located on the watershed divide between Walley Run to the northeast, Little Coon Run to the west and northwest and Toby Creek to the south and southeast. In 1987, County Environmental began operating the landfill, which continues to the present. The leachate from the site is collected and treated. The treatment plant effluent from the landfill forms the headwaters of Lard Run, a tributary to Walley Run.

In 1996, 2.8 miles of Walley Run was added to the EPA’s 303D list of impaired streams and rivers. Contamination from metals, presumably due to AMD, was the reason for the listing. Little Coon Run has not yet been assessed for inclusion on the list. Conversely, in 2001, the Pennsylvania Fish and Boat Commission investigated Walley Run. As a result of their investigation, Walley Run was reclassified as a Reproducing Trout Stream (Damariscotta, 2001).

II. Project Description

A. Scope of Work and Schedule

The primary goal of this project was to complete a mine drainage remediation and stream restoration plan for the study area. Table 1 shows major project milestones.

Table 1: Major Project Milestones

Date	Notes
March 9, 2001	Proposal submitted to Growing Greener
July 2001	DEP announced successful proposals
August – September 2001	Field investigations and reconnaissance
October 2001	Sampling Stations Established
November 2001	Monthly Sampling Started
March 21, 2002	Mid-project update meeting with all partners
September 6 and 24, 2002	Biological Sampling by Confluence Ecology
October 2002	Monthly Sampling Ended
December 5, 2002	End of Sampling update meeting with all partners
May 13, 2003	Draft Report Presented at Public Meeting
June 2, 2003	Comments on Draft Report Collected
June 27, 2003	Final Report Submitted to DEP

In August and September 2001, the study area was investigated, historical data were examined and sampling locations were selected. The stream sections were walked in their entirety to locate potential sources of pollution.

In October 2001, 54 sampling locations were established and flow-monitoring equipment was installed where practical (See Figure 2). This equipment consisted of flow measuring flumes or installed pipes to collect the flow, which was then measured with a bucket.

Most sites were sampled monthly for flow and chemistry. Some sites were sampled monthly and measured for flow quarterly using a flow velocity meter. All data were entered into an Access database. This report represents the final report for this project.

B. Sampling Period

Monthly sampling began in November 2001 and continued until October 2002. Biological sampling took place in September 2002. Figure 3 shows the monthly rainfall amounts during the sampling period, as well as the average monthly rainfall amounts. All data were taken from the Clarion weather station, located approximately 13 miles south of the study area. Standard deviation bars are also shown. A total of 48.1 inches of rain fell during the sampling period of 12 consecutive months. The average yearly rainfall is 40.18 inches with a standard deviation of 12.23 inches. Therefore, the rainfall during the sampling period falls within the standard deviation of the average rainfall.

C. Sampling Methods

Hedin Environmental personnel and Farmington Township personnel made monthly measurements of chemistry and flow rate. Biological data were collected and analyzed by Confluence Ecological. Methods used for data collection are described below.

In order to organize the sample data, a simple naming system was used for the points. Each point was given a name consisting of two letters that indicated the stream on which it was located followed by two numbers indicating its location within the watershed. Additionally, the letter "D" was added to discharge sample stations. The letters CC were used to indicate Coon Creek stations, LC was used for Little Coon Run, WR was used for Walley Run, and LR was used for Lard Run, the main tributary to Walley Run. Stations were numbered beginning at the mouth with station number 01. Not all numbers were used in sequence in order to allow the future establishment of more stations between existing points while remaining within the naming system.

Chemistry

Water samples were analyzed for mine drainage parameters. Alkalinity, temperature, and pH were measured in the field. Alkalinity was measured using a Hach digital titration kit. In this method, samples are titrated to a pH of 4.5 using 1.6 N H_2SO_4. If a sample begins at a pH of 4.5 or lower, there is no alkalinity in the sample. Temperature and pH were measured using a Hanna pH meter. The meter was calibrated with pH 4.01 and pH 7.01 buffers prior to use.

All other parameters (conductivity, total acidity, iron, aluminum, manganese, total suspended solids and sulfate) were measured in the laboratory. G&C Laboratories of Brookville, PA performed the analyses using standard methods. Samples for metals were preserved in the field using nitric acid. Field samples were unfiltered, so concentrations of metals reflect total concentrations, not dissolved concentrations. Efforts were made in the field to collect clear samples as close to discharge points as possible, so dissolved and total concentrations should be similar.

For some discharges, ALKast tests were performed by incubating discharge water in limestone. This method was developed by Hedin Environmental and has been shown to accurately predict the alkalinity generating capacity of each unique discharge.

Flow Rate

Several flow measurement techniques were used. At locations where flow could be collected to a common point and was not expected to be above 100 gpm, the flow was directed to a pipe. Flow rate was measured at these sites by capturing the flow in a bucket and timing how long it took to collect a known volume of water. This is called the "timed volume" method.

At sites with higher flow rates where flow could be directed to a single point, H-flumes were installed to measure the flow rate. After installation, flow was determined by measuring the depth of water in the flume and converting the depth to a flow rate using the appropriate flume chart.

At in-stream stations where flow rates were desired, a Swoffer Model 3000 flow velocity meter was used. A cross-section was established and the velocity was measured at several locations along the cross-section. The flow meter automatically calculated the flow rate from these measurements.

At some stations, it was not practical to measure flow rate, so only chemistry was measured.

Fish

Fish surveys were conducted at five locations in the Coon Creek watershed after Confluence Ecological received a permit from the Pennsylvania Game Commission to gain access to State Game Lands #24. Surveys were conducted at the mouths of Little Coon Run (LC01), Bull Run, and Walley Run (WR01). Two samples were taken on Coon Creek, one above the mouth of Walley Run (CC16) and one below the mouth of Little Coon Run (CC10). These stations are shown on Figure 2. Fish samples were located to coincide with water sample locations to maximize the utility of both data sets.

Fish were sampled during base flow conditions in September 2002 to maximize visibility and capture efficiency. Sample stations were approximately 75 - 100 meters in length depending on the size of the stream being sampled. All sampling took place between 10 AM and 6 PM. Electrofishing was conducted with a Smith-Root POW backpack unit (pulsed DC) with 2 hand-held electrodes mounted on fiberglass poles. The sample crew consisted of one member carrying the backpack, operating one electrode, and one dip net and a second crewmember operating the other electrode and a dip net. A third crewmember followed with a net to capture drifting fish that may have eluded forward personnel and a bucket for specimen transport and care. All fish were identified to species in the field and recorded on data sheets. Voucher specimens were retained when appropriate.

Bull Run, Little Coon Run, Walley Run, and Coon Creek were sampled on September 6, 2002. A follow-up survey was conducted on Coon Creek on September 24, 2002. Most of these samples were done on a qualitative basis only (no distinct counts) and dominate species were determined based on observations only. At CC16 (Coon Creek upstream of Walley Run), counts were performed that allow some quantitative analysis (See Appendix B).

Macroinvertebrates

Nine stations were surveyed for macroinvertebrates as part of this project. They included the five stations that were sampled for fish species (CC16, WR01, Bull Run mouth, LC01 and CC10), plus four additional stations. These stations were the mouth of Lard Run (LR01), and three stations at various locations on the main stem of Little Coon Run above the mouth (LC30, LC21 and LC09). These stations are shown on Figure 2.

Macroinvertebrate community surveys were conducted following the benthic macroinvertebrate protocols described in the EPA’s Rapid Bioassessment Protocols for Use in Wadeable Streams and Rivers (Barbour et al. 1999). Three samples were taken at each station from one riffle using a D-frame net (500 μ screen). The D-frame was randomly placed in the selected riffle and all substrate 18 inches upstream of the net was disturbed for approximately one minute. Large cobble and boulders were placed in the net and removed to the streams’ edge where they were brushed into a collection pan. The D-frame net was inverted and all contents were placed into the collection pan. Following the initial transfer of material the net was washed into the pan and inspected for specimens clinging to the mesh. Samples were placed in individual containers, labeled, and preserved with 95% ethanol. Preserved samples were delivered to the laboratory for processing and identification. Laboratory procedures also followed EPA protocols (Barbour et al. 1999).

All portions of the sample were carefully examined and organisms were picked from the debris in the laboratory. The picked organisms were transferred to a specimen vial and preserved with 70% ethanol. The contents of the vials were examined under a stereoscopic microscope for identification and enumeration to the lowest taxonomic level practically achievable by experienced biologists practicing in the field.

Taxonomic composition, number of taxa, individual counts, and other metrics for the benthic macroinvertebrate assessment were derived directly from identification and enumeration of macroinvertebrates collected in the three replicate D-frame samples from each station. These metrics have been developed and tested by the USEPA and other agencies and researchers to relate benthic macroinvertebrate community structure to the overall water quality of the aquatic system and as a means of evaluating the nature and magnitude of disturbances to aquatic systems (USEPA 1990a and Barbour et al. 1999).

The following metrics were used to analyze the benthic macroinvertebrate data for this study:

(1) total number of individuals;
(2) richness measures, such as the total number of taxa;
(3) composition measures, such as percent (% EPT); and
(4) tolerance/intolerance measures, including percent of intolerant taxa and percent total numbers of intolerant .

The following section discusses these measures in detail.

Richness, Composition and Tolerance / Intolerance Measures

The total number of individuals was derived from the total count of individuals identified in the three replicate D-frame samples collected from each station. The total number of taxa was derived from the total number of genera identified in the replicate samples. Increasing taxa diversity is correlated with increasing health of the benthic community, and suggests that adequate habitat is available to support the survival and the propagation of many species (Barbour et al. 1999).

The EPT measure is the number of distinct taxa within the orders Ephemeroptera (mayflies), Plecoptera (stoneflies) and Trichoptera (caddisflies) compared to the total number of taxa present. The three orders of insects are typically comprised of pollution-sensitive species. The number of EPT taxa increase with improving water quality (USEPA 1990a and Barbour et al. 1999).

The percent total EPT and their individual percentages provide information on the relative contribution of these pollution-intolerant taxa to the total fauna. Generally, increasing abundance and diversity among the taxa are associated with increasing water quality (USEPA 1990a).

The Shannon-Weiner diversity (H) index and Evenness (E) were calculated for each station. Diversity is affected both by the richness of taxa and the distribution of individuals among taxa. Evenness is the component of diversity related to the distribution of individuals among the taxa. Evenness is sensitive to slight physical differences between sample locations (USEPA 1990a). USEPA (1990a) states that evenness values greater than 0.5 are indicative of water not affected by oxygen demand wastes.

Percent intolerant taxa and percent total numbers intolerant taxa provide information on the benthic community's relative sensitivity to environmental stress. The number of intolerant taxa was determined using regional tolerance values obtained from the PA DEP Bureau of Watershed Conservation's Tolerance Values for Pennsylvania Macroinvertebrate Taxa. A community dominated by relatively few species or that is dominated by pollution-tolerant species may indicate environmental stress (USEPA 1990a).

III. Problem Identification

A. Chemistry of Walley Run and Tributaries

Table 2 lists and describes the stations on Walley Run and its tributaries. A total of 24 stations were established on Walley Run and its tributaries. Walley Run has one main tributary in the study area, Lard Run. Of the 24 total stations, 17 were on Lard Run. Of these 17 stations, 3 measured in-stream chemistry and 14 measured discharges (stations ending in "D"). Of the 7 stations on Walley Run, 3 measured in-stream chemistry and 4 measured discharges. In addition to chemistry measurements, the mouth of Walley Run (WR01) was also sampled for macroinvertebrates and fish. The mouth of Lard Run (LR01) was sampled for macroinvertebrates. Points are listed beginning in the headwaters and working towards the mouth. See Appendix C for more information on each point.

Table 2: Water Sampling Stations on Walley Run and Tributaries

Name	Description
WR21D	4" Pipe near WR20D
WR20D	36" Pipe Discharge to Walley Run Headwaters from Fuelheart Property
WR12	Walley Run Above Confluence with Lard Run
WR11D	Orange seep to Walley Run just upstream of confluence with Lard Run
WR10	Walley Run Below Confluence with Lard Run
WR05D	Seep alongside small tributary to Walley Run
WR01	Mouth of Walley Run (also sampled for fish and macroinvertebrates)
LR45D	Treatment plan discharge to the headwaters of Lard Run
LR40D	Intermittent orange seep area to Lard Run just north of TP discharge
LR35D	Intermittent seep to Lard Run emerging from northeast corner of landfill spoil
LR33D	Intermittent seep at the corner of Walley and Mealy Roads
LR30D	Intermittent discharge from the east side of Lard Run near corner of field
LR29D	Discharge from spoil piles to Lard Run
LR27	In-stream sampling location approximately 200 feet below LR30D
LR26D	Intermittent seep to Lard Run just south of Aaron Road
LR25D	Road Ditch discharge to Lard Run just south of Aaron Road
LR21D	Spring to Lard Run on just north of Aaron Road
LR20D	Spring to Lard Run on just north of Aaron Road
LR18	Lard Run just above LR17D
LR17D	Primary Discharge from high on hill from west side of Lard Run
LR16D	Smaller Discharge from high on hill from west side of Lard Run (just north of LR17D)
LR15D	Smaller Discharge from high on hill from west side of Lard Run (just north of LR16D)
LR10D	Spring / Tributary to Lard Run from the west (TWP 12)
LR01	Mouth of Lard Run at Walley Run (also sampled for macroinvertebrates)

Table 3 shows the average in-stream chemistry at stations on Walley Run. Lard Run, the largest tributary to Walley Run, enters the stream between WR12 and WR10. The stations are listed beginning in the headwaters and moving towards the mouth.

Table 3: Average Chemistry of In-Stream Stations on Walley Run

Name	Field pH (SU)	Cond (uS)	Field Alk (mg/L as $CaCO_3$)	Acid (mg/L as $CaCO_3$)	Iron (mg/L)	Mn (mg/L)	Al (mg/L)	Sulfate (mg/L)
WR12	6.2	90	8	7	1.6	0.3	0.3	28
WR10	6.7	572	27	0	2.4	0.5	0.4	175
WR01	7.1	368	33	0	0.2	0.1	0.1	129

As shown Table 3, the pH and concentrations of alkalinity, conductivity, iron and sulfate of Walley Run all increase significantly due to the inflow of Lard Run. By the time the stream reaches the mouth of Walley Run, water quality is fairly good with only elevated conductivity and sulfate.

Table 4 shows the average chemistry of the in-stream stations on Lard Run.

Table 4: Average Chemistry of In-Stream Stations on Lard Run

Name	Field pH (SU)	Cond (uS)	Field Alk (mg/L as $CaCO_3$)	Acid (mg/L as $CaCO_3$)	Iron (mg/L)	Mn (mg/L)	Al (mg/L)	Sulfate (mg/L)	TSS (mg/L)
LR27	8.1	7,171	813	0	1.0	1.9	2.0	2,345	14
LR18	7.2	3,247	280	0	6.2	1.9	1.1	884	7
LR01	7.4	1,482	99	0	1.5	0.8	0.5	418	5

As shown, Lard Run displays water quality that is not typical of natural streams in this area, with elevated pH, greatly elevated alkalinity, conductivity and sulfate and low to moderate metal concentrations.

These water quality parameters are all dictated by the discharge LR45D, which forms the headwaters of Lard Run. This discharge flows from the treatment plant of the landfill, and displays elevated pH, alkalinity, conductivity, sulfate and TSS. Table 23 shows the chemistry and flow rate of this discharge.

B. Chemistry of Little Coon Run and Tributaries

Table 5 lists and describes the stations on Little Coon Run and its tributaries. A total of 26 stations were established on Little Coon Run and its tributaries. Of these 25 stations, 8 measured in-stream chemistry and 18 measured discharges (LC19D and LC20D measured two sources of the same water and are considered one station). In addition to chemistry measurements, the mouth of Little Coon Run (LC01) was also sampled for fish and macroinvertebrates. LC30, LC21 and LC09 were sampled for macroinvertebrates. Points are listed beginning in the headwaters and working towards the mouth. See Appendix C for more information on each point.

Table 6 shows the average chemistry of the in-stream stations on the main stem of Little Coon Run. Stations are listed beginning in the headwaters and moving towards the mouth. Some of these data are also shown graphically on Figure 4. The in-stream stations not listed in Table 6 are located on tributary streams.

Table 5: Water Sampling Stations on Little Coon Run and Tributaries

Name	Description
LC62D	Seep from toe feeding constructed wetland
LC61D	Discharge from Sediment Basin 2
LC60D	Tributary / Discharge to Little Coon Run just east of Marshall Road
LC57D	Intermittent toe-of-spoil discharge to Little Coon Run (Landfill Seep 6)
LC56	Little Coon Run below Seep 6
LC55D	Intermittent discharge from the west to Little Coon Run
LC50	Little Coon Run at Marshall Road
LC47D	Intermittent Spoil Discharge flowing west into field to Little Coon Run
LC46D	Intermittent Spoil Discharge flowing west into field to Little Coon Run (north of LC47D)
LC45D	Intermittent Discharge near the corner of Marshall and Mealy Roads, collected in road ditch
LC40D	Possible gas well discharge with large iron accumulation
LC37D	Flow under township road upstream of LC36
LC36	Unnamed tributary to Little Coon Run at Mealy Road
LC35D	Large seep, possible gas well on Barth property
LC30	Little Coon Run at Saltzgiver Bridge (also sampled for macroinvertebrates)
LC29D	Discharge to tributary of Little Coon Run Above Mealy Spring
LC28D	Discharge to tributary of Little Coon Run Above Mealy Spring
LC27D	Discharge to tributary of Little Coon Run Above Mealy Spring
LC26D	Mealy’s Spring Overflow
LC25	Tributary to Little Coon Run above Mealy’s Spring, just south of Township road.
LC21	Little Coon Run upstream of LC20D (also sampled for macroinvertebrates)
LC20D	Large seep, possibly old well, to Little Coon Run, large kill area
LC19D	Second place to measure water near LC20D (FLOW ONLY)
LC14	Little Coon Run downstream of LC15D and LC20D
LC10D	Discharge to Little Coon Run from high on the hill to the east (spring?)
LC09	Station just downstream of LC10D (sampled for macroinvertebrates only)
LC01	Mouth of Little Coon Run (also sampled for fish and macroinvertebrates)

Table 6: Average Chemistry and Flow of In-Stream Little Coon Run Stations (Main Stem)

Name	Flow (gpm)	Field pH (SU)	Cond (uS)	Field Alk (mg/L as $CaCO_3$)	Acid (mg/L as $CaCO_3$)	Iron (mg/L)	Mn (mg/L)	Al (mg/L)	Sulfate (mg/L)
LC56	39	3.59	1,142	0	114	15.5	13.6	5.9	632
LC50	69	3.47	952	0	88	5.3	9.9	4.3	488
LC30	471*	4.04	471	0	38	2.2	3.8	2.0	222
LC21	1,237*	4.96	218	2	12	0.3	1.3	0.8	84
LC14	1,611*	4.50	272	0	16	2.4	1.8	0.8	110
LC01	1,563*	5.27	235	0	10	0.3	1.6	0.7	98

**Represents the average of limited flow data (1, 2 or 3 samples)*

As shown in Table 6 and in Figure 4, the water quality of Little Coon Creek is extremely poor in its headwaters and improves as it flows towards the mouth (LC01). The degradation is due to acidic seeps from surface mines, which form the headwaters. The middle reaches of the stream receive larger flows of moderately contaminated water, such as LC20D, which enters the stream between LC21 and LC14. The improvement in water quality is due to dilution from clean surface water and unaffected tributaries. However, the water quality at the mouth is still poor with a low pH, 10 mg/L net acidity and elevated aluminum. LC01 was sampled 8 times and was net acidic each time, with aluminum concentrations as high as 1.7 mg/L.

C. Chemistry of Coon Creek

Table 7 lists the stations on Coon Creek. Stations were established above and below the mouths of Little Coon Run and Walley Run. In addition, biological sampling was conducted at 2 stations on Coon Creek (CC16 and CC10). Points are listed beginning upstream of the study area and working downstream. See Appendix C for more information on each point.

Table 7: Sampling Stations on Coon Creek

Name	Description
CC16	Coon Creek Upstream of the mouth of Walley
CC15	Coon Creek Downstream of the mouth of Walley Run
CC11	Coon Creek Upstream of the mouth of Little Coon Run
CC10	Coon Creek Downstream of the mouth of Little Coon Run

A total of 8 rounds of sampling were performed at these stations. At the start of the project, samples were taken monthly from November 2001 – April 2002. After that point, it was decided that quarterly samples of these points would be sufficient so samples were also taken in July and October 2002.

Table 8 presents average chemistry data for the sampling stations on Coon Creek. Samples are listed starting at the most upstream station (above Walley Run) and proceeding down stream to below Little Coon Run.

Table 8: Average Chemistry of the Coon Creek Stations

Name	Field pH (SU)	Cond (uS)	Field Alk (mg/L as $CaCO_3$)	Acid (mg/L as $CaCO_3$)	Net Alk (mg/L as $CaCO_3$)	Iron (mg/L)	Mn (mg/L)	Al (mg/L)	Sulfate (mg/L)	TSS (mg/L)
CC16	7.0	64	27	0	27	0.3	0.1	0.1	11	3
CC15	7.2	146	27	0	27	0.3	0.1	0.1	63	3
CC11	7.2	125	21	0	21	0.2	0.1	0.1	34	3
CC10	6.7	159	10	2	8	0.3	0.6	0.3	57	3

As shown above, the water quality of Coon Creek above the study area (CC16) is good with neutral pH, excess alkalinity, low metals and low sulfate concentrations. As Coon Creek receives Walley Run (between CC16 and CC15) and Little Coon Run (between CC11 and CC10), some degradation occurs. Net alkalinity decreases an average of 70%, while aluminum and manganese increase slightly. Between CC15 and CC11, Bull Run flows into Coon Creek, providing some dilution of contaminants.

While these data represent averages, Figure 5 graphically presents the data on net alkalinity at these stations for each of the sampling dates as well as the average net alkalinity. On two sampling occasions (March and April 2002), Coon Creek was net acidic (acidity greater than alkalinity) below Little Coon Run, indicating that it was not able to assimilate the pollution from Little Coon Run during that period.

D. In-Stream Biology

Dr. Bruce Dickson of Confluence Ecological conducted sampling and prepared the biological portions of this report. Five stations in the study area were sampled for fish and macroinvertebrates. An additional four stations were sampled for macroinvertebrates only. The fish sampling stations were CC16 (Coon Creek above Walley Run), WR01 (mouth of Walley Run), the mouth of Bull Run, LC01 (mouth of Little Coon Run), and CC10 (Coon Creek below Little Coon Run). Bull Run was sampled near the mouth to serve as a local reference stream. This tributary to Coon Creek is very small (approximately 5 feet wide) and has not been impacted by acid mine drainage.

Fish Results

Table 9 shows the fish species that were identified at each station.

Two stations were surveyed on Coon Creek; Coon Creek downstream of the confluence with Little Coon Run (CC10) and Coon Creek upstream of the confluence of Walley Run (CC16). Coon Creek upstream of the mouth of Walley Run (CC16) is upstream of current or historical influence by acid mine drainage and contained twenty-six species. Of these species, five species are classified by the EPA as tolerant and contributed nearly 50 percent of the total number of fish collected. Twelve species collected at CC16 are classified as intermediate and nine as intolerant. Intermediates accounted for 28.3 percent of total numbers while intolerants accounted for 21.9 percent. Bluntnose Minnow dominated at this station with 27.6 percent of total numbers collected.

Walley Run did not show visible signs of AMD impacts but has a history of surface mining in its watershed. Eleven fish species were collected from the mouth of Walley Run (WR01). The pollution-tolerant Blacknose Dace was dominant at this station. However, several intolerant species were collected, including Mottled Sculpin, Horneyhead Chub, Mimic Shiner, Redside Dace, and Northern Hogsucker.

Blacknose Dace and Brook Trout were co-dominant at the Bull Run station. Of the six species collected from Bull Run two are classified by the EPA as tolerant, two as intermediate, and two as intolerant.

Little Coon Run is visibly impacted by mine drainage. An electrofishing survey was conducted at the mouth of Little Coon Run (LC01) and yielded one species, Blacknose Dace. This species is classified by EPA as tolerant and is often found to dominate unpolluted headwater streams and larger streams where pollutants have eliminated more sensitive species. Blacknose Dace and Creek Chubs are often the dominant species in streams with significant AMD problems in western Pennsylvania.

Table 9: Identified Fish Species and Pollution Tolerance, September 2002

Common Name	Genus, Species	CC16	WR01	Bull Run	LC01	CC10
Pollution Tolerant Species						
Blacknose Dace	Rhinichthys atratulus	X	X	X	X	X
Bluntnose Minnow	Pimephales notatus	X				X
Brown Bullhead	Ameiurus nebulosus	X				
Creek Chub	Semotilus atromaculatus	X	X	X		X
White Sucker	Catostomus commersoni	X				X
Intermediate Species						
Bluegill	Lepomis macrochirus	X				
Brook Trout	Salvelinus fontinalis	X	X	X		X
Central Stoneroller	Campostoma anomalum	X				
Common Shiner	Luxilus cornutus	X				
Fantail Darter	Etheostoma flabellare	X				X
Greenside Darter	Etheostoma blennioides	X				
Johnny Darter	Etheostoma nigrum	X	X	X		X
Pumpkinseed	Lepornis gibbosus	X	X			
Rock Bass	Ambloplites rupestris	X				
Sand Shiner	Notropis ludibundus	X				
Smallmouth Bass	Micropterus dolomieu	X				
Striped Shiner	Luxilus chrysocephalus	X	X			
Pollution Intolerant Species						
American Brook Lamprey	Lampetra appendix	X				X
Bigeye Chub	Hybopsis amblops	X				
Horneyhead Chub	Nocomis biguttatus	X	X			
Longnose Dace	Rhinichthys cataractae	X				X
Mimic Shiner	Notropis volucellus	X	X	X		X
Mottled Sculpin	Cottus bairdi	X	X	X		X
Northern Hog Sucker	Hypentelium nigricans	X	X			X
Redside Dace	Clinostomus elongatus	X	X			
River Chub	Nocomis micropogon	X				
	TOTAL	**26**	**11**	**6**	**1**	**12**

Sampling performed by Dr. Bruce Dickson of Confluence Ecological, on September 6, 2002 with follow-up sampling on Coon Creek on September 24, 2002.

At CC10 (Coon Creek downstream of Little Coon Run), twelve fish species were collected. Creek Chub and Blacknose Dace, both EPA tolerant species, dominated total numbers. Several intolerant species (American Brook Lamprey, Longnose Dace, Mimic Shiner, Mottled Sculpin, and Northern Hogsucker) and intermediate species (Brook Trout, Fantail Darter, Johnny Darter) were also collected at CC10.

These data demonstrate the biological impacts of mine drainage, particularly on Little Coon Run and on Coon Creek. Above mine drainage impacts, Coon Creek supports 26 species of fish, compared with on 12 species of fish below the study area.

Macroinvertebrate Results

Table 10 shows a summary of the macroinvertebrate sampling. Stations are listed beginning in the headwaters and proceeding downstream (See Figure 2).

Table 10: Macroinvertebrate Results and Richness, Composition and Tolerance Measures

Category	Metric	Metric Description	Coon Creek above	Lard Run	Walley Run	Bull Run	Little Coon Run				Coon Creek below
			CC16	LR01	WR01	Mouth	LC30	LC21	LC09	LC01	CC10
Richness Measures	Taxa Richness	Number of distinct genera of organisms.	32	13	24	30	6	5	11	7	23
	Total Numbers	Number of individual organisms counted.	615	240	263	196	24	12	58	52	232
	Taxa Diversity (H)	One measure of diversity, higher numbers indicate greater diversity.	2.039	0.830	0.995	0.985	0.863	0.622	0.438	0.346	0.887
	Evenness (E)	Measures how individuals are distributed among taxa (0.5 and above is desirable)	0.588	0.324	0.313	0.290	0.481	0.387	0.183	0.178	0.283
Composition Measures	% Ephemeroptera	Percent Mayflies	12.5	*0*	20.8	26.7	*0*	*0*	*0*	*0*	21.7
	% Plecoptera	Percent Stoneflies	12.5	38.5	20.8	26.7	16.7	20.0	27.3	28.5	13.0
	% Trichoptera	Percent Caddisflies	28.1	23.0	20.8	23.3	*0*	20.0	27.3	14.3	30.4
	% EPT	Percent total of mayflies, stoneflies and caddisflies, three pollution-sensitive groups	53.1	61.5	62.5	76.7	16.7	40.0	54.5	42.8	65.2
	% Chironomidae	Percent total of Chironomidae (a pollution-tolerate family of flies)	14.8	2.5	15.6	3.6	54.2	16.7	20.7	15.4	12.5
Tolerance / Intolerance Measures	% Intolerant Taxa (PADEP: 0, 1, 2)	Indicates the number of pollution-sensitive types of organisms	37.5	37.5	53.3	53.8	16.7	20.0	36.4	28.6	43.5
	% Intolerant Numbers (PADEP: 0, 1, 2)	High values indicate a station dominated by high numbers of pollution-sensitive organisms	19.0	66.5	8.2	85.8	29.2	8.3	12.1	7.7	15.5

Numbers reflect totals from three D-frame samples at each station

Seven of the nine sample locations are currently or have been historically subject to impact from acid mind drainage (AMD) discharges. CC16 and Bull Run are not influenced by mining activities, past or current. Taxa richness and the extremely low total number of individuals collected at the four sample stations located on Little Coon Run clearly demonstrate the severity of AMD impacts to this stream. No Ephemeroptera (mayflies), which are sensitive to pollution, were collected from any of the stations on Little Coon Run.

Taxa richness on Lard Run is also depressed and the number of individuals collected at this site is much lower than at stations on Coon Creek, Walley Run and Bull Run. No Ephemeroptera (mayflies) were collected in the samples from Lard Run. Two Plecoptera (stonefly) taxa (Leuctridae g. sp. and *Peltoperla sp*.), both relatively pollution intolerant, made up 38.5% of the individuals collected at this location. Percent EPT (Ephemeroptera, Plecoptera, and Trichoptera) was 61.5%.

Walley Run was sampled upstream of the confluence with Coon Creek. Two hundred sixty-three individuals comprising twenty-four (24) taxa were collected at this site. The EPT (62.5%) was evenly distributed between the three orders, each comprising 20.8% of the total EPT. The dominant taxa, *Leuctra sp.*, is considered pollution intolerant.

Bull Run is a very small stream located between Walley Run and Little Coon Run that has no mining history. One hundred ninety-six individuals were collected at this sampling location representing 30 taxa. The highest EPT value (76.7%) of any of the sampling locations was recorded for Bull Run with all three EPT orders well represented. The occurrence of highly intolerant taxa (53.8%) and the proportion of individuals within these taxa (85.8%) reflect excellent water quality in Bull Run.

Coon Creek was sampled upstream of all areas influenced by mining (CC16) and below the mouth of Little Coon Run (CC10). These locations were chosen to determine the effects of AMD from Walley Run and Little Coon Run on the biology of Coon Creek. CC16 contained 615 individuals in 32 taxa while CC10 samples contained 232 individuals representing 23 taxa. This represents a decrease of 9 taxa (28%) and 383 individuals (62%) between the two stations. Taxa diversity (H = 2.039) and productivity at CC16 are superior to all other sites sampled. Percent EPT values were similar at both sites with CC10 (65.2%) having a marginally higher value than CC16 (53.1%). Tricoptera (caddisflies) were the dominant taxa at both CC10 (30.4%; dominant genus *Hydropsyche sp*.) and CC16 (28.1%; dominant genus *Chimarra sp*).

Discussion

Field surveys of the benthic macroinvertebrate community at the nine locations and fish community surveys of five stations show that Little Coon Run is severely impacted by acid mine drainage effluents. Poor taxa richness for both macroinvertebrates and fish, low total numbers collected, and community dominance by pollution-intolerant species indicate that the level of impact in Little Coon Run remains severe long after the cessation of mining activities. Poor water quality (low pH, high acidity, metals) and the deposition of metal precipitates on the substrate of Little Coon Run combine to impair habitat utilization and reproduction by benthic macroinvertebrates and fish.

The landfill treatment plant discharge (LR45D) has resulted in alkaline conditions in Lard Run and Walley Run below Lard Run. Historically, Lard Run and Walley Run have received AMD discharges that impaired water quality and reduced biological productivity (Dickson, 1988). Walley Run has undergone a considerable recovery and now supports an aquatic community. Bull Run, the only stream that is not impacted by AMD, supports a very diverse, pollution intolerant macroinvertebrate community and fishery (Dickson, 1988) and can serve as a model for biotic recovery potential for small, AMD impacted tributaries in this watershed.

Coon Creek upstream of the mouth of Walley Run (CC16) shows no evidence of AMD impacts as it maintains a diverse aquatic community containing a significant number of pollution intolerant macroinvertebrates and fishes. Downstream at CC10, species richness and total numbers are reduced, reflecting the degradation from receiving Little Coon Run. Remediation of AMD sites in the Little Coon Run watershed will reduce the pollution load in Little Coon Run and improve water quality and habitat conditions.

The most significant problem facing Little Coon Run is the occurrence of low pH values in conjunction with elevated concentrations of dissolved aluminum, iron, and manganese. The metal solids physically degrade in-stream substrates by smothering habitat with metal precipitates (i.e., yellow boy) resulting in poor productivity and reproduction by substrate dependent species. Although iron and manganese can have negative effects on aquatic life and precipitate deposition is evident in Little Coon Run, their contribution in this case is probably minor when compared to the impact caused by aluminum.

Aluminum in the dissolved form is the most bio-reactive of the aluminum species and is highly toxic to aquatic life. While generally not encountered in undisturbed aquatic systems, aluminum can be encountered following land disturbance activities. The presence of aluminum- and acid-bearing sandstones and the further production of acid generated during and after surface mining often leads to the mobilization of large quantities of dissolved aluminum and its release to surface waters through ground water, surface seeps, and abandoned wells.

Dissolved aluminum in combination with low pH can be highly toxic in aquatic systems. Elimination of most fish and macroinvertebrate species generally occurs at a combined pH of less than 5.5 and a dissolved aluminum concentration greater than 0.5 mg/l. Water quality in Little Coon Run exceeds this criterion with an average pH of 5.27 and a dissolved aluminum concentration of 0.7 mg/l.

Some aquatic species (i.e., Brook Trout) are even more sensitive to low pH and dissolved aluminum. The threshold for mortality in brook trout appears to occur between 0.10 and 0.20 mg/l (total dissolved aluminum) when combined with pH values between 4.4 and 5.5 (Van Sickle 1996; Gagen and Sharpe 1987; Baldigo and Murdoch 1997). Research on western Pennsylvania streams (DeWalle et al. 1995) reported brook trout mortality from episodic increases in dissolved aluminum and a relationship between aluminum concentrations and stream discharge. Their research showed mortality to occur following an exposure event of 24 – 48 hours with concentrations of total dissolved aluminum between 0.10 and 0.20 mg/l. Fiss and Carline (1993) reported poor brook trout embryo survival when total dissolved aluminum concentrations exceeded 0.06 mg/l.

Periods of high flows and elevated aluminum concentrations combined with low pH values have been directly linked to mortality in brook trout and other fish species. However, the threshold (approximately 0.20 – 0.30 mg/l total dissolved aluminum) is not always reached. These sub-lethal conditions also negatively affect fish populations. In some instances, intermittent spikes in total dissolved aluminum caused greater cumulative mortality and decreased growth rates in sub-adult brook trout than continuous exposure (Siddens et al. 1986). Additionally, sub-lethal exposure can negatively affect brook trout survival and the stress induced by episodic exposure may be additive (Baldigo and Murdoch 1997).

The lack of a diverse, abundant macroinvertebrate and fish community in Little Coon Run is the direct result of the occurrence of low pH and dissolved aluminum concentrations exceeding threshold levels. Biotic conditions in Little Coon Run are likely to improve following the treatment of AMD sites in the Little Coon Run watershed. A positive effect is also anticipated on Coon Creek downstream of the mouth of Little Coon Run (CC10) as water quality improves.

IV. Watershed Goals and Objectives

The following goals have been established for the watershed:

1. ***Improve Little Coon Run starting at the mouth.*** This will also improve Coon Creek and allow fish species present in Coon Creek to begin migrating up into Little Coon Run.
2. ***Protect and Improve Coon Creek.*** This goal will be accomplished by treating discharges anywhere in the study area, but particularly in Little Coon Run. Coon Creek below Little Coon Run still has a biological community, but this goal seeks to make this community more robust and diverse.
3. ***Improve Lard Run and Walley Run.*** These streams are not as badly impacted as Little Coon Run, but still display room for improvement.

The watershed goals will be accomplished by meeting the following objectives:

1. Inform the public and all agencies (DEP, Army Corps of Engineers, DCNR, County Conservation District, etc.) of the findings and recommendations of this Restoration Plan.
2. Establish and maintain good communications with those who own land in the areas of the proposed projects.
3. Pursue funding for high-priority projects through Growing Greener and other sources.
4. Explore various other ways to accomplish reclamation projects, including coal extraction projects (GFCC), reclamation trading by coal operators, and/or reclamation by the Bureau of Abandoned Mine Reclamation (BAMR).
5. Monitor the successes and stream improvements that result from the various projects at least every five years.

V. Introduction to General Source Reduction and Treatment Alternatives

There are several ways to treat mine drainage that vary depending upon the origin, chemistry and geographical surroundings of the discharge. Source reduction (one-time activities that lessen the amount or severity of pollution that is produced) is also an alternative in some cases. Source Reduction is often referred to as "mitigation." The purpose of this section is to describe the basic treatment and mitigation alternatives that are available for discharges in the study area.

A. Source Reduction Alternatives

Source Reduction targets the amount (flow rate) or severity (pollutant concentration) of mine drainage discharges through a one-time effort. Typical types of mitigation include surface reclamation, revegetation, alkaline addition to the surface or subsurface, and plugging. This section will discuss these mitigation alternatives.

When the source of contaminated mine water is a discrete point source, such as a mine opening or a well, it may be feasible to eliminate the discharge by blocking the flow path. Deep mine entries may be sealed with either wet seals that allow the discharge to flow through the seal or with dry seals that prevent discharges.

Artesian flows from abandoned oil or gas wells can be plugged with concrete. Hundreds of abandoned wells are plugged each year in Pennsylvania to prevent flows of brine water and explosive gases, and to prevent the cross-contamination of aquifers penetrated by the wells. Abandoned wells in the Coon Creek watershed and in many surrounding watersheds in Venango, Clarion and Jefferson Counties act as conduits for AMD flows. Dozens of AMD-producing wells have been plugged in Clarion County in the last two years by the USDA Natural Resource Conservation Service and other entities.

Before attempting to eliminate a point discharge, it is advisable to evaluate the hydrologic setting and determine where the diverted water is likely to discharge. When successful, plugging can be an inexpensive alternative to treatment. It can also be a "last resort" alternative for discharges that do not allow passive treatment because of location (proximity to the stream or on a steep bank, for instance). When partially successful, plugging can reduce the cost of the treatment system by reducing the flow rate. When plugging is unsuccessful, it can cause the water to emerge in an unwanted location either directly adjacent to the plugged well or some distance away.

If the discharge cannot be eliminated, methods to decrease the contaminant loadings should be considered. Acidity and metals loading can be decreased using several methods, including:

- Reducing contact between water and acid-producing materials by increasing runoff;
- Isolating the materials by capping or moving them to a dry location; and
- Adding alkaline materials to neutralize acid production.

Surface reclamation is common mitigation effort which involves grading spoil piles, identifying and isolating acid-producing spoils, eliminating impounded water and encouraging surface runoff. Surface reclamation to pre-existing contours is now required by mining laws but was not required when many mines were active. Bare soil and spoil contact water and air, causing mine drainage. Reclamation can reduce both the flow rate and the severity of mine drainage.

Reclamation usually includes revegetation and some form of alkaline addition. Establishing good cover vegetation on poor mine spoil or soil typically requires heavy additions of agricultural lime or another alkaline product. Fertilizer and mulch are also used. Vegetation prevents erosion and allows more water to run off a site rather than percolate into the spoil, causing more mine drainage.

Neutralization is increased through the addition of alkaline materials to the site. Limestone ($CaCO_3$) and lime ($Ca(OH)_2$ or CaO) products are widely available and are commonly used for alkaline addition. In some cases, low-grade limestone not suitable for commercial mining but suitable for alkaline addition may exist on the site. The remediation plan may include plans to mine the low-grade limestone specifically for alkaline addition. Alkaline waste products can also be used. Examples include fly ash, fluidized bed bottom ash, processed slag, bag house lime, and paper, pulp, or tannery by-products.

Reclamation, alkaline addition and revegetation are most effective for small flows of contaminated drainage that flow directly from the surface of spoils. Reclamation is not as effective for seeps and discharges that may be influenced by groundwater flow or deep mine voids.

Many reclamation projects are supported by state and federal reclamation programs. However, the presence of marketable coal on a site makes reclamation through coal mining activities possible. In this case, the mining company is provided with incentives to "re-mine" the site and thus remove remaining coal and reclaim the abandoned spoils. The result of these activities is usually a reduction in the contaminant production. The mining company pays the costs of the reclamation on a re-mining project. Government Financed Construction Contracts (GFCCs) have been used to encourage re-mining in areas where it will provide benefits to land and/or water problems.

While mitigation is an important component of any restoration plan, the results of mitigation are difficult or impossible to predict. At some sites, reclamation and well plugging have dramatically reduced the amount of pollution to a watershed, while other efforts have had little to no effect. Often, mitigation efforts such as reclamation must be performed over wide areas to be effective and treatment may be a less expensive option. Cost/benefit analyses that include the possible successes and failures of treatment and mitigation should be examined in order to choose the best alternative.

B. Active Treatment Alternatives

Active treatment involves the use of chemicals and mechanical devices to treat mine water. Active treatment methods are well-developed. Sodium-based products such as sodium hydroxide (NaOH, caustic) or sodium carbonate (Na_2CO_3, soda ash) or calcium-based products such as hydrated lime ($Ca(OH)_3$) and quick lime (CaO) are generally used. The sodium products are more soluble and are easier to use for low flows, in remote locations, and/or where a permit requires manganese removal. The calcium products are less expensive, but generally require mechanical mixing and aeration to be effective. Large flows can usually be treated more cost-effectively with lime. Chemical treatment produces metal sludge that must be periodically collected and disposed of. Disposal usually occurs in an on-site sludge disposal pond or into an underground coal mine. The costs of sludge management are substantial, often exceeding the costs of the chemically treating the contaminated water.

The long-term costs of active treatment make it an unattractive treatment solution. However, there are circumstances where it is the used, often with highly effective results. The quality of the East Branch of the Clarion River Reservoir is maintained through mechanical lime additions to a highly acidic stream (Swamp Creek). Major improvements in the quality of Toby Creek are largely due to installation of several active treatment systems. Active treatment is usually proposed when it is the only feasible alternative, either because the chemistry of the discharge is too severe for passive treatment or because there is not enough land area to achieve treatment using passive methods.

C. Passive Treatment Alternatives

Passive treatment involves the use of natural products, natural processes, ponds and constructed wetlands to remediate mine drainage. Acidity is neutralized by limestone and microbial processes. Metals are precipitated as oxides and hydroxides in sedimentation ponds and wetlands. The chemistry of the mine drainage determines what type of passive system is required. The flow rate of the mine drainage determines the size of the system.

A variety of passive treatment technologies exist. In general, the more acidic the mine water the more problematic passive treatment becomes. Waters with aluminum concentrations less than 20 mg/L are being effectively treated with reasonable O&M requirements. Waters with higher aluminum concentrations can be effectively treated with passive treatment, but the frequency of system renovations is likely to increase. The selection of the appropriate technology is generally dependent on the mine drainage chemistry. Figure 6 is a flow chart that is commonly used to develop the conceptual designs for passive systems.

Ponds and Wetlands

Mine waters that are naturally net alkaline (alkalinity greater than acidity) are usually contaminated with iron (Fe). The iron can be passively precipitated through oxidation and settling in sedimentation ponds and constructed wetlands. The systems are designed to promote aeration (sheet flow and waterfalls) and provide long retention times. Ponds are usually used to decrease iron concentrations to 10-15 mg/L, and wetlands are used to remove the residual iron. The theoretical retention time in effective pond and wetland systems is usually at least 24 hours. Ponds and wetlands are also placed after other passive treatment system components to provide settling and polishing.

Anoxic Limestone Drains

Mine water that is net acidic (acidity greater than alkalinity), contaminated with iron, and has low dissolved oxygen and aluminum concentrations can be treated with an anoxic limestone drain (ALD). An ALD is a buried bed of limestone that is designed to be completely flooded to maintain anoxic conditions throughout. These conditions result in the generation of alkalinity (through limestone dissolution) without the precipitation of iron solids. The alkaline discharge from the anoxic limestone drain is followed by sedimentation ponds and constructed wetlands, where iron precipitates as an iron oxide solid. Properly designed and constructed anoxic limestone drain systems are among the most effective type of passive treatment and have been proven viable for treatment in the long term (over 15 years).

Vertical Flow Ponds

Mine waters that are net acidic and contain aluminum are the most challenging cases for passive treatment. The acidic waters require neutralization, but the tendency for aluminum to precipitate within alkaline substrate and decrease its permeability complicates the treatment. Many passive systems constructed to treat mine water with aluminum fail because they plug, and the acid water cannot flow through the alkaline materials. The plugging problem has been partially mitigated through the design of ponds where water flows vertically through a large bed of limestone. The bed is typically covered with an organic substrate in order to remove oxygen that would otherwise cause the precipitation of iron within the limestone aggregate. These ponds have been referred to as vertical flow ponds (VFP), successive alkalinity producing systems (SAPS), and reducing and alkalinity producing systems (RAPS). While some systems may work well for several years with no maintenance, the accumulation of iron and aluminum solids eventually causes permeability problems that can result in system failure. Renovation typically requires replacement of the organic substrate and a portion of the limestone aggregate. To counter this problem, VFPs are usually constructed with solids flushing capabilities. The flushing systems operate passively and are driven by head designed into the VFPs.

The challenges presented by highly acidic mine drainage have resulted in the development of innovative technologies. There is little consensus among treatment system designers on the details of the flushing systems. A belief that increased flushing frequency results in better removal of aluminum and iron solids has resulted in the incorporation of automatic flushing devices into some passive systems. These devices cause the system to flush whenever the water level reaches a predetermined level. Experimental systems that flush every 3-6 hours have been installed. The observation that aluminum solids tend to accumulate in the upper portion down-flow limestone beds has prompted the installation of flush systems in the top of some limestone beds. Calculations on the velocities needed to move particles suggest the need for closely spaced flush pipes with small flushing orifices. However, many systems that appear to effectively flush solids are designed with widely spaced pipes with numerous large orifices.

Oxic Limestone Beds and Channels

Limestone is not effective for AMD treatment if it plugs or is coated with metal solids. In cases where iron and aluminum concentrations are low, additional alkalinity can be generated with flow through an open bed of limestone aggregate. Oxic limestone beds are increasingly being placed at the end of passive systems to boost pH and promote microbial manganese-removal processes.

In cases where steep gradients exist between the discharge and the receiving stream, it may be feasible to partially treat the water with an open limestone channel. The velocity of water moving through the limestone carries solids out and prevents plugging. Research shows that even though the limestone in open channels is armored with iron, it is still reactive.

Pyrolusite™ Beds

Manganese precipitates as an oxide under alkaline conditions in the absence of iron. The process is microbially mediated. The Pyrolusite™ process involves the inoculation of oxic limestone beds with microbes selected for manganese oxidation.

Maintenance of Passive Treatment Systems

Wetlands usually require minimal maintenance. Some maintenance is related to the activities of pests, such as muskrats and beavers, which burrow in berms, plug outlets and destroy vegetation. Wetlands can be designed to minimize the risk of pest damage, but visual inspections and sometimes trapping are necessary. Wetlands have also been damaged by ATVs, which run through the wetlands and cause channels to develop.

The primary maintenance issue with ponds is solids removal. Ponds can also be susceptible to damage by pests. The purpose of ponds is to collect metals that form solids and accumulate. Over time, these solids build up and require removal. The solids are not hazardous and can usually be buried on site. Ponds are typically designed to operate for 15 – 25 years before being cleaned out. The required frequency of cleaning depends upon the flow rate of the discharge, the concentrations of metals, and the size of the pond.

When ALDs are properly constructed and designed to treat water that does not contain oxygen, aluminum or ferric iron (Fe^{3+}), they usually require no maintenance. However, ALDs have recently been used to treat discharges that do contain low levels of oxygen, aluminum or ferric iron (Fe^{3+}). These drains are equipped with flush plumbing similar to that found in VFPs and require regular flushing. As ALDs neutralize acidity and add alkalinity, the limestone dissolves. ALDs are typically designed with enough limestone to provide full treatment for 25 years. After that period of time, more limestone must be added to the bed.

VFPs require regular flushing to avoid plugging by solids. Few scientific studies have been performed to determine the best flushing frequency, which likely varies widely based on the size of the system, the design of the flush plumbing and the chemistry of the water. Typically, the water level in the VFP is monitored and flushing is recommended when water levels rise, indicating that the VFP is beginning to plug. Alternatively, flushing can be performed on a regular basis before plugging begins. Existing systems are usually flushed once a month to once a year.

VI. General Problem Description

Numerous mine drainage seeps of varying quality were identified and sampled in the study area. In general, the discharges with the worst quality emerge in the headwaters of Little Coon Run and its tributaries and, to a lesser extent, the headwaters of Lard Run. These seeps, which are characterized by very low pH and elevated aluminum levels, originate from surface mines and mine refuse. These flows are typically highly dependant upon precipitation and do not flow during drier months of the year. These discharges are of concern primarily due to the highly toxic nature of aluminum.

Further from the headwaters, the mine drainage pollution is typically from ground water seeps that have larger, more constant flows of water than the surface flows near the headwaters. These discharges typically contain some alkalinity, elevated concentrations of iron and low concentrations of aluminum. The primary concern from this type of discharge is the increased acidity present due to elevated iron.

The following sections will discuss each of the spoil areas and discharges in detail. Section VII describes reclamation projects that may result in improved water quality. Sections VIII and IIX describe treatment recommendations for Walley Run and Little Coon Run, respectively.

VII. Reclamation Alternatives and Recommendations

Several distinct areas of spoil have been identified using the USGS map and field reconnaissance. These spoil areas are located in the headwaters of Little Coon Run and Lard Run and generally occur on the watershed boundary between the study area and streams that flow to the south (Licking Creek and Toby Creek). These spoil areas and watershed boundaries are shown on Figure 7. Watershed boundaries are shown on the figure as well. Table 11 provides information on each spoil area.

Table 11: Spoil Reclamation Area Information

		Watershed					
Spoil Area	**Total Acres**	**Walley**	**Little Coon**	**Licking**	**Toby**	**Landowner(s)**	**Notes**
A	116	26	34		56	County Environmental	Portions used for landfill and not available for reclamation.
B	121		33	47	41		Portions used for landfill-related activities. Landfill may expand here.
C	17	10	7			Various private landowners	
D	29		18	11			No distinct discharges found.
E	52		25	27			No distinct discharges found.
F	23		12	11			
G	17		17				No distinct discharges found.
Total	375	36	146	96	97		

Table 12 shows a matrix of which spoil areas contribute to which discharges. An "X" indicates that the discharge is directly from the spoil. A "?" indicates that the discharge does not flow directly from the spoil but is thought to be flowing indirectly from these spoil areas. These seeps are generally located geographically below spoils and have more steady flow rates than seeps directly from spoil. The seeps likely represent shallow groundwater flow, the principle source of which is infiltration into surface spoils that travels a short distance underground before emerging. Note that some discharges may be influenced by more than one spoil area.

Table 13 summarizes the direct (X) and indirect (?) loadings from each of the spoil areas to streams in the study area. Note that spoil areas A, B, D, E and F straddle the watershed divide and may contribute pollution to Licking Creek and/or Toby Creek, which were not included in this study area. However, the underlying coal structure dips towards the northwest, which probably directs most infiltration and groundwater from the spoil areas towards Walley Run and Little Coon Run.

While Table 13 represents total direct and indirect loadings from each site, the loading reductions expected for each reclamation job will vary depending upon the type, extent and effectiveness of reclamation. Direct loading is more likely to be affected by reclamation than indirect loading, which may not be influenced at all. Also, it is important to realize that not all of Areas A and B are available for further reclamation. Large portions are Areas A and B are being used for landfilling and landfill support activities.

Table 12: Discharges Associated with Spoil Areas

Discharge	A	B	C	D	E	F	G
LR40D	X						
LR35D	X						
LR33D	X						
LR30D	?		?				
LR29D			X				
LR26D			?				
LR25D			?				
LR21D			?				
LR20D			?				
LC62D	?	X					
LC61D	X						
LC60D		X					
LC57D	X						
LC55D	X						
LC47D			X				
LC46D			X				
LC45D	X						
LC37D						X	
LC36		X		?	?	?	
LC25						?	
LC29D							?
LC28D							?
LC27D							?

X = direct discharge from that spoil area, ? = possibly influenced by it

Table 13: Spoil Area Loading Summary

		Direct Loading (pounds per day)			Indirect Loading (pounds per day)		
Area	**Total Acres**	**Acid**	**Iron**	**Al**	**Acid**	**Iron**	**Al**
A	116	45	2	7	1	0	0.1
B	121	62	1	6	91	1	11
C	17	62	1	8	14	0	2
D	29				91	1	11
E	52				91	1	11
F	23	25	0	3	104	1	11
G	17				1	0	0

The following sections discuss each spoil area in detail, included expected results of reclamation efforts.

A. *Area A*

Area A covers a total of 116 acres, but much of this area is either capped landfill or is in the process of being used for landfilling. Of the total area, 26 acres are located in the Walley Run watershed, 34 acres are located in the Little Coon Run watershed, and 56 acres are located in the Toby Creek watershed.

The main opportunities for reclamation of Area A exist on the north and west perimeter of Area A, and some opportunity may exist on the eastern edge. Any proposed reclamation in these areas would require close coordination with County Environmental.

Table 14 shows the average flow, chemistry and loading of discharges that flow directly from this spoil area (above the dark line) and those that may be influenced by the spoil (below the dark line).

Table 14: Average Flow, Chemistry and Loading of Spoil Area A Discharges

								Loading (Pounds Per Day)		
Name	**Flow (gpm)**	**pH (SU)**	**Field Alk (mg/L as $CaCO_3$)**	**Acid (mg/L as $CaCO_3$)**	**Iron (mg/L)**	**Mn (mg/L)**	**Al (mg/L)**	**Net Acid**	**Iron**	**Al**
LC61D	10.8	5.8	27	7	7.0	9.8	10.6	-2	0.7	1.2
LC57D	0.9	3.3	0	396	1.4	26.7	55.8	5	<0.1	0.7
LC55D	3.6	3.2	0	126	13.6	9.3	4.4	4	0.5	0.2
LC45D	5.5	3.3	0	481	2.7	24.6	70.0	36	0.2	5.0
LR40D	0.5	3.2	0	476	19.1	31.2	44.5	3	0.1	0.3
LR35D	0.2	3.7	0	150	1.3	8.9	19.3	<1	<0.1	<0.1
LR33D	0							0	0	0
LC62D	0.5	4.0	0	55	0.7	12.1	4.6	1	<0.1	<0.1
LR30D	3.0	5.1	1	21	0.1	3.0	3.4	1	<0.1	0.1
Total Average Loading From Spoil Area A								**50**	**1.5**	**7.5**

NOTE: Discharges above the dark line represent direct discharges; indirect discharges are below the line.

As part of the grant that funded this project, County Environmental provided matching in-kind services to reclaim 8 acres of spoil near the northeast corner of landfill property. Reclamation of this area was on-going as of the writing of this report and may reduce loadings at LR40D, LR35D and LR30D.

Table 14 shows that the most significant source of pollution from the Area A spoils is LC45D, which flows to Little Coon Run from the northwest portion of the landfill spoil area. This discharge has a low, intermittent flow but is highly contaminated. These two factors make the discharge unsuitable for passive treatment. Reclamation of spoil areas in the northwest portion of Area A may help to reduce the severity of the contamination of this discharge. At least 10 acres in this area should be reclaimed and the effects of this reclamation on LC45D should be monitored before continuing with more reclamation of Area A.

Large portions of Area A have been used or are being used as landfill space and have been reclaimed to the furthest extent possible by capping and vegetation. The landfill also has an extensive liner system that directs leachate to their treatment plant. Therefore, only 70% of the loading from LC45D is expected to mitigated by reclamation.

LC55D and LC57D are the largest sources after LC45D. However, both of these discharges originate near the edge of the landfill. They most likely travel to their current discharge locations under the liner. Therefore, reclamation targeting these discharges is not possible.

B. Area B

Area B covers 121 acres but most of this area is across the surface watershed divide. Of the total acreage, 33 acres are in the Little Coon Run watershed, 47 are in the Licking Creek watershed and 41 are located in the Toby Creek watershed. An active railroad right of way and a township road also cross Area B. The area is owned by County Environmental and may be the site of future landfill space and/or landfill support activities. Some support activities, such as cover soil mining, are already taking place on portions of Area B. Sediment Pond 2 is also located in this area. As with Area A, any reclamation activities planned in this area must be coordinated with County Environmental.

Table 15 shows the average flow, chemistry and loading of discharges that flow directly from this spoil area (above the dark line) and those that may be influenced by the spoil (below the dark line).

Table 15: Average Flow, Chemistry and Loading of Spoil Area B Discharges

								Loading (Pounds Per Day)		
Name	**Flow (gpm)**	**pH (SU)**	**Field Alk (mg/L as $CaCO_3$)**	**Acid (mg/L as $CaCO_3$)**	**Iron (mg/L)**	**Mn (mg/L)**	**Al (mg/L)**	**Net Acid**	**Iron**	**Al**
LC62D	0.5	4.0	0	55	0.7	12.1	4.6	1	< 0.1	< 0.1
LC60D	23.3	3.4	0	211	5.7	20.1	22.7	61	1.4	6.2
LC36	104.8	3.7	0	70	1.1	5.4	7.7	91	1.0	10.5
Total Average Loading From Spoil Area B								**153**	**2.4**	**16.7**

NOTE: Discharges above the dark line represent direct discharges; indirect discharges are below the line.

As shown in Table 15, LC60D is the largest direct contributor of loading from Spoil Area B. LC60D flows to the LC36 monitoring point. The LC60D discharge emerges from a diffuse area just east of Marshall Road near the watershed divide between Little Coon Run and Licking Creek. This discharge may be influenced by parts of Spoil Area B located across the surface watershed divide.

Reclamation in Spoil Area B should begin in areas around LC60D in an attempt reduce the loading from this discharge. Because reclamation of the entire area would not be as cost-effective, 15 acres of spoil directly around the discharge should be initially targeted and the results should be monitored. Because reclamation is only anticipated on a portion of the area, only 70% of the loading from this discharge is expected to removed.

After the initial 15 acres of reclamation have been completed, LC60D and LC36 should be monitored to assess the effectiveness. It may then be advisable to perform additional reclamation in Area B.

C. Area C

Area C encompasses approximately 17 acres of open spoil located just north of Mealy Road. Of the total acreage, 7 acres are located in the Little Coon Run watershed and 10 acres are located in the Walley Run watershed. The area is poorly vegetated with some birch and pine trees and very sparse ground cover. Many impoundments exist that are up to 20 feet deep.

Table 16 shows the average flow, chemistry and loading of discharges that flow directly from this spoil area (above the dark line) and those that may be influenced by the spoil (below the dark line).

Table 16: Average Flow, Chemistry and Loading of Spoil Area C Discharges

								Loading (Pounds Per Day)		
Name	**Flow (gpm)**	**pH (SU)**	**Field Alk (mg/L as $CaCO_3$)**	**Acid (mg/L as $CaCO_3$)**	**Iron (mg/L)**	**Mn (mg/L)**	**Al (mg/L)**	**Net Acid**	**Iron**	**Al**
LC47D	0.6	3.4	0	647	4.6	13.8	98.1	5	0.0	0.8
LC46D	1.6	3.7	0	358	2.4	13.5	51.4	8	0.0	1.0
LR29D	6.8	3.3	0	690	14.1	12.4	95.0	49	0.9	6.6
LR20D	0							0	0	0
LR21D	4	5.0	0	18	0.4	2.0	3.1	1	< 0.1	0.2
LR30D	3	5.1	1	21	0.1	3.0	3.4	1	< 0.1	0.1
LR26D	2.0	4.8	0	50	0.4	1.9	6.0	4	0.0	0.5
LR25D	6.5	5.1	2	46	0.2	2.0	4.2	8	0.0	0.9
Total Average Loading From Spoil Area C								**76**	**0.9**	**10.1**

NOTE: Discharges above the dark line represent direct discharges; indirect discharges are below the line.

Two discharges, LC46D and LC47D, flow directly from this spoil to Little Coon Run. One discharge LR29D, flows directly from the spoil to Lard Run. These discharges represent significant loadings to these streams. Several other discharges to Lard Run (LR20D, LR21D, LR25D, LR26D and LR30D) may also be influenced by this spoil area.

Reclamation of this entire area is recommended in order to reduce the loadings from the direct discharges and possibly influence the indirect discharges as well. Reclamation of this area is likely to be highly successful because it is isolated from other areas and can be completely reclaimed. After reclamation, LC46D, LC47D, and LR29D should be monitored.

D. Area D and Area E

No discharges have been found flowing directly from Area D or Area E. Area D covers 29 acres, 18 of which are located in the Little Coon Run watershed and 11 of which are located in the Licking Creek watershed. Area E covers 52 acres, 25 of which are located in the Little Coon Run watershed and 27 of which are located in the Licking Creek watershed.

Table 17 shows the average flow, chemistry and loading of LC36, which may be influenced by the Area D and/or Area E spoils. The LC36 monitoring point measured all the flow from the headwaters of this tributary because no distinct discharges were found.

Table 17: Average Flow, Chemistry and Loading of Spoil Area D and E Discharges

Name	Flow (gpm)	pH (SU)	Field Alk (mg/L as $CaCO_3$)	Acid (mg/L as $CaCO_3$)	Iron (mg/L)	Mn (mg/L)	Al (mg/L)	Loading (Pounds Per Day) Net Acid	Iron	Al
LC36	104.8	3.7	0	70	1.1	5.4	7.7	91	1.0	10.5

NOTE: This discharge may or may not be influenced by Spoil Areas D and E. This discharge is also influenced by Area B may also be influenced by Area F.

LC36 gains approximately two thirds of its pollution from LC60D, which flows from Spoil Area B. However, LC36 receives an average of 30 pounds per day of additional acidity from unknown sources such as groundwater recharge from Spoil Areas B, D, E and/or F. Because of the uncertainty associated with Spoil Areas D and E, reclamation in these areas has a lower priority than other areas where reduction of loading is more likely.

E. Area F

Area F encompasses 23 acres, of which 12 are located in the Little Coon Run watershed and 11 are located in the Licking Creek watershed.

Table 18 shows the average flow, chemistry and loading of discharges that flow directly from this spoil area (above the dark line) and those that may be influenced by the spoil (below the dark line).

Table 18: Average Flow, Chemistry and Loading of Spoil Area F Discharges

Name	Flow (gpm)	pH (SU)	Field Alk (mg/L as $CaCO_3$)	Acid (mg/L as $CaCO_3$)	Iron (mg/L)	Mn (mg/L)	Al (mg/L)	Loading (Pounds Per Day) Net Acid	Iron	Al
LC37D	6.5	3.6	0	316	2.1	26.3	40.1	25	0.1	3.0
LC25	10.8	4.2	0	100	1.9	5.9	11.5	13	0.2	1.6
LC36	104.8	3.7	0	70	1.1	5.4	7.7	91	1.0	10.5
Total Average Loading From Spoil Area F								**129**	**1.3**	**15.1**

NOTE: Discharges above the dark line represent direct discharges; indirect discharges are below the line. LC36 may also be influenced by Spoil Areas D and E.

LC37D flows directly from the toe of the spoil in Area F. Reclamation of this entire area is recommended in order to target this discharge. Some improvement in stations LC25 and LC36 may result. After reclamation, LC25, LC36 and LC37D should be monitored.

F. Area G

Area G covers 17 acres, all located within the Little Coon Run watershed. No discharges have been discovered flowing directly from this area. Table 19 shows the average flow, chemistry and loading of discharges that may be influenced by Spoil Area G.

Table 19: Average Flow, Chemistry and Loading of Spoil Area G Discharges

								Loading (Pounds Per Day)		
Name	**Flow (gpm)**	**pH (SU)**	**Field Alk (mg/L as $CaCO_3$)**	**Acid (mg/L as $CaCO_3$)**	**Iron (mg/L)**	**Mn (mg/L)**	**Al (mg/L)**	**Net Acid**	**Iron**	**Al**
LC27D	1	4.4	0	69	0.0	7.2	10.0	1	< 0.1	0.2
LC28D	1	4.9	0	16	0.0	1.3	1.4	< 1	< 0.1	< 0.1
LC29D	3	5.3	0	3	0.1	0.1	0.2	< 1	< 0.1	< 0.1
Total Average Loading From Spoil Area G								**1**	**< 0.1**	**0.2**

NOTE: These discharges may or may not be influenced by Spoil Area G.

Because there are no direct discharges from Spoil Area G, reclamation of this area has a lower priority than reclamation of other areas.

G. Reclamation Recommendations

At this time, the following reclamation projects are recommended:

- Reclaim all of Area F
- Reclaim 15 acres of Area B around LC60D
- Reclaim all of Area C
- Reclaim 10 acres of Area A around LC45D

Reclamation of Areas D, E, G and other portions of Areas A and B should be evaluated after the high-priority projects have been completed. Table 20 summaries the high priority reclamation projects.

The costs above were based on BAMR's unit costs for reclamation, which are included as Appendix D. The assumptions made above are summarized below:

- Regrading will cost $4,000 per acre, based on $0.50 per cubic yard
- Revegetation, including mulch and fertilizer, will cost $1,000 per acre
- 20 tons of agricultural lime per acre at $26 per ton applied costs ($520 per acre) will be added
- E&S control will be 5% of direct costs ($275 per acre).

These costs add to $5,795 per acre for direct costs. Indirect costs were calculated per job regardless of the acreage of the job. These costs include:

- $6,000 for mapping
- $8,000 for permitting and E&S control design

- $16,000 for the reclamation design
- $15,000 for construction oversight

Table 20: High Priority Reclamation Project Summary

Spoil Area	**A**	**B**	**C**	**F**
Total Spoil Area (Acres)	116	121	17	23
Area to Reclaim (Acres)	10	15	17	23
Direct Costs* (in thousands)	$ 58	$ 87	$ 99	$ 133
Indirect Costs* (in thousands)	$ 40	$ 40	$ 40	$ 45
Total Cost	**$ 98**	**$ 127**	**$ 139**	**$ 178**
Anticipated Average Loading Reductions (pounds per day)				
Acidity	25	43	55	22
Iron	0	1	1	0
Aluminum	4	4	8	3
Cost (in thousands) / pound per day				
Acidity	$ 4	$ 3	$ 3	$ 8
Iron	$ 700	$ 130	$ 171	$ 1,981
Aluminum	$ 28	$ 29	$ 18	$ 66

**Direct costs include construction and materials; indirect costs include design, permitting, mapping and construction oversight.*

For areas adjacent to the landfill, the mapping cost was estimated to be only $1,000 because aerial mapping already exists for these areas. Therefore, for areas connected to the landfill, total indirect costs are estimated to be $40,000. All other areas are estimated to require $45,000 in indirect costs.

In addition to the above costs, it may be desirable to add more than 20 tons per acre of alkaline material. Several types of low-cost alkaline products are available, including bag house lime, reclamation mix, fly ash, tannery by-products, paper mill by-products and others. While these sources of alkalinity are generally cheaper to obtain than agricultural lime, they are more costly to incorporate or apply. Therefore, $26 per ton should be assumed for additional alkaline addition.

BAMR has recent experience in the area with adding several hundred tons per acre of alkaline material. A project of this type was completed in Strattenville, PA in 2002. While the short-term results of this project appear promising, long-term monitoring is necessary to determine to cost-effectiveness of massive alkaline addition versus more traditional reclamation.

For all spoil areas, the recommended reclamation should involve:

- Re-grading of spoil to eliminate impounded water, reduce infiltration and provide for positive drainage off the site;
- 20 tons per acre of alkaline addition to the spoil and to the surface; and
- Revegetation with temporary and permanent ground cover.

In each case, the targeted discharge or discharges should be monitored in order to assess the effectiveness of the reclamation. In some cases, the reclamation may not be effective and in others it may eliminate pollution entirely.

In order to proceed with reclamation on any property, landowner permission must be obtained. The land remains the property of the landowner, with permission granted to contractors, construction oversight personnel and DEP personnel to work on the site during the project and to monitor the work as it takes place. Permanent site access should be granted to DEP in order to check on the success of the vegetation and ensure that erosion is not taking place on reclaimed areas. The agreement should also protect the reclamation work from undue disturbance by the landowner, if possible.

VIII. Specific Discharges and Treatment Recommendations – Walley Run

Four discharges were identified to Walley Run. Fourteen discharges were identified to Lard Run, the main tributary of Walley Run. An important goal of this assessment was to characterize discharges and assess their impacts on the receiving streams to allow for project prioritization. Some of the discharges exhibited such a low pollution loading that they can be considered insignificant and given a very low remediation priority. Table 21 shows the criteria that were used to classify discharges as insignificant.

Table 21: Criteria For Insignificance

	Loading (Pounds Per Day)		
	Net Acidity	Iron	Aluminum
Average Load	< 5	< 0.5	< 0.5
Maximum Load	< 15	< 1.0	< 1.0

These values were chosen based on an examination of the average and maximum loadings for all the discharges. Few of the discharges had loadings that were near these cutoff values; the loadings were generally well above or below these values. The same criteria were used for Little Coon Run discharges.

Of the discharges on Lard Run, eight were found to be insignificant. Table 22 shows the average chemistry and loadings of these discharges.

Table 22: Average Chemistry and Loadings of Insignificant Lard Run Discharges

									Loading (Pounds Per Day)		
Name	**Count**	**Flow (gpm)**	**Field pH (SU)**	**Field Alk (mg/L as $CaCO_3$)**	**Acid (mg/L as $CaCO_3$)**	**Iron (mg/L)**	**Mn (mg/L)**	**Al (mg/L)**	**Net Acid**	**Iron**	**Al**
LR10D	11		6.0	5	5	0.2	0.2	0.5			
LR15D	12	5	4.7	0	14	0.1	1.6	0.8	2	< 0.1	0.1
LR16D	11	0.3	5.0	12	184	79.4	15.8	0.3	1	0.3	< 0.1
LR20D	10	0							0	0	0
LR21D	12	4	5.0	0	18	0.4	2.0	3.1	1	< 0.1	0.2
LR30D	12	3	5.1	1	21	0.1	3.0	3.4	1	< 0.1	0.1
LR33D	11	0							0	0	0
LR35D	11	0.2	3.7	0	150	1.3	8.9	19.3	0.3	0	0

The remaining 6 discharges on Lard Run and the 4 discharges on Walley Run were found to contribute significant loadings of acidity, iron and/or aluminum. Each discharge will be discussed in detail below.

A. LR45D

LR45D is the discharge from the landfill's leachate treatment plant. The discharge forms the headwaters of Lard Run, the main tributary to Walley Run. Table 23 shows the flow, chemistry and loading from the discharge. Table 24 shows selected permit discharge limits for the treatment plant. The flow was measured using the timed volume method directly from the effluent pipe.

Table 23: Flow, Chemistry and Loading of LR45D

										Loading (Pounds Per Day)		
Date	**Flow (gpm)**	**pH (SU)**	**Cond (uS)**	**Field Alk (mg/L as $CaCO_3$)**	**Acid (mg/L as $CaCO_3$)**	**Iron (mg/L)**	**Mn (mg/L)**	**Al (mg/L)**	**Sulfate (mg/L)**	**Net Acid**	**Iron**	**Al**
11/21/01	12.5	7.5	10,380		0	4.0	0.9	0.1	2,948		0.6	0.0
12/11/01	17.6	8.5	11,900	1,680	0	0.6	0.3	0.1	3,584	-355	0.1	0.0
1/15/02	14.16	8.0	11,850	1,980	0	0.7	0.5	0.1	4,264	-336	0.1	0.0
2/19/02	20	7.9	10,020	1,612	0	1.2	0.4	0.0	3,807	-387	0.3	0.0
3/20/02	9	8.0	13,330	2,053	0	0.3	0.1	0.0	4,951	-222	0.0	0.0
4/9/02	3.75	8.1	11,990	1,950	0	0.3	0.1	0.2	2,516	-88	0.0	0.0
5/16/02	30	8.4	6,592	2,268	0	1.2	0.2	0.3	608	-816	0.4	0.1
6/14/02	20.4	8.1	9,880	1,442	0	5.3	0.5	0.0	2,181	-353	1.3	0.0
7/17/02	12	8.0	12,770	1,244	0	1.0	0.2	0.1	4,488	-179	0.1	0.0
8/14/02	20	8.0	12,500	1,402	0	1.4	0.2	0.0	3,428	-336	0.3	0.0
9/11/02	20	8.3	15,090	2,100	0	3.0	0.4	0.0	5,658	-504	0.7	0.0
10/17/02	20	8.6	15,100	1,912	0	1.5	0.2	0.1	3,473	-459	0.4	0.0
Average	**16.6**	**8.1**	**11,784**	**1,786**	**0**	**1.7**	**0.3**	**0.1**	**3,492**	**-367**	**0.4**	**0.0**

Table 24: Selected Treatment Plant Discharge Limits

Parameter	**Limit**
pH	Between 6.0 and 9.0
Alkalinity	Must exceed acidity
Total Iron	3.5 mg/L average, 7.0 mg/L maximum
Dissolved Iron	1.24 mg/L average, 2.48 mg/L maximum
	0.31 pounds per day average, 0.62 pounds per day maximum
Total Manganese	1.0 mg/L average, 2.0 mg/L monthly

This discharge is highly alkaline and offsets the acidity from mine drainage discharges to both Lard Run and Walley Run downstream of the plant discharge. However, the discharge also has extremely high conductivity and sulfate concentrations and moderate level of iron. The discharge may also contain other constituents that were not measured as part of this project. The discharge causes staining along Lard Run, which was observed to be white, black, brown and red during different sampling events.

In December 2001, a study was performed to specifically estimate the effects of this discharge on the aquatic community of Lard Run and Walley Run. This study concluded that while the discharge offers positive benefits (increased pH and alkalinity), the detriments from the discharge (increase conductivity) harm aquatic communities in Lard Run and Walley Run (Damariscotta, 2001).

Because LR45D is not a mine discharge, it is not within the scope of this project to recommend alternatives for further treatment of the discharge. However, it may be possible to use the high level of excess alkalinity in the discharge to offset acidic inputs to Little Coon Run. This would involve rerouting all or a portion of the discharge to the west side of the landfill area where acidic seeps originate.

It may also be possible to construct a small pond to collect LR45D and mix it with acidic discharges in the area prior to discharge to the stream. The pond would provide a place for metals from mine drainage to react with the alkalinity in LR45D and form solids. This solution may also improve the visual appearance of the stream. These efforts would require a high degree of cooperation between County Environmental, Farmington Township, the DEP and residents.

B. LR40D

LR40D discharges from a diffuse seep area downstream of LR45D and just east of the landfill access road. The discharge emerges less than 5 yards from the stream. Table 25 shows the flow, chemistry and loading for the discharge. Flow was measured using the timed volume method from a pipe installed to capture the flow.

Table 25: Flow, Chemistry and Loading of LR40D

										Loading (Pounds Per Day)		
Date	**Flow (gpm)**	**pH (SU)**	**Cond (uS)**	**Field Alk (mg/L as $CaCO_3$)**	**Acid (mg/L as $CaCO_3$)**	**Iron (mg/L)**	**Mn (mg/L)**	**Al (mg/L)**	**Sulfate (mg/L)**	**Net Acid**	**Iron**	**Al**
11/21/01	0									0.0	0.0	0.0
12/11/01	0									0.0	0.0	0.0
1/15/02	0.1	3.2	2,878	0	646	0.5	9.7	2.0	2,400	0.8	0.0	0.0
2/20/02	0.37	3.1	3,040	0	713	59.3	38.3	81.5	2,308	3.2	0.3	0.4
3/20/02	0.25	4.0	2,484	0	422	29.4	33.4	48.7	1,733	1.3	0.1	0.1
4/9/02	0.25	3.0	2,376	0	468	4.8	32.0	53.7	1,600	1.4	0.0	0.2
5/16/02	1	3.0	2,444	0	508	9.7	28.5	67.8	1,410	6.1	0.1	0.8
6/14/02	3.5	3.2	2,316	0	336	10.0	30.5	38.4	1,378	14.1	0.4	1.6
7/17/02	0.5	3.5	2,987	0	363	14.6	39.3	34.9	1,705	2.2	0.1	0.2
8/14/02	0.25	2.3	2,854	0	349	24.5	38.1	28.8	1,677	1.0	0.1	0.1
9/11/02	0									0.0	0.0	0.0
10/17/02	0									0.0	0.0	0.0
Average	**0.5**	**3.2**	**2,672**	**0**	**476**	**19.1**	**31.2**	**44.5**	**1,776**	**2.5**	**0.1**	**0.3**

As shown in Table 25, the discharge is intermittent and was not flowing during four of the sampling events. The average loadings were insignificant, but aluminum loading during June 2002 qualifies this as a significant discharge. Although the flow rate was usually very low, exceeding 1 gpm on only one occasion, the discharge contains very high levels of acidity and aluminum.

The intermittent nature of this discharge and its proximity to the unreclaimed spoil at the northeast corner of the landfill suggest that it is highly dependent upon infiltration of surface water and precipitation into bare spoils upgradient. Reclamation of the adjacent spoil may have a significant impact on the discharge.

County Environmental is currently performing reclamation of 8 acres in this area as part of the match for this project. Alkaline addition and revegetation will also be completed. The discharge should be monitored after reclamation is complete to assess any positive impacts that the work may have on the quality and quantity of the discharge. Treatment is not recommended at this time.

C. LR29D

LR29D discharges from Spoil Area C near the intersection of Aaron Road and Walley Run Road. The discharge flows east to Little Coon Run. The flow spreads out and does not reach the stream at a distinct point. Table 26 shows the flow, chemistry and loading from the discharge. Flow was measured using a six-inch H-flume. Sampling at this discharge started in April after it was located during field reconnaissance.

Table 26: Flow, Chemistry and Loading of LR29D

										Loading (Pounds Per Day)		
Date	**Flow (gpm)**	**pH (SU)**	**Cond (uS)**	**Field Alk (mg/L as $CaCO_3$)**	**Acid (mg/L as $CaCO_3$)**	**Iron (mg/L)**	**Mn (mg/L)**	**Al (mg/L)**	**Sulfate (mg/L)**	**Net Acid**	**Iron**	**Al**
4/9/02	5	3.0	1670	0	715	15.6	11.7	102	1125	42.9	0.9	6.1
5/16/02	15	2.9	1793	0	732	10.6	12.0	95	1320	131.8	1.9	17.0
6/14/02	20	3.0	1218	0	441	10.8	8.8	64	1266	105.8	2.6	15.3
7/17/02	1	4.4	2140	0	871	19.6	17.1	120	1394	10.5	0.2	1.4
8/14/02	0									0.0	0.0	0.0
10/17/02	0									0.0	0.0	0.0
Average	**6.8**	**3.3**	**1705**	**0**	**690**	**14.1**	**12.4**	**95.0**	**1277**	**48.5**	**0.9**	**6.6**

As shown above, the discharge is intermittent, indicating that it is dependant upon surface flows from the spoil area. When flowing, the discharge is highly contaminated with acidity and aluminum. This discharge is too acidic and too high in aluminum to treat using current passive treatment technologies. Therefore, reclamation is recommended.

The discharge originates from Spoil Area C (See Figure 7). Other sources of contamination from this spoil flow to Little Coon Run (LC46D and LC47D). Reclamation of this spoil will likely improve these discharges. See Section VII for a more detailed description of the recommended reclamation plan, which is expected to cost $139,000.

After reclamation, the discharge should be monitored. If the discharge is still flowing but has experienced a reduction in contamination as a result of the reclamation it may then be possible to install some type of passive treatment.

D. LR25D and LR26D

LR25D discharges from the road ditch on the southern side of Aaron Road. The discharge flows from west to east to Little Coon Run just upstream of the Aaron Road culvert. LR26D is a separate seep to Little Coon Run that also enters the stream near the Aaron Road culvert. Tables 27 and 28 show the flow, chemistry and loading for the discharges. The flows were measured using the timed volume methods using pipes installed at each discharge.

Table 27: Flow, Chemistry and Loading of LR25D

										Loading (Pounds Per Day)		
Date	**Flow (gpm)**	**pH (SU)**	**Cond (uS)**	**Field Alk (mg/L as $CaCO_3$)**	**Acid (mg/L as $CaCO_3$)**	**Iron (mg/L)**	**Mn (mg/L)**	**Al (mg/L)**	**Sulfate (mg/L)**	**Net Acid**	**Iron**	**Al**
11/21/01	0									0.0	0.0	0.0
12/11/01	3	5.0	278	0	10	0.1	1.3	1.4	147	0.4	0.0	0.1
1/16/02	2.5	5.0	305	0	12	0.0	1.4	1.4	160	0.4	0.0	0.0
2/20/02	12	5.1	372	5	19	0.0	2.0	2.2	221	2.0	0.0	0.3
3/20/02	40	6.0	670	0	158	0.9	4.5	18.2	438	75.7	0.4	8.7
4/9/02	10.5	4.7	406	0	70	0.1	2.3	1.5	240	8.9	0.0	0.2
5/16/02	3.9	4.8	174	4	8	0.1	0.6	0.7	76	0.2	0.0	0.0
7/17/02	0									0.0	0.0	0.0
8/14/02	0									0.0	0.0	0.0
9/11/02	0									0.0	0.0	0.0
10/17/02	0									0.0	0.0	0.0
Average	**6.5**	**5.1**	**368**	**2**	**46**	**0.2**	**2.0**	**4.2**	**214**	**8.0**	**0.0**	**0.9**

Table 28: Flow, Chemistry and Loading of LR26D

										Loading (Pounds Per Day)		
Date	**Flow (gpm)**	**pH (SU)**	**Cond (uS)**	**Field Alk (mg/L as $CaCO_3$)**	**Acid (mg/L as $CaCO_3$)**	**Iron (mg/L)**	**Mn (mg/L)**	**Al (mg/L)**	**Sulfate (mg/L)**	**Net Acid**	**Iron**	**Al**
11/21/01	0.5	5.0	373		17	0.2	2.7	3.1	203		0.0	0.0
12/11/01	2	5.0	281	0	17	0.2	1.3	1.6	154	0.4	0.0	0.0
1/15/02	0.5	4.7	271	0	25	0.0	1.0	1.6	146	0.1	0.0	0.0
2/20/02	1	4.9	234	0	17	0.0	0.8	1.2	118	0.2	0.0	0.0
3/20/02	3.75	5.5	222	0	10	0.1	1.0	1.0	116	0.5	0.0	0.0
4/9/02	2	4.8	196	0	10	0.1	0.7	0.9	99	0.2	0.0	0.0
5/16/02	12.5	3.7	827	0	251	2.3	5.5	33.0	559	37.6	0.3	5.0
7/17/02	0									0.0	0.0	0.0
8/14/02	0									0.0	0.0	0.0
9/11/02	0									0.0	0.0	0.0
10/17/02	0									0.0	0.0	0.0
Average	**2.0**	**4.8**	**343**	**0**	**50**	**0.4**	**1.9**	**6.0**	**199**	**3.9**	**0.0**	**0.5**

As shown in Tables 27 and 28, the discharges are moderately contaminated and intermittent. There was no flow at LR25D during five of the eleven sampling events and no flow at LR26D for four of the eleven sampling events (no samples were taken here in June). This suggests that the discharges are dependent upon rainfall and surface flows.

The discharges are likely contaminated by Spoil Area C (See Figure 7). Several sources of contamination from Spoil Area C flow to Little Coon Run. Reclamation of this spoil will likely improve these discharges as well as flows to Little Coon Run. See Section VII for a more detailed description of the recommended reclamation plan.

After the reclamation job is completed, these discharges should be monitored to assess the effects of reclamation on the discharges.

E. LR17D

LR17D discharges from a natural spring area approximately 50 yards west of Lard Run. LR15D and LR16D, two discharges that are contaminated but were found to be insignificant, are located near LR17D. Table 29 shows the flow, chemistry and loading from LR17D. Flow was measured using the timed volume method in a pipe installed in the discharge channel.

Table 29: Flow, Chemistry and Loading of LR17D

										Loading (Pounds Per Day)		
Date	**Flow (gpm)**	**pH (SU)**	**Cond (uS)**	**Field Alk (mg/L as $CaCO_3$)**	**Acid (mg/L as $CaCO_3$)**	**Iron (mg/L)**	**Mn (mg/L)**	**Al (mg/L)**	**Sulfate (mg/L)**	**Net Acid**	**Iron**	**Al**
11/21/01	2	4.5	1,492	0	179	128.1	20.5	0.4	939	4.3	3.1	0.0
12/11/01	3.5	5.8	1,182	0	122	47.3	8.7	0.4	703	5.1	2.0	0.0
1/15/02	2.5	5.6	1,288	72	140	69.0	10.1	0.4	602	2.0	2.1	0.0
2/20/02	7.5	5.0	817	17	87	37.9	6.3	0.4	549	6.3	3.4	0.0
3/19/02	2.25	5.4	917	5	91	50.0	7.9	0.4	418	2.3	1.4	0.0
4/9/02	6	5.1	702	0	75	33.0	5.2	0.4	334	5.4	2.4	0.0
5/16/02	12	4.7	448	4	37	13.8	2.9	0.3	152	4.8	2.0	0.0
6/14/02	9	6.0	620	0	57	26.9	4.9	0.3	324	6.1	2.9	0.0
7/17/02	1	5.0	1,942	0	259	107.7	19.8	0.3	1,193	3.1	1.3	0.0
8/14/02	1.5	3.8	1,910	0	224	114.6	19.6	0.1	1,384	4.0	2.1	0.0
9/11/02	1.25	5.0	1,904	0	226	111.8	20.2	1.3	1,335	3.4	1.7	0.0
10/17/02	1	4.8	1,991	10	223	111.6	20.0	0.5	1,016	2.6	1.3	0.0
Average	**4.1**	**5.1**	**1,268**	**9**	**143**	**71.0**	**12.2**	**0.4**	**746**	**4.1**	**2.1**	**0.0**

As shown in Table 29, the discharge has a low flow rate and high levels of acidity and iron. The discharge is a perennial flow, indicating that it is connected to a groundwater source. The contamination may be due to Spoil Areas A, B and C, which may contaminate the groundwater aquifer. However, reclamation of these areas is unlikely to have much of an effect on this discharge.

ALKast tests indicate that approximately 183 mg/L of alkalinity would be produced by an anoxic limestone drain. This would be sufficient to neutralize the average acidity (143 mg/L) and add an additional 40 mg/L. However, acidity exceeded this value on four of the 12 sampling events, indicating that this system would be capable of fully treating the discharge the majority of the time. During the high acidity periods, the alkalinity would not be sufficient to fully neutralize the discharge.

Assuming a high flow rate of 12 gpm and an average flow rate of 4 gpm, 160 tons of limestone would be required. This would be a bed of limestone 5 feet deep, 8 feet wide and 80 feet long. A 3,500 square foot pond/wetland should follow the ALD in order to provide a place for metals to precipitate. If it is not possible to locate a pond in this area due to topographical restrictions, the ALD can be constructed alone. This will add alkalinity but metals will continue to form in the stream.

If possible, the system should also treat LR15D and LR16D. It may be possible to collect these discharges and direct them to the limestone drain, or they may be mixed with the treated water in the pond/wetland.

Cost estimates for this system, including mapping, design, permitting and construction are as follows:

- $7,000 for the access road
- $8,000 for ALD (limestone and construction)
- $5,000 pond/wetland construction
- $5,000 plumbing and materials
- $15,000 mapping, design and permitting

Therefore, the total anticipated system cost is $40,000.

F. WR20D and WR21D

WR20D and WR21D are discharges from two adjacent pipes. (WR21D is insignificant but is included because the discharges would be difficult to separate.) While the exact source of the discharges is unclear, they appear to originate from the Fuelhart property near the village of Crown. Tables 30 and 31 show the flow, chemistry and loading for the two discharges. Flow was measured using the timed volume methods from the existing pipes.

Table 30: Flow, Chemistry and Loading of WR20D

										Loading (Pounds Per Day)		
Date	**Flow (gpm)**	**pH (SU)**	**Cond (uS)**	**Field Alk (mg/L as $CaCO_3$)**	**Acid (mg/L as $CaCO_3$)**	**Iron (mg/L)**	**Mn (mg/L)**	**Al (mg/L)**	**Sulfate (mg/L)**	**Net Acid**	**Iron**	**Al**
11/28/01			280		0	3.9	0.3	0.0	20			
12/11/01	19	6.5	295	15	0	2.1	0.2	0.0	15	-3.4	0.5	0.0
1/15/02	22.5	6.5	252	35	0	1.9	0.1	0.1	27	-9.5	0.5	0.0
2/20/02	40	6.4	267	26	0	1.4	0.1	0.0	28	-12.5	0.7	0.0
3/20/02	75	6.5	652	49	0	4.7	0.1	0.6	91	-44.1	4.2	0.5
4/9/02	40	6.5	295	30	0	1.4	0.1	0.1	16	-14.4	0.7	0.0
5/16/02	60	6.5	232	33	0	1.2	0.1	0.2	21	-23.8	0.9	0.1
6/14/02		6.5	145	41	0	0.8	0.1	1.3	19			
7/17/02	3	8.2	209	42	0	1.9	0.2	0.0	9	-1.5	0.1	0.0
8/14/02		6.9										
9/11/02	0.25	7.1	198	32	0	30.3	0.2	0.1	14	-0.1	0.1	0.0
10/17/02	1	7.8	183	31	0	0.6	0.1	0.0	19	-0.4	0.0	0.0
Average	**29.0**	**6.9**	**273**	**33**	**0**	**4.6**	**0.1**	**0.2**	**25**	**-12.2**	**0.8**	**0.1**

Table 31: Flow, Chemistry and Loading of WR21D

										Loading (Pounds Per Day)		
Date	**Flow (gpm)**	**pH (SU)**	**Cond (uS)**	**Field Alk (mg/L as $CaCO_3$)**	**Acid (mg/L as $CaCO_3$)**	**Iron (mg/L)**	**Mn (mg/L)**	**Al (mg/L)**	**Sulfate (mg/L)**	**Net Acid**	**Iron**	**Al**
12/11/01	3	5.8	100	27	0	5.3	0.3	0.1	14	-1.0	0.2	0.0
1/15/02	0.5	5.7	109	49	0	5.4	0.2	0.1	19	-0.3	0.0	0.0
2/20/02	3.5	6.0	187	50	0	4.9	0.3	0.1	27	-2.1	0.2	0.0
3/20/02	1.5	6.5	234	104	0	2.1	0.2	0.9	42	-1.9	0.0	0.0
4/9/02	0.3	6.0	91	0	0	0.8	0.3	0.0	11	0.0	0.0	0.0
5/16/02	9	5.7	98	15	0	3.0	0.2	0.3	15	-1.6	0.3	0.0
7/17/02	3	7.3	254	136	0	7.4	0.5	0.0	15	-4.9	0.3	0.0
8/14/02	2	6.7	136	29	0	5.5	0.4	0.0	5	-0.7	0.1	0.0
9/11/02	1.5	7.1	144	47	0	7.5	0.5	0.3	10	-0.8	0.1	0.0
10/17/02	2	6.6	142	42	0	6.4	0.5	0.0	2	-1.0	0.2	0.0
Average	**2.6**	**6.3**	**150**	**50**	**0**	**4.8**	**0.3**	**0.2**	**16**	**-1.4**	**0.1**	**0.0**

The discharges are highly variable and may be tied to groundwater drains, surface water flows, septic discharges or gray water flows from the Fuelhart estate. Field observations indicate that the flow exhibits surges of extremely turbid water. Attempts were made to avoid sampling during these times.

The discharges contribute a low combined iron loading (average of 0.9 pounds per day). The discharge could be easily treated using a wetland system, which would provide retention time and reduce the iron concentration.

Assuming an average combined flow rate of 33 gpm and a desired retention time of 24 hours, 12,800 square feet of wetland 6 inches deep is required. At the high flow rate of 76 gpm, the retention time will be just over 10 hours. Six inches of compost placed in the bottom of the wetland should be planted with wetland plants. Limestone riprap should be placed in the inlet and outlet channel of the wetland.

Construction of the system is expected to cost approximately $20,000. In order to construct the wetland, mapping, design and permitting will be required. This is expected to cost approximately $8,000, for a total system cost of $28,000.

G. WR11D

WR11D is a diffuse seep zone just upstream of the confluence of Walley Run and Lard Run. The discharge flows approximately 10 yards to the stream using various surface and subsurface paths. Table 32 shows the flow, chemistry and loading of the discharge. Flow was measured by directing as many flows as possible to one pipe and using the timed volume method.

Table 32: Flow, Chemistry and Loading of WR11D

										Loading (Pounds Per Day)		
Date	**Flow (gpm)**	**pH (SU)**	**Cond (uS)**	**Field Alk (mg/L as $CaCO_3$)**	**Acid (mg/L as $CaCO_3$)**	**Iron (mg/L)**	**Mn (mg/L)**	**Al (mg/L)**	**Sulfate (mg/L)**	**Net Acid**	**Iron**	**Al**
11/23/01		6.0										
12/11/01	1	6.0	1146	16	87	67.3	5.9	0.0	591	0.9	0.8	0.0
1/15/02	0	5.7	924	17	120	71.3	5.3	0.1	645	0.0	0.0	0.0
2/20/02	1	5.3	868	10	115	81.7	5.5	0.1	615	1.3	1.0	0.0
3/19/02	1.5	5.9	773	17	103	63.3	5.0	0.1	472	1.5	1.1	0.0
4/9/02	2	5.8	643	25	78	41.7	3.5	0.2	320	1.3	1.0	0.0
5/17/02	3	4.0	380	0	51	20.1	1.9	0.3	191	1.8	0.7	0.0
6/14/02	18	6.0	451	7	58	44.8	3.2	0.2	245	11.1	9.7	0.0
7/18/02	6.32	7.3	904	0	103	80.0	5.3	0.0	459	7.8	6.1	0.0
8/14/02	1.5	2.7	982	0	131	103.5	6.0	0.0	635	2.4	1.9	0.0
9/11/02	0.5	3.1	955	0	119	151.0	6.3	1.1	443	0.7	0.9	0.0
10/17/02	4	6.6	972	25	129	75.9	6.4	0.0	488	5.0	3.6	0.0
Average	**3.5**	**5.4**	**818**	**11**	**99**	**72.8**	**4.9**	**0.2**	**464**	**3.1**	**2.4**	**0.0**

Due to subsurface flows, the flow rates are probably underestimates of the actual flow rate. As shown in Table 32, the discharge contains high concentrations of iron. However, treatment of this discharge is unlikely due to the extremely limited space between the discharge and the stream. Subsurface flows would also be difficult to collect.

One possible strategy for the discharge would be to excavate a pit in the area around the discharge and bury limestone. ALKast results indicate 165 mg/L of alkalinity would be produced by such a system. On average, this would be enough to neutralize the discharge and provide 66 mg/L of excess alkalinity. The acidity of the discharge did not exceed 165 mg/L on any of the sampling dates.

The system would function like an anoxic limestone drain, although waters would enter uncollected into the sides and bottom of the bed and discharge out a single point at the top. There is no room to place a pond or a wetland in this location. Therefore, the system would not remove the high levels of iron in the discharge. Iron would continue to accumulate in the stream as it does now, but the stream would be protected from the acidity of the discharge.

Considering the high flow rate of 18 gpm and an average flow rate of 4 gpm, 265 tons of limestone would be required to treat the discharge. This limestone would fill a pit 5 feet deep and 33 feet square. The limestone would be covered with clay and allowed to discharge from plumbing in the top.

There are several site-related difficulties and uncertainties that make cost estimates for this project difficult to formulate. The discharge is located near the stream and forms a wetland around the discharge area. Lard Run or Walley Run would also need to be crossed to provide access to the discharge location. These issues may greatly complicate permitting of the work.

In addition, the area is very wet, which will make excavation difficult. The discharge is located only a few feet above the elevation of the stream bottom, which may make excavation below that elevation impossible.

Due to these uncertainties, a conservative cost estimate of $82,000 is estimated for this project.

H. WR05D

WR05D emerges from a distinct source on the hillside above Walley Run. The discharge flows approximately 30 yards to the stream. Table 33 shows the flow, chemistry and loading of the discharge. Flow was measured using an installed pipe.

Table 33: Flow, Chemistry and Loading of WR05D

Date	Flow (gpm)	pH (SU)	Cond (uS)	Field Alk (mg/L as $CaCO_3$)	Acid (mg/L as $CaCO_3$)	Iron (mg/L)	Mn (mg/L)	Al (mg/L)	Sulfate (mg/L)	Loading (Pounds Per Day) Net Acid	Loading (Pounds Per Day) Iron	Loading (Pounds Per Day) Al
11/25/01		6.0	600		0	32.3	2.4	0.4	301			
12/11/01	5.1	6.0	618	94	0	14.9	1.7	0.0	248	-5.8	0.9	0.0
1/15/02	5	6.6	685	99	0	16.6	1.7	0.1	333	-5.9	1.0	0.0
2/19/02	3.75	7.1	700	110	0	25.7	1.8	0.1	348	-5.0	1.2	0.0
3/19/02	6	6.4	678	96	0	21.1	2.0	0.0	220	-6.9	1.5	0.0
4/11/02	6	6.8	664	107	0	20.2	1.9	0.1	225	-7.7	1.5	0.0
7/18/02	3	7.6	641	116	0	22.9	1.9	0.1	209	-4.2	0.8	0.0
10/18/02	4.5	7.5	596	137	0	16.7	1.7	0.0	309	-7.4	0.9	0.0
Average	**4.8**	**6.7**	**648**	**108**	**0**	**21.3**	**1.9**	**0.1**	**274**	**-6.1**	**1.1**	**0.0**

This discharge is net alkaline and would only require a small wetland for treatment. Assuming an average flow rate of 5 gpm and a desired retention time of 24 hours, a wetland covering 2,000 square feet that is 6 inches deep will suffice. At the high flow rate of 6 gpm, this wetland will have a retention time of 15.5 hours. Six inches of compost placed in the bottom of the wetland should be planted with wetland plants. Limestone riprap should be placed in the inlet and outlet channel of the wetland. Construction of the system is expected to cost $5,000.

A major obstacle to treating this discharge is its inaccessible location. The closest access is via a small camp road several hundred yards from the site. Landowner cooperation will be vital to gain access to the site. Although the construction of this system would not require large volumes of stone, access to the site would be needed for construction equipment and some materials.

The road installation is expected to cost approximately $5,000. In addition, approximately $5,000 would be required for mapping, design and permitting of the system, yielding a total project cost of approximately $15,000. This is not likely to be a cost-effective project due to the low loading and high site access costs.

IX. Specific Discharges and Treatment Recommendations – Little Coon Run

Eighteen discharges were identified to Little Coon Run and its tributaries. An important goal of this assessment was to characterize discharges and assess their impacts on the receiving streams to allow for project prioritization. Some of the discharges exhibited such a low pollution loading that they can be considered insignificant and given a very low remediation priority (See Table 21 for Significance Criteria).

Table 34 shows the flow, chemistry and loading of the 5 discharges that were insignificant.

Table 34: Average Chemistry and Loadings of Insignificant Little Coon Run Discharges

									Loading (Pounds Per Day)		
Name	**Count**	**Flow (gpm)**	**Field pH (SU)**	**Field Alk (mg/L as $CaCO_3$)**	**Acid (mg/L as $CaCO_3$)**	**Iron (mg/L)**	**Mn (mg/L)**	**Al (mg/L)**	**Net Acid**	**Iron**	**Al**
LC26D	9	27	4.8	3	8	0.0	0.6	0.6	< 1	< 0.1	0.1
LC27D	7	1	4.4	0	69	0.0	7.2	10.0	1	< 0.1	0.2
LC28D	4	1	4.9	0	16	0.0	1.3	1.4	< 1	< 0.1	< 0.1
LC29D	5	3	5.3	0	3	0.1	0.1	0.2	< 1	< 0.1	< 0.1
LC62D	12	0.5	4.0	0	55	0.7	12.1	4.6	1	< 0.1	< 0.1

The remaining 13 discharges were found to contribute significant loadings of acidity, iron and/or aluminum. In addition to discharges, two unnamed tributaries with diffuse sources were found to be extremely contaminated (LC25 and LC36). Each discharge will be discussed in detail below.

A. LC61D

LC61D is the discharge from the landfill's Sediment Pond 2. The pond receives mine drainage from the landfill property and is treated using lime. The pond discharge forms the headwaters of Little Coon Run. No distinct sources were found flowing into the pond. Table 35 shows the flow, chemistry and loading for the discharge. Flow was measured using the timed volume method on the discharge pipe from the sediment pond.

Table 35: Flow, Chemistry and Loading of LC61D

										Loading (Pounds Per Day)		
Date	**Flow (gpm)**	**pH (SU)**	**Cond (uS)**	**Field Alk (mg/L as $CaCO_3$)**	**Acid (mg/L as $CaCO_3$)**	**Iron (mg/L)**	**Mn (mg/L)**	**Al (mg/L)**	**Sulfate (mg/L)**	**Net Acid**	**Iron**	**Al**
11/29/01	10.2	5.0	944		19	0.7	16.1	2.7	606		0.1	0.3
12/13/01	7.1	5.0	954	0	21	0.3	9.8	30.9	529	1.8	0.0	2.6
1/16/02	9	5.3	898	0	29	68.3	34.0	78.8	571	3.1	7.4	8.5
2/20/02	2.5	5.8	830	58	5	0.8	9.5	0.4	552	-1.6	0.0	0.0
3/20/02	8	6.0	937	25	0	1.1	14.9	0.2	568	-2.4	0.1	0.0
4/9/02	3	6.5	916	67	0	2.2	12.4	0.2	331	-2.4	0.1	0.0
5/17/02	75	6.5	412	21	0	1.0	3.7	2.6	147	-18.9	0.9	2.3
6/13/02	5	6.8	492	5	0	0.6	4.8	0.2	158	-0.3	0.0	0.0
7/17/02	0									0.0	0.0	0.0
8/14/02	1.25	5.6	457	62	0	0.8	0.7	0.1	205	-0.9	0.0	0.0
9/11/02	0.63	5.6	468	0	0	0.9	1.2	0.3	214	0.0	0.0	0.0
10/17/02	8	6.2	438	34	0	0.5	0.6	0.1	153	-3.3	0.0	0.0
Average	**10.8**	**5.8**	**704**	**27**	**7**	**7.0**	**9.8**	**10.6**	**367**	**-2.3**	**0.7**	**1.2**

At the beginning of the sampling program, little or no treatment was taking place for the discharge. On two occasions, very high concentrations of aluminum were measured. Based on the pH of the discharge, this aluminum was likely in particulate form.

In February, lime treatment was started or increased and the discharge quality was much improved. However, low levels of iron and aluminum, probably in particulate form, were still measured.

While this discharge is not a significant contributor of pollution to Little Coon Run when adequate treatment is taking place, it is a contributor if treatment is stopped or not performed properly. The presence of metal particulates may also indicate that the pond does not have enough retention time.

It is recommended that the landfill examine their treatment practices at Sediment Pond 2 and formulate a plan to improve and ensure treatment at the site.

B. LC60D

LC60D is a very diffuse seep area that was measured just east of Marshall Road where the flows converge and pass under the road in a culvert. LC60D originates in unreclaimed spoils of Area B. The discharge forms the headwaters of an unnamed tributary to Little Coon Run. Table 36 shows the flow, chemistry and loading of the discharge. Flow was measured using the timed volume method from a pipe installed just upstream of the road culvert.

Table 36: Flow, Chemistry and Loading of LC60D

										Loading (Pounds Per Day)		
Date	**Flow (gpm)**	**pH (SU)**	**Cond (uS)**	**Field Alk (mg/L as $CaCO_3$)**	**Acid (mg/L as $CaCO_3$)**	**Iron (mg/L)**	**Mn (mg/L)**	**Al (mg/L)**	**Sulfate (mg/L)**	**Net Acid**	**Iron**	**Al**
11/27/01	14.2		1,146		113	4.3	15.1	17.5	703		0.7	3.0
12/13/01	17.5	4.0	1,320	0	124	2.8	11.7	4.3	890	26.0	0.6	0.9
1/16/02	12	3.4	1,845	0	204	4.1	17.6	21.9	1,270	29.4	0.6	3.2
2/20/02	30	3.6	1,683	0	177	3.6	18.2	21.7	1,302	63.8	1.3	7.8
3/20/02	40	4.0	1,634	0	180	4.1	17.4	16.7	944	86.6	2.0	8.0
4/9/02	37.5	3.4	1,830	0	210	3.2	19.5	22.7	1,066	94.6	1.4	10.2
5/17/02	45	3.3	1,476	0	190	2.0	13.6	21.2	748	102.8	1.1	11.4
6/13/02	30	3.0	2,332	0	258	6.8	23.2	31.2	967	92.8	2.5	11.2
7/17/02	11.25	3.6	2,590	0	299	9.5	27.8	30.7	1,564	40.4	1.3	4.1
8/14/02	17.5	2.3	2,617	0	331	11.3	27.6	24.9	1,439	69.6	2.4	5.2
9/11/02	12	2.9	2,685	0	251	10.6	28.1	36.6	1,581	36.1	1.5	5.3
10/17/02	12.5	3.5	1,970	0	196	6.3	21.0	23.4	1,523	29.4	0.9	3.5
Average	**23.3**	**3.4**	**1,927**	**0**	**211**	**5.7**	**20.1**	**22.7**	**1,166**	**61.0**	**1.4**	**6.2**

As shown in Table 36, the discharge flowed between 11 gpm and 45 gpm, with the higher flows occurring from February to June. The flow contained moderate to high levels of acidity and aluminum and moderate iron concentrations. The perennial flow indicates that groundwater provides some of the water to the discharge.

As discussed in Section VII, reclamation of 15 acres of Spoil Area B adjacent to LC60D may significantly reduce the loading from this discharge. See Section VII for a complete discussion of the recommended reclamation plan, which is expected to cost $127,000. After reclamation is complete, the discharge should be monitored in order to assess the effectiveness of the reclamation.

If reclamation of spoil does not sufficiently reduce the loadings from these discharges, or if reclamation cannot be performed due to landowner or other restrictions, treatment of the discharge with a vertical flow pond (VFP) system may be possible. The system should consist of a VFP cell, a sediment pond, and a polishing wetland. Flow into the VFP should be controlled to limit sedimentation to the VFP. Construction of this treatment system is recommended only if reclamation cannot be performed or does not meet expectations.

C. LC55D and LC57D

LC55D is a diffuse seep zone that originates west of Little Coon Run and flows 10 yards to the stream. LC57D is a diffuse, intermittent discharge that emerges from the toe of the spoil. Tables 37 and 38 show the flow, chemistry and loading for the discharges. Flows were measured using the timed volume method from installed pipes.

Table 37: Flow, Chemistry and Loading of LC55D

										Loading (Pounds Per Day)		
Date	**Flow (gpm)**	**pH (SU)**	**Cond (uS)**	**Field Alk (mg/L as $CaCO_3$)**	**Acid (mg/L as $CaCO_3$)**	**Iron (mg/L)**	**Mn (mg/L)**	**Al (mg/L)**	**Sulfate (mg/L)**	**Net Acid**	**Iron**	**Al**
11/29/01	4	4.0	974	0	84	12.2	13.4	5.6	489	4.0	0.6	0.3
12/13/01	4.5	4.5	1,050	0	108	8.8	9.4	4.1	571	5.8	0.5	0.2
1/16/02	3	3.2	1,074	0	127	10.4	1.9	4.6	570	4.6	0.4	0.2
2/20/02	4	3.5	990	0	93	9.6	9.2	3.9	546	4.4	0.5	0.2
3/20/02	5	4.0	992	0	96	10.7	9.8	3.4	451	5.8	0.6	0.2
4/9/02	4.5	3.2	1,018	0	96	8.0	8.7	2.7	376	5.2	0.4	0.1
5/17/02	12	3.3	709	0	73	8.6	4.9	2.4	293	10.5	1.2	0.3
6/13/02	2	2.8	1,239	0	119	1.5	6.7	18.6	430	2.8	0.0	0.4
7/17/02	0.8	3.1	1,500	0	190	20.4	12.9	1.7	626	1.8	0.2	0.0
8/14/02	1	2.0	1,515	0	206	23.3	11.9	1.4	580	2.5	0.3	0.0
9/11/02	0.5	2.0	1,585	0	189	27.4	11.9	1.8	690	1.1	0.2	0.0
10/17/02	2	3.3	1,230	0	137	22.5	10.8	2.5	536	3.3	0.5	0.1
Average	**3.6**	**3.2**	**1,156**	**0**	**126**	**13.6**	**9.3**	**4.4**	**513**	**4.3**	**0.5**	**0.2**

Table 38: Flow, Chemistry and Loading of LC57D

										Loading (Pounds Per Day)		
Date	**Flow (gpm)**	**pH (SU)**	**Cond (uS)**	**Field Alk (mg/L as $CaCO_3$)**	**Acid (mg/L as $CaCO_3$)**	**Iron (mg/L)**	**Mn (mg/L)**	**Al (mg/L)**	**Sulfate (mg/L)**	**Net Acid**	**Iron**	**Al**
11/27/01	0									0.0	0.0	0.0
12/13/01	0									0.0	0.0	0.0
1/16/02	0									0.0	0.0	0.0
2/20/02	0									0.0	0.0	0.0
3/20/02	0									0.0	0.0	0.0
4/9/02	1.5	3.7	2,165	0	468	0.6	29.5	57.4	1,216	8.4	0.0	1.0
5/17/02	4.5	3.4	2,238	0	604	0.5	31.3	78.3	1,567	32.6	0.0	4.2
6/13/02	2	3.5	1,900	0	359	0.7	24.4	53.8	1,181	8.6	0.0	1.3
7/17/02	1.5	3.8	1,887	0	376	1.4	25.9	53.3	1,150	6.8	0.0	1.0
8/14/02	0.87	2.7	1,784	0	317	3.0	23.9	38.3	1,272	3.3	0.0	0.4
9/11/02	0.25	2.6	1,760	0	255	2.2	25.3	53.6	1,325	0.8	0.0	0.2
10/17/02	0									0.0	0.0	0.0
Average	**0.9**	**3.3**	**1,956**	**0**	**396**	**1.4**	**26.7**	**55.8**	**1,285**	**5.0**	**0.0**	**0.7**

As shown above, LC57D was only flowing on six of the twelve sampling occasions, with some flow measured in April through September. This indicates that the source of water is surface water (precipitation) and that a perennial groundwater influence is not present. The discharge contains very high levels of aluminum and acidity and low levels of iron. LC55D has a low flow rate and moderate levels of acidity, iron and aluminum.

Both of these discharges are located near the edge of the landfill cell and most likely originate under the liner system. There is also little vertical relief in the area to use for a vertical flow pond (VFP) system.

However, it may be possible to treat both of these discharges in a common wetland that is heavily amended with alkaline substrate. The discharges should be collected and piped to the northwest. There are several acres of flat land available in this area between the landfill and Marshall Road.

The wetland should cover approximately 60,000 square feet. Six inches of substrate that consists of 60% (by weight) compost and 40% limestone chips should be placed in the bottom of the wetland and planted with wetland plants. Three to six inches of water should be in the wetland.

The wetland should discharge through a clean, 400-ton limestone bed, which will provide additional polishing. The cost of this project is estimated to be $140,000, of which $120,000 is for direct construction costs and $20,000 is for design, mapping, permitting and construction oversight.

D. LC46D and LC47D

LC46D and LC47D are intermittent flows that originate in Spoil Area C. These discharges eventually reach the headwaters of an unnamed tributary to Little Coon Run. Tables 39 and 40 show the flow, chemistry and loading of each discharge. The flow rates were measured using the timed volume method from installed pipes.

Table 39: Flow, Chemistry and Loading of LC46D

										Loading (Pounds Per Day)		
Date	**Flow (gpm)**	**pH (SU)**	**Cond (uS)**	**Field Alk (mg/L as $CaCO_3$)**	**Acid (mg/L as $CaCO_3$)**	**Iron (mg/L)**	**Mn (mg/L)**	**Al (mg/L)**	**Sulfate (mg/L)**	**Net Acid**	**Iron**	**Al**
11/27/01	0									0.0	0.0	0.0
12/20/01	0									0.0	0.0	0.0
1/16/02	0									0.0	0.0	0.0
2/20/02	0.25	4.1	985	0	156	0.2	9.2	20.7	733	0.5	0.0	0.1
3/20/02	0.5	4.5	1,380	0	268	0.3	14.7	37.8	916	1.6	0.0	0.2
4/9/02	1	3.4	1,093	0	428	0.8	7.0	64.6	773	5.1	0.0	0.8
5/17/02	15	3.3	1,452	0	389	1.2	13.5	49.0	848	70.1	0.2	8.8
6/13/02	2.5	3.1	1,967	0	460	5.7	17.9	70.7	1,381	13.8	0.2	2.1
7/17/02	0.5	3.5	1,877	0	445	6.4	18.4	65.5	1,108	2.7	0.0	0.4
8/14/02	0									0.0	0.0	0.0
9/11/02	0									0.0	0.0	0.0
10/17/02	0									0.0	0.0	0.0
Average	**1.6**	**3.7**	**1,459**	**0**	**358**	**2.4**	**13.5**	**51.4**	**960**	**7.8**	**0.0**	**1.0**

Table 40: Flow, Chemistry and Loading of LC47D

										Loading (Pounds Per Day)		
Date	**Flow (gpm)**	**pH (SU)**	**Cond (uS)**	**Field Alk (mg/L as $CaCO_3$)**	**Acid (mg/L as $CaCO_3$)**	**Iron (mg/L)**	**Mn (mg/L)**	**Al (mg/L)**	**Sulfate (mg/L)**	**Net Acid**	**Iron**	**Al**
11/27/01	0									0.0	0.0	0.0
12/20/01	0.11	3.5		0								
1/16/02	0									0.0	0.0	0.0
2/20/02	0									0.0	0.0	0.0
3/20/02	0.75	4.5	886	0	305	0.9	6.6	46.7	667	2.7	0.0	0.4
4/9/02	0.25	3.5	1,548	0	314	0.6	15.2	42.9	1,022	0.9	0.0	0.1
5/17/02	4.5	3.3	1,486	0	730	2.4	10.7	104.8	927	39.4	0.1	5.7
6/13/02	1	3.1	1,912	0	859	4.8	15.7	139.1	1,480	10.3	0.1	1.7
7/17/02	0.25	3.6	2,140	0	1013	9.6	19.0	151.3	1,310	3.0	0.0	0.5
8/14/02	0.12	2.3	1,947	0	661	9.6	15.8	103.7	1,342	1.0	0.0	0.1
9/11/02	0									0.0	0.0	0.0
10/17/02	0									0.0	0.0	0.0
Average	0.6	**3.4**	**1,653**	**0**	**647**	**4.6**	**13.8**	**98.1**	**1,124**	**5.2**	**0.0**	**0.8**

As shown in Tables 39 and 40, these discharges only flow about half the year. This indicates that a perennial groundwater flow is not present and that the discharges are heavily influenced by seasonal rainfall that infiltrates the spoil and becomes contaminated. When flowing, the discharges have high concentrations of acidity and aluminum.

As discussed in Section VII, reclamation of Spoil Area C is expected to reduce the loading from these discharges by lowering the flow rate and improving the quality of runoff from the site. Several discharges to Lard Run may also be improved. After the recommended reclamation has been completed, the discharges should be monitored to assess the effectiveness of the project. The reclamation project is projected to cost approximately $139,000.

E. LC45D

LC45D is a seep emerging from Spoil Area A adjacent to current landfill operations. The discharge is located near power lines and flows along the road. Table 41 shows the flow, chemistry and loading of the discharge. The flow at this station was measured using the timed volume from an installed pipe.

Table 41: Flow, Chemistry and Loading of LC45D

										Loading (Pounds Per Day)		
Date	**Flow (gpm)**	**pH (SU)**	**Cond (uS)**	**Field Alk (mg/L as $CaCO_3$)**	**Acid (mg/L as $CaCO_3$)**	**Iron (mg/L)**	**Mn (mg/L)**	**Al (mg/L)**	**Sulfate (mg/L)**	**Net Acid**	**Iron**	**Al**
11/27/01	0									0.0	0.0	0.0
12/20/01	1.3	3.5		0								
1/16/02	2.5	3.3	2,190	0	558	0.8	25.0	69.8	1,918	16.7	0.0	2.1
2/20/02	6	3.6	2,234	0	486	2.1	25.8	77.4	2,042	35.0	0.1	5.6
3/20/02	5	4.0	2,124	0	462	2.1	25.7	61.0	1,336	27.7	0.1	3.7
4/9/02	9	3.4	2,214	0	478	3.0	25.7	61.6	1,364	51.6	0.3	6.7
5/17/02	25	3.3	2,187	0	529	3.3	24.8	73.0	1,224	158.8	1.0	21.9
6/13/02	9	3.2	2,174	0	495	2.9	24.0	74.0	1,252	53.4	0.3	8.0
7/17/02	6	3.5	2,073	0	476	2.7	24.3	70.5	941	34.2	0.2	5.1
8/14/02	2	2.4	2,085	0	429	3.9	22.9	56.7	1,187	10.3	0.1	1.4
9/11/02	0.75	2.5	2,006	0	417	3.6	23.2	86.4	1,474	3.8	0.0	0.8
10/17/02	0									0.0	0.0	0.0
Average	**5.5**	**3.3**	**2,143**	**0**	**481**	**2.7**	**24.6**	**70.0**	**1,415**	**35.6**	**0.2**	**5.0**

As shown in Table 41, the discharge is highly contaminated with acidity, iron and aluminum. The aluminum levels are higher than is currently being treated with reliable passive treatment. As discussed in Section VII, reclamation of 10 acres of spoil adjacent to the discharge is recommended before treatment of this discharge is considered. This project is expected to cost approximately $98,000.

If reclamation of Spoil Area A does not sufficiently reduce the loadings from these discharges, or if reclamation cannot be performed due to landowner or other restrictions, it may be possible to direct this discharge to the common wetland constructed for LC55D and LC57D. If this is to be done, the wetland should be expanded to at least 100,000 square feet. This should be done only if reclamation is unsuccessful.

F. LC40D

LC40D discharges from a distinct source and spreads out over a wide area. The flow reaches Little Coon Run after flowing approximately 100 yards through partially wooded areas that were once occupied by beavers. Table 42 shows flow and chemistry, which were measured near the discharge point. Flow was measured using the timed volume method from a pipe installed near the discharge.

Table 42: Flow, Chemistry and Loading of LC40D

										Loading (Pounds Per Day)		
Date	**Flow (gpm)**	**pH (SU)**	**Cond (uS)**	**Field Alk (mg/L as $CaCO_3$)**	**Acid (mg/L as $CaCO_3$)**	**Iron (mg/L)**	**Mn (mg/L)**	**Al (mg/L)**	**Sulfate (mg/L)**	**Net Acid**	**Iron**	**Al**
11/28/01	8		1,746		335.3	255.4	19.1	0.04	1,176		24.5	0.0
12/13/01	10	6.0	1,631	19	253.1	151.5	10.4	* 11.20	1,190	28.1	18.2	* 1.3
1/16/02	10.5	5.8	1,582	43	319.8	181.3	11.8	0.13	1,293	34.9	22.8	0.0
2/19/02	12	5.9	1,582	42	328.2	204.7	12.7	0.04	1,450	41.2	29.5	0.0
3/19/02	30	6.7	1,583	31	346.0	215.5	13.7	0.04	961	113.4	77.6	0.0
4/9/02	12	5.9	1,560	52	332.3	191.2	12.9	0.04	839	40.4	27.5	0.0
5/17/02	13.5	5.8	1,554	27	338.9	177.5	12.9	0.23	970	50.5	28.8	0.0
6/13/02	12	5.7	1,587	3	333.5	197.2	13.4	0.04	1,010	47.6	28.4	0.0
7/17/02	15	6.0	1,577	44	329.0	191.3	13.4	0.04	825	51.3	34.4	0.0
8/14/02	12	5.0	1,600	35	325.8	197.6	13.4	0.06	1,062	41.9	28.5	0.0
9/11/02	10.5	5.9	1,612	43	363.0	182.0	13.0	0.69	1,006	40.3	22.9	0.1
10/17/02	6	5.7	1,601	37	321.8	198.3	13.3	0.04	1,251	20.5	14.3	0.0
Average	**12.6**	**5.8**	**1,601**	**34.2**	**327.2**	**195.3**	**13.3**	**0.13**	**1,086**	**46.4**	**29.8**	**0.0**

**Suspected erroneous readings not included in averages*

As shown in Table 42, the discharge is highly net acidic with high iron concentrations. Because it emerges from a distinct source near other known well locations, this location may be an abandoned gas well. An application was submitted to the Growing Greener program in February 2003 to plug this well and LC35D, another nearby discharge. The total cost of the proposal was $50,000, half of which can be assumed for this discharge and half for LC35D. Grant awards should be announced during the summer of 2003.

If plugging is not funded or is unsuccessful, this water is well suited for treatment using an anoxic limestone drain (ALD). On all dates except one (12/13/01), the aluminum concentration was low. The one high value is likely the result of a laboratory or sampling error.

ALKast tests indicate that an ALD would generate approximately 207 mg/L of alkalinity. This would not be sufficient to neutralize all of the acidity in the discharge, leaving an average of 120 mg/L of excess acidity (a range of 46 – 156 mg/L). Additional treatment using a vertical flow pond will be required if all of the acidity and iron are to be treated.

The system components should have the following specifications:

- ALD – 500 tons of limestone, 5’ deep by 15’ wide by 135 feet long

- Pond/Wetland – 8,350 ft^2 (60’ by 140’)
- VFP – 1,000 tons of limestone, 29,500 ft^2
- Pond/Wetland – 8,800 ft^2 (90’ by 100’)

The ALD only system is expected to cost $55,000, of which $40,000 is direct construction cost and $15,000 is for indirect costs (mapping, design, permitting, construction oversight). The addition of the VFP is expected to add an additional $70,000 of direct costs and $10,000 of indirect costs, for a total system cost of $135,000.

Table 43: LC40D Treatment Options and Expected Average Results

		Expected System Outlet Chemistry (mg/L)		**Reduced Loading (average pounds per day)**	
Treatment System Elements	**Estimated Cost**	**Net Acidity (as $CaCO_3$)**	**Iron**	**Acidity**	**Iron**
ALD, Pond, Wetland	$55,000	120	80	31	17
ALD, Pond, Wetland, VFP, Pond, Wetland	$135,000	-50	1	54*	30
Untreated Discharge Chemistry		**327**	**195**		

**includes additional alkalinity*

Construction of a system at this discharge should only be performed if plugging is not performed or if it is unsuccessful.

G. LC37D

LC37D is a discharge from the toe of the spoil in Spoil Area F. Table 44 shows the flow, chemistry and loading from the discharge. Flow rates were measured in a pipe at the road crossing. Samples were taken at the discharge area approximately 100 feet west of the road.

Table 44: Flow, Chemistry and Loading of LC37D

										Loading (Pounds Per Day)		
Date	**Flow (gpm)**	**pH (SU)**	**Cond (uS)**	**Field Alk (mg/L as $CaCO_3$)**	**Acid (mg/L as $CaCO_3$)**	**Iron (mg/L)**	**Mn (mg/L)**	**Al (mg/L)**	**Sulfate (mg/L)**	**Net Acid**	**Iron**	**Al**
11/29/01	4.75	4.0	2,213	0	241	7.5	35.2	49.5	1,642	13.7	0.4	2.8
12/13/01	7.5	3.5	2,161	0	269	2.3	21.8	3.8	1,597	24.2	0.2	0.3
1/16/02	5	3.4	2,420	0	339	0.6	26.0	41.5	1,840	20.3	0.0	2.5
2/20/02	1	3.7	2,357	0	361	0.8	27.4	47.4	1,980	4.3	0.0	0.6
3/20/02	30	4.5	2,011	0	285	2.1	24.5	34.9	1,492	102.6	0.8	12.6
4/9/02	7.5	3.4	2,445	0	399	1.0	29.9	53.4	1,632	35.9	0.1	4.8
5/16/02	15	3.3	2,370	0	398	0.5	27.3	52.0	1,553	71.7	0.1	9.4
6/13/02	3	3.5	2,254	0	350	1.3	24.2	46.2	1,337	12.6	0.0	1.7
7/17/02	0.5	3.8	2,163	0	304	2.0	24.6	41.0	1,253	1.8	0.0	0.2
8/14/02	1.12	2.8	2,126	0	301	1.9	24.5	36.3	1,327	4.0	0.0	0.5
9/11/02	0									0.0	0.0	0.0
10/17/02	2.5	3.7	2,120	0	230	2.8	24.1	35.3	1,746	6.9	0.1	1.1
Average	**6.5**	**3.6**	**2,240**	**0**	**316**	**2.1**	**26.3**	**40.1**	**1,582**	**24.8**	**0.1**	**3.0**

As shown in Table 44, the discharge has a highly variable flow and high concentrations of acidity and aluminum. Reclamation of Area F is recommended in order to mitigate this discharge. The detailed reclamation plan is contained in Section VII. After reclamation, the discharge should be monitored for quantity and quality in order to assess the effectiveness of the project. The reclamation is expected to cost approximately $178,000.

H. LC35D

LC35D emerges from a distinct source that is likely an abandoned well and spreads out over a wide area. Old wooden well casing is visible just below the water surface. Iron deposits from the discharge are spread over a large area. The discharge is on an unnamed tributary approximately 50 yards from Little Coon Creek in an area that is generally wet and swampy. Table 45 shows flow and chemistry, which were measured near the discharge point. Flow was measured using the timed volume method from an installed pipe.

Table 45: Flow, Chemistry and Loading of LC35D

										Loading (Pounds Per Day)		
Date	**Flow (gpm)**	**pH (SU)**	**Cond (uS)**	**Field Alk (mg/L as $CaCO_3$)**	**Acid (mg/L as $CaCO_3$)**	**Iron (mg/L)**	**Mn (mg/L)**	**Al (mg/L)**	**Sulfate (mg/L)**	**Net Acid**	**Iron**	**Al**
11/27/01	8		1,640		277	235.5	14.2	0.0	980		22.6	0.0
12/13/01	18.5	5.8	1,543	30	226	124.5	9.5	0.2	708	43.5	27.6	0.0
1/16/02	12	5.8	1,219	20	203	112.5	7.2	0.4	780	26.3	16.2	0.1
2/19/02	15	5.8	1,500	48	279	179.8	9.8	0.0	1,318	41.6	32.4	0.0
3/19/02	15	5.2	1,500	45	259	178.2	10.2	0.0	814	38.5	32.1	0.0
4/9/02	37.5	5.9	1,463	42	260	166.8	9.9	0.0	877	98.2	75.0	0.0
5/17/02	40	4.4	1,180	0	219	91.3	6.7	0.5	671	105.1	43.8	0.2
6/13/02	12	6.0	1,483	4	282	159.2	9.6	0.0	654	40.1	22.9	0.0
7/17/02	22.5	6.0	1,503	46	279	164.3	10.2	0.0	773	62.8	44.4	0.0
8/14/02	35	5.4	1,550	45	306	179.3	10.7	0.0	1,111	109.5	75.3	0.0
9/11/02	6	5.6	1,545	51	285	163.9	10.4	0.3	984	16.8	11.8	0.0
10/17/02	25	5.8	1,569	40	273	180.9	10.6	0.0	1,223	69.9	54.3	0.0
Average	**20.5**	**5.6**	**1,475**	**34**	**262**	**161.4**	**9.9**	**0.1**	**908**	**59.3**	**38.2**	**0.0**

As shown in Table 45, this discharge is net acidic with very high concentrations of iron and little to no aluminum. An application was submitted to the Growing Greener program in February 2003 to plug this well and LC40D, another nearby discharge. The total cost of the proposal was $50,000, half of which can be assumed for this discharge and half for LC40D. Grant awards should be announced during the summer of 2003.

If plugging is not funded or is unsuccessful, this water is well suited for treatment using an anoxic limestone drain (ALD) followed by a pond and wetland. ALKast tests show that about 197 mg/L of alkalinity could be generated using an ALD. This would not be enough to neutralize all of the acidity in the discharge, leaving an average of 65 mg/L of net acidity (a range of 6 – 109 mg/L). Additional treatment would be required if this acidity is to be complete neutralized and all iron is to be removed. However, the location of the discharge and geographical features of the surrounding land will greatly complicate installation of a treatment system.

The discharge is located on the edge of an unnamed tributary to Little Coon Run in an area that is always wet and swampy. This complicates both construction and permitting of any treatment system. Construction of a treatment system for the discharge should not be considered unless plugging is unsuccessful.

Table 46 shows the expected results from the treatment system.

Table 46: LC35D Treatment Options and Expected Average Results

	Expected System Outlet Chemistry (mg/L)		Reduced Loading (average pounds per day)	
Treatment System Elements	**Net Acidity (as $CaCO_3$)**	**Iron**	**Acidity**	**Iron**
ALD, Pond, Wetland	65	52	48	27
	262	**161**		

If complete treatment of all acidity is required, it will be necessary to add an alkaline-amended wetland or limestone polishing bed to the system. However, due to the nature of the site, it is unlikely that space or elevation drop will be available for these components.

I. LC20D

LC20D emerges near the toe of a rock outcropping. The discharge spreads out and flows approximate 50 yards to Little Coon Creek. Large iron deposits from the discharge have covered the area. The site is located on State Game Lands 24. This discharge was sampled where it emerged from the ground. Flow was measured using the timed volume method from two pipes (LC20D and LC19D). The flow rates were added to arrive at the total flow rate. Table 47 shows the sampling results for this discharge.

Table 47: Flow, Chemistry and Loading of LC20D

										Loading (Pounds Per Day)		
Date	**Flow (gpm)**	**pH (SU)**	**Cond (uS)**	**Field Alk (mg/L as $CaCO_3$)**	**Acid (mg/L as $CaCO_3$)**	**Iron (mg/L)**	**Mn (mg/L)**	**Al (mg/L)**	**Sulfate (mg/L)**	**Net Acid**	**Iron**	**Al**
11/28/01	24	5.8	1,132		200	165.1	20.6	0.0	733		47.5	0.0
12/13/01	46.5	5.8	1,167	48	183	105.0	13.8	0.1	680	75.3	58.6	0.0
1/16/02	48	5.8	1,135	48	185	114.0	12.9	0.2	791	79.0	65.7	0.1
2/19/02	75	5.9	1,117	44	206	116.5	13.9	0.1	861	145.8	104.8	0.0
3/19/02	62	6.1	1,137	6	186	125.7	14.7	0.1	772	133.8	93.5	0.0
4/11/02	72.5	6.0	1,120	55	198	118.2	13.9	0.1	626	124.6	102.8	0.1
5/16/02	135	5.9	1,146	50	206	118.3	13.6	0.2	585	253.1	191.6	0.2
6/13/02	51	7.5	1,123	5	197	120.2	14.8	0.0	632	117.6	73.5	0.0
7/18/02	54	6.8	1,138	52	192	117.0	15.0	0.1	602	90.9	75.8	0.1
8/14/02	54	6.2	1,160	54	194	117.8	14.7	0.0	614	90.4	76.3	0.0
9/11/02	51	6.1	1,133	55	229	112.8	15.0	1.4	761	106.5	69.0	0.9
10/17/02	55	6.2	1,137	53	188	127.4	15.3	0.2	860	88.8	84.1	0.1
Average	**60.7**	**6.2**	**1,137**	**43**	**197**	**121.5**	**14.8**	**0.2**	**710**	**118.7**	**86.9**	**0.1**

As shown in Table 47, this discharge is net acidic with little aluminum and high iron concentrations. This type of water is well-suited for treatment using an anoxic limestone drain (ALD) followed by a pond and wetland.

ALKast tests indicate that an ALD would produce water with 253 mg/L of alkalinity. This would be sufficient to neutralize all the acidity in this discharge and add an average of 56 mg/L of excess alkalinity to the stream (range of 24 – 70 mg/L). The acidity of the discharge never exceeded 253 mg/L.

The ALD should contain 1,700 tons of limestone (5' deep by 40' wide by 170' long) followed by a 47,000 square foot pond/wetland. Dimensions of the pond/wetland will depend upon topographical features of the building site. The system will remove all of the iron and acidity and add an average of 40 pounds per day of excess alkalinity (-40 pounds of net acidity) under average conditions.

Construction of this system will cost approximately $126,000 in direct construction costs, water collection and site preparation (sludge removal). Site mapping, design, permitting and construction oversight will cost approximately $25,000. Another major cost associated with this project will be site access. It is approximately 1 mile to the nearest road. The site can be approached from the bridge near sampling point LC30 or from a township road located to the west (across Little Coon Run). For either access scenario, a road must be constructed to allow trucks full of limestone to access the site. The projected cost of this road is approximately $20,000, for a total project cost of $171,000.

Access from the bridge near LC30 could follow an existing path, much of which is located on the State Game Lands. It may be possible to work with the Game Commission in installing the road if they have any planned logging operations in the area. This possibility should be explored during initial contacts with the Game Commission seeking approval to construct the system.

J. LC10D

LC10D discharges from a natural spring in a shallow ravine on the eastern side of Little Coon Run. The discharge is located on State Game Lands #24 and emerges approximately 80 yards from the stream. Table 48 shows the flow, chemistry and loading of the discharge. Flow was measured using the timed volume method from an installed pipe.

Table 48: Flow, Chemistry and Loading of LC10D

										Loading (Pounds Per Day)		
Date	**Flow (gpm)**	**pH (SU)**	**Cond (uS)**	**Field Alk (mg/L as $CaCO_3$)**	**Acid (mg/L as $CaCO_3$)**	**Iron (mg/L)**	**Mn (mg/L)**	**Al (mg/L)**	**Sulfate (mg/L)**	**Net Acid**	**Iron**	**Al**
11/28/01	5.5	6.0	463		0	16.2	1.8	0.0	176		1.1	0.0
12/13/01	6.5	6.5	475	98	0	9.4	1.3	0.1	150	-7.6	0.7	0.0
1/15/02	6	6.6	489	100	0	13.6	1.3	0.1	214	-7.2	1.0	0.0
2/19/02	6.75	6.7	482	105	0	14.6	1.4	0.0	193	-8.5	1.2	0.0
3/19/02	6	5.4	480	87	0	12.6	1.4	0.0	187	-6.3	0.9	0.0
4/11/02	7.5	6.7	440	100	0	10.9	1.2	0.0	107	-9.0	1.0	0.0
5/16/02	20	7.0	263	50	0	5.2	0.7	0.1	92	-12.0	1.3	0.0
6/13/02	7	7.6	480	9	0	11.8	1.3	0.0	167	-0.8	1.0	0.0
7/17/02	6	7.9	489	112	0	20.1	1.4	0.0	123	-8.1	1.4	0.0
8/14/02	6	6.7	495	106	0	11.4	1.3	0.0	123	-7.6	0.8	0.0
9/11/02	6	5.8	464	128	0	11.8	1.4	0.5	154	-9.2	0.8	0.0
10/17/02	5	7.1	497	101	0	11.9	1.5	0.0	220	-6.1	0.7	0.0
Average	**7.4**	**6.7**	**460**	**91**	**0**	**12.4**	**1.3**	**0.1**	**159**	**-7.5**	**1.0**	**0.0**

As shown in Table 48, the discharge is net alkaline with moderate levels of iron. A small wetland would provide retention time and remove the iron from the discharge. Based on the average and high flow rates, a wetland that covers approximately 1,400 square feet should be sufficient to treat the discharge.

Constructing the system would cost approximately $3,000, with an additional $3,000 for mapping, design and permitting. However, the topography of the land around the discharge and the inaccessible location of the discharge make construction of a treatment system highly unlikely. Accessing the site would cost at least $20,000, for a total system cost of $26,000. Accessing the site would somewhat less expensive if access is funded and constructed to reach LC20D, which is 3,000 feet from LC10D. At this time, no treatment is recommended at this discharge due to the low loading and prohibitive access cost.

K. Other Sources of Mine Drainage to Little Coon Run

Two unnamed tributaries to Little Coon Run (LC25 and LC36) were monitored just south of Mealy Road. Tables 49 and 50 show the flow, chemistry and loading of the tributaries. The flows were measured using H-flumes installed at the sites after the February round of sampling.

Table 49: Flow, Chemistry and Loading of LC25

										Loading (Pounds Per Day)		
Date	**Flow (gpm)**	**pH (SU)**	**Cond (uS)**	**Field Alk (mg/L as $CaCO_3$)**	**Acid (mg/L as $CaCO_3$)**	**Iron (mg/L)**	**Mn (mg/L)**	**Al (mg/L)**	**Sulfate (mg/L)**	**Net Acid**	**Iron**	**Al**
11/29/01		5.0	580	0	69	1.2	4.8	11.8	258			
12/13/01		5.0	592	0	63	0.2	3.4	8.2	238			
1/16/02		4.1	734	0	89	0.2	4.3	12.4	397			
2/20/02		4.4	652	0	85	0.1	4.0	10.6	403			
3/20/02	20	5.0	635	0	83	0.5	4.5	12.3	335	20.0	0.1	3.0
4/9/02	15	4.1	712	0	91	0.2	4.7	12.8	439	16.5	0.0	2.3
5/16/02	40	3.7	670	0	108	0.4	4.9	13.1	366	51.9	0.2	6.3
6/13/02	5	3.8	852	0	125	12.1	10.4	1.7	433	7.5	0.7	0.1
7/17/02	5	3.7	1,020	0	146	2.1	9.0	18.2	534	8.7	0.1	1.1
8/14/02	1	2.9	1,063	0	169	3.1	9.1	14.8	623	2.0	0.0	0.2
9/11/02	0									0.0	0.0	0.0
10/17/02	0.75	4.1	721	0	72	1.3	6.3	10.3	433	0.6	0.0	0.1
Average	**10.8**	**4.2**	**748**	**0**	**100**	**1.9**	**5.9**	**11.5**	**405**	**13.4**	**0.2**	**1.6**

Table 50: Flow, Chemistry and Loading of LC36

										Loading (Pounds Per Day)		
Date	**Flow (gpm)**	**pH (SU)**	**Cond (uS)**	**Field Alk (mg/L as $CaCO_3$)**	**Acid (mg/L as $CaCO_3$)**	**Iron (mg/L)**	**Mn (mg/L)**	**Al (mg/L)**	**Sulfate (mg/L)**	**Net Acid**	**Iron**	**Al**
11/27/01			379	0	35	0.3	4.3	5.3	200			
12/13/01			370	0	38	0.3	2.9	5.5	185			
1/16/02		3.9	485	0	49	0.3	4.1	6.1	265			
2/20/02		4.2	438	0	47	0.3	3.8	6.0	170			
3/20/02	245	5.0	486	0	58	0.4	4.1	6.4	261	169.4	1.1	18.8
4/9/02	130	3.9	522	0	61	0.3	4.2	5.9	247	94.8	0.5	9.2
5/16/02	300	3.7	478	0	54	0.5	3.7	6.4	184	195.0	1.7	22.9
6/13/02	100	3.3	1089	0	141	2.9	10.6	17.5	592	169.1	3.4	21.0
7/17/02	4	3.7	815	0	89	2.6	6.8	6.5	397	4.3	0.1	0.3
8/14/02	10	2.8	805	0	103	1.7	7.4	7.5	459	12.4	0.2	0.9
9/11/02	2	3.1	298	0	19	1.6	1.6	0.6	105	0.5	0.0	0.0
10/17/02	47	3.8	1164	0	141	1.5	11.6	19.4	954	79.2	0.8	10.9
Average	**105**	**3.7**	**611**	**0**	**70**	**1.1**	**5.4**	**7.7**	**335**	**90.6**	**1.0**	**10.5**

As shown in Tables 49 and 50, the flow rates of the tributaries vary widely based on seasonal rainfall. The quality of the discharges also varies widely, with the highest concentrations of contaminants generally occurring during lower flow rates. This indicates that some dilution from uncontaminated surface water or rainfall is occurring. Figure 8 demonstrates this for LC36 for conductivity, acidity and sulfate. Although the levels of acidity and aluminum are low to moderate, the high flow rate of LC36 makes it a major contributor of these pollutants. LC25 is also a significant contributor during high flow events.

Hedin Environmental and Farmington Township personnel walked the headwaters areas of these tributaries several times in an attempt to locate discrete sources of contaminated discharge. However, only one discrete source (LC60D) was found. LC60D eventually flows to LC36 but contains only two thirds of the pollutants that LC36 contains. The rest of the contamination at LC36 and all contamination at LC25 appear to be caused by diffuse seepage and shallow groundwater contaminated by Spoil Areas D, E and F (See Figure 7). These spoil areas lie on hilltops that form the watershed divide between Little Coon Run and Licking Creek.

Reclamation of these areas may reduce pollution to LC25 and LC36 by reducing the amount of infiltration to the spoil areas, eliminating ponded areas within the spoil, and adding alkalinity. However, the uncertain benefits and high costs of reclaiming these three spoil areas, which total 104 acres, make full reclamation of these areas unlikely. At this time, it is recommended that Spoil Area F and portions of Spoil Area B be targeted for reclamation. See Section VII for details. After the results of these projects have been evaluated, it may then be advisable to continue with more reclamation in Areas B, D and/or E.

X. Restoration Plan

The restoration plan consists of a specific sequence of projects that will achieve the stated watershed goals as efficiently as possible. These projects were selected based on their potential impact on reaching the watershed goals, technical feasibility and cost-effectiveness.

A. Priority Projects

Table 51 summarizes the average flow, chemistry and loading of the significant discharges described in detail in the previous sections.

Table 51: Average Flow, Chemistry and Loading of All Significant Discharges

										Loading (Pounds Per Day)		
Name	Flow (gpm)	pH (SU)	Cond (uS)	Field Alk (mg/L as $CaCO_3$)	Acid (mg/L as $CaCO_3$)	Iron (mg/L)	Mn (mg/L)	Al (mg/L)	Sulfate (mg/L)	Net Acid	Iron	Al
LR45D	16.6	8.1	11,784	1,786	0	1.7	0.3	0.1	3,492	-367	0.4	0.0
LR40D	0.5	3.2	2,672	0	476	19.1	31.2	44.5	1,776	2.5	0.1	0.3
LR29D	**6.8**	**3.3**	**1705**	**0**	**690**	**14.1**	**12.4**	**95.0**	**1277**	**48.5**	**0.9**	**6.6**
LR26D	2.0	4.8	343	0	50	0.4	1.9	6.0	199	3.9	0.0	0.5
LR25D	6.5	5.1	368	2	46	0.2	2.0	4.2	214	8.0	0.0	0.9
LR17D	4.1	5.1	1,268	9	143	71.0	12.2	0.4	746	4.1	2.1	0.0
WR21D	2.6	6.3	150	50	0	4.8	0.3	0.2	16	-1.4	0.1	0.0
WR20D	29.0	6.9	273	33	0	4.6	0.1	0.2	25	-12.2	0.8	0.1
WR11D	3.5	5.4	818	11	99	72.8	4.9	0.2	464	3.1	2.4	0.0
WR05D	4.8	6.7	648	108	0	21.3	1.9	0.1	274	-6.1	1.1	0.0
LC61D	10.8	5.8	704	27	7	7.0	9.8	10.6	367	-2.3	0.7	1.2
LC60D	**23.3**	**3.4**	**1,927**	**0**	**211**	**5.7**	**20.1**	**22.7**	**1,166**	**61.0**	**1.4**	**6.2**
LC57D	0.9	3.3	1,956	0	396	1.4	26.7	55.8	1,285	5.0	0.0	0.7
LC55D	3.6	3.2	1,156	0	126	13.6	9.3	4.4	513	4.3	0.5	0.2
LC47D	0.6	3.4	1,653	0	647	4.6	13.8	98.1	1,124	5.2	0.0	0.8
LC46D	1.6	3.7	1,459	0	358	2.4	13.5	51.4	960	7.8	0.0	1.0
LC45D	**5.5**	**3.3**	**2,143**	**0**	**481**	**2.7**	**24.6**	**70.0**	**1,415**	**35.6**	**0.2**	**5.0**
LC40D	**12.6**	**5.8**	**1,601**	**34.2**	**327.2**	**195.3**	**13.3**	**1.0**	**1,086**	**46.4**	**29.8**	**0.1**
LC37D	**6.5**	**3.6**	**2,240**	**0**	**316**	**2.1**	**26.3**	**40.1**	**1,582**	**24.8**	**0.1**	**3.0**
LC35D	**20.5**	**5.6**	**1,475**	**34**	**262**	**161.4**	**9.9**	**0.1**	**908**	**59.3**	**38.2**	**0.0**
LC20D	**60.7**	**6.2**	**1,137**	**43**	**197**	**121.5**	**14.8**	**0.2**	**710**	**118.7**	**86.9**	**0.1**
LC10D	7.4	6.7	460	91	0	12.4	1.3	0.1	159	-7.5	1.0	0.0
LC25	10.8	4.2	748	0	100	1.9	5.9	11.5	405	13.4	0.2	0.6
LC36	104.8	3.7	611	0	70	1.1	5.4	7.7	335	**90.6**	1.0	**10.5**

***Bold** indicates priority discharges*

Table 52 summarizes the recommendations of this Restoration Plan. Cost estimates and expected reductions in loading are listed for each recommended project.

Table 52: Summary of Recommended Alternatives

Name	Priority	Recommended Action	Initial Cost (X $1,000)*	Reduced Loading (Pounds Per Day) Net Acid	Iron	Al
LR45D		None – assess feasibility of transferring to Little Coon	$ 0	-	-	-
LR40D		Source Reduction through Reclamation (Ongoing by County Environmental**)	$ 0	2	< 1	< 1
LR29D LR26D LR25D	See LC46D and LC47D below for recommended alternative, cost, and expected reduction in loadings.					
LR17D	Low	ALD , pond/wetland (possibly with LR15D and LR16D	$ 40	4	< 1	< 1
WR21D WR20D	Low	Aerobic Wetland	$ 28	< 1	1	< 1
WR11D	Medium	Upflow limestone pit next to stream	$ 82	3	< 1	< 1
WR05D	Low	Small aerobic wetland	$ 15	< 1	1	< 1
LC61D		County Environmental Sed. Pond 2 – maintain current treatment	$ 0	-	-	-
LC60D	High	Reclaim 15 acres of Spoil Area B, monitor results*	$ 127	43	1	4
LC57D LC55D	Medium	Combined wetland system with alkaline amended substrate followed by limestone polishing bed	$ 140	9	< 1	1
LC47D LC46D	High	Reclaim Spoil Area C (17 Acres)**	$ 139	55	1	8
LC45D	High	Reclaim 10 acres of Spoil Area A, monitor results*	$ 98	25	< 1	4
LC40D	High	Plug (grant application pending)	$ 25	46	30	< 1
LC37D	High	Reclaim 23 Acres of Area F**	$ 178	22	< 1	3
LC35D	High	Plug (grant application pending)	$ 25	59	38	< 1
LC20D	High	ALD + pond + wetland (plus 41 ppd excess alk)	$ 171	119	87	<1
LC10D	Low	Construct small wetland	$ 26	< 1	1	< 1
LC25 LC36		Target LC60D and Area F for reclamation and monitor results	$ 0	-	-	-

**Does not include costs paid by County Environmental*
***Reclamation of part of the Spoil Area assumed to remove 70% of the loading of the targeted discharge(s).*
****Reclamation of the entire Spoil Area assumed to remove 90% of the loading of the targeted discharge(s).*

The restoration plan for the study area was formulated by selecting the order of priority of the projects listed in Table 52. At this time, the following sequence of projects is recommended. The sequence has been selected based on the loading of the discharge, anticipated results of the project, cost-effectiveness, technical feasibility, landowner cooperation, and the goals outlined in this restoration plan.

1. Plug LC40D and LC35D (Growing Greener grant application pending)
2. Construct ALD pond and wetland for LC20D
3. Reclaim Area F (23 acres)
4. Reclaim 15 Acres of Spoil Area B near LC60D
5. Reclaim Area C (17 acres)
6. Reclaim 10 Acres of Spoil Area A near LC45D

These six high priority projects should be completed first. The total cost of these high-priority projects is estimated at $763,000. They are listed roughly in order from the mouth of Little Coon to the headwaters. The plugging project was applied for first because the proposal could be put together quickly and because the landowners involved were highly cooperative. Upon the completion of these high priority projects, the resulting stream improvements should be assessed. If more improvement is desired, the other low- and medium-priority projects should be completed.

B. Anticipated Stream Improvements

If the top six projects listed above are successfully completed, stream improvements will be realized primarily in Coon Creek and Little Coon Run because they are the most heavily affected by mine drainage. Some improvements will also be seen in Lard Run and Walley Run.

These projects should remove an average of 312 pound per day of acidity, 156 pounds per day of iron and 12 pounds per day of aluminum from Little Coon Run. Lard Run will also experience reduced loading due to reclamation of Spoil Area C.

These projects will ensure that Coon Creek maintains a net alkaline condition at all times. Little Coon Run should also be net alkaline with low metals concentrations from LC30 downstream during all periods of the year. Some pollution will still be entering the stream from unreclaimed spoil areas. However, the chemical and biological condition of the stream will improve dramatically from LC30 to the mouth (3 stream miles). More modest improvements, including decreased acidity and metals concentrations, will be seen upstream of LC30. Chemical improvements should be realized fairly quickly after projects are implemented.

These chemical improvements resulting from the high-priority projects should allow the biological community in Coon Creek (CC10) to improve to conditions near those of unaffected areas of Coon Creek (CC16). Increased numbers of fish and macroinvertebrates as well as increased diversity should result. The biological community of each station on Little Coon Run should also greatly improve.

Biological improvement may take several years to be realized after the projects are completed. This "lag time" is due to the slow upstream migration rate, particularly of macroinvertebrates. In addition, decades worth of acidic metal precipitates on the stream bottom will be dissolved and scoured away over time, resulting in a better habitat for fish and macroinvertebrates.

C. Assessing Plan Effectiveness

This report provides a baseline of both chemical and biological stream quality at many points on Coon Creek, Little Coon Run and Walley Run. Any data collected after restoration efforts are in place can be readily compared to the data in this report to assess the effectiveness at the plan. Future sampling efforts should take place at the stations established by this report.

The streams should be reassessed for their chemical and biological improvements after all of the high priority projects are completed or on an interim basis after two or three of the projects. At that time, decisions regarding additional watershed restoration can be made.

D. Potential Funding Sources

The largest source of potential funding for watershed projects is the DEP’s Growing Greener program. This program can provide funding for passive treatment and mitigation work in the watershed. Applications are typically due to the program in February, with announcements made in the late summer. The grants last for two to three years. Non-profit organizations, educational institutions and municipalities may apply for Growing Greener Grants. By applying for Growing Greener funds, projects are also considered for federal EPA 319 Watershed grants. As of the writing of this report, the Knox office of the DEP is beginning an TMDL (Total Maximum Daily Load) study of Walley Run, which will make 319 funding more accessible for projects that will affect this stream.

DEP’s Bureau of Abandoned Mine Reclamation (BAMR) can also provide funds for surface reclamation projects. BAMR can also design and construct passive treatment systems. BAMR typically administers their projects and does not require a non-profit group or agency as a project sponsor. BAMR’s involvement in a watershed can begin by contacting BAMR directly. BAMR also can become involved by choosing projects from among the Growing Greener applications. If reclamation projects are desired, contacting BAMR can get the projects on their list, but the work may not take place for several years.

The U.S. Army Corps of Engineers (the Corps) may also be interested in the study area because Coon Creek flows to the Tionesta Reservoir, which is managed by the Corps. The Corps generally works on a watershed-wide basis. In similar situations, the Corps adopts the entire watershed, performs their own watershed assessment, and provides designs for the watershed projects. The local sponsor is then required to produce matching funds to complete the construction projects. The Corps typically limits their involvement in each watershed to five million dollars. The rest of the money can be used to construct projects. The local sponsor is required to produce 35% in additional matching funds ($1,750,000 if the entire 5 million allotment is spent), which can be state funds such as Growing Greener or in-kind services. With Corps involvement, at least two years is spent in study and design before projects are implemented.

One important aspect of project funding is community involvement, volunteerism, and matching funds. Local volunteers and businesses may be willing to supply goods and services to assist with projects. Volunteer time and other “in-kind” services should be sought for each grant and included as matching on the grant application.

XI. References

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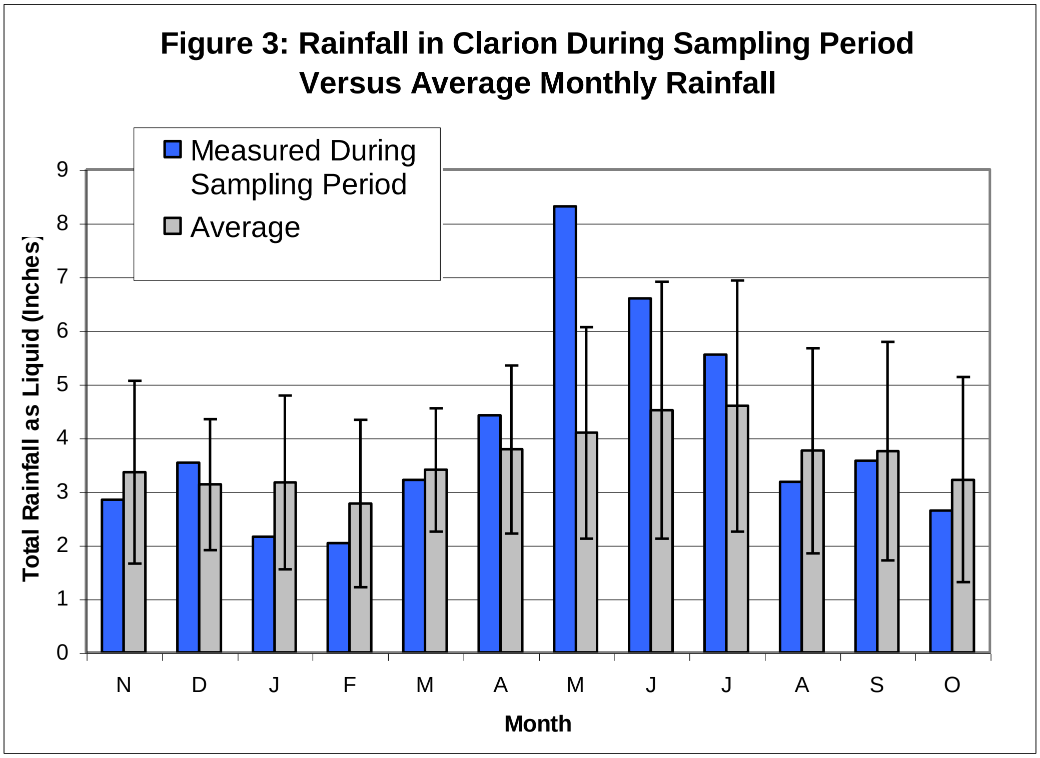


Figure 3: Rainfall in Clarion During Sampling Period
Versus Average Monthly Rainfall
Measured During Sampling Period
Average
Total Rainfall as Liquid (Inches)
0
1
2
3
4
5
6
7
8
9
N
D
J
F
M
A
M
J
J
A
S
O
Month

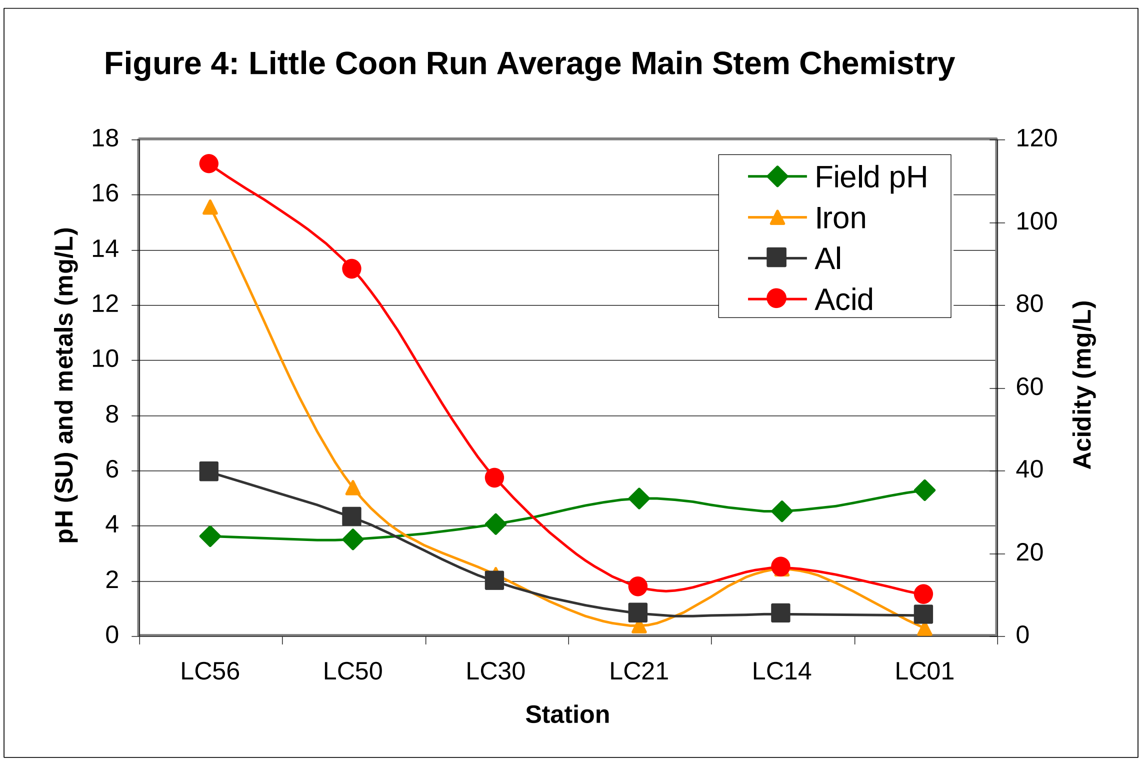


Figure 4: Little Coon Run Average Main Stem Chemistry
Field pH
Iron
Al
Acid
pH (SU) and metals (mg/L)
0
2
4
6
8
10
12
14
16
18
Acidity (mg/L)
0
20
40
60
80
100
120
LC56
LC50
LC30
LC21
LC14
LC01
Station

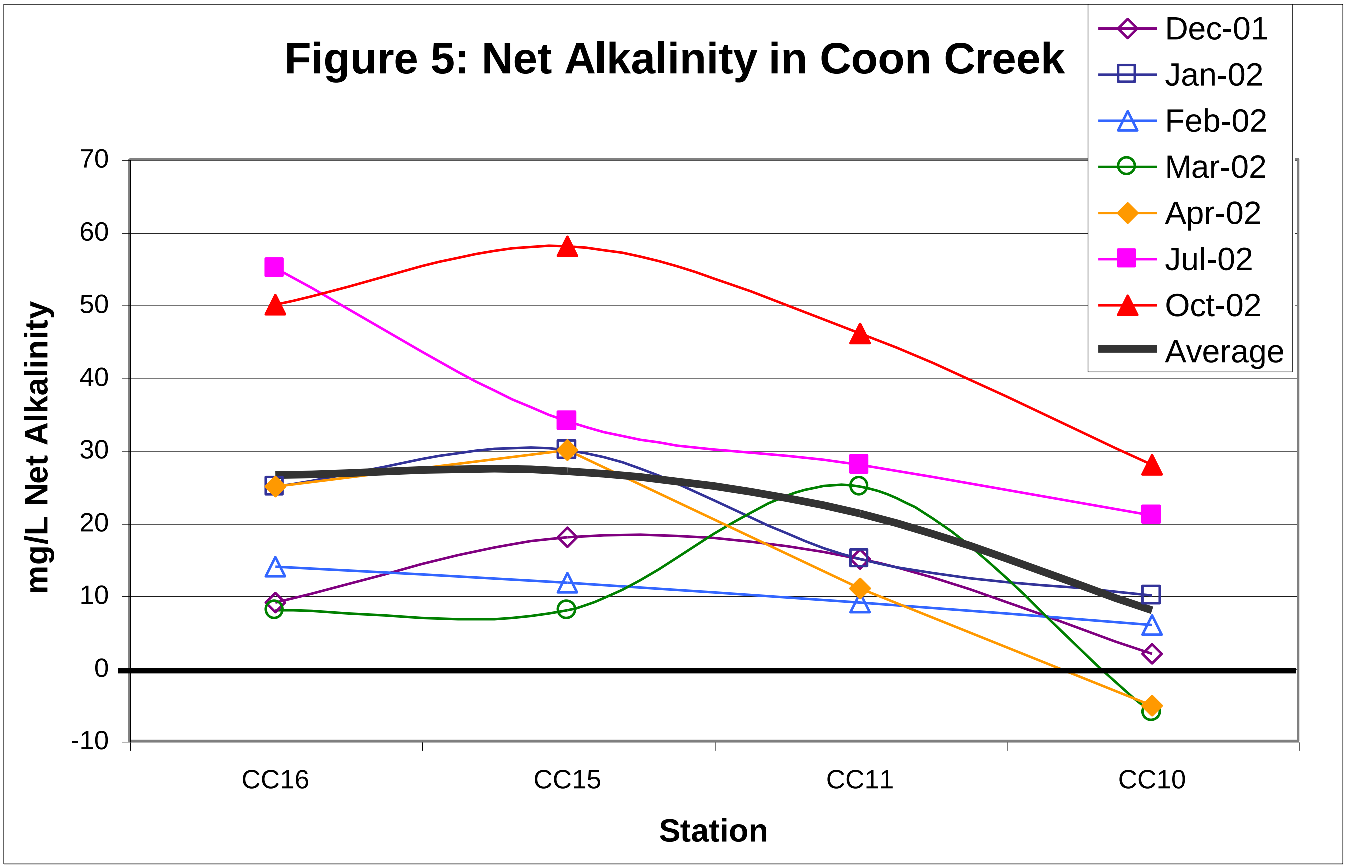
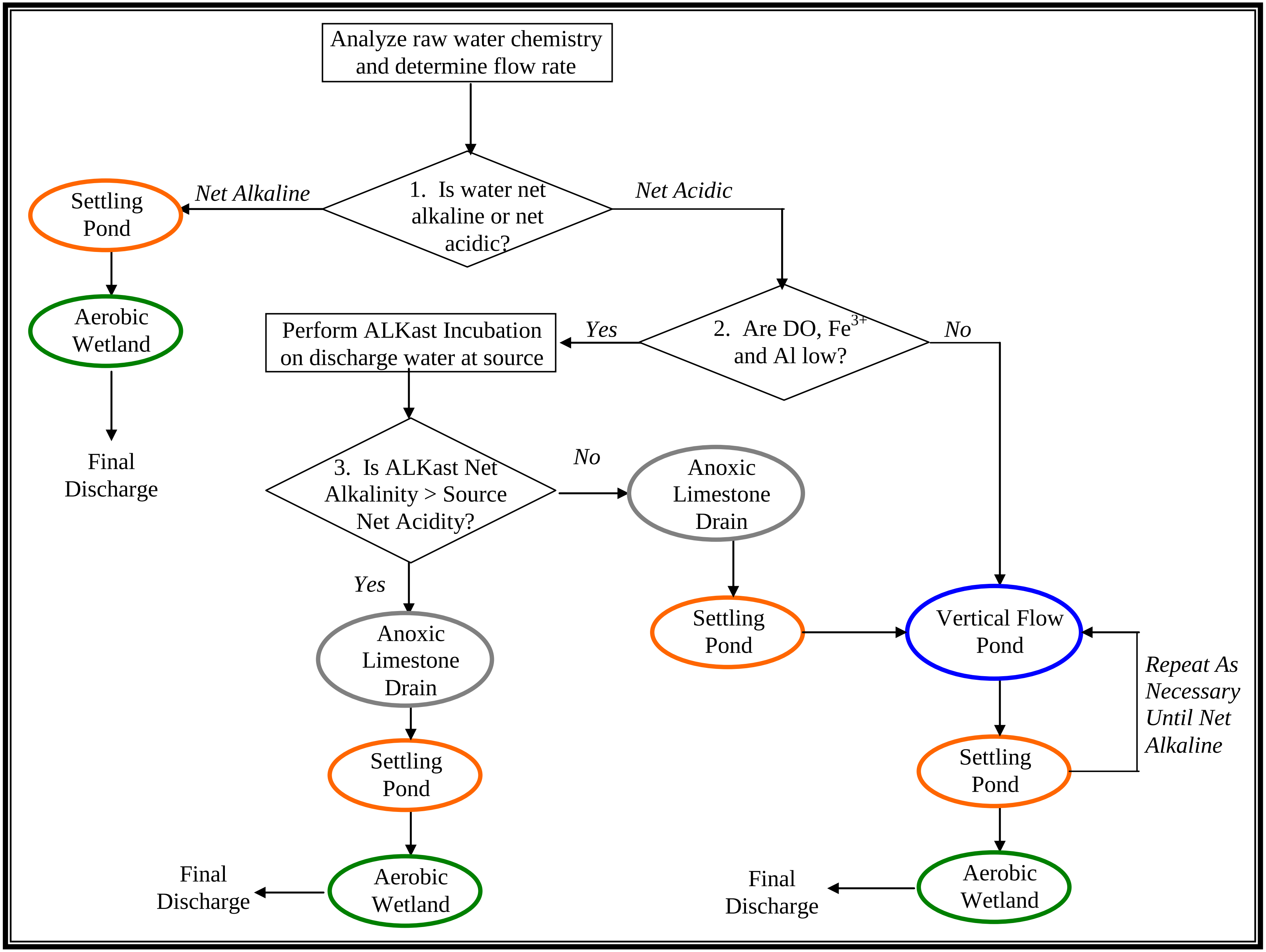
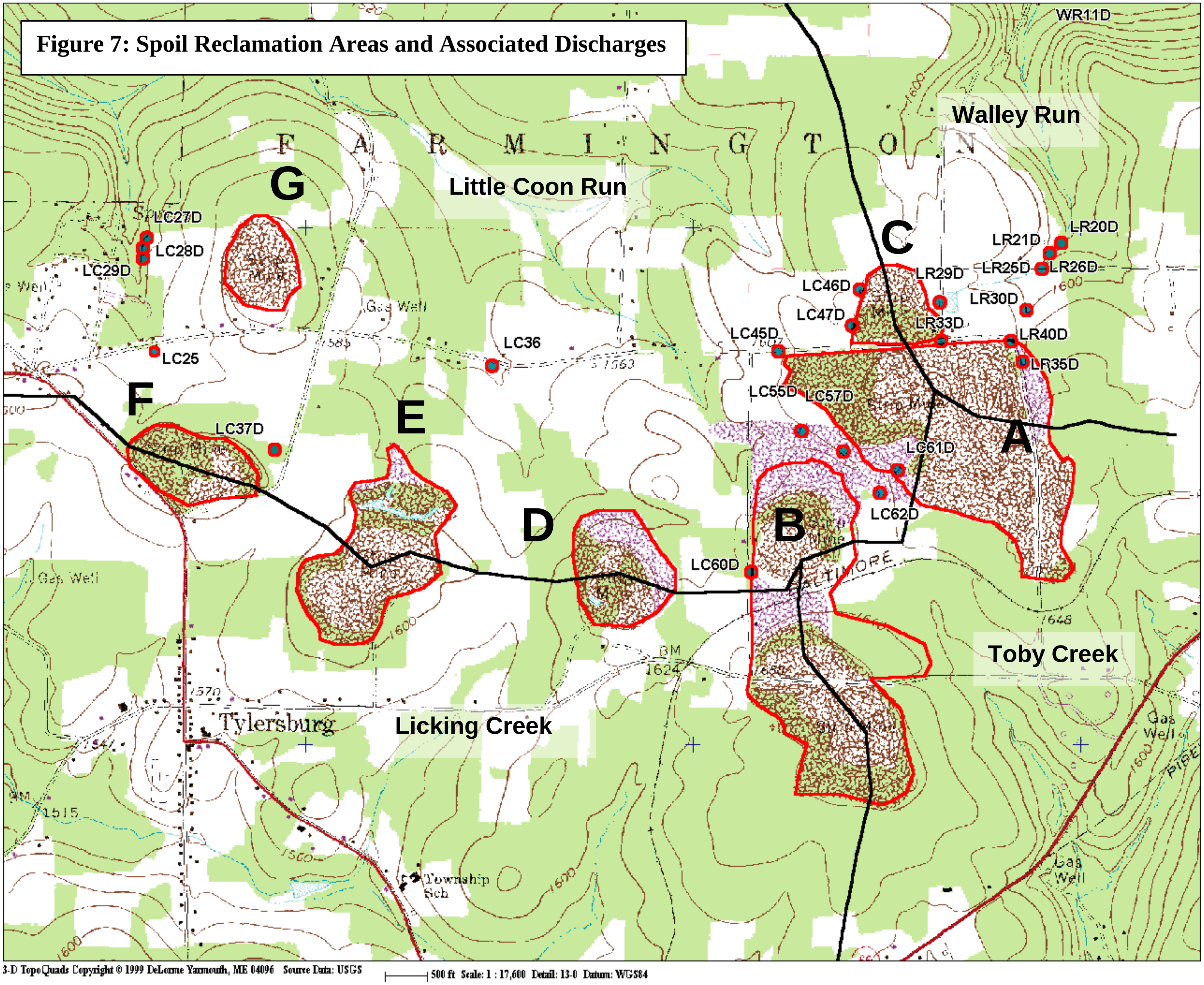


Figure 5: Net Alkalinity in Coon Creek
mg/L Net Alkalinity
70
60
50
40
30
20
10
0
-10
CC16
CC15
CC11
CC10
Station
Dec-01
Jan-02
Feb-02
Mar-02
Apr-02
Jul-02
Oct-02
Average

Figure 6: Passive Treatment Decision Flow Chart





Surface Watershed Boundaries

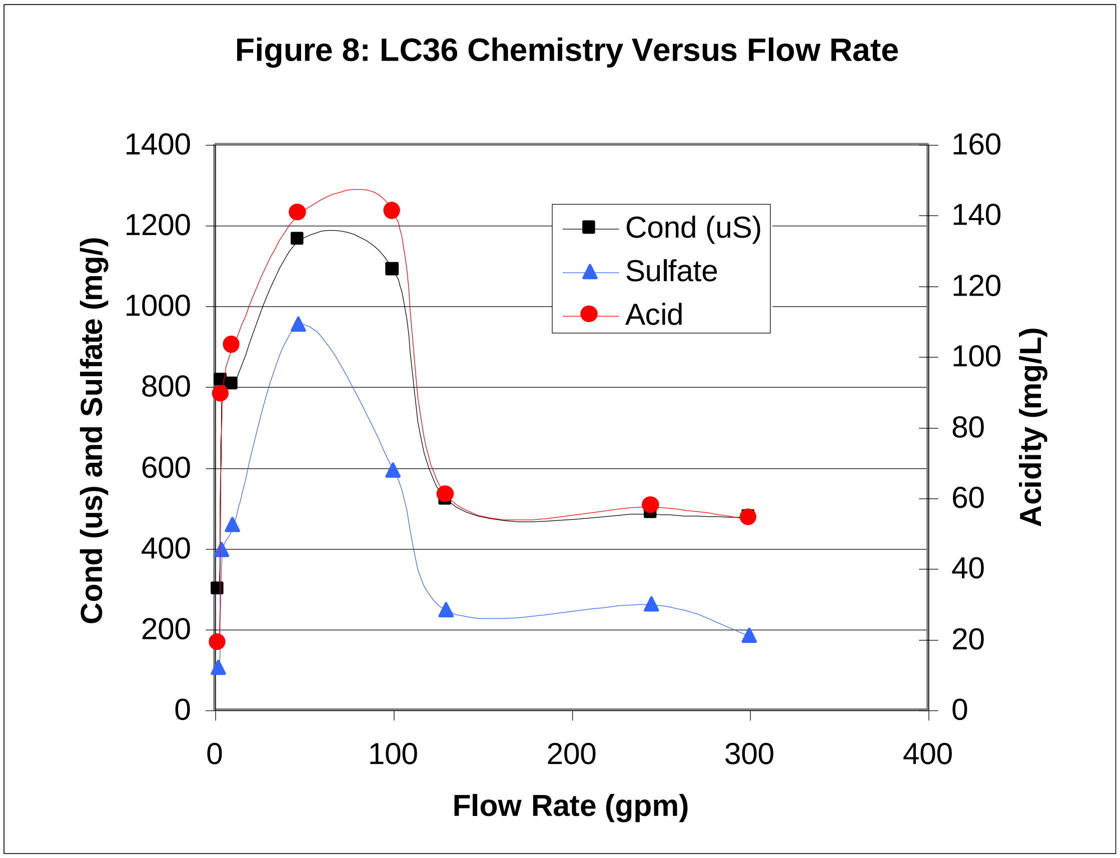


Figure 8: LC36 Chemistry Versus Flow Rate
Cond (us) and Sulfate (mg/l)
Acidity (mg/L)
Flow Rate (gpm)
Cond (uS)
Sulfate
Acid
0
200
400
600
800
1000
1200
1400
0
20
40
60
80
100
120
140
160
0
100
200
300
400

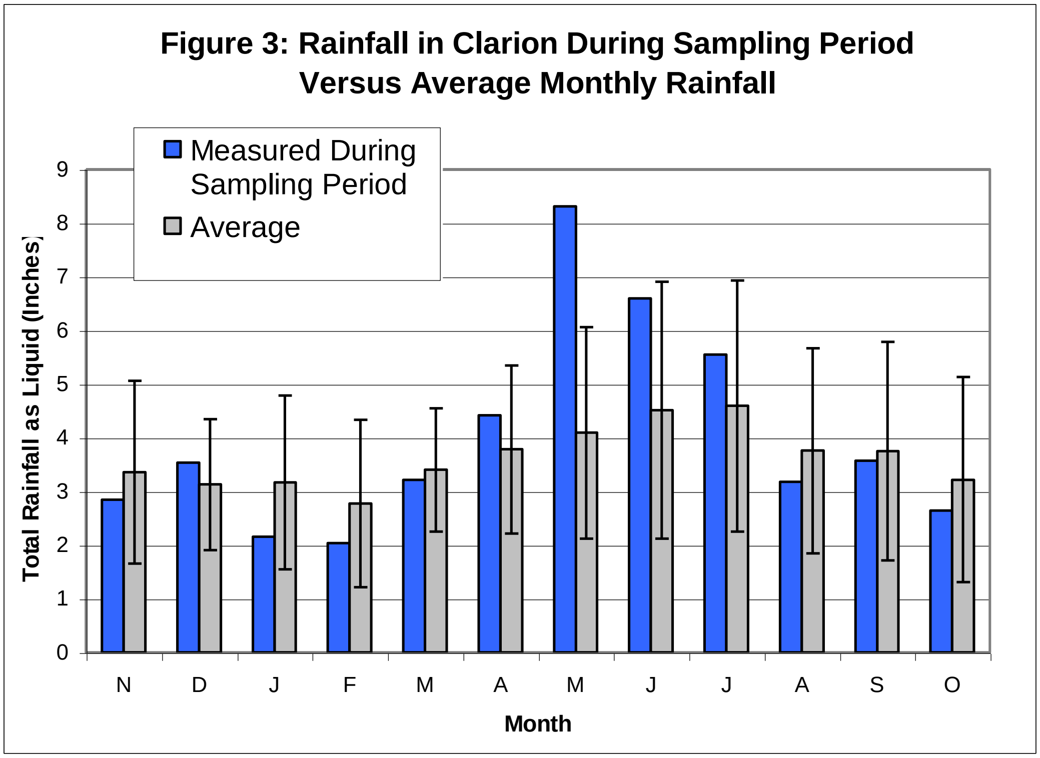


Figure 3: Rainfall in Clarion During Sampling Period Versus Average Monthly Rainfall
Measured During Sampling Period
Average
Total Rainfall as Liquid (Inches)
0
1
2
3
4
5
6
7
8
9
N
D
J
F
M
A
M
J
J
A
S
O
Month

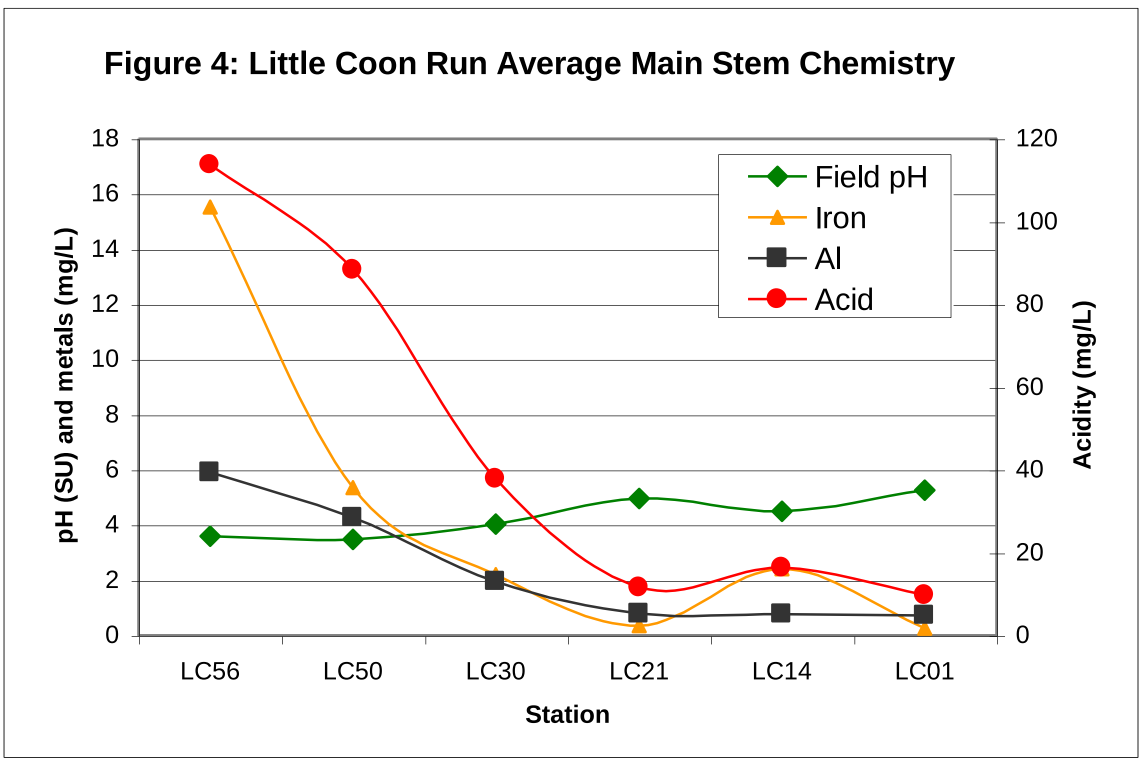


Figure 4: Little Coon Run Average Main Stem Chemistry
Field pH
Iron
Al
Acid
pH (SU) and metals (mg/L)
0
2
4
6
8
10
12
14
16
18
Acidity (mg/L)
0
20
40
60
80
100
120
LC56
LC50
LC30
LC21
LC14
LC01
Station

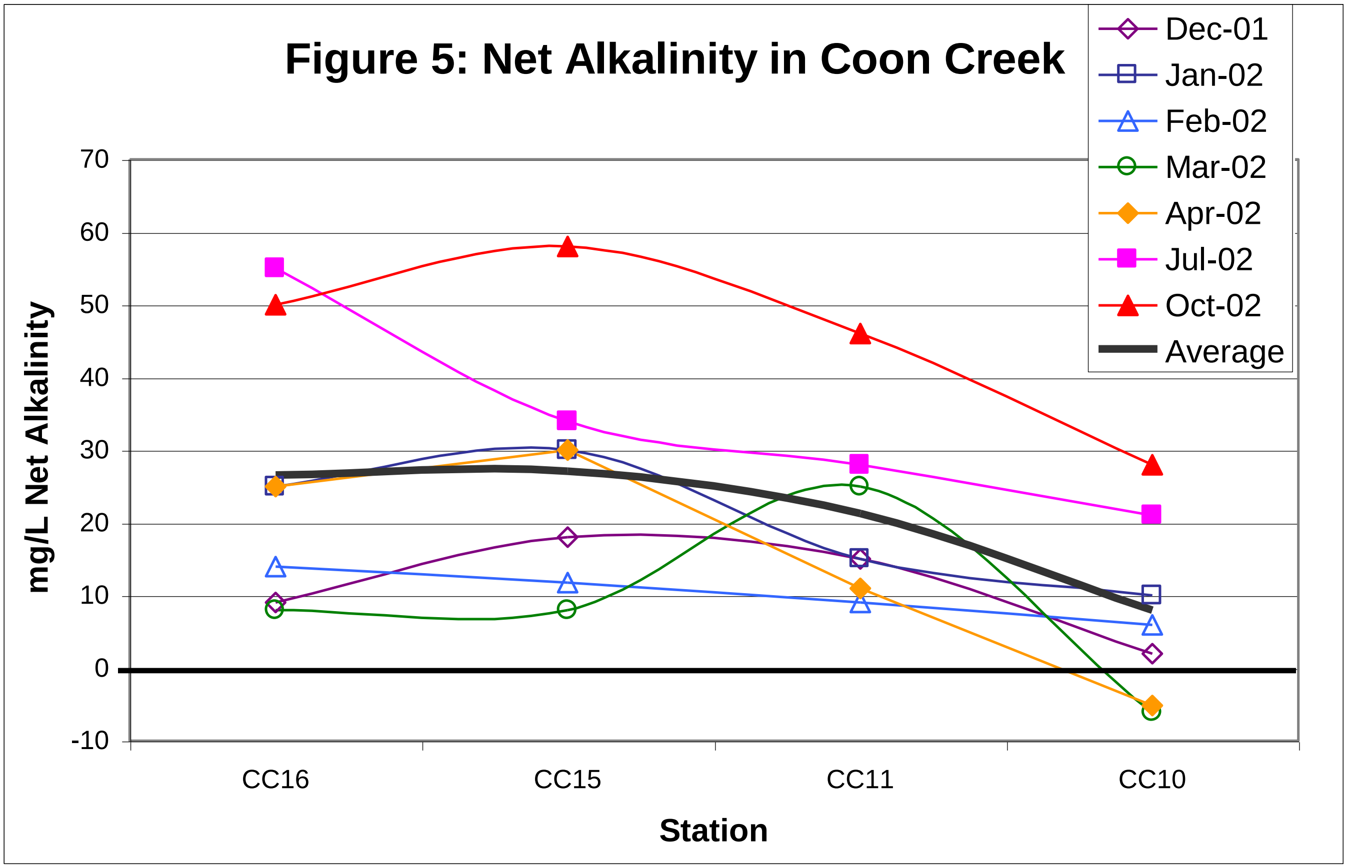
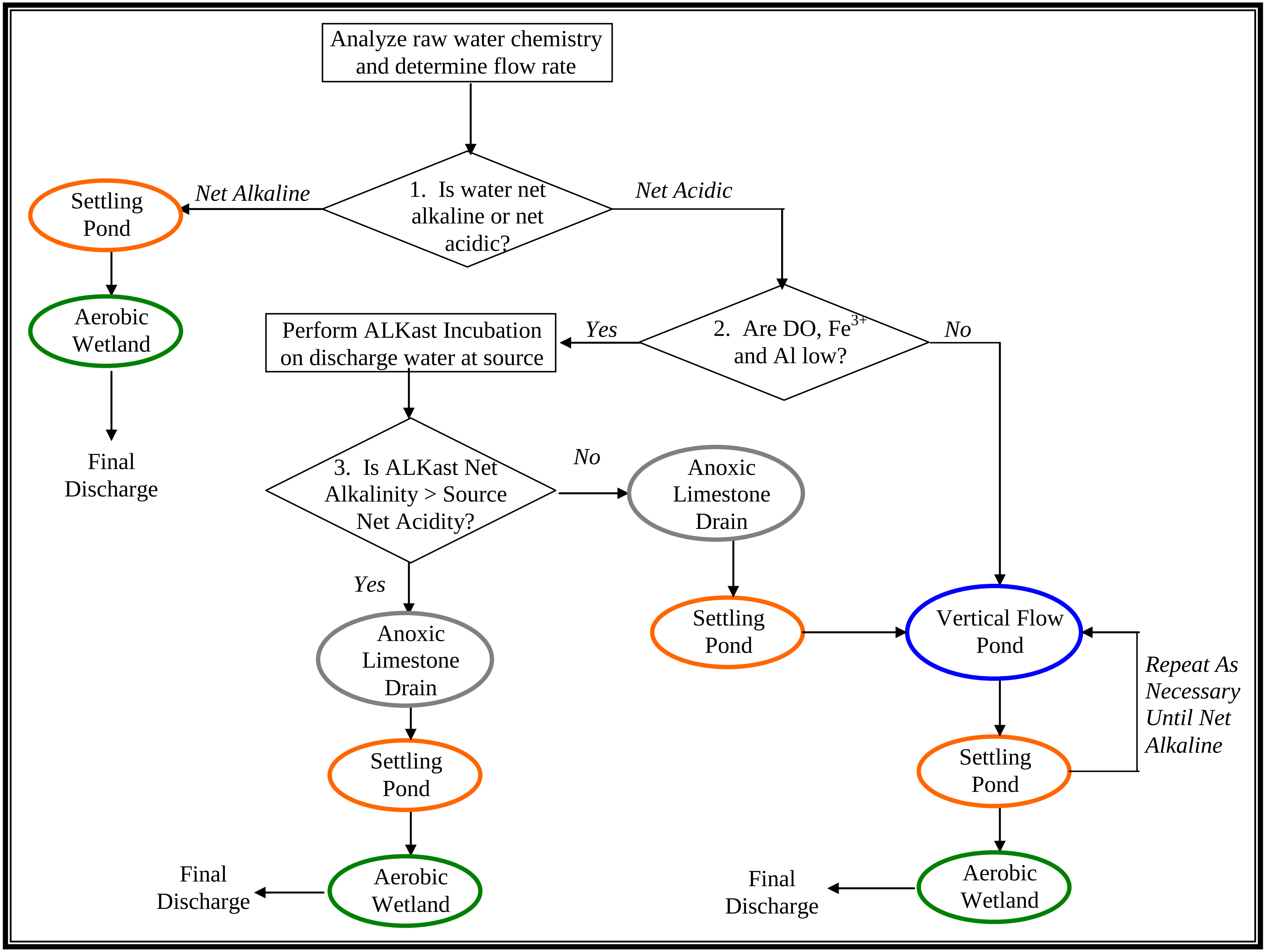


Figure 5: Net Alkalinity in Coon Creek
Dec-01
Jan-02
Feb-02
Mar-02
Apr-02
Jul-02
Oct-02
Average
70
60
50
40
30
20
10
0
-10
mg/L Net Alkalinity
CC16
CC15
CC11
CC10
Station

Figure 6: Passive Treatment Decision Flow Chart



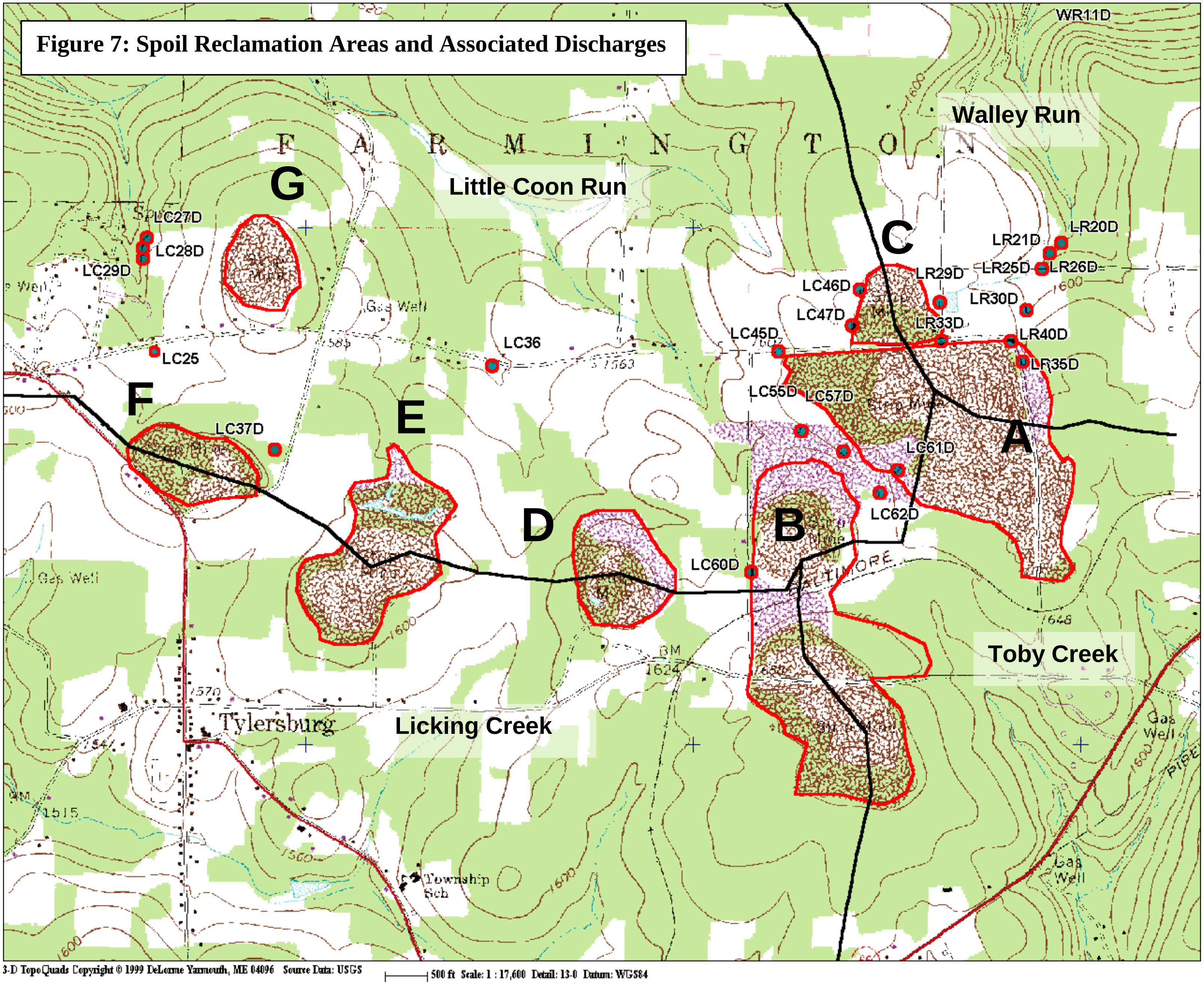
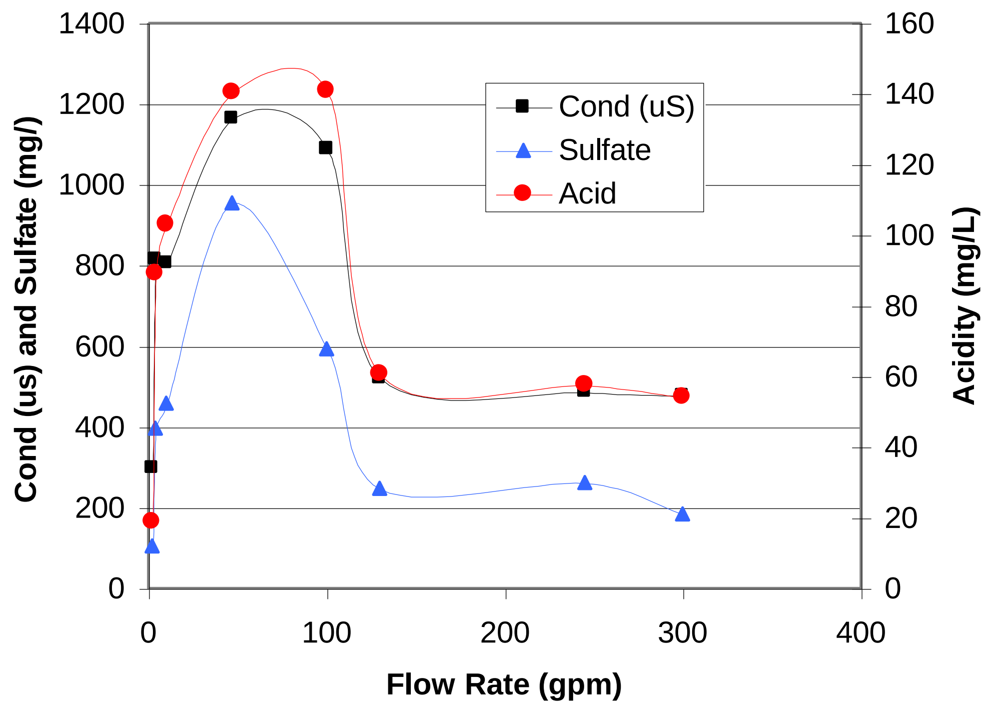


Figure 7: Spoil Reclamation Areas and Associated Discharges

Surface Watershed Boundaries

Figure 8: LC36 Chemistry Versus Flow Rate



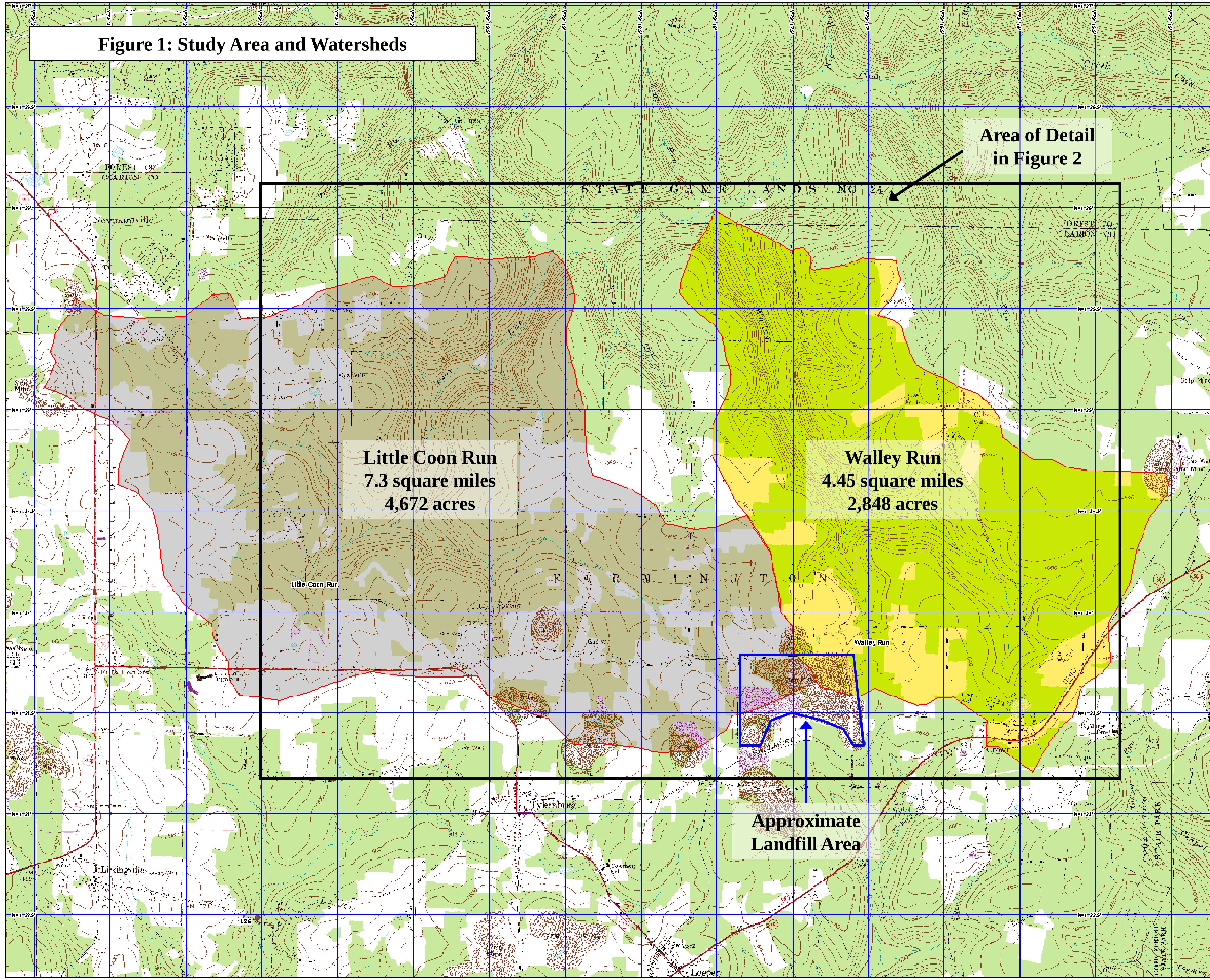
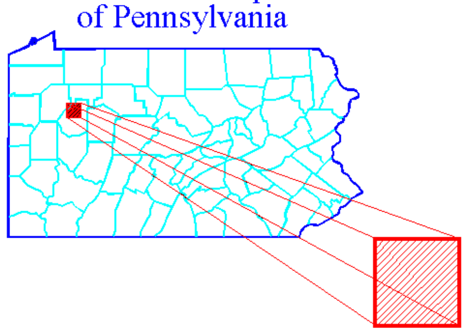


Figure 1: Study Area and Watersheds



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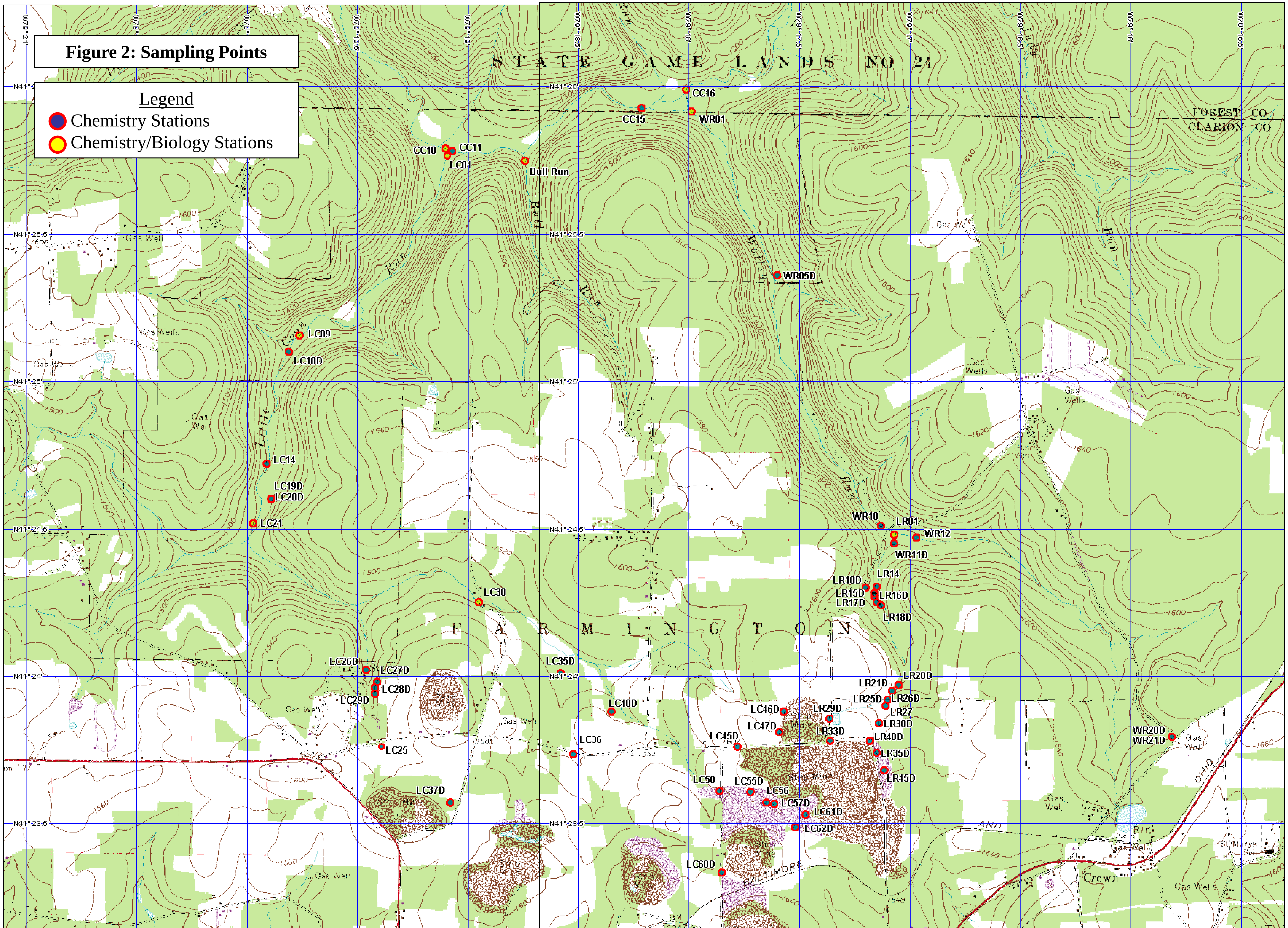

Figure 2: Sampling Points

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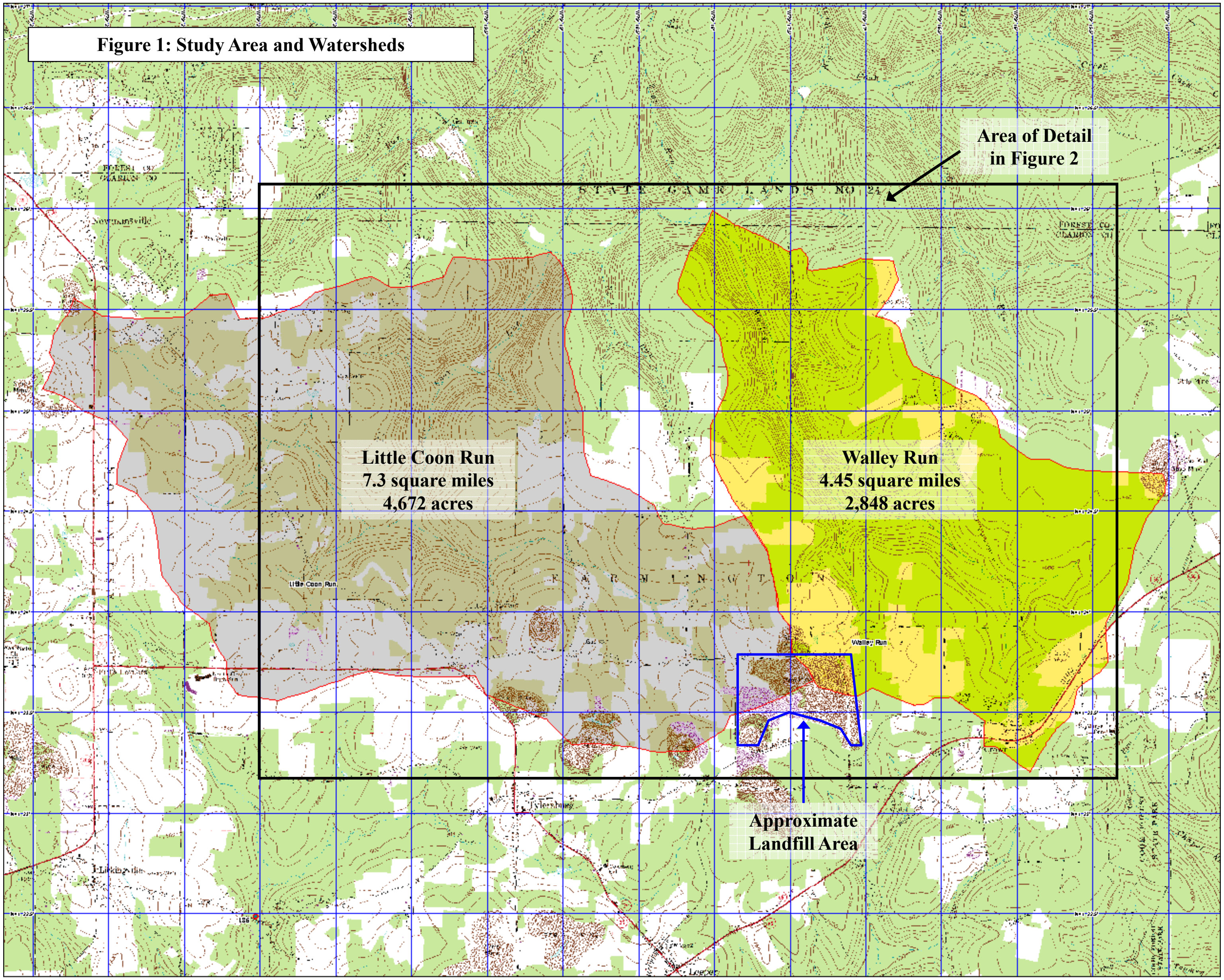

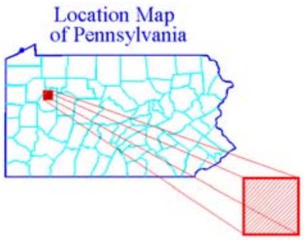

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