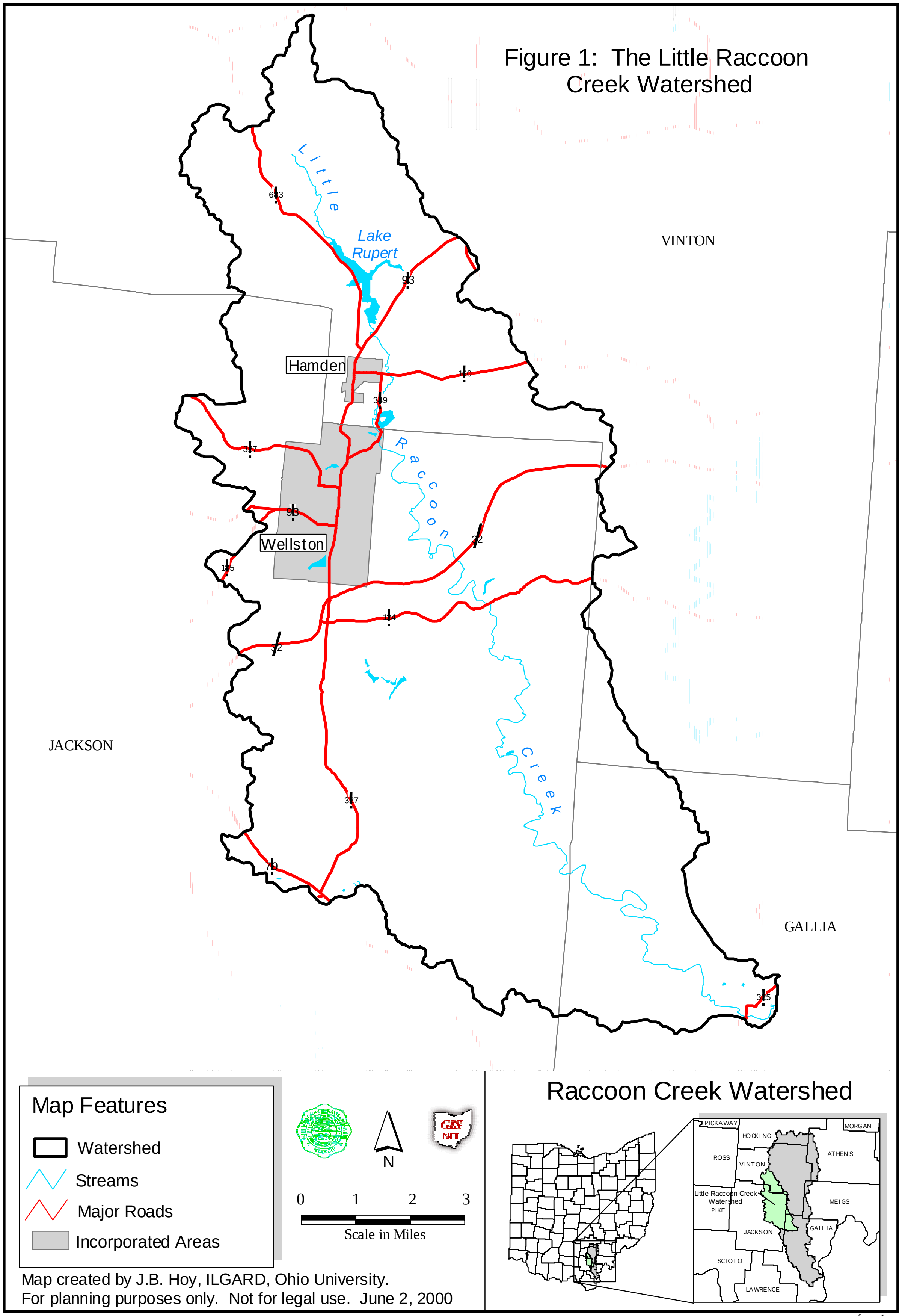


Figure 1: The Little Raccoon Creek Watershed
VINTON
JACKSON
GALLIA
Little
Lake Rupert
Hamden
Wellston
Raccoon
Creek
Map Features
Watershed
Streams
Major Roads
Incorporated Areas
N
0 1 2 3
Scale in Miles
Raccoon Creek Watershed
Map created by J.B. Hoy, ILGARD, Ohio University.
For planning purposes only. Not for legal use. June 2, 2000
figure_1.apr

Biological studies conducted by the United States Geological Survey (USGS) in 1999 led study managers to state that, in their opinion, modest reductions in acid mine drainage could lead to significant improvements in aquatic populations (personal communication-John Tertuliani, USGS Biologist).

MINING HISTORY

Coal mining occurred in approximately 22% of the Little Raccoon Creek basin. Coal has been mined underground in the watershed since at least the 1840's. Surface mining became the dominant type of mining starting in the 1930's and accounts for more than 90% of the coal removed to date. There are numerous abandoned underground mines in the watershed that are discharging AMD as well as abandoned surface mines where the AMD comes from coalmine spoils and coal refuse piles. Surface mining continues in the watershed.

Mines are found throughout the Little Raccoon Creek watershed, but those that most affect the water quality are in Jackson County between Dickason Run (RM 12.57) and Mulga Run (RM 24.45). Most of the AMD being discharged into Little Raccoon Creek comes from these tributaries. Water quality problems occur when pyritic material and other rocks are exposed to oxygen and water. Through oxidation of the pyrite, sulfuric acid is formed. As this acid passes over different rock strata surrounding the pyrite, it dissolves metals including iron, aluminum, and manganese. Acid and metals reduce the number and diversity of aquatic organisms, increase the corrosiveness of the water, limit domestic use of the water, and impair the aesthetic qualities of the water.

Water-quality levels that suggest impact by AMD are shown below (FWPCA, 1968; USEPA, 1986).

Ph	< 6
Alkalinity	< 20 mg/l
Iron	>0.5 mg/l
Manganese	>0.5 mg/l
Sulfate	> 74 mg/l
Aluminum	>0.3 mg/l
Conductivity	> 800 mhos/cm
Zinc	> 5 mg/l

WATER QUALITY

Historical Water Quality

Several studies of water quality in Little Raccoon Creek were undertaken during the past 25 years. The Ohio Biological Survey designated Little Raccoon Creek as Classification IV (surface waters grossly polluted and requiring extensive renovation to achieve Class I standards) in 1976 (USDA, 1994). The U.S. Geological Survey (Wilson, 1985 and 1988) studied Raccoon Creek, sampling ten sites in Little Raccoon Creek in 1983 and five sites in 1984-1986, and in both studies concluded that sources in the Little Raccoon Creek basin are major contributors of AMD to Raccoon Creek. Those data are included in this report (Appendix 1, Table 1). Buffer Run, Goose Run, an unnamed tributary to Little Raccoon, Mulga Run and Sugar Run were the main sub-watersheds that produced AMD.

Mainstem Water Quality

Twenty-three sampling sites were chosen along Little Raccoon Creek between tributaries and at the mouths of tributaries (Figure 2; Appendix 1, Table 1). The tributaries sampled were Sugar Run, Meadow Run, Mulga Run, Middleton Run, Rich Run, Coal Run, Flint Run,

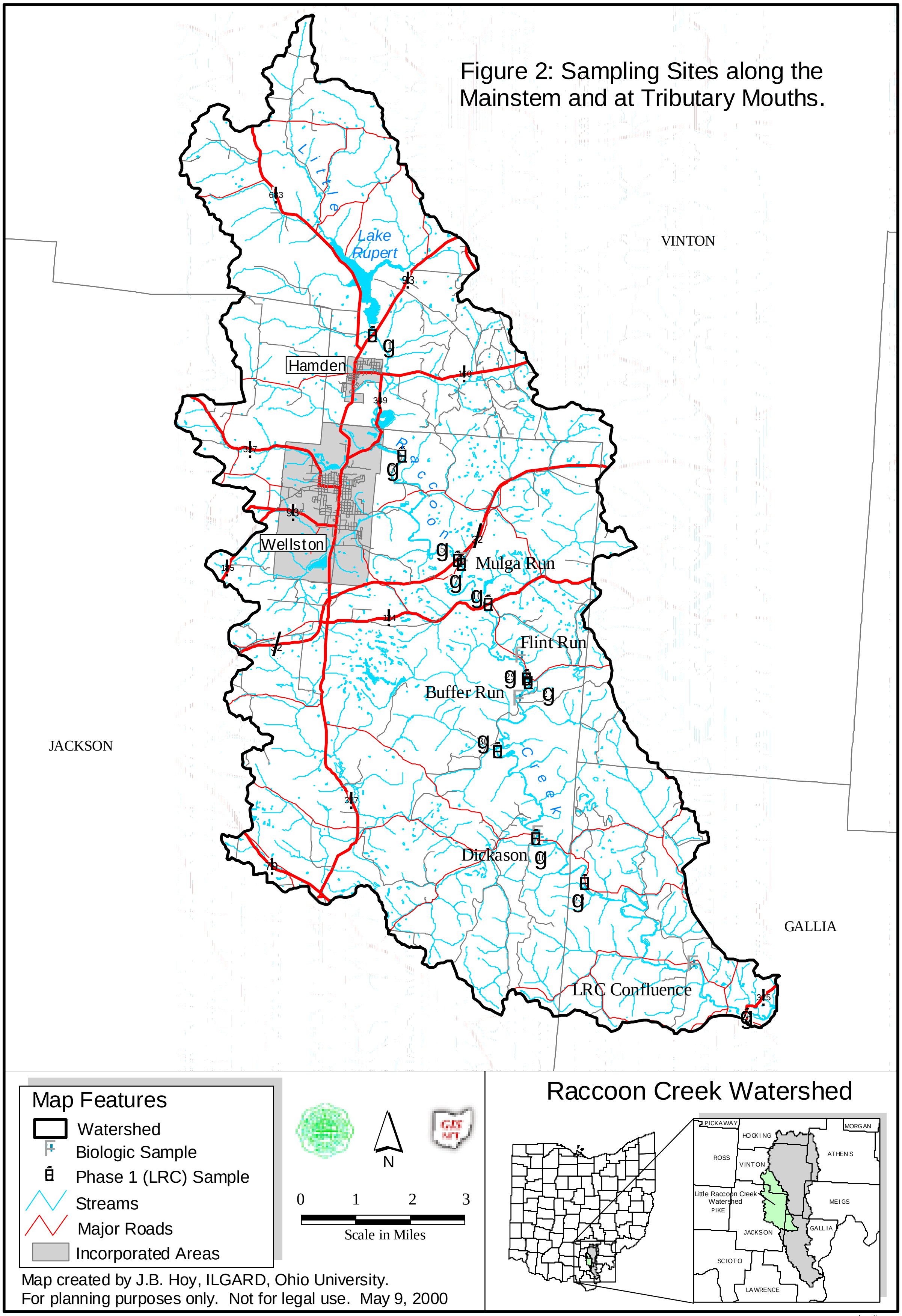


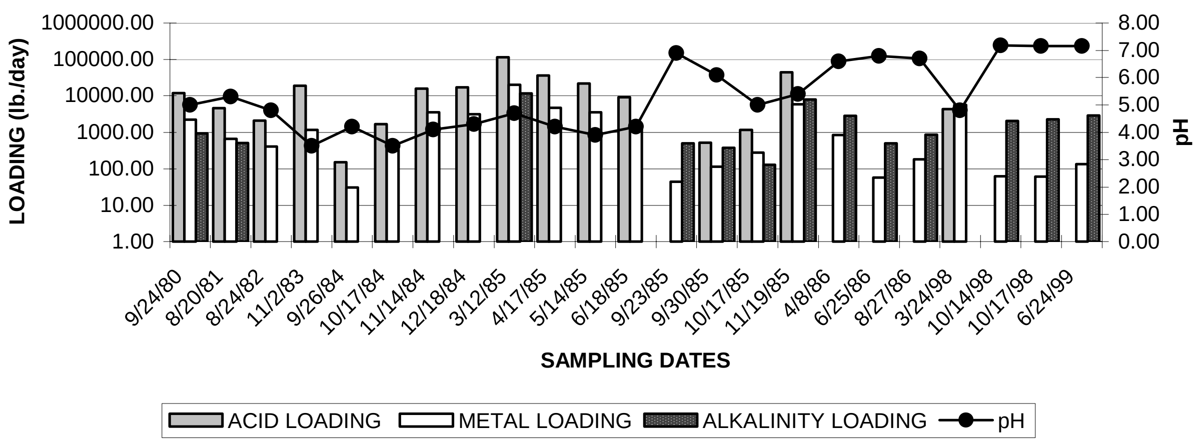
Figure 2: Sampling Sites along the Mainstem and at Tributary Mouths.
Lake Rupert
Little
Raccoon
Creek
Hamden
Wellston
Mulga Run
Flint Run
Buffer Run
Dickason
LRC Confluence
VINTON
JACKSON
GALLIA
Map Features
Watershed
Biologic Sample
Phase 1 (LRC) Sample
Streams
Major Roads
Incorporated Areas
N
0
1
2
3
Scale in Miles
Raccoon Creek Watershed
PICKAWAY
HOCKING
MORGAN
ROSS
VINTON
ATHENS
Little Raccoon Creek Watershed
PIKE
MEIGS
JACKSON
GALLIA
SCIOTO
LAWRENCE
Map created by J.B. Hoy, ILGARD, Ohio University.
For planning purposes only. Not for legal use. May 9, 2000
sample_sites.apr

Greasy Run, Tar Camp Run, Goose Run, Dickason Run, Dixon Run, and Kyger Run. Those tributaries that showed serious impact by AMD are Mulga Run (RM 24.45), Middleton Run (RM 22.40), Rich Run (RM 22.22), Flint Run (RM 20.74), Greasy Run (RM 18.2), Goose Run (RM 16.41), and Dixon Run (RM 1.5 on Dickason Run, which is at RM 12.57 on Little Raccoon Creek). Buffer Run (RM 19.18) showed serious impact by AMD in other studies.

At the mouth of Little Raccoon Creek where it enters Raccoon Creek, the acidity loading ranges from 4300 lbs/day during high flow (>400 cfs) to 0 lbs/day (69 mg/l total alkalinity) during low flow (<10 cfs). Because data are variable, higher acidity loads are possible (Figure 3).

The Ohio Environmental Protection Agency's 1990 Ohio Non-point Source Assessment classified Little Raccoon Creek as Priority Classification One: "stream segments with aquatic life use impairment caused by non-point sources." The non-point sources contributing to the

Figure 3: Acidity and Metal Loading from the Mouth of Little Raccoon Creek Over Time (Wilson 1985, 1988)



classifications include sedimentation, residential sewage, industrial waste, and above all abandoned coalmine lands (USDA, 1994). Just upstream from where Little Raccoon Creek enters Raccoon Creek there is significant acidity loading and no alkalinity during high flow periods. Lake Alma and Lake Rupert, in the headwaters of Little Raccoon Creek, were targeted by Ohio EPA as lakes impacted by non-point sources associated with Priority Classification One streams (USDA, 1994), but are not affected by AMD. Water quality analyses in the Little Raccoon Creek mainstem show increasing metal loads downstream, under high-flow conditions, with the metal loading to Raccoon Creek being 2200 lb/day iron, 2400 lb/day aluminum, and 1000 lb/day manganese (Figure 4). Low-flow loading is much smaller as shown in Figure 5. Note the change in scale in comparison to Figure 4.

While pH levels in much of Little Raccoon Creek are circum-neutral, occasionally dropping into the pH 5 range, available literature suggests that the alkalinity levels below 20 mg/l can be limiting to biota where other mine drainage constituents are present. Alkalinity levels in the Little Raccoon Creek mainstem are often below this threshold in the primary study area.

Figure 4: Acidity, Alkalinity and Metal Loading in the Little Raccoon Creek Mainstem Under High-Flow Conditions (3/24/98 - 3/25/98)

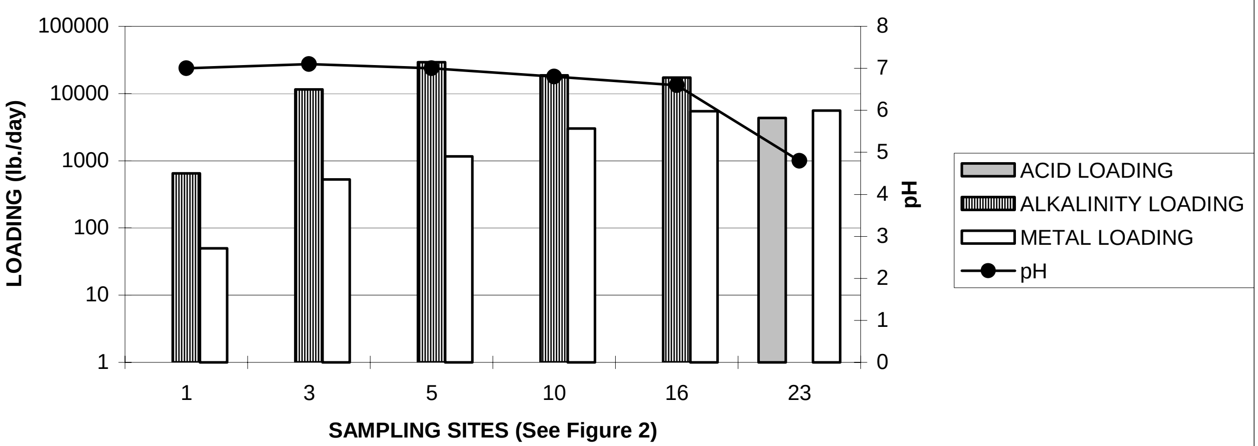
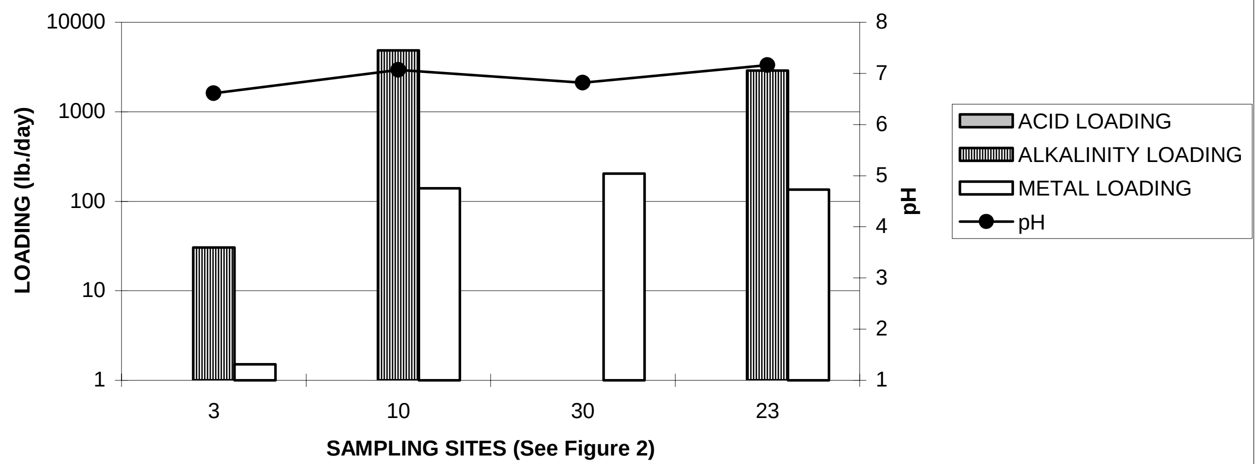


Figure 5: Acidity, Akalinity and Metal Loading in the Little Raccoon Creek Mainstem Under Low-Flow Conditions (6/22/99-6/24/99)



Tributary water quality

Of the 12 tributaries studied, six contribute 99% of the total acidity to Little Raccoon Creek, which varies from 8700 lbs/day during high flow (March, 1998) to 1000 lbs/day during low flow (June, 1999). These six priority sub-watersheds show elevated levels of acidity, conductivity, total dissolved solids (TDS) and metals, and low levels of pH and alkalinity, during both high- and low- flow periods. The six priority sub-watersheds are all located in northeastern Jackson County, where coal mining was most active. Under high-flow conditions the heavy acidity loading tributaries are Middleton Run (43%), Flint Run (42%), Mulga Run (7%), Goose Run (4%) and the 124 Seep (4%) (Figure 6). Under low-flow conditions, the total loading is much less, and the tributaries play different roles in the total: Flint Run (51%), Goose Run (29%), Mulga Run (17%), the 124 Seep (2%), and Greasy Run (1%) (Figure 7). The remaining <1% of the acidity load comes from Rich Run during low flow. While the relative role of tributaries under different conditions varies (e.g., Middleton Run is the heaviest loader under high-flow conditions, but contributes a negligible amount under low-flow conditions), Flint Run is consistently a heavy source of acidity, and ranks as the top-priority source[1]. The tributaries are discussed in detail after the section Biological Health.

Figure 6: Percent Acidity and Metal Loading to Little Raccoon Creek from Various Tributaries Under High-Flow Conditions (3/24/98-3/25/98)

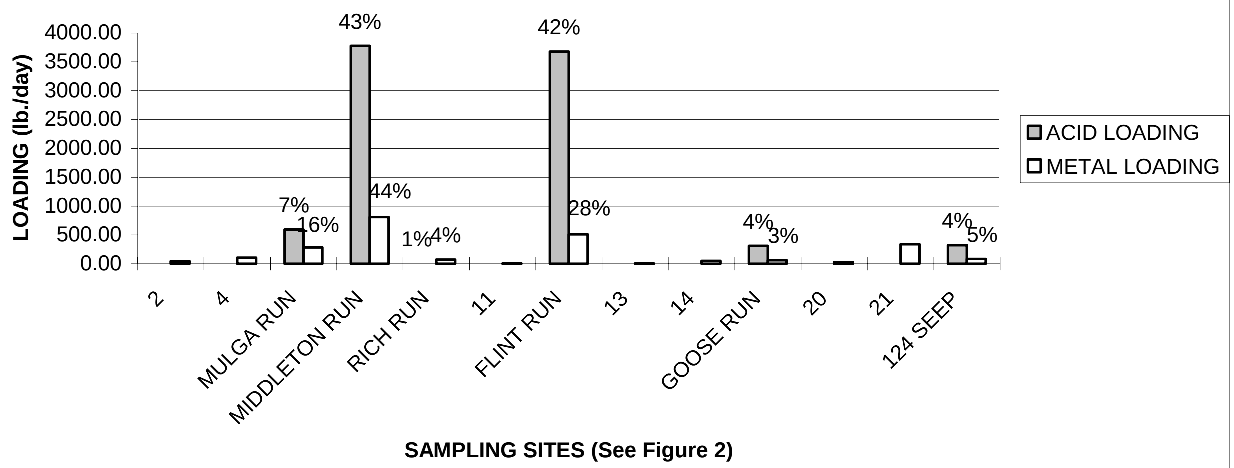
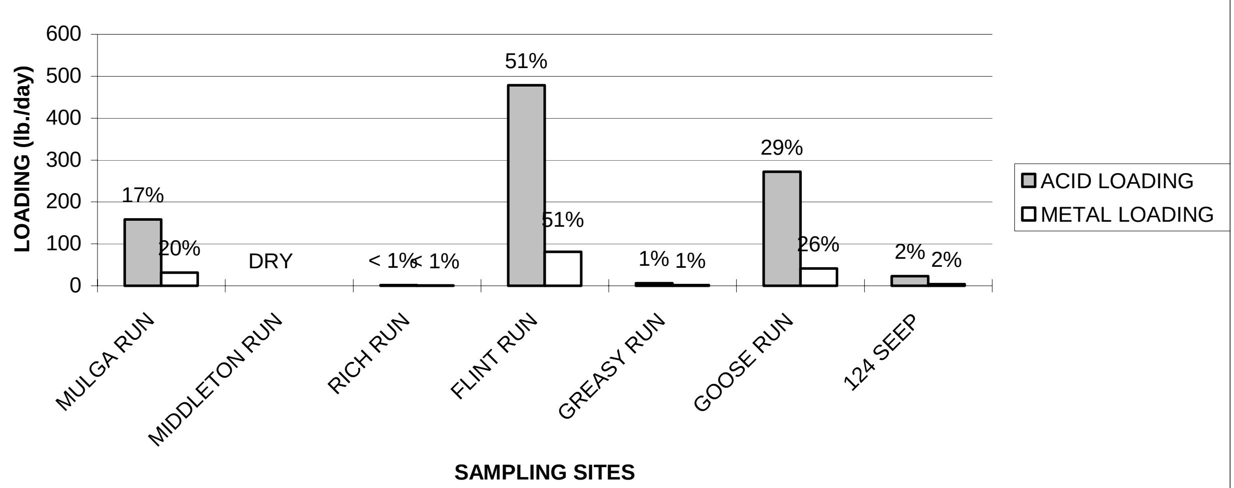


Figure 7: Percent Acidity and Metal Loading to Little Raccoon Creek from Various Tributaries Under Low-Flow Conditions (6/22/99-6/24/99)



[1] Reclamation of 60.5 acres of coal refuse and additional underground mine drainage discharges at the Buckeye Furnace Reclamation Project was completed in 1999. An 84 percent, average reduction in acidity has been observed in sampling data to date. Quarterly monitoring of Buffer Run through 2000 will yield sufficient information to determine whether this stream will merit further remediation in the future.

BIOLOGICAL HEALTH

Several groups have measured conditions in Little Raccoon Creek related to biological health, specifically habitat, macroinvertebrate populations and fish populations.

The Ohio EPA qualitatively evaluated numerous small streams in the Raccoon Creek basin during the summer of 1995 to determine the "use" designation. Three biological indices determine aquatic life uses: (1) the index of biological integrity (IBI) for fish communities, (2) the macroinvertebrate community index (ICI), and (3) the modified index of well being (MIwb). These indices measure the numbers and diversity of fish and aquatic macroinvertebrates. Several uses are designated:

- Exceptional Warm water Habitat (EWH) is the most biologically productive environment. These waters support "unusual and exceptional" assemblages of aquatic organisms, which are characterized by a high diversity of species, particularly those that are highly intolerant and/or rare, threatened, endangered, or special status. This use represents a protection goal for water resource management efforts dealing with Ohio's best water resources. None of the waters of Little Raccoon Creek have this designation.
- Warm water Habitat (WWH) defines the "typical" warm water assemblage of aquatic organisms for Ohio streams. It is the principal restoration target for the majority of water resource management efforts in Ohio. Little Raccoon Creek mainstem partially achieves WWH use designation, as does the tributary Greasy Run. Other Little Raccoon Creek waters could achieve this designation, if restored.
- Modified Warm water Habitat (MWH) applies to streams with extensive and irretrievable physical habitat modifications, for which the biological criteria for warm water habitat are not attainable. The activities contributing to the modified warm water habitat designation have been sanctioned and permitted by state or federal law. The representative aquatic assemblages are generally composed of species that are tolerant to low dissolved oxygen, silt, nutrient enrichment, and poor habitat quality. The category applies to dammed or channelized rivers, and also can be applied to streams affected by AMD, although the designation was not used in Little Raccoon Creek.
- Limited Resource Water (LRW) applies to streams that have drainage areas of less than three square miles and either lack water on a recurring annual basis, or have been

irretrievably altered to the extent that no appreciable assemblage of aquatic life can be supported; no formal biological criteria are established for this designation. OEPA stated that mining impacts cause severe degradation in Mulga Run, Flint Run, Buffer Run, and Goose Run. Poor performance of the biological communities and in-stream chemical impacts from unreclaimed acid mine drainage with no near term prospect for reclamation in these basins warrant the Limited Resource Water (LRW) – Acid Mine Drainage aquatic life use designation for these streams. The designation affects what future activities are permitted on these tributaries.

- Limited Warm water Habitat (LWH) was adopted in 1978 as a temporary variance mechanism for individual segments that had point source discharge problems and as a result could not meet Clean Water Act goals. Rich Run, Flint Run, Buffer Run, and Goose Run are currently designated LWH because of AMD. This designation is being phased out. These tributaries are being considered for LRW designation (above).

The biological health summary that follows primarily describes the macroinvertebrate community health in Little Raccoon Creek. In 1999 USGS evaluated the fish community (IBI) at two sites, one above and one below Dickason Run. The USGS IBI data is included in Appendix 2.

According to the Ohio EPA Raccoon Creek Basin Study (1995), several tributaries of Little Raccoon Creek were evaluated. Mulga Run showed high acid mine drainage impacts and contributed high amounts of sediment to the Little Raccoon Creek mainstem. Flint Run and Buffer Run were qualitatively evaluated as very poor for both macroinvertebrate and fish communities. No mayfly, stonefly, caddisfly, or tanytarsini midges were collected in these two tributaries. Less than 10 taxa total were collected from the natural substrate. In Buffer Run, coal fines made up the majority of the stream sediment.

In the 1999 USGS study (Appendix 2), sampling was not done in the tributaries, but on the mainstem directly below the confluence of the tributaries (Figure 2). Starting at the furthest upstream sites, Sites 1 (Mulga Run) and 2 (Flint Run) had identical ICI values of 30, which indicate fair water quality. These sites lacked mayfly taxa, had low numbers of caddisfly taxa, and a low EPT metric score. The low percent tolerant organisms combined with the moderate percentages of the "Other Diptera and non-insects" metric indicate that a high proportion of the samples were made up of indicators of moderate water quality at these two sites.

After examining water quality data from both 1997 and 1999, these sites appear slightly different in potential causes of pollution and degradation. At both sites 1 and 2, sedimentation is indicated by a substrate composition of mainly silt, muck and sand. This high embeddedness limits biological productivity. Recent metal and acidity loadings data indicate that during high flow, Flint Run, and to a lesser extent, Mulga Run, can contribute high amounts of acidity to Little Raccoon Creek. Because of the relatively high volume of water in LRC, the AMD is diluted at both of these sites. In both sites, dissolved oxygen and/or AMD may be limiting the mayfly and caddisfly taxa.

Water quality in Mulga Run is highly variable and seasonally dependent. A variety of complicating factors have yielded sample results varying from pH 6.7, 0.0 mg/l acidity in February 1998 to pH 3.45, acidity 130 mg/l acidity in October 1998 (Appendix 1, Table 2). Factors contributing to this variability include the high seasonal percentage of underground mine drainage present in stream flow, the diminishing effects on alkalinity from the Jaymar Limestone Plant and the channelized flow through the large Mulga Run wetland. These factors deprive Mulga Run of a substantial percentage of its buffering capacity, yielding a significant output of acid mine drainage constituents during low flow periods.

Water quality data from 1997 indicate that below Flint Run (Site 2), pH was 6.1 at high flow, but alkalinity was low. This indicates a poor buffering capacity, even if pH is at 6.1. Furthermore, elevated metal concentrations indicate that metals and acidity due to AMD are limiting factors for the macroinvertebrate community, especially at higher flows. In the 1999 USGS study, this site had much lower macroinvertebrate abundance as compared to Site 1. The dominant organisms were Hydropsychidae (filter feeding caddisfly) and chironomidae (midge), both general indicators of moderate water quality. Water quality data (1999 USGS) indicate good alkalinity levels, neutral pH, low dissolved oxygen, and slightly elevated specific conductance at Site 2. Because macroinvertebrates are indicators of overall stream health through time, it is very likely that at high flows, AMD is a limiting pollution factor. Sedimentation and high embeddedness are a year-long factor. During the lower flow months, however, low dissolved oxygen and elevated nutrient levels may further impact the macroinvertebrate community.

Below Buffer Run (Site 3), the macroinvertebrate community shows a considerable decrease in number of taxa present, relative percentages of taxa present, and a corresponding low ICI value of 24. Previously the OEPA had characterized Buffer Run as one of the worst AMD sites in LRC. However, it should be noted that a large reclamation project was just completed within the Buffer Run tributary watershed. It is too soon to draw any conclusions regarding recovery of the biota in this watershed, or Little Raccoon Creek downstream; however, water quality monitoring is currently taking place so that future analysis can be done and recommendations can be made.

Substrate conditions at this site contain more cobble and gravel than at the two upstream sites and only moderate embeddedness. Water quality sampling in 1997 indicates elevated concentrations of metals at this site (during high flow). During the USGS sampling, it was noted that Buffer Run forms a white precipitate (aluminum) at the confluence with LRC. Metals are most likely still a problem during the low flow periods (although metals were not measured in 1999). Buffer Run appears to be substantially acid mine drainage impacted and is negatively affecting the water quality of the LRC mainstem. Furthermore, low dissolved oxygen levels may also be limiting to macroinvertebrates. Because of the low ICI value at this site and the low abundance of organisms, the biological health at this site can be characterized as poor.

The Site 4 sample, above Dickason Run, showed a moderate to good number of taxa, and even included a few mayflies. Caddisfly numbers remained similar to previous sites. Diptera increased, however, probably due to the increase in tanytarsini midges, which are a relatively intolerant midge. The EPT metric was moderate (9) and the overall ICI was high (42) relative to other LRC sites. Despite high embeddedness and sedimentation, this site has relatively good macroinvertebrate health, as indicated by its good diversity and high ICI. The diverse macroinvertebrate community seen here is most likely due to the distance downstream from some of the AMD problems. Samples taken by Wilson (1988) indicate that this site was impacted by AMD in 1986.

Site 5, below Dickason, shows a reduction in ICI (34) from the upstream Dickason site. All metrics are reduced as compared to above Dickason, except for tanytarsini midges, which increased. There appears to be some pollution input above this point, which has caused the loss of diversity and reduction in metric values. Although the caddisfly percentage is not as high as it is at upstream sites, this could be attributed to a difference in habitat. Water quality information from 1997 shows elevated metal levels at this site, indicating that AMD is the most likely problem. Dixon Run was noted to be an AMD-impacted tributary of Dickason Run, although not a priority watershed for purposes of the LRC Hydrologic Unit Document. The 1999 USGS study showed below normal dissolved oxygen levels and elevated specific conductance at this site. The OEPA (1997) study noted that downstream of Dickason Run the ICI value was only 18, the higher value in the 1999 study (34) may indicate an increase in the biological health of this section of LRC. It should be noted that the current ICI (34) and other metrics indicate fair water quality and fair diversity.

Site 6, near Vinton, is the furthest downstream and has the best overall metrics and ICI value (44). This site has excellent diversity and a good EPT metric value (17), which is the highest of all the sites sampled. The percent mayflies are higher relative to the other sites as well. This site appears to be relatively free of AMD pollution although sedimentation is most likely still an issue. Because there is a nine-mile stretch between the Dickason Run site (RM 12.8) and the Vinton site (RM 3.4), it can be concluded that the nearest tributaries above the Vinton site are contributing negligible amounts of AMD pollution. Water quality samples taken by Wilson (1988) near this site indicate that pH and alkalinity improved over the sampling period from 1984 to 1986. Macroinvertebrate samples taken by Wilson (1988) indicate low diversity as compared to the 1999 sample. AMD-tolerant organisms such as *Sialis (*Alderfly) and chironomidae (midge) dominated the 1986 samples. It appears that the biological health and water quality at this site have experienced a drastic improvement since 1986.

It appears that much of the Little Raccoon mainstem is still impacted to various degrees by problems related to acid mine drainage. High flow periods appear to contribute the highest levels of acidity and metals to the mainstem at sites 2, 3, and 5. Site 3 (Buffer Run) is the most impacted by AMD. Extensive embeddedness is a problem for the entire length of the mainstem. Dissolved oxygen (DO) levels remain low until Dickason Run when they rise to 6.5. Explanations for the low DO include both low stream flows and an increase in water temperature as well as possible nutrient enrichment. Comparisons of the 1999 data with previous studies indicate that the biological health of sites along the mainstem has improved. Sites determined to have little to no AMD impact in this study were considered AMD-impacted in the 1988 USGS study (Wilson 1988). Site 4 may have also improved (from poor to fair) since the 1988 study. Of the sites sampled in the 1999 USGS study, the largest AMD impact occurs below the Buffer Run tributary. In contrast, the furthest site downstream (Vinton, OH) shows essentially no AMD impact. Acid mine drainage impacts are probably limited to the mainstem above river mile 12.5 (below Dickason Run). The smallest density of organisms was found at the Buffer Run site and the greatest density was found at the Vinton, OH site, coinciding directly with the level of AMD-impact.

It should be noted that even with the high AMD impact at site 3, the ICI metrics show that there were no "tolerant organisms" in the Buffer Run sample. The ICI index is roughly based on tolerance values for organisms, which thrive in degraded environments in Ohio. Most of these tolerances are based on organic pollution, not high metals and high acidity as found in AMD. For this reason, it is possible that ICI values are over-estimated in AMD impacted areas. As of yet, there are no published indices for assessing AMD impacts. Regardless, it should be noted that the ICI's do give an accurate *relative* indication of the biological health, even in AMD-impacted areas.

TRIBUTARIES

In this and the next few sections, high-priority tributaries are discussed individually.

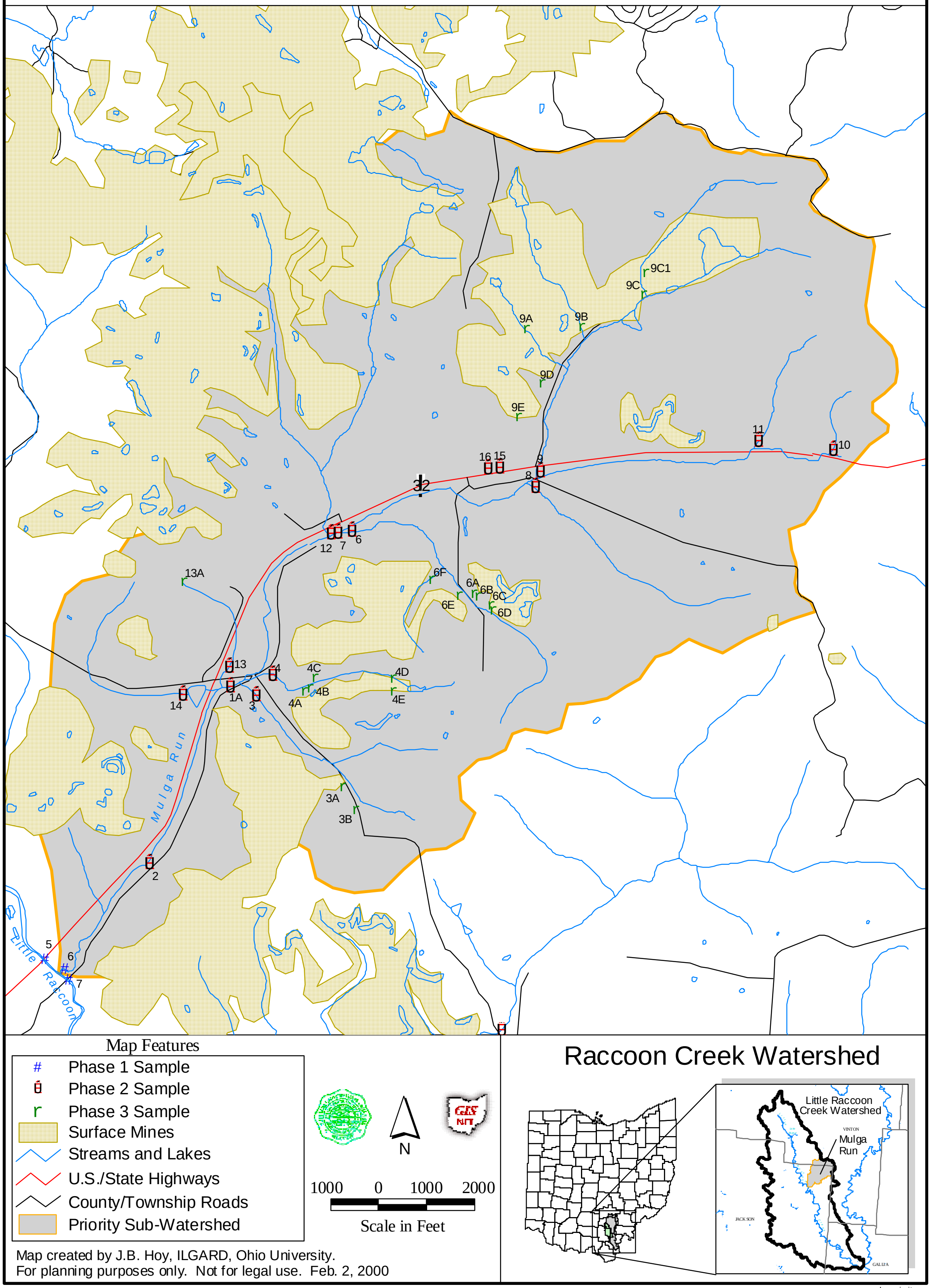
MULGA RUN

NAME:	Mulga Run
LOCATION:	Milton Township, Jackson County, Ohio
QUADRANGLE:	Mulga (sec. 2, 3, 10, and 11), McArthur (sec. 25, 26, 27, 34, 35, and 36)
DRAINAGE AREA:	7.9 mi^2

Overview

Based on available water quality data, Mulga Run (Figure 8) is the third largest contributor of acid-mine drainage (AMD) in the Little Raccoon Creek watershed. Abandoned deep-mine drainage and associated unreclaimed coal refuse piles affect Mulga Run. Sands Hill Coal Company is actively strip mining for coal in the headwaters of tributaries 4 and 6.

Figure 8: Mulga Run Sub-Watershed

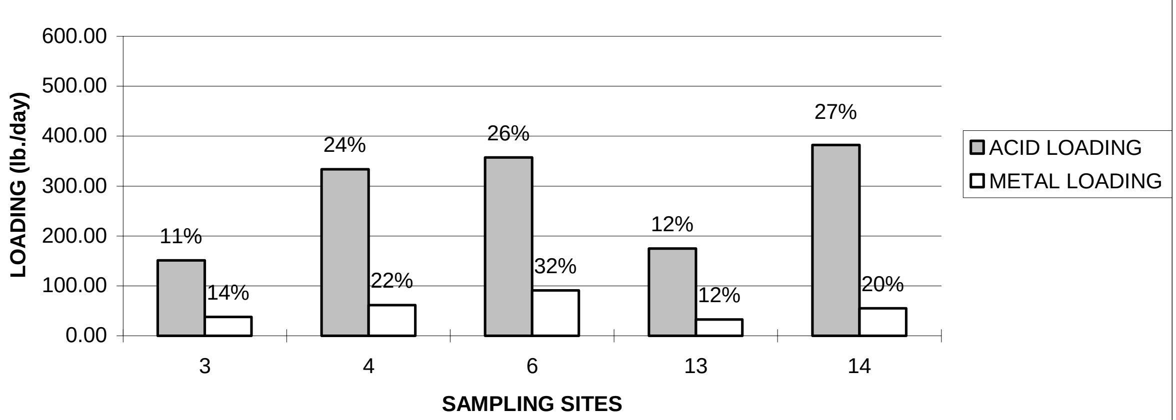


Jaymar Limestone is strip mining for limestone in the headwaters of tributary 9. During Phase I sampling it was determined that at high flow, Mulga Run contributes 7% of the acidity loading and 16% of the metal loading to Little Raccoon Creek (Figure 6). At low flow, Mulga Run contributes 17% of the acidity loading and 20% of the metal loading in the Little Raccoon Creek watershed (Figure 7). As previously noted, highly variable water chemistry in Mulga Run can be attributed to a variety of factors which reduce the streams buffering capacity at low flow. Thorough monitoring and the initiation of a remediation design will begin in late 2000.

Phase II water sampling occurred between 4/28/98 and 4/29/98 to determine which tributaries entering the Mulga Run mainstem contribute the most AMD. This phase of sampling does not include a high- and low-flow period, but is expected to provide a relative measure of sources within Mulga Run sub-watershed[2]. Five of the 12 Mulga Run tributaries contribute significant AMD to Mulga Run (Figure 9). The largest AMD-contributors during this sampling period included tributaries 6, 14, and 4. Tributary 6 contributes 26% of the acidity loading and 32% of the metal loading. Tributary 6 acidity loading ranges from about 400 to 1200 lb/day, and metal loading ranges from 90 to 500 lb/day (Appendix 1,Table 2). Tributary 14 contributes 27% of the acidity loading and 20% of the metal loading. Tributary 14 loading is about 350 lb/day and metal loading is about 50 lb/day. Tributary 4 contributes 24% of the acidity loading and 22% of the metal loading. Tributary 4 acidity loading is about 350 lb/day and metal loading is about 60 lb/day. Based on available water quality data, tributary 6 is the largest contributor of AMD in the Mulga Run sub-watershed followed by tributaries 14 and 4.

[2] As previously noted, seasonally variable water chemistry in this stream has been observed to contribute significant acidity loading to Little Raccoon Creek, with levels reaching 1746 lbs/day in October 1998 (Appendix 1, Table 2).

Figure 9: Acidity and Metal Loading into Mulga Run from All Sources (4/28/98 - 4/29/98)



Phase III water sampling occurred between 9/27/99 and 10/13/99 to locate point sources for AMD-generation in each of the affected tributaries to Mulga Run. Again, high- and low-flow periods are not represented; the purpose of the sampling was to determine relative importance of seeps. In tributary 6, the Lincoln Pit Seeps (sites 6A and 6B, Figure 8) contribute 95% of the acidity loading and 97% of the metal loading. Site 6E contributes 4% of the acidity loading and 3% of the metal loading. No Phase III point source information is available for tributary 14 due to drought conditions at the sampling time. In tributary 4, site 4E contributes 78% of the acidity loading and 77% of the metal loading. Site 4D contributes 22% of the acidity loading and 23% of the metal loading. The remaining sites contributed 1% or less to the total acidity and metal loading in Mulga Run. Based on available water quality data, sites 6A and 6B are the largest contributors of acid mine drainage in the Mulga Run sub-watershed followed by tributary 14 (discussed above under Phase II water quality sampling), and sites 4E, 4D, and 6E. These sources are described in more detail in the following sections.

Site 6 - Confluence of Mulga Run and Little Raccoon Creek, site 1A, 2 and 14

Location/Access: Site 6 at the confluence of Mulga Run is reached by traveling west on Hollingshead Road until it dead-ends at the abandoned bridge (Figure 8). The confluence is approximately 30 yards upstream from the abandoned bridge. The site is located on the Mulga Quadrangle in the southwest corner of section 10. The site is only accessible by foot travel. Mead Paper Company in Chillicothe, Ohio owns the property at the confluence. The individual in charge of the abandoned mine lands for Mead Paper Company is Steve Mathy (740-772-3472).

Site 1A is located on the corner of Hollingshead Road and Mulga Road just downstream of the Mulga Road Bridge. This site is situated just upstream from the entrance to the Mulga Run wetland and is accessible by both vehicle and foot travel. Sites 14 and 2 enter the Mulga Run mainstem below site 1A.

Site Description: The confluence of Mulga Run is situated at the outflow of a large wetland complex that extends along U.S. Route 32 almost to Mulga Run Road (Co. Rd. 39). During periods of high flow there are multiple discharge points emanating from the wetland into Little Raccoon Creek and during low-flow periods the discharge is typically limited to a single channel.

Water Quality: Acidity loading at the confluence of Mulga Run can exceed 3000 lb/day, but waters may also carry a small net alkaline load. Metal loading ranges from 30 to 1300 lb/day.

Recommendation: Continuous monitoring should be done at the confluence of Mulga Run. The purpose for this is two-fold: 1) the Mulga Run wetland provides a unique system for acid and metal removal and further study of the process may prove beneficial, and 2) water quality monitoring at the confluence of Mulga Run and at site 1A reveals increased AMD degradation below site 1A. Site 14 has the potential for large loading episodes and is therefore suspected of degrading the water quality in the Mulga Run wetland. It is recommended that monitoring begin with a monthly schedule of filtered Group I samples until the point source for the AMD degradation and reasonable high- and low-flow conditions have been identified. Sampling sites should include sites 6, 1A, 2, and 14.

Site 3A- Mount Carmel Seeps

Location/Access: Site 3A is located on Mulga Road (Co. Rd. 39) south of U.S. 32 and north of Mount Carmel Church (Figure 8). Site 3A cannot be seen from the road, but drainage from the sight is visible along the hillside on a steep-grade section of Mulga Road (Co. Rd. 39). The site is located on the Mulga Quadrangle in the southwest corner of section 2. The site is only accessible by foot travel.

Site Description: This site is an abandoned deep-mine site most likely associated with deep-mine JKN-101. The mine entrance is not visible, but a positive-draining pond marks the most probable location of a mine entrance or hydraulic connection to the mine. The site drains along a road culvert on Mulga Rd. (Co. Rd. 39) and into the mainstem of tributary 3. This site has a large quantity of unreclaimed coal tailings extending from the mine entrance to Mulga Run Road (Co. Rd. 39).

Water Quality: Site 3A has exhibited acidity loading of 5 lb/day and less than 1 lb/day of metal loading. Site 3A is believed to be a low-priority site, but has not been fully characterized in terms of high- and low-flow chemical loading.

Recommendation: Continuous monitoring is recommended at site 3A to capture high- and low-flow conditions and to identify a range of acidity and metal loadings. The limited water quality information presently available for this site may underrate the impact of the site as a significant point source. Monitoring should begin with a monthly schedule of filtered Group I samples until reasonable high- and low-flow conditions have been identified. At that time, a reassessment can be made of the impact this site has upon the sub-watershed. Sampling sites should only include site 3A.

Site 3B - Mount Carmel Seeps

Location/Access: Site 3B is located in the headwaters of tributary 3 just northwest of Mount Carmel church on Mulga Road. (Co. Rd. 39) (Figure 8). The site is located on the Mulga Quadrangle in the southwest corner of section 2 and the northwest corner of section 11. The site is only accessible by foot travel.

Site Description: This site is an abandoned deep-mine site most likely associated with deep-mines JKN-98 and JKN-103. The mine entrance is not visible, but a pool of standing water marks the most probable location of a mine entrance or hydraulic connection to the mine. The site drains into an open storm-water ditch along Mulga Run Road (Co. Rd. 39), which constitutes the headwaters of tributary 3. No coal refuse piles are visible around the site, but the owner of the property is using the site as an open dump.

Water Quality: During water quality sampling of potential project sites in September of 1999, Site 3B was not draining, but there was a large area of metal precipitate to indicate this site may be active during periods of higher rainfall. Site 3B is believed to be a low-priority site.

Recommendation: Continuous monitoring is recommended at site 3B, to capture high- and low-flow conditions and identify a range of acidity and metal loadings. The limited water quality information presently available for this site may underrate the impact of the site as a significant point source. Monitoring should begin with a monthly schedule of filtered Group I samples until reasonable high- and low-flow conditions have been identified. At that time, a reassessment can be made of the impact this site has upon the sub-watershed. Sampling sites should only include site 3B.

Site 4A - Hollingshead Road Seeps

Location/Access: Site 4A is located near the entrance of the tributary 4 valley. This site is located on the Mulga Quadrangle on the west-central portion of section 2 (Figure 8). Access to tributary 4 is severely limited and can only be approached on foot through the north cul-de-sac section of Hollingshead Road.

Site Description: Site 4A is an abandoned deep-mine site and most likely associated with deep-mine JKN-121. The mine entrance is not visible, but a bog area and large quantities of metal precipitate on the hillside mark the most probable location of a mine entrance or hydraulic connection to the mine. A substantial quantity of unreclaimed coal refuse piles are located along the hillsides near the seep and on the opposite hillside a short distance upstream. These unreclaimed coal refuse piles are labeled 4B and 4C on Figure 8.

Water Quality: During water quality sampling of potential project sites in September of 1999, Site 4A was not draining, but there was a large area of metal precipitate to indicate this site may be active during periods of higher rainfall. No water quality information is available for this site.

Recommendation: Continuous monitoring is recommended at site 4A to capture high- and low-flow conditions and to identify a range of acidity and metal loadings. The limited water quality information presently available for this site may underrate the impact of the site as a significant point source. Monitoring should begin with a monthly schedule of filtered Group I samples until reasonable high- and low-flow conditions have been identified. At that time, a reassessment can be made of the impact this site has upon the sub-watershed. Sampling sites should only include site 4A.

Site 4D - Hollingshead Road Seeps

Location/Access: Site 4D is located within the north fork of the headwaters of tributary 4 (Figure 8). The site, located on the Mulga Quadrangle in the west-central portion of section 2, is downstream from sedimentation ponds constructed by the Sands Hill Coal Company. Access to tributary 4 is severely limited and can only be approached on foot through the north cul-de-sac section of Hollingshead Road. It is assumed that the Sands Hill Coal Company holds property ownership.

Site Description: Site 4D is an abandoned deep-mine site and most likely associated with deep-mines JKN-128, JKN-130 and JKN-133. The mine entrance is not visible, but diffuse seeps can be seen all along the banks and hillsides of the north fork. The microbial colony *Euglena mutabilis* can be seen in abundance along this section. Areas along the banks and hillsides contain unreclaimed coal refuse piles and other mining wastes (i.e. metal and wood timbers).

Water Quality: During this sampling period sites 4D and 4E contributed flow to the mainstem of tributary 4. No additional discharge emanated from the Sands Hill Coal Company sedimentation ponds. Site 4D exhibited acidity loading of 13 lb/day and metal loading of 5 lb/day. This site has not been fully characterized in terms of high- and low-flow chemical loading.

Recommendation: Site 4D is a Little Raccoon Creek priority treatment site. Recommendations for treatment will be covered in section 1 under the heading *Proposed Treatment*. A monthly monitoring schedule of filtered Group II samples should be initiated before beginning any treatment programs in order to fully characterize a variety of acidity and metal loading ranges. Sampling sites should include the confluence of tributary 4, site 4D, and site 4E.

Site 4E - Hollingshead Road Seeps

Location/Access: Site 4E is located within the south fork of the headwaters of tributary 4 (Figure 8). Site 4E is also located downstream from sedimentation ponds constructed by the Sands Hill Coal Company. This site is located on the Mulga Quadrangle on the west-central portion of section 2. Access to tributary 4 is severely limited and can only be approached on foot through the north cul-de-sac section of Hollingshead Rd. It is assumed that the Sands Hill Coal Company holds property ownership.

Site Description: Site 4E is an abandoned deep-mine site and most likely associated with deep-mine JKN-130. The mine entrance is not visible but diffuse seeps can be seen all along the banks and hillsides of the south fork. The microbial colony *Euglena mutabilis* can be seen in abundance along this section. A large portion of the banks and hillsides contain unreclaimed coal refuse materials and other mining wastes (i.e. metal, wood timbers, and a mining car).

Water Quality: During this sampling period, only sites 4D and 4E contributed flow to the mainstem of tributary 4. No additional discharge emanated from the Sands Hill Coal Company sedimentation ponds. Site 4E exhibited acidity loading of 46 lb/day and metal loading of 18 lb/day. This site has not been fully characterized in terms of high- and low-flow chemical loading.

Recommendation: Site 4E is a Little Raccoon Creek priority treatment site and recommendations for treatment will be covered in section 1 under the heading *Proposed Treatment*. It is suggested that a monthly monitoring schedule of filtered Group II samples be initiated before beginning any treatment programs in order to fully characterize a variety of acidity and metal loading ranges. Sampling sites should include the confluence of tributary 4, site 4D, and site 4E.

Site 6A and 6B - Lincoln Pit Seeps

Location/Access: Site 6B is located in the east fork of the tributary 6 headwaters (Figure 8). To reach the site, enter Sands Hill Coal Company property and follow the Lincoln Pit Haul Road to a road culvert at the base of a steep grade in the haul road. Active mining can be seen at the top of the steep grade. The site is located on the Mulga Quadrangle in the northeast corner of section 2. This site is accessible by both vehicle and foot travel. Do not enter Sands Hill Coal Company property without permission and a visitor's pass. Please contact Brenda Weber at the Hamden Office 740-384-4211.

Site Description: Site 6B is an abandoned deep-mine site and is most likely associated with the north section of the deep-mine complex JKN-38. No unreclaimed coal refuse material can be found at this site. The mine entrance is not visible, but a high-discharge seep marks the most probable location of the mine entrance or hydraulic connection to the mine. Close to this seep is an area of diffuse seeps along the bank of the road culvert and this is labeled site 6A. These diffuse seeps are also assumed to be associated with the north section of the deep-mine complex JKN-38.

Water Quality: Sites 6A and 6B have exhibited a combined acidity loading of 1200 lb/day and metal loading of 550 lb/day. These sites have not been fully characterized in terms of high- and low-flow chemical loading. It is important to note that some alkaline discharge is being added to tributary 6. In the headwaters of tributary 6, sites 6A and 6B merge with 6C and 6D to begin the mainstem of tributary 6. Site 6C is a sedimentation/runoff pond installed by Sands Hill Coal Company. In September of 1999, it was producing 50 lbs of alkalinity per day. Site 6D is a pipe draining an unknown area and is located next to site 6C. In September of 1999, it was producing 40 lbs of alkalinity per day.

Recommendation: Site 6A and 6B are Little Raccoon Creek priority treatment sites and recommendations for treatment will be covered in section 1 under *Proposed Treatment*. A monthly monitoring schedule of filtered Group II samples should be initiated before beginning any treatment programs in order to fully characterize a variety of acidity and metal loading ranges. Sampling sites should include sites 6A, 6B and a site downstream from the net alkaline discharges.

Site 6E - Deep Mine JKN-38

Location/Access: Site 6E is located downstream from the Lincoln Pit Seep in the east fork of the tributary 6 headwaters (Figure 8). To reach this site, enter the property of Sands Hill Coal Company and follow the Lincoln Pit Haul Road to a road culvert at the base of a steep grade in the haul road. The abandoned mine site is located approximately 75 yards downstream from the haul road culvert. The site is located on the Mulga Quadrangle in the northeast corner of section 2. The site is only accessible by foot travel. Do not enter Sands Hill Coal Company property without permission and a visitor's pass. Please contact Brenda Weber at the Hamden Office 740-384-4211.

Site Description: Site 6E is an abandoned deep-mine site and is most likely associated with the south section of the deep-mine complex JKN-38. No unreclaimed coal refuse materials are associated with this site. The mine entrance is not visible, but discharge from a seep marks the most probable location of the mine entrance or hydraulic connection to the mine.

Water Quality: Site 6E has exhibited acidity loading of 51 lb/day and metal loading of 17 lb/day. This site has not been fully characterized in terms of high- and low-flow chemical loading.

Recommendation: Continuous monitoring is recommended at site 6E, to capture high- and low-flow conditions and identify a range of acidity and metal loadings. The limited water quality information presently available for this site may underrate the impact of the site as a significant point source. Monitoring should begin with a monthly schedule of filtered Group I samples until reasonable high- and low-flow conditions have been identified. At that time, a reassessment can be made of the impact this site has upon the sub-watershed.

Site 6F - Deep Mine JKN -38

Location/Access: Site 6F is located in the west fork of the headwaters in tributary 6. To reach the site, enter the property of Sands Hill Coal Company and take the Lincoln Pit Haul Road. The confluence of this stream is approximately 150 yards downstream of the haul road culvert. The site is located on the Mulga Quadrangle in north-central portion of section 2. The site is only accessible by foot travel. Do not enter Sands Hill Coal Company property without permission and a visitor's pass. Please contact Brenda Weber at the Hamden Office 740-384-4211.

Site Description: Site 6F is an abandoned deep-mine site and is most likely associated with the south section of the deep-mine complex JKN-38. Some unreclaimed coal refuse materials are associated with this site. The mine entrance is not visible, but diffuse seeps along the bank of the stream mark the most probable location of the mine entrance or hydraulic connection to the mine.

Water Quality: Site 6F has exhibited acidity loading of 11 lb/day and metal loading of 3 lb/day. Site 6F is believed to be a low-priority site, but has not been fully characterized in terms of high- and low-flow chemical loading.

Recommendation: Continuous monitoring is recommended at site 6F to capture high- and low-flow conditions and identify a range of acidity and metal loadings. The limited water quality information presently available for this site may underrate the impact of the site as a significant point source. Monitoring should begin with a monthly schedule of filtered Group I samples until reasonable high- and low-flow conditions have been identified. At that time, a reassessment can be made of the impact this site has upon the sub-watershed.

Site 13A - Deep Mine JKN-206

Location/Access: This site is located at the end of a dirt road on the corner of Mulga Road and U.S. Route 32. The dirt road dead-ends into a logging road that can be followed back to the mine site. The site is located on the Mulga quadrangle in the northwest corner of section 3. The site is only accessible by foot travel.

Site Description: Site 13A is an abandoned deep-mine site and is most likely associated with deep-mine JKN-206. No mine entrance is visible, but a bog area and large amounts of metal precipitate mark the most probable location of a mine entrance or hydraulic connection to the mine. The site constitutes the headwaters of tributary 13 and is the only point source of AMD in this tributary. It is believed that unaffected base flow from the surrounding watershed is mixing with and diluting the AMD-influx.

Water Quality: Site 13A has exhibited acidity loading of 18 lb/day and metal loading of 3 lb/day. Site 13A is believed to be a low-priority site, but has not been fully characterized in terms of high- and low-flow chemical loading.

Recommendation: Continuous monitoring is recommended at site 13A to capture high- and low-flow conditions and identify a range of acidity and metal loadings. The limited water quality information presently available for this site may underrate the impact of the site as a significant point source. Monitoring should begin with a monthly schedule of filtered Group I samples until reasonable high- and low-flow conditions have been identified. At that time, a reassessment can be made of the impact this site has upon the sub-watershed. Sampling sites should include the confluence of tributary 13 and site 13A.

Site 14 - Mulga Road Mine Complex

Location/Access: A majority of tributary 14 occurs as a roadside ditch along Mulga Road (Co. Rd. 39) on the west side of U.S. Rt. 32. The tributary is located on the Mulga quadrangle in the central portion of section 3. The tributary is accessible by both vehicle and foot travel, but most of the land is posted as no trespassing.

Site Description: Because of poor sampling conditions and lack of access to private property no point source for AMD-generation has been located to date. The west side of tributary 14 has abandoned strip-mine lands while in the headwaters abandoned deep-mines are thought to exist. These abandoned deep-mines are most likely associated with deep mines JKN-153, JKN-81, and JKN-206.

Water Quality: During a canvas of the AMD-impacted tributaries in April 1998, site 14 was producing 380 lbs of acidity per day and 30 lbs of metals per day making this tributary the second largest AMD-producer in the Mulga Run sub-watershed. Site 14, near the Mulga Run confluence, and the upstream site 1A have under gone intensive water quality monitoring since January of 1997. Beginning in the spring of 1998, the confluence of Mulga Run began to show uncharacteristically high levels of acidity and metal loading. This trend continued until June of 1999 when levels began to dramatically decrease. This trend was not evident when the same loading data was compared with the data set from site 1A. Only 2 tributaries enter the Mulga Run mainstem below site 1A and this includes tributaries 14 and 2. Tributary 2 has shown very little AMD-generation in the past. Therefore, it is proposed that site 14 is the most likely point source for increased AMD-degradation below site 1A. The reason for the cessation of AMD degradation in June 1998 may be due to drought related conditions. Discharge from site 14 is suspected to have been decreasing since June 1998 until it was found completely dry in September of 1998.

Recommendation: Site 14 is a Little Raccoon Creek priority treatment site. Recommendations for treatment will be covered in section 1 under *Proposed Treatment*. A more intense characterization of site 14 should be completed before implementing any remediation strategy. It is recommended that monitoring begin with filtered Group I samples until high- and low-flow conditions have been sampled and point sources have been identified.

Summary of Potential Treatment Sites: Mulga Run

Site	Recommendation	Site Identification
6	Monitor	Confluence Of Mulga Run
3A	Monitor	Mt. Carmel Seeps
3B	Monitor	Mt. Carmel Seeps
4A	Monitor	Hollingshead Road Seeps
4D	Treatment	Hollingshead Road Seeps
4E	Treatment	Hollingshead Road Seeps
6A & 6B	Treatment	Lincoln Pit Seeps
6E	Monitor	Deep Mine Jkn-38
6F	Monitor	Deep Mine-Jkn-38
13A	Monitor	Deep Mine Jkn-206
14	Treatment	Mulga Road Mine Complex

RICH RUN

NAME:	Rich Run
LOCATION:	Milton Township, Jackson County, Ohio
QUADRANGLE:	Mulga (T9N, R17W, S10, 11, 12, 13, 14 and 15)
DRAINAGE AREA:	~6 mi^2

Overview

During Phase I sampling it was determined that Rich Run (Figure 10) contributes <1% of the acidity loading and 4% of the metal loading during high flow and <1% of the acidity and metal loading during low flow to the mainstem of Little Raccoon Creek (Figures 6 and 7). Most surface runoff is from reclaimed and unreclaimed strip-mined land, but it is not acidic. Acidity derives mainly from abandoned deep mines. The sub-watershed contains a large, inaccessible wetland formed by beaver damming, and provides potentially valuable waterfowl habitat. Rich Run is only a minor part of the acid mine drainage into Little Raccoon Creek, but future work may occur in the area because of the wetland. For this reason, the data are included in this report (Appendix 1, Table 3).

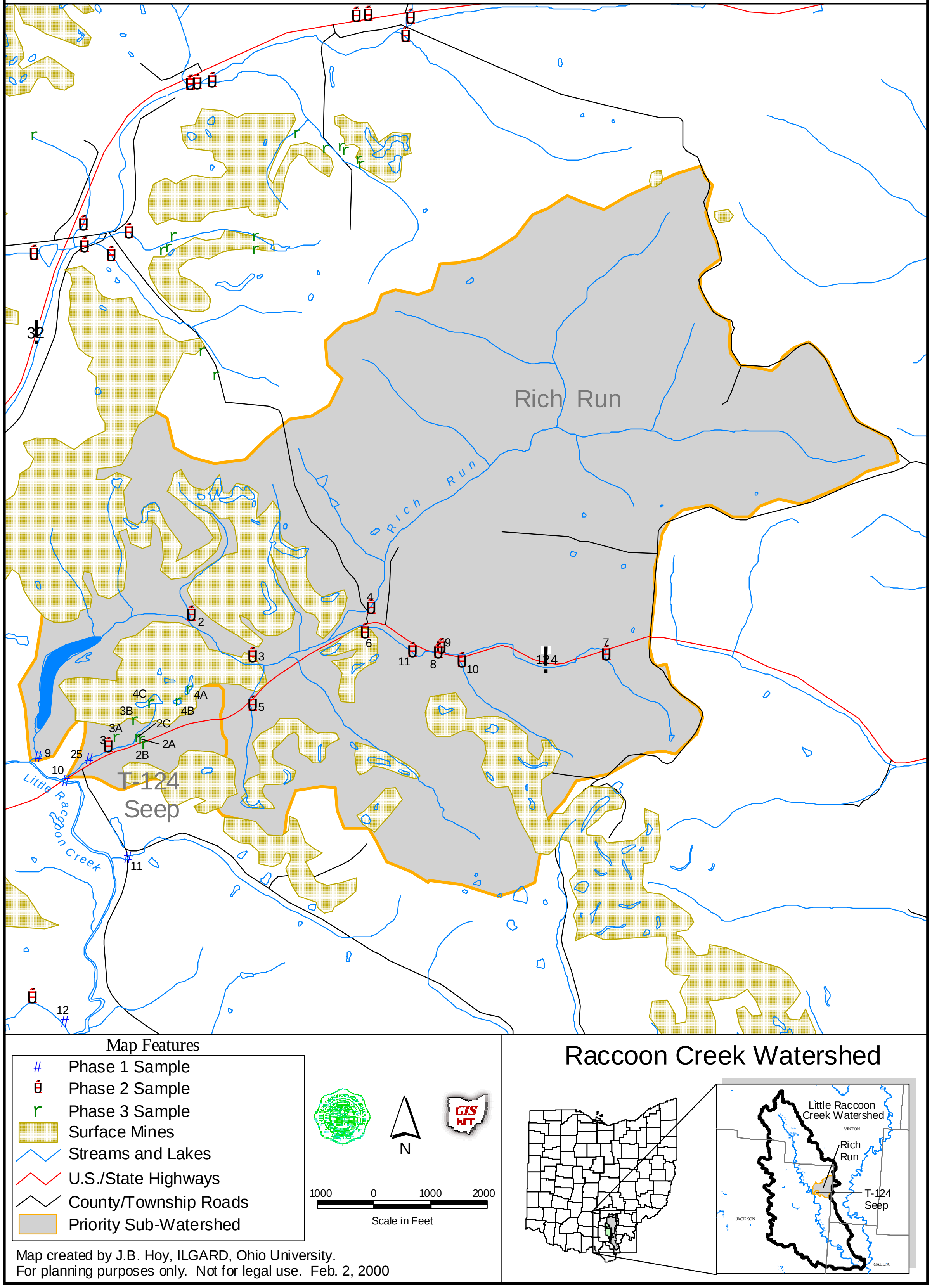
T-124 SEEP

NAME:	124 Seep Project Site
LOCATION:	Milton Township, Jackson County, Ohio
QUADRANGLE:	Mulga (T9N,17W, S14&15)
DRAINAGE AREA:	<0.5 mi^2

Overview

The 124 Seep is located along Route 124 in Jackson County (Figure 10). It is an abandoned surface coalmine draining directly into Little Raccoon Creek. During Phase I sampling it contributes 4% of the acidity loading to Little Raccoon Creek during high flow and 2% during low flow. It contributes 5% of the metal loading during high flow and 2% during low flow (Figures 6 and 7). The watershed is small, but carries a relatively large load of acidity and metals directly into Little Raccoon Creek. Construction on a remediation project will begin in the fall of 2000. Data have been included here for comparison with post-construction monitoring (Appendix 1, Table 4).

Figure 10: Rich Run and T-124 Seep Sub-Watersheds



MIDDLETON RUN

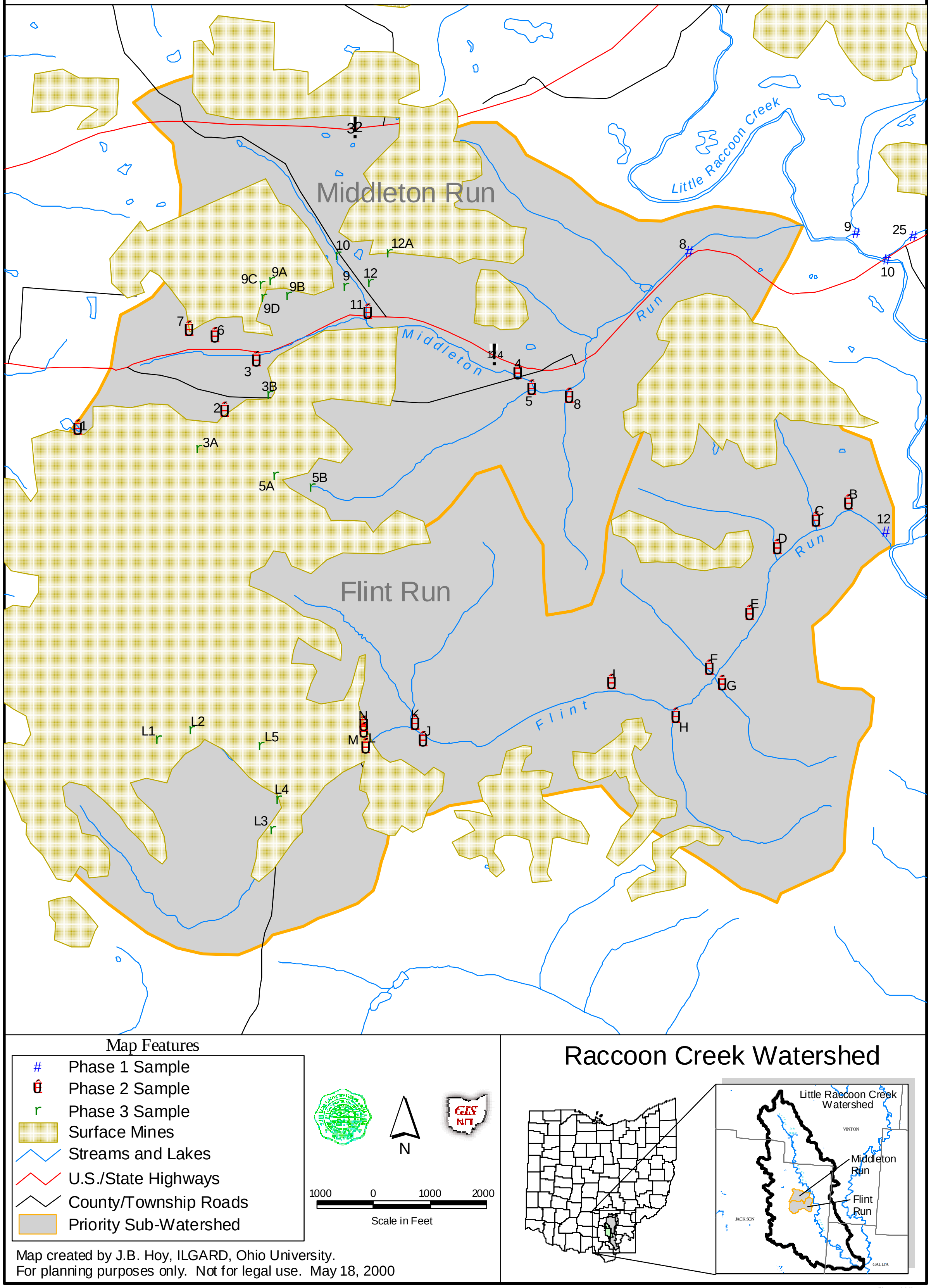
NAME:	Middleton Run
LOCATION:	Milton Township, Jackson County, Ohio
QUADRANGLE:	Mulga (S 15, 16, 21 and 22), Wellston (S 17, 18, 19 and 20)
DRAINAGE AREA:	2.28 mi^2

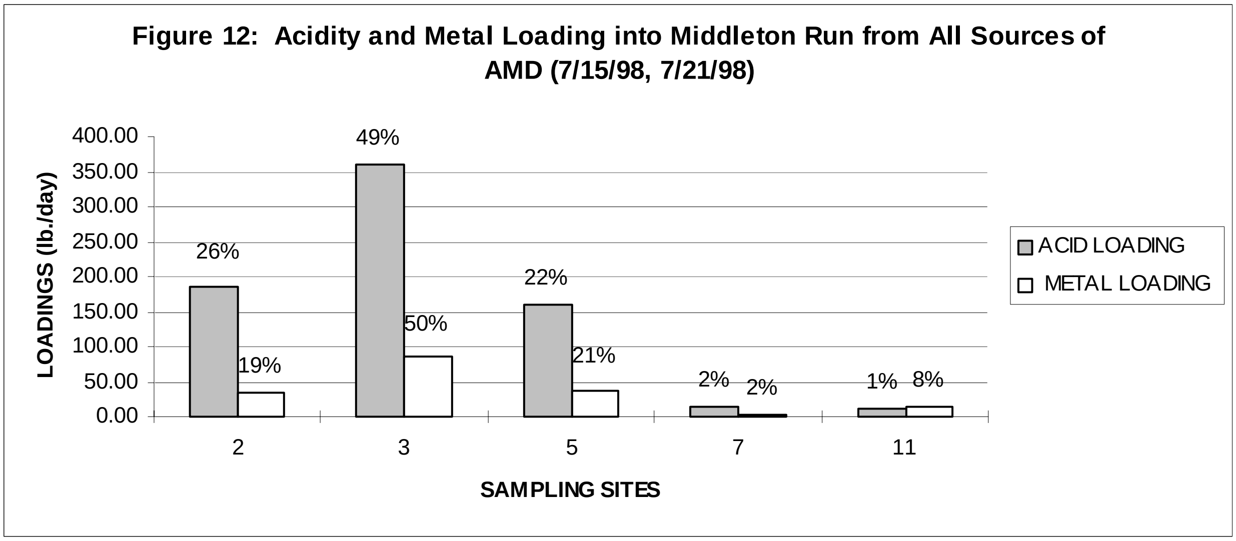
Overview

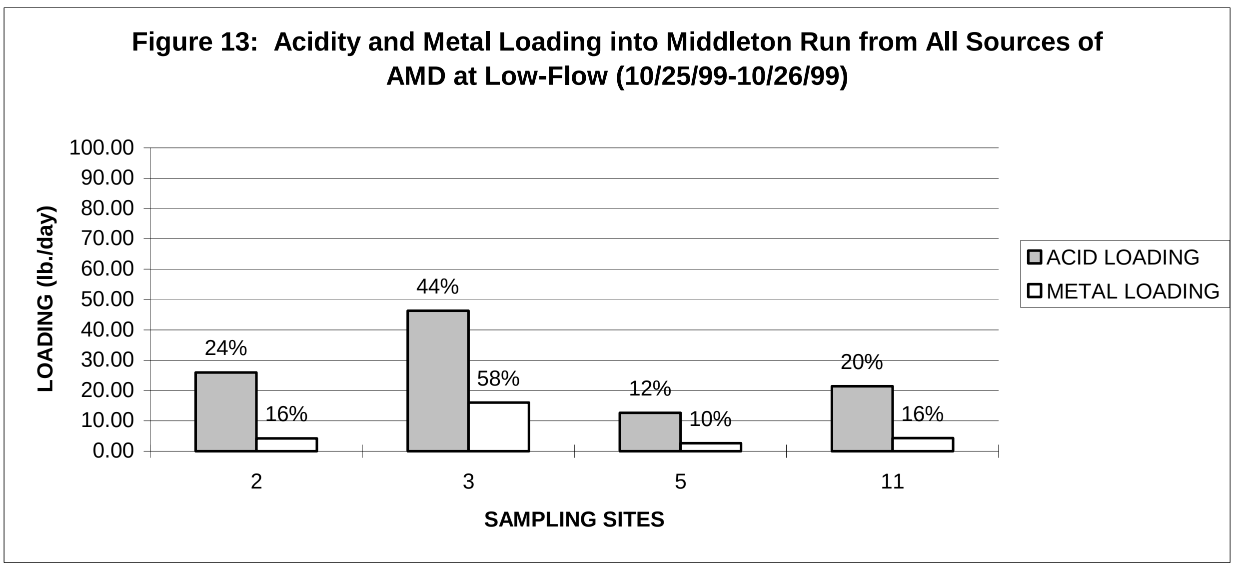
Middleton Run sub-watershed is affected by abandoned deep-mines, abandoned strip-mine lands and associated unreclaimed coalmine spoil (Figure 11). Abandoned surface mines affect 63% of the watershed and abandoned subsurface mines affect 5% (Childress, 1985). The environmental impact of Middleton Run on Little Raccoon Creek was established by comparing the water quality of the main tributaries entering Little Raccoon Creek during a high-flow period (3/24/98-3/25/98) and the primary acid-mine drainage (AMD) affected tributaries during a low-flow period (6/22/99-6/24/99) (Appendix 1, Table 5). During Phase I sampling it was determined that at a high-flow period, Middleton Run contributed 43% of the acidity loading and 44% of the metal loading in the Little Raccoon Creek watershed. Due to unseasonable drought conditions at the time of the low-flow monitoring, Middleton Run was not flowing (Figures 6 and 7). The confluence of Middleton Run has exhibited acidity loading of 115 to 4700 lb/day and metal loading of 23 to 975 lb/day. Based on available water quality data, Middleton Run is the second largest contributor of acid-mine drainage (AMD) in the Little Raccoon Creek watershed.

Phase II water sampling occurred in the typically low-flow period between 7/15/98 and 7/21/98, and 10/25/99 through 10/26/99. The purpose of this second phase of water sampling was to determine which tributaries entering the Middleton Run mainstem contribute AMD. It is important to note that this phase of sampling does not include a high-flow sample. During each canvas, it was determined that 5 of the 9 Middleton Run tributaries contributed significant AMD. The largest AMD contributors during each of the sampling periods included sites 2, 3, 5, and 11 (Figure 12, Figure 13). Site 2 contributed 26% of the acidity loading and 19% of the metal loading in Middleton Run in July of 1998 and 24% of the acidity loading and 16% of the metal

Figure 11: Middleton Run And Flint Run Sub-Watersheds







loading at a low-flow period in October of 1999. Site 2 has exhibited acidity loading of 26 to 187 lb/day and metal loading of 4 to 34 lb/day. Site 3 contributed 49% of the acidity loading and 50% of the metal loading in Middleton Run in July of 1998 and 44% of the acidity loading and 58% of the metal loading at a low-flow period in October of 1999. Site 3 has exhibited acidity loading of 46 to 360 lb/day and metal loading of 16 to 87 lb/day. Site 5 contributed 22% of the acidity loading and 21% of the metal loading in Middleton Run in July of 1998 and 12% of the acidity loading and 10% of the metal loading at a low-flow period in October of 1999. Site 5 has exhibited acidity loading of 13 to 160 lb/day and metal loading of 3 to 37 lb/day. Site 11 contributed 1% of the acidity loading and 8% of the metal loading in Middleton Run in July of 1998 and 20% of the acidity loading and 16% of the metal loading at a low-flow period in October of 1999. Site 11 has exhibited acidity loading of 10 to 21 lb/day and metal loading of 4 to 15 lb/day. Site 3 is the largest contributor of AMD in the Middleton Run sub-watershed followed by sites 2, 5 and 11 respectively.

Phase III water sampling occurred between 10/25/99 and 10/26/99 to locate point sources for AMD-generation in each of the affected tributaries. It is important to note that this phase of sampling does not include a high- and low-flow sample. During this sample period, the Salem Road Seep (site 3B) contributed 29% of the acidity loading and 41% of the metal loading in Middleton Run. Site 2 contributed 16% of the acidity loading and 11% of the metal loading. Site 5B contributed 20% of the acidity loading and 20% of the metal loading. Site 9 contributed 18% of the acidity loading and 16% of the metal loading. Site 12A contributed 12% of the acidity loading and 8% of the metal loading. Site 3B is the largest contributor of AMD in the Middleton Run sub-watershed followed by sites 2, 5B, 9 and 12A respectively. These sources are described in more detail in the following sections.

Site 2 - Salem Road Seeps

Location/Access: Site 2 is located along Salem Road just west of Site 3B and east of St. Rt. 124 in Milton Township. Tributary 2 is the first stream to cross Salem Road when entering from the west. The site is located on the Wellston quadrangle in the north-central portion of section 20. This site is accessible only by foot travel.

Site Description: Site 2 consists of a small area of diffuse seeps, which during low-flow periods, combine to form the headwaters of this tributary. During high-flow periods, the tributary receives additional upstream drainage from the Broken Aro mine site. Site 2 is believed to be associated with abandoned deep-mines and sub-surface drainage from Lake Rice. Active subsidence from room and pillar mining can be observed from Lake Rice to the active seeps.

The abandoned deep mine is not listed on the USGS Abandoned Underground Mine maps. It is believed that leakage from Lake Rice is entering the abandoned mine and discharging at the seep area. No abandoned coalmine refuse piles were identified with this site.

Water Quality: Site 2 has exhibited acidity loading ranges of 26 to 187 lb/day and metal loading ranges of 5 to 25 lb/day. Site 2 is the only known source of AMD generation in this tributary and is believed to be the second largest AMD-generator in the Middleton Run sub-watershed. This site has not been fully characterized in terms of high- and low-flow chemical loading.

Recommendation: Site 2 is a Little Raccoon Creek priority treatment site and recommendations for treatment will be covered in section 1 under *Proposed Treatment*. It is suggested that a monthly monitoring schedule of filtered Group II samples be initiated before beginning any treatment programs in order to fully characterize the acidity and metal loading ranges. Sampling sites should include the confluence of the site 2 tributary and the headwaters of the site 2 tributary.

3B - Salem Road Seeps

Location/Access: Site 3B is on Salem Road just west of the sawmill property in Milton Township. Site 3B is located on the second tributary to cross Salem Road when entering from the west. The site can be found on the Wellston quadrangle in the north-central portion of section 20. This site is accessible by foot travel and limited vehicle traffic. The mine complex should not be accessed by vehicle during wet periods.

Site Description: Site 3B is believed to be associated with drainage from the Broken Aro mine complex, strip mine lands, which have been abandoned since the late 1950's and a last-cut lake. Large quantities of unreclaimed mine spoil dominate the mine complex. Drainage off the site is divided between overland flow off the unreclaimed spoil and sub-surface leakage from Lake Rice (site 3A). It is believed that leakage from Lake Rice is discharging at a single seep along Salem Road. The lake appears to be acting as a storage basin for AMD products captured as runoff during precipitation events and released over time to the Salem Road seep. It is also believed that sub-surface flow leaving Lake Rice continues to degraded as it moves through the mine spoil to Salem Road. During water sampling in October 1999, the Broken Aro site was not discharging, but the seep on Salem Road was providing the majority of the discharge to the adjacent tributary. An alternative explanation is that abandoned deep-mine site JKN-160 is also providing recharge to the seep. Further investigation of this hydrologic phenomenon is recommended.

Water Quality: Site 3B has exhibited acidity loading ranges of 87 to 360 lb/day and metal loading ranges of 16 to 46 lb/day. Site 3B is the only known source of AMD generation in the adjacent tributary. Site 3B is the largest AMD generator in the Middleton Run sub-watershed. This site has not been fully characterized in terms of high- and low-flow chemical loading.

Recommendation: Site 3B is a Little Raccoon Creek priority treatment site and recommendations for treatment will be covered in section 1 under *Proposed Treatment*. It is suggested that a monthly monitoring schedule of filtered Group II samples be initiated before beginning any treatment programs in order to fully characterize the acidity and metal loading ranges. Sampling sites should include the confluence of tributary 3, site 3B, site 3A (Lake Rice), and any runoff from the Broken Aro mine complex.

Site 5B - Lake Farley Drainage

Location/Access: Site 5B is located directly behind the sawmill on Salem Road. This site is located on the Wellston quadrangle in the east-central portion of section 20 and is only accessible by foot travel.

Site Description: Site 5B is associated with leakage from the Lake Farley tailings dam (site 5A). Site 5B consists of an area of diffuse seeps along the banks of the tributary 5 valley and at the base of the tailings dam. Lake Farley is located down hill from the Broken Aro mine complex and receives periodic runoff from the site. It is believed that Lake Farley is acting as a storage basin for AMD-products captured as runoff during precipitation events and released over time to site 5B. It is also believed that sub-surface flow leaving Lake Farley continues to degrade as it moves through the mine refuse materials to site 5B.

Water Quality: Tributary 5 has exhibited acidity loading ranges of 13 to 160 lb/day and metal loading ranges of 3 to 37 lb/day. During a low-flow period, site 5B has exhibited acidity loading of 13 lb/day and metal loading of 2 lb/day. Site 5B is the only known source of AMD generation in tributary 5. This site has not been fully characterized in terms of high- and low-flow chemical loading.

Recommendation: Continuous monitoring is recommended in tributary 5 for design purposes. The purpose of a continuous monitoring program is to capture high- and low-flow conditions and identify a range of acidity and metal loadings. The limited water quality information presently available for this tributary may underrate the impact of the point source(s) and warrant an upgrade in status to a priority treatment site. Monthly monitoring should include filtered Group I samples until reasonable high- and low-flow conditions have been identified after which a reassessment can be made of the site's impact upon the sub-watershed. It is recommended that water sampling include site 5 (confluence of tributary 5), site 5A (Lake Farley), and site 5B.

Site 9 - Hiram West Road Project

Location/Access: Site 9 is located on the Sands Hill Coal Company strip mine land along Hiram West Road in Milton Township. This site is located on the Wellston quadrangle in the southern corner of section 17. The site is accessible by vehicle provided that permission is granted from Sands Hill Coal Company to open the company gate. Please contact Brenda Weber at the Hamden Office for access 740-384-4211.

Site Description: Site 9 is a partially reclaimed strip-mine complex, but abandoned deep mines have been documented during recent surface mining operations. It is important to note that no deep-mines are listed on the USGS Abandoned Underground Mine maps. Reclamation activities were conducted at the site by Sands Hill Coal Company and included covering the mine spoil with Bypro®, a paper mill sludge product, and grass seeding. It is believed that AMD-generation at the site is due to the abandoned underground mine seeps, which discharge into tributary 9. The site consists of a series of diffuse seeps along the east bank of tributary 9. Most of the seeps occur near the lower storm-water pond (site 9A), sites 9B and 9C (Figure 11). An AMD-consultant is presently under contract by the Ohio Department of Natural Resources to study remediation options for this mine site. A second source of stream degradation may be due to a landfill site west of the mine complex, which drains into tributary 9. Site 9D marks an area of diffuse seeps that appear to be draining from the landfill. Water quality sampling in October 1999 showed AMD-products present in the stream draining from site 9D. The Ohio EPA is monitoring water quality at the landfill site.

Water Quality: Site 9 has exhibited acidity loading ranges of 29 to 44 lb/day and metal loading is about 6 lb/day. The Sands Hill mine site is the only source of AMD generation in tributary 9. Site 9 is the largest generator of AMD into tributary 11. This site has not been fully characterized in terms of high- and low-flow chemical loading.

Recommendation: Continuous monitoring is recommended at site 9 to capture high- and low-flow conditions and identify a range of acidity and metal loadings. The limited water quality information presently available for this site may underrate the impact of the site as a significant point source. Monitoring should begin with a monthly schedule of filtered Group I samples until reasonable high- and low-flow conditions have been identified. Sampling should include site 9 (confluence of tributary 9), site 9B and site 9C. The sampling schedule for site 9D should include organic contaminants because of the nearby landfill. Funding has been secured to design and construct a remediation project in 2001 at site 9.

Site 12A - Middleton Run Deep Mine Site

Location/Access: Site 12A is located near the junction of St. Rt. 124 and Hiram West Road. It is the first stream draining into tributary 11 when entering Hiram West Road from the south. This site is located on the Wellston quadrangle in the west-central portion of section 16 and is only accessible by foot travel.

Site Description: Site 12A is believed to be associated with abandoned deep mine JKN-123. The mine entrance is not visible, but a large bog area at the valley head marks the most probable location of the entrance. This site drains into tributary 11 just above the confluence to the Middleton Run mainstem.

Water Quality: Site 12A has shown acidity loading of 19 lb/day and metal loading of 3 lb/day. This site is the only known source of AMD generation in tributary 12. This site has not been fully characterized in terms of high- and low-flow chemical loading.

Recommendation: Continuous monitoring is recommended at site 12A to capture high- and low-flow conditions and identify a range of acidity and metal loadings. The limited water quality information presently available for this site may underrate the impact of the site as a significant point source. Monitoring should begin with a monthly schedule of filtered Group I samples until reasonable high- and low-flow conditions have been identified. At that time, a reassessment can be made of the impact this site has upon the sub-watershed. Water sampling should include site 12 (confluence of tributary 12) and site 12A.

Site 11 - Confluence Of Tributary 11

Location/Access: Site 11 is located near the junction of St. Rt. 124 and Hiram West Road. The stream crosses underneath St. Rt. 124 via a cement culvert. This site is located on the Wellston quadrangle in the southwest corner of section 16.

Site Description: Site 11 is the confluence of tributary 11 to the mainstem of Middleton Run. The importance of site 11 is that it drains tributaries 9, 10, and 12. Tributary 10 has not previously been mentioned because its AMD-contribution has shown to be minimal. Tributary 10 begins at the confluence of tributary 9, which constitutes the headwaters for tributary 11. It is believed tributary 10 is receiving drainage from deep mine JKN-123. Visual inspection of the stream shows that degradation starts in the vicinity of a mailbox marked 372 Hiram West Road. Geochemical meters show very little degradation occurring upstream of this location. Tributary 10 has shown an acidity loading of 7 lb/day and metal loading of 2 lb/day.

Water Quality: Tributary 11 has exhibited acidity loading of 10 to 21 lb/day and metal loading of 4 to 15 lb/day. Tributary 11 is the fifth largest AMD-producer in the Middleton Run sub-watershed.

Recommendation: Continued water quality monitoring of site 11 is recommended to insure that increased degradation in any of the upstream tributaries will be noted. It is recommended that monitoring include a quarterly schedule of filtered Group I samples. It is also recommended that water sampling include site 11 (confluence of tributary 11) and site 10.

Summary of Potential Treatment Sites: Middleton Run

Site	Recommendation	Site Identification
2	Treatment	Salem Road Seeps
3B	Treatment	Salem Road Seeps
5B	Treatment	Lake Farley Drainage
9	Treatment	Hiram West Road Project
12A	Monitor	Middleton Run Deep Mine Site
11	Monitor	Confluence Of Tributary 11

FLINT RUN

NAME:	Flint Run
LOCATION:	Milton Township, Jackson County, Ohio
QUADRANGLE:	Wellston and Mulga (T9N, R17W, S28&29)
DRAINAGE AREA:	3.4 mi^2

Overview

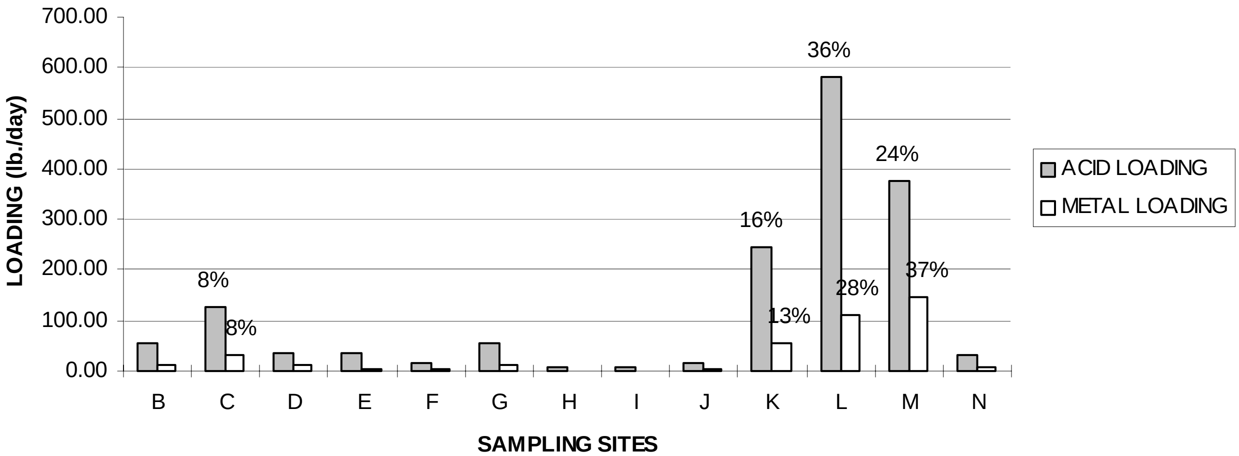
The Flint Run sub-watershed is affected primarily by abandoned strip mine drainage and associated unreclaimed coal refuse piles (Figure 11). The environmental impact of Flint Run on Little Raccoon Creek was established during Phase I sampling by comparing the water quality of the main tributaries entering Little Raccoon Creek during a high-flow period (3/24/98-3/25/98) and the primary AMD-affected tributaries during a low-flow period (6/22/99-6/24/99) (Figures 6 and 7; Appendix 1, Table 6). At a high-flow period, Flint Run contributed 42% of the acidity loading and 28% of the metal loading in the Little Raccoon Creek watershed. At a low-flow period, Flint Run contributed 51% of the acidity loading and 51% of the metal loading in the Little Raccoon Creek watershed. Tributaries sampled during the low-flow canvas included Flint Run, Greasy Run, Goose Run, Middleton Run, Mulga Run, and the 124 Seep project area. Since the spring of 1985, the confluence of Flint Run has exhibited acidity loading ranges of 500 to 28,000 lb/day and metal loading of 80 to 3000 lb/day. Since February 1997, the average value for acidity loading has been 2000 lb/day and the average metal loading has been 400 lb/day. Based on available water quality data, Flint Run is the largest contributor of acid-mine drainage (AMD) in the Little Raccoon Creek watershed.

Recent hydrologic and geochemical investigations (Laverty, 2000) have indicated that 90% of the AMD generated within the Flint Run basin can be attributed to a 240-acre site in the headwaters. The site is a former coal preparation facility and mine-tailings dump operated by the Broken Aro Coal Company. The coal preparation facility is a part of a larger strip-mine complex that was active during the 1950's. It is estimated that between 1952 and 1956 the preparation plant processed approximately 400,000 tons of coal annually. The preparation plant separated marketable coal from wastes such as shale, coal fines, low-grade and non-marketable coal, and other mineral impurities such as pyrite. Prior to mining, the mine-tailings dump was an incised valley, and waste material was disposed of in either coal screening dumps in the upper valley or piped to a series of slurry impoundments in the lower valley. The Mead Paper Corporation purchased the Broken Aro coal preparation facility and the mine-tailings dump in 1962 for timber reserves. Beginning in October of 1984, Mead began a five-phase reclamation project at the site, which included grading the site, re-routing drainage channels, applying a paper-mill sludge product for revegetation and buffering of the toxic tailings. Reclamation of the site was completed in the winter of 1987.

An investigation of the Broken Aro mine spoil is underway by Ohio University master's candidate Brett Laverty and will culminate with a master's thesis in August 2000. The main focus of this investigation is to characterize the groundwater flow system, especially the relationship between on-site strip-mine lakes and the groundwater regime, the geology and spatial extent of the mine tailings, and the extent and magnitude of AMD production. Long-term remediation goals are to reduce the acidity and metal loadings to Flint Run and to Little Raccoon Creek. The Broken Aro investigation is a combined effort of the Ohio Department of Natural Resources Division of Mineral Resources, Raccoon Creek Improvement Committee, Ohio University, West Virginia University's National Mine Land Reclamation Center, Mead Paper Company and Ohio Environmental Protection Agency Southeast District Office.

Phase II water sampling occurred between 5/24/98 and 5/25/99 (Figure 14). The purpose of this second phase of water sampling is to determine which tributaries entering the Flint Run mainstem contribute a significant amount of AMD. During the canvas, it was determined that tributaries K, L and M contributed the largest percentage of AMD. Tributary K contributed 16% of the acidity loading and 13% of the metal loading in Flint Run. Tributary K has exhibited acidity loading ranges of 160 to 250 lb/day and metal loading of 30 to 50 lb/day. Tributary L contributed 36% of the acidity loading and 28% of the metal loading in Flint Run. Tributary L has exhibited acidity loading ranges of 4700 lb/day to 85 lb/day and metal loading of 24 to 240 lb/day. Tributary M contributed 24% of the acidity loading and 37% of the metal loading in Flint Run. Tributary M has exhibited acidity loading ranges of 45 to 1700 lb/day and metal loading of 25 to 650 lb/day. Based on available water quality data, tributary L is the largest contributor of AMD in the Flint Run sub-watershed followed by tributaries M and K respectively.

Figure 14: Acidity and Metal Loading into Flint Run from All Sources (5/24/99-5/25/99)



Phase III water sampling occurred on 11/19/99 to locate point sources for AMD-generation in each of the affected tributaries. The tributary draining site L5 produced 83% of the acidity loading and 79% of the metal loading in tributary L. Site L2 produced 17% of the acidity loading and 21% of the metal loading in tributary L. Sites L5, L2, and tributary K have not been characterized in terms of high- and low-flow loading. Based on available water-quality data, site L5 and tributary M are the largest contributors of AMD in the Flint Run sub-watershed, followed by tributary K and site L2[3]. These sources are described in more detail in the following sections.

Tributary L - Lake Milton Drainage

Location/Access: Tributary L is a part of the Broken Aro investigation site located in Milton Township. The tributary is located on the Wellston Quadrangle in the southeast portion of section 29. The majority of the tributary can be accessed by vehicle. Mead Paper Company in Chillicothe, Ohio owns the majority of the property surrounding the tributary. The individual in charge of the abandoned mine lands for Mead Paper Company is Steve Mathy (740-772-3472).

[3] In light of the severity of acid mine drainage pollution emanating from Flint Run, the Ohio Division of Mineral Resources has set aside funding to begin engineering design plans in 2001 for a future remediation project.

Site Description: Tributary L is a manmade drainage that consists of two major branches: a western branch and a northern branch (Figure 11). The western branch has its origin in Lake Milton, which is labeled site L1. Lake Milton is a large strip pit lake, which is held back by an unstable mine-tailings dam. Site L2 is at the foot of the tailings dam and characterizes the discharge, which is undercutting the dam by means of a piping complex. There are no other sources of influx to the western branch of tributary L. The northern branch drains a portion of the Broken Aro investigation site and is labeled site L5. There is no other source of influx to the northern branch of tributary L. Shortly after the two branches merge the stream drains into Hothouse Lake, which is labeled site L3. The confluence of the stream into Hothouse Lake is labeled site L4. Hothouse Lake is a strip pit lake that is supported by a mine-tailings dam. The upper section of tributary L is the only source of influx into Hothouse Lake. In the southeast corner of the lake a man-made culvert diverts flow from the lake to the Flint Run mainstem. The confluence of tributary L with Flint Run is labeled site L.

Water Quality: Site L has exhibited acidity loading of 210 to 4700 lb/day and metal loading of 24 to 240 lb/day. Site L5 has exhibited acidity loading of 270 lb/day and metal loading of 80 lb/day. Site L2 has exhibited acidity loading of 60 lb/day and metal loading of 20 lb/day.

Recommendation: Site L5 is a Little Raccoon Creek priority treatment site and preliminary recommendations for treatment will be covered in section 1 under *Proposed Treatment*. Additional treatment recommendations will follow upon completion of a master's thesis by Ohio University master's candidate Brett Laverty. A range of acidity and metal loadings will be included in the final investigation.

Tributary M - Broken Aro Investigation Site

Location/Access: Tributary M drains the Broken Aro investigation site located in Milton Township. The tributary is located on the Wellston Quadrangle in the southeast portion of section 29. A large part of the tributary can be accessed by vehicle through the use of access roads. Extreme caution should be observed when driving on the coal tailings material. Poor conditions can develop rapidly when the material becomes wet. Mead Paper Company in Chillicothe, Ohio owns a majority of the property surrounding the tributary. The individual in charge of the abandoned mine lands for Mead Paper Company is Steve Mathy (740-772-3472).

Site Description: Tributary M is a part of an ongoing study of the abandoned Broken Aro mine-tailings dumpsite. Tributary M is a result of Mead Paper's reclamation activities and it effectively captures the majority of the base flow and runoff from the Broken Aro investigation site. The study proposes that last cut, strip-pit lakes (Lake Laverty), located at a higher elevation surrounding the mine spoil are draining freely under gravity through the mine spoil and exiting a distance down the valley. Water quality analysis has shown that this water increasingly degrades as it moves down the valley through the toxic mine tailings. The components of degradation include a lowering of the pH, an increase in acid production and an increase in the concentration of dissolved metals.

Water Quality: Tributary M has exhibited acidity loading ranges of 45 to 1700 lb/day and metal loading of 25 to 650 lb/day. A large database is presently under construction to characterize the water quality of tributary M in terms of high- and low-flow chemical loading.

Recommendation: Tributary M is a Little Raccoon Creek priority treatment site and preliminary recommendations for treatment will be covered in section 1 under *Proposed Treatment*. Additional treatment recommendations will follow upon completion of a master's thesis by Ohio University master's candidate Brett Laverty. A range of acidity and metal loadings will be included in the final investigation.

Tributary K - Lake Latrobe Drainage

Location/Access: Tributary K is in the Broken Aro strip-mine complex located in Milton Township. The tributary is located on the Wellston Quadrangle in the southeast portion of section 20. A majority of the tributary has extremely limited access and can only be reached by foot travel. Lake Latrobe has limited access to vehicular traffic. Mead Paper Company in

Chillicothe, Ohio owns most of the property surrounding the tributary. The individual in charge of the abandoned mine lands for Mead Paper Company is Steve Mathy (740-772-3472).

Site Description: Tributary K enters the Flint Run mainstem below the Broken Aro investigation site and consists of a western branch and an eastern branch. The western branch has its origin in Lake Latrobe located within the Broken Aro strip-mine complex. Lake Latrobe is a large strip-pit lake supported by a mine-tailings dam. Discharge from the lake infiltrates through the tailings material of the dam and discharges at the base of the dam. A large amount of toxic mine spoil lines the perimeter of the lake. It is believed that AMD-products are generated during precipitation events as runoff interacts with the toxic mine spoil surrounding the lake. Once the AMD-products are generated they are stored in the lake and released over time at the base of the dam. It is also proposed that water infiltrating the mine-tailings dam degrades as it infiltrates through toxic mine spoil. The eastern branch of tributary K also has its origin in the Broken Aro strip-mine complex. Drainage in this section consists primarily of runoff and baseflow from the mine site.

Water Quality: Tributary K has exhibited acidity loading ranges of 160 to 250 lb/day and metal loading of 35 to 50 lb/day. This site has not been fully characterized in terms of high- and low-flow chemical loading.

Recommendation: Tributary K is a Little Raccoon Creek priority treatment site and recommendations for treatment will be covered in section 1 under *Proposed Treatment*. It is suggested that a monthly monitoring schedule of filtered group 2 samples be initiated before instituting any treatment programs in order to fully characterize the acidity and metal loading ranges. Sampling sites should include the confluence of tributary K, Lake Latrobe and the western and eastern forks of the mainstem.

Summary of Potential Treatment Sites: Flint Run

Tributary	Recommendation	Site Identification
L	Treatment	Lake Milton Drainage
M	Treatment	Broken Aro Study Site
K	Treatment	Lake Latrobe Drainage

GOOSE RUN

NAME: Goose Run
LOCATION: Bloomfield Township, Jackson County, Ohio
QUADRANGLE: Mulga (S 3, 4, and 10)
DRAINAGE AREA: 1.31 mi^2

Overview

Goose Run sub-watershed (Figure 15) is affected primarily by abandoned deep-mines with some abandoned strip mine drainage and associated unreclaimed coal refuse piles. During Phase I sampling the environmental impact of Goose Run on Little Raccoon Creek was established by comparing the water quality of the main tributaries entering Little Raccoon Creek during a high-flow period (3/24/98-3/25/98) and the primary acid-mine drainage (AMD) affected tributaries during a low-flow period (6/22/99-6/24/99) (Figures 6 and 7; Appendix 1, Table 7). At a high-flow period, Goose Run contributed 4% of the acidity loading and 3% of the metal loading in the Little Raccoon Creek watershed. At a low-flow period, Goose Run contributed 29% of the acidity loading and 26% of the metal loading in the Little Raccoon Creek watershed. Tributaries sampled during the low-flow canvas included Flint Run, Greasy Run, Goose Run, Middleton Run, Mulga Run, and the 124 Seep project area. The confluence of Goose Run has exhibited acidity loading ranges of 300 to 1100 lb/day and metal loading of 50 to 250 lb/day. Based on available water quality data, Goose Run is the fourth largest contributor of acid-mine drainage (AMD) in the Little Raccoon Creek watershed.

Figure 15: Goose Run Sub-Watershed