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8.0 Evaluation of Postmining Values and Functions of Stream, Wetlands, and Riparian Areas

8.1 Study Objectives

The purpose of this portion of the study is to assess the effects of land surface subsidence associated with longwall mining on water resources. In particular, aquatic habitats and riparian-wetland communities in mined and unmined reaches of Robinson Fork will be characterized and compared where appropriate. Aquatic habitats were classified as channel units (CU) to facilitate comparison of physical features and biological communities.

8.2 Background

The effects of longwall mining on water resources are not well documented or understood. Relatively little literature exists that compares geomorphic and hydrologic alterations in subsided and reference reaches of streams in areas where longwall mining is practiced. Sidle, et al. (2000) examined the effects of subsidence on a 700-meter reach of Burnout Creek in Utah and found that surface subsidence ranged from 0.3 to 1.5 meters 1 year following longwall mining in this mountain stream. Their findings indicated that the subsided reach had (1) extent glides; (2) increases in pool length, numbers, and volume; (3) increase in median particle diameter of bed sediment in pools; and (4) some constriction in channel geometry. They concluded that most changes appeared to be temporary in this reach of Burnout Creek and that the stream recovered to approximate premining conditions within a year.

Sidle, et al. (2000) demonstrated that subsidence affects stream hydrology and morphology, but they did not examine any associated impacts on biotic communities. Although Burnout Creek may have recovered to near premining conditions in a geomorphic/hydrologic sense, biological communities were not assessed and, therefore, any short- or long-term changes in benthic macroinvertebrate and fish communities remain unknown.

The lack of empirical data and a clear demonstration of subsidence effects from longwall mining on physical and biological resources remain an area of needed research. Therefore, this study will examine both the physical and biological components of a subsided (mined) and reference (unmined) reach individually and in association with one another to determine the effects, if any, of subsidence from longwall mining on a low-gradient, third order, warm water stream on the Appalachian Plateau in southwestern Pennsylvania.

8.3 Channel Classification

To evaluate the effects of subsidence on Robinson Fork, we chose to characterize and compare stream habitats through a habitat classification system applied at the reach level. Reaches are stream segments (1 to 10 kilometers long) where gradient, valley width, and channel morphology are relatively homogenous and distinct from other reaches that influence the development and distribution of in-stream habitat. The purpose of habitat classification is to group physical features of streams by common factors (ranges of depth and velocity; and substrate type) that influence biological processes (Peterson and Rabeni, 2001) and to have an approach where habitat units are consistently recognizable by position relative to the main current during normal (low-flow) base conditions (McKenney, 1997). While there are numerous stream habitat classification systems (Bain and Stevenson, 1999), the application of a system should be based on the purpose(s) of a particular investigation and tailored to the temporal and spatial scales associated with that research or management question. In this case, panel dimensions, extent of undermined areas within the watershed, stream size and location, and available budget/time frame dictated that a reach level investigation was appropriate. Because this research is targeted at the reach/subreach level, we chose to avoid large-scale habitat/stream channel classification systems.

Instead, we opted to use a habitat classification system developed and validated in the Ozark Plateau (Missouri, USA) based on CUs that is applicable to southwestern Pennsylvania, and this research project in particular (McKenney, 1997; Peterson and Rabeni, 2001; Peterson, pers. comm., 2001). Peterson and Rabeni (2001) define CUs as "relatively discrete morphological stream features that are formed as the result of fluid mechanical process and complex interactions between a stream and its surrounding watershed that occur during high flow events." CU types (e.g., pool, riffle, race, and glide) are unique entities that are combinations of physical characteristics (depth, velocity, and substrate type) that provide the local habitat context for benthic macroinvertebrates and fish that utilize streams for part or all of their life cycle. CUs operate at a scale that is directly related to stream-fish life-history requirements and have been shown to be effective in predicting stream-fish communities in Ozarkian streams (Peterson and Rabeni, 2001). They used a hierarchical CU classification system with 4 levels containing a total of 11 habitat types (Table 8-1) based on CU position relative to the main channel at base flow, gradient, and how the unit was formed (morphology).

Table 8-1

Channel Unit Classification as Developed by Peterson and Rabeni (2001) for Ozarkian Streams

Level	CU Type	Morphology (formation process)
Scour	bluff pool lateral pool obstruction pool	Low gradient, formed from high flow convergent scour; located in main current and contains thalweg.
Slackwater	forewater backwater unvegetated edgewater vegetated edgewater	Low gradient, formed from high flow scour across point-bar and low angle bar deposition; located outside main flow along channel margins.
Transition	race glide	Transition areas between pools and riffles located in main current; races form during high flow events from flow convergence downstream of riffles and glides. Glides form from bedload deposition and generally contain no thalweg.
Riffle	low gradient high gradient	Located in main current; low gradient riffles form during high flow events at channel bend inflection points by instability between flow and sediment transport. High gradient riffles form during high flow events at inflection points downstream from a large supply of coarse bed material.

Ozarkian stream CUs are similarly described in more detail by McKenney (1997). This additional information is useful as field classification of CUs is subjective and can be tedious depending on observer experience and flow stage. Those CUs applicable to this study are listed in Table 8-2 as adapted from McKenney (1997). Marginal units (referred to as slackwater units in Table 8-1) are omitted because there was a lack of CUs located outside the channel margin in Robinson Fork.

Table 8-2

Channel Units Descriptive Information as Adapted from McKenney (1997)

CU Type	General Morphology (low flow conditions) and other characteristics
Bluff pool	Located in main flow; low gradient; deep, cross section skewed toward outer bank; bank/bed material bedrock or boulders; flow impinges at an angle on bedrock walls creating scour conditions; coarse woody debris rare.
Lateral pool	Located in main flow; low gradient; deep, cross section skewed toward outer bank; bank/bed material sand – cobble; flow converges on alluvial bank at outside of bend (cut-bank); coarse woody debris common with localized deepening.
Obstruction pool	Located in main flow; low gradient; localized deepening around an obstruction (boulder, rootwad, tree) due to turbulence; variable cross section; bed material gravel to cobble; coarse woody debris common.
Glide	Located in main flow; low gradient; shallow to moderate depth, trapezoidal cross section; bed material sand – cobble; commonly symmetric and typically lacks thalweg; particle-size distribution poorly sorted; bedload deposition often against outer bank.
Alluvial riffle	Located in main flow; high gradient; wide, shallow depth, trapezoidal cross section; well sorted bed material consisting of gravel – cobble; particle size slightly less than flow depth.
Tributary riffle	Located in main flow; high gradient; shallow, U-shaped cross section; bed material cobble – boulder; particle size greater than flow depth; channel constriction caused by tributary input of coarse sediment that cannot be transported by main stem flow.
Bedrock riffle	Located in main flow; high gradient; shallow, trapezoidal cross section; steep to vertical bed elevation changes (may contain steps or shelves); particle size dominated by thin lag of boulder and cobble material; boulders partially emergent at low flow.
Race	Located in main flow; high gradient; moderate depth, U-shaped cross section; well sorted cobble to gravel bed material; cross section typically asymmetrical with prominent thalweg; located at flow convergence zones downstream of riffle.

CU identification and classification are typically conducted under low-flow conditions because habitats can change during high-flow events (i.e., bank full discharge) and taking in-stream measurements during high flows is impractical. Additionally, streams exhibit low-flow conditions during the majority of the year (approximately 90 percent in the Ozarks) and are considered as "normal" flow condition by biologists (McKenney, 1997). Biological data (benthic macroinvertebrates, and fish) are difficult to collect during higher discharges because of poor visibility (greater turbidity) and reduced efficiency of sampling procedures in high-velocity waters. Fish tend to utilize more habitat types during normal low-flow conditions (McKenney, 1997) with some species concentrating in specific CUs seasonally (Peterson, 1996; Peterson and Rabeni, 2001) while others utilize CUs for particular purposes including rearing, spawning, feeding, and cover.

The abundance of CUs varies among reaches depending on bedrock type, gradient, sediment size (bed load and wash load components), and location in the drainage network (i.e., longitudinal position). Human-induced influences including modified land use (logging, agriculture, commercial and residential development, mining, and roads) resulting in altered hydrologic regimes (i.e., short duration and steep hydrographs) and increased sediment delivery to streams can negatively alter CUs by widening stream channels and reducing pool area and depth. Direct physical impact (e.g., channelization) or the removal of coarse woody debris (snagging) reduces CU diversity and promotes the development of reaches that are relatively homogenous with reduced biotic integrity.

Subsidence associated with longwall mining cannot be expected to produce uniform results at the surface because differences exist in overburden composition and depth, coal seam thickness, geologic formations, panel aspect relative to the stream channel, locations of support pillars (i.e., gates), surface topography, and stream hydrologic aspects. Furthermore, other factors must be considered that influence channel morphology (stream order, stream gradient, land use, and longitudinal position) and their associated effect on habitat quantity/quality and ultimately biotic communities (species richness, abundance, and dominance).

It is hypothesized that if the physical characteristics of CUs (number, dimensions, and distribution) are modified following subsidence, then there may also be associated effects on stream biota that depend on specific CUs to meet their life history requirements resulting in reduced biological integrity. Reduction in biological integrity would be readily apparent if species richness and abundance decreases (habitat specialists/disturbance intolerants) and/or dominance of particular species increased (habitat generalists/disturbance tolerants) in subsided reaches. In addition, sensitive species with narrow habitat requirements adapted to specific CUs could be reduced or lost if reaches become more homogenous or dominated by specific CU types.

8.4 Study Area Description

Robinson Fork is a low-order (third), warm water stream originating near Claysville, Washington County, Pennsylvania that empties into the Enlow Fork of Wheeling Creek near the Pennsylvania-West Virginia state line (see Figure 8-1). The main stem is approximately 12 miles long and drains roughly 14,300 acres.

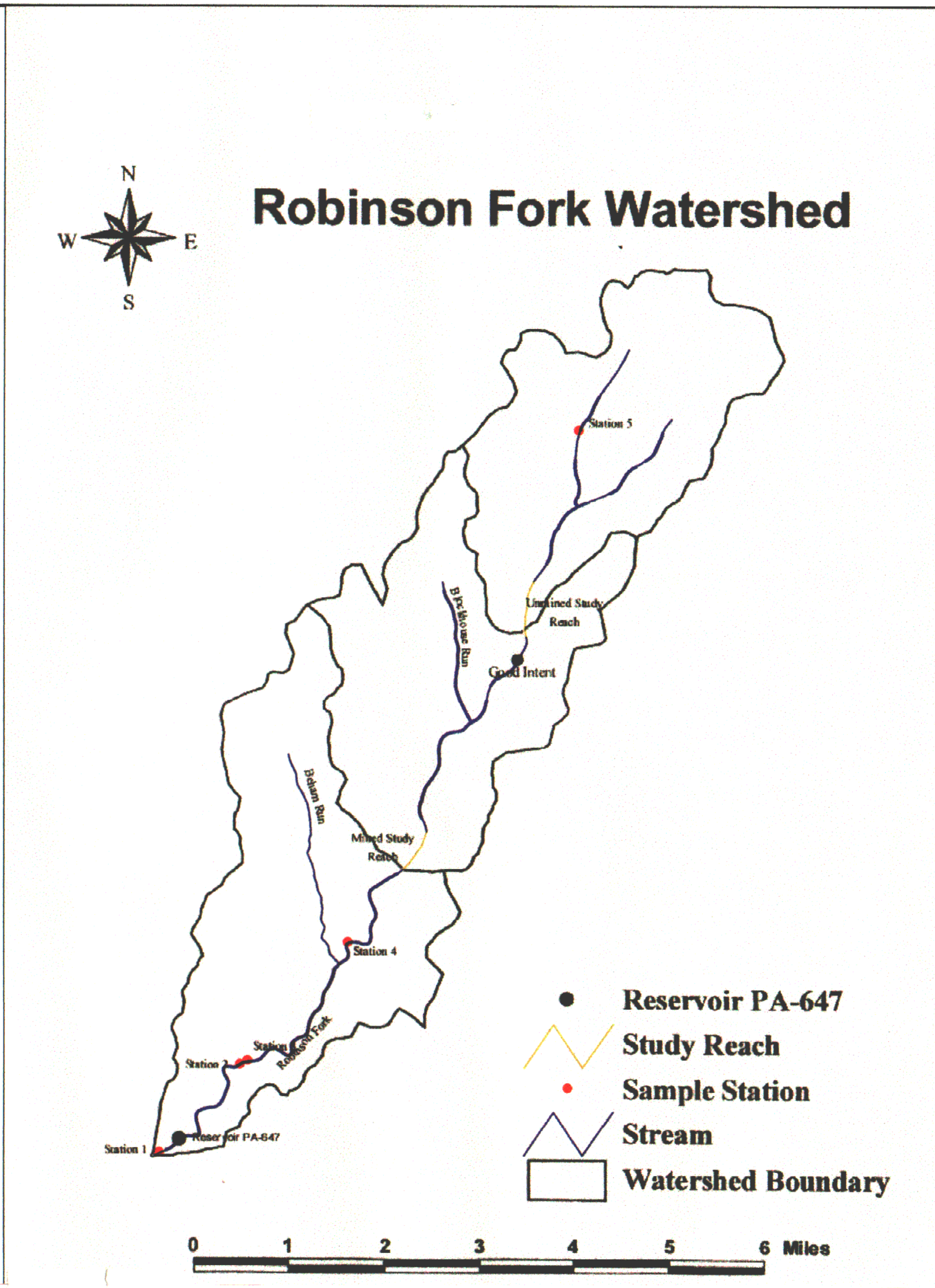


Figure 8-1. Robinson Fork Watershed, Washington County, Pennsylvania.

The Robinson Fork watershed is located in the Western Allegheny Plateau Ecoregion (Omernick, 1987). The Western Allegheny Plateau Ecoregion is a dissected plateau of horizontally bedded sandstone, siltstone, shale, and limestone characterized by steep, rugged terrain that is predominantly forested. Soils are formed from unglaciated sedimentary rock. Steep topography and high erosion potential limit land uses.

The northern portion of the Western Allegheny Plateau Ecoregion contains a forest cover type described as Appalachian Oak Forest with major species being white oak, black oak, northern red oak, scarlet oak, shagbark hickory, bitternut hickory, pignut hickory, mockernut hickory, basswood, American beech, tuliptree, black gum, sugar maple, red maple, black maple, white ash, American elm, slippery elm, cucumber tree, Eastern white pine, black walnut, black cherry, and eastern hemlock.

The Robinson Fork watershed is dominated by forested uplands mixed with hayland and pasture (see Figure 8-2). Haying occurs primarily on ridge tops. Several commercial farms (dairy and row crops) still operate along Robinson Fork in the headwaters. Stream bank damage is severe where cattle have direct access to Robinson Fork (Figure 8-3). Hillside pastures are located where slopes are less severe and can also be found on the narrow valley floor (Figure 8-4). Corn is grown in several locations directly adjacent to the stream channel.

Figure 8-2. Typical land use pattern found in the Robinson Fork watershed with hayland and pasture on ridgetops and forested areas on steeper hillsides and in ravines.

Figure 8-3. Stream bank damage associated with cattle access in headwaters of Robinson Fork.

Figure 8-4. Typical valley-floor view of Robinson Fork. Stream channel is located against hillside at left of photograph inside treeline.

8.5 Methods

An assessment of the physical characteristics of CUs and fish communities of two reaches of Robinson Fork in Washington County, Pennsylvania was conducted in June and July 2001. The reaches were selected in areas that would be representative of locations where longwall mining had previously occurred (hereafter referred to as mined) and where undermining has not yet occurred (hereafter referred to as unmined). The mined reach was situated downstream of the settlement of Good Intent. Mining occurred throughout this area from 1995 to 1996 at greater than 500 feet (Panels B7 and B8). The mined study reach for biological assessments was approximately 687 meters in length (see Figure 8-1).

The unmined study reach was located just upstream of Good Intent where the influence of housing and associated development activities was diminished. This reach for biological assessments was approximately 725 meters long.

8.5.1 Physical Habitat Measurement

An evaluation of CUs was conducted in both the mined and unmined reaches of Robinson Fork. The classification system used by Peterson and Rabeni (2001) was utilized to assign CU types but was simplified because of the limited size and diversity of habitats in Robinson Fork. CUs included pools (lateral and obstruction), riffles (not differentiated by gradient), races, and glides (see Figures 8-5 to 8-8). Identification and classification of CUs was achieved by the consensus of the two principal investigators (fishery biologists)[1].

Figure 8-5. Obstruction pool (left) and lateral pool (right) in mined reach of Robinson Fork. Note large boulder in center of channel in left photograph deflecting flow forming scour area and undercut bank.

[1] CUs identified for physical characterization and comparison and associated fish community comparison and analysis should not be assumed to be the same as units described elsewhere in this report.

Figure 8-6. Bedrock riffle in mined reach (left) and alluvial riffle in unmined reach (right) of Robinson Fork.

Figure 8-7. Glide in mined (left) and unmined (right) reaches of Robinson Fork.

Figure 8-8. Race located in unmined reach of Robinson Fork. Note severe bank failure and erosion along upper portion of photograph.

Research on Ozarkian streams indicated that mean depth and velocity could be used to characterize CUs (McKenney, 1997; Peterson and Rabeni, 2001). Habitat measurements were made during June when Robinson Fork was at base flow (low-flow conditions). Physical attributes were measured in CUs in both reaches. Mean current velocity (meters per second) and depth (meters) was calculated by averaging readings at 3 to 7 randomly selected transects in each CU. The number of transects was dependent upon the length of each CU with longer CUs having a greater number of transects. Velocity was measured with a Marsh-McBirney M2000 water current meter attached to a top wading staff. Velocity was measured at 0.6 depth where depth less than 0.65 meter. At depths exceeding 0.65 meter, the average of velocities at 0.2 and 0.8 depths was calculated.

Bank condition was assessed following USEPA Rapid Bioassessment Protocols (Barbour, et al., 1999). Bank stability (score for each bank) was taken at each transect where depth and velocity were measured and averaged for each CU. (Note: We departed from USEPA protocol by designating left and right bank locations by facing upstream).

CU channel capacity (channel flow status) was calculated as the difference between wetted width and active channel width for each transect within a CU. Transect measurements for each CU were averaged to determine the degree to which the channel substrate was covered with water and reported as a percentage of channel fill.

8.5.1.1 Statistical Analyses

Data for CUs were assessed for normality and transformed before further analysis. ANOVA was performed to detect differences in reaches and selected CUs. Ninety-five percent confidence intervals were calculated for examining differences among CUs and are presented in tables. Box plots of various CU parameters were also used to display data. Cluster analysis of CUs was performed with SYSTAT software using the Complete-Euclidian method.

8.5.2 Fish Sampling

Electrofishing surveys were conducted during July 2001. Fish were sampled in both the unmined and mined reach CUs during low-flow conditions to maximize visibility and capture efficiency. Qualitative samples were taken at five other locations (outside of study reaches) for further reference purposes. All sampling took place between 9:00 a.m. and concluded by 7:00 p.m. daily.

Electrofishing was conducted with a Smith-Root POW backpack unit (pulsed DC) with two hand-held electrodes mounted on fiberglass poles. The sample crew consisted of one member carrying the backpack and operating the electrodes, a crew member located to the left and right of the backpack operator netting stunned fish, and a fourth member following with a net to capture drifting fish that may have eluded forward personnel and a bucket for specimen transport and care. In non-riffle habitats (glides, runs, and pools), sampling consisted of blocking off a habitat type (CU), where necessary, with 6-millimeter-diameter mesh nets (seines) to prevent fish from running into adjacent CUs. All fish were identified to species in the field, sorted, and weighed on an Acculab VI-1200. Voucher specimens were retained when appropriate.

8.5.2.1 Statistical Analysis

Species richness and biomass data were assessed for normality and transformed before analysis when necessary. Biomass data excludes rare species (species found in less than 5 percent of collections) as they usually have little influence on community dynamics (Gausch, 1982). ANOVA was performed to detect differences between reaches and selected CUs. Ninety-five percent confidence intervals were calculated for examining differences among CUs and are presented in tables. Box plots of fishery data were also used to display data.

Index of Biotic Integrity (IBI) scores were not calculated for the two study reaches because the collection and analysis of fish data was focused at the CU level. IBI scores are typically calculated for specific reach lengths in wadeable streams (e.g., 100 to 300 meters) and predicated on the assumption that several habitat sequences (e.g., pool-riffle) are sampled (Barbour, et al., 1999; OEPA, 1987). Theoretically, one could subdivide the study reaches and develop IBI scores for aggregated CUs. However, we felt that the length of mined CUs in particular would not meet the representation guidelines for habitat as outlined in accepted protocols, could be arbitrary, potentially produce biased results, and would not produce additional useful information about the fish community.

8.5.3 Benthic Macroinvertebrates

Benthic macroinvertebrates were collected in each study reach (unmined and mined). The sampling plan was semiquantitative using a standard 500-micron mesh D-frame net (approximately 0.3 meter x 0.15 meter) following the multihabitat approach (Barbour, et al., 1999). Because of the selection of CUs as the primary sampling unit for fish, it was deemed appropriate to conform with CU segregation for benthic macroinvertebrate sampling with a focus on pool and riffle CUs.

Three riffles and three pools were selected in each study reach. Locations were selected based on CUs having similar flow velocity and depth characteristics (near mean for all similar CUs in each reach). This would ensure that each of the three riffles and three pools selected in their respective reach would be representative of that reach. The length of each CU sampled for benthic macroinvertebrates was not considered to be overly important in CU selection because of the high variability of CU lengths between the two study reaches.

Benthic macroinvertebrates were collected in the selected CUs by kicking the substrate (riffles) or jabbing (pools) with the D-frame net. A total of 5 jabs or kicks were taken in each CU (30 total samples in each reach), and the 5 samples were composited for each CU.

Riffle Sampling: A kick sample on the riffle CU was taken by placing the D-frame stationary and flush on the substrate. The substrate was then disturbed for a distance of 0.5 meter upstream of the net to a depth of at least 6 inches into the substrate. Larger substrate particles (e.g., cobble) were cleaned with a fine brush near the net to allow dislodged benthic macroinvertebrates to be carried into the net. Brushed cobble was then returned to the stream.

Pool Sampling: A jab sample in pool CUs consisted of forcefully thrusting the D-frame net into the substrate or debris for a linear distance of 0.5 meter. To ensure consistency in the pool CU samples, three substrate jabs were taken; one each in the tail, middle, and head of the pool and one each in cover adjacent to the stream bank on the opposite banks.

D-frame net samples from each sample effort were field sorted by removing the contents of the net into a white enamel pan. The net was washed down over the pan with a spray bottle to remove organisms attached to the sides of the net and was subsequently inspected for additional organisms that were removed with forceps and placed in the sorting pan. The contents of the pan were placed in labeled jars containing 70 percent ethanol and returned to the laboratory.

Upon arrival at the laboratory, the benthic macroinvertebrates collected from each CU were thoroughly picked from other materials (i.e., gravel and organic debris) in the sample jar and placed in labeled vials for identification. All individuals in collections were identified and enumerated to the genus level or lower with the exception of flatworms (Planariidae), aquatic worms (Oligochaeta), and midges (Chironomidae) that were identified to the family level.

Several metrics were selected to assess and compare the benthic macroinvertebrate assemblages on the riffle CUs in the two study reaches (Barbour, et al., 1999). The same metrics were not applied to pool CUs because of the low diversity and similarity between the pools in the mined and unmined reaches.

The following metrics were selected for bioassessment and comparison of the benthic macroinvertebrate communities on the riffle CUs in the two study reaches:

- Total Number of Taxa: The number of distinct taxa or taxa richness measures reflect the diversity of the benthic macroinvertebrate assemblage. Increasing diversity correlates with increasing health of the assemblage and suggests that niche space, habitat, and food sources are adequate to support survival and propagation of many species. Number of taxa measures the overall variety of the benthic macroinvertebrate community. No identities of major taxonomic groups are derived from the total taxa metric, but the elimination of taxa from a naturally diverse system can be readily detected. The predicted response to increasing perturbation is a decrease in the total number of taxa.

- Percent EPT Taxa: This metric is a community comparison measure. The value for this metric is the total number of distinct taxa within the group Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies). These aquatic insects are generally considered pollution sensitive and decrease to the point of absence under increasing environmental stress. A benthic macroinvertebrate community containing few to no members of these families (E, P, T) indicates significant disturbance.

- Percent Dominant Taxon: This metric is a tolerance/intolerance measure and is intended to be representative of relative sensitivity to perturbation. This metric shows the percent composition of the numerically dominant taxon relative to the rest of the population. A community dominated by relatively few tolerant taxa indicates environmental stress.

- Ratio of EPT and Chironomidae Abundance: The EPT (mayflies, stoneflies, and caddisflies) and Chironomidae (midge fly larvae) abundance ratio uses relative abundance of these indicator groups as a measure of community balance. Generally, good biotic condition is reflected in assemblages with an even distribution of all four major groups with substantial representation by sensitive EPT groups. Assemblages having a disproportionate number of the more tolerant Chironomidae relative to EPT numbers indicate environmental stress.

8.5.4 Riparian Vegetation

For the purposes of this study, the riparian zone along Robinson Fork in the mined and unmined reaches is identified as encompassing a perpendicular distance of 10 meters from the edge of the active channel onto the floodplain.

The initial phase of the riparian zone assessment included a survey along each study reach to observe, identify, and record the plant species (tree, shrub, and herbaceous) that occurred in these areas. This generalized survey was completed to assess plant diversity in the riparian zone and determine the presence of exotic or naturalized species that often invade or increase because of a single catastrophic disturbance, or chronic disturbances.

A more detailed survey of the riparian zone vegetation structure and plant association was also conducted using a modified approach to the Environmental Monitoring and Assessment Program (EMAP) protocol (Kaufmann, et al., 1999). A total of 11 transects were evenly spaced along each study reach (equidistant from lower end to upper end) of Robinson Fork. The transects were established perpendicular to the stream channel and extended (on both sides of the stream channel) a distance of 10 meters into the riparian zone. Transects were 5 meters wide creating a sampling plot (5 meters x 10 meters) on both sides of the stream (2 plots per transect). This approach resulted in 22 plots being surveyed in each of the study reaches. The riparian plot dimensions were estimated, not measured, and on steeply sloped areas the riparian plot sample boundaries were defined as if they were projected down as in an aerial view.

The detailed survey of the riparian zone vegetation structure included a determination of the prevalent species in each transect plot (n = 22). A species was deemed prevalent in the transect plot if it had greater than 20 percent coverage in the plot.

Steam canopy cover was estimated (i.e., percentage at mid-channel) on the 11 transects. Land use was recorded along both sides at each transect (e.g., agriculture, forested slope, floodplain forest, and floodplain herbaceous). Riparian vegetation structural coverage (percent tree, understory, and herbaceous ground cover) and species occurrence (frequency of prevalent species) was also recorded.

8.5.5 Wetlands

This section of the report will examine the effects of longwall mining on wetland resources within the mined area. Because there is limited secondary information (previous studies) on wetland resources in the Robinson Fork watershed and no delineation studies were performed during the premining permitting phase, the effect on wetland resources will utilize best professional judgment based on scientific information to the maximum extent available.

Wetland resources in the context of this investigation are defined as jurisdictional wetlands that meet the criteria for positive indications for a wetland plant community, hydric (poorly drained) soils, and wetland hydrology. This assessment scheme is known as the three-parameter approach methodology for wetland delineation as described in the Corps of Engineers Wetland Delineation Manual (May 1987).

Initially, an examination of the National Wetlands Inventory (NWI) mapping quadrangle (Claysville, Pennsylvania) revealed that no wetland resources were identified on the mined reach floodplain. Several small wetlands were identified on the floodplain along the unmined study reach (see Figure 8-1A following this chapter).

The two jurisdictional wetlands along the unmined reach consist of a palustrine (freshwater) emergent, persistent, temporary (PEM1A) wetland, and a mixed palustrine forested, broad-leaved deciduous and emergent, persistent, temporary (PFO1/PEM1A) wetland. These wetland classifications are based on Cowardin (1979).

An examination of the soil associations in the Robinson Fork valley based on information contained in the County Soil Survey (Seibert, et al., 1983) revealed that soils in the study reaches are in the Dormont-Culleoka-Newark Association. This association is found on the larger streams in Washington County and consists of well-drained to somewhat poorly drained, deep and moderately deep, nearly level to very steep soils on hilltops, ridges, hillsides, and floodplains.

Based on soil probing with an Oakfield probe, hand auger, and sharpshooter shovel at various locations on the floodplain in both study reaches, the floodplain soil is Newark silt loam, which is the alluvial soil in the catena of the Dormont-Culleoka-Newark Association. Newark silt loam (Nw) is somewhat poorly drained (not hydric) and was derived from limestone, sandstone, siltstone, and shale. Although not listed as a hydric soil by the National Resources Conservation Service (NRCS), this soil can be poorly drained where it is flooded or where seepage from adjacent slopes occurs (bottomlands). Generally, Newark soils can flood occasionally for brief periods, and the water table is apparent at 0.5 foot to 1.5 feet depths (usually deeper).

The NWI identified wetlands on the unmined reach were not specifically located. One small area (estimated at less than 0.2 acre) was located along the eastern edge of the floodplain. This area could be classified as a palustrine emergent, persistent, temporary (PEM1A) wetland. The site was situated within a depressional area where a small tributary to Robinson Fork entered the floodplain.

The floodplain on the mined reach study area was thoroughly investigated for jurisdictional wetlands using the three-parameter approach and is described in the results section.

Jurisdictional wetlands in the Robinson Fork watershed are generally small and occur primarily along the floodplain of the main stem and the floodplains of its larger tributaries. These wetlands, other than man-made ponds, are situated within depressional areas that constitute old stream channels or active (intermittent) tributary channels as they cross the floodplain to the main stem. Other wetland areas occur at the base of the slopes where seepage occurs.

These types of wetlands have seasonal or temporary saturation of the soils with a fluctuating water table. Wetlands that are saturated for a majority of the growing season are not common in the watershed. These areas are usually associated with beaver (*Castor canadensis*) activity as beaver dams are located throughout the watershed.

The Western Pennsylvania Conservancy (Conservancy) conducted a Natural Heritage Inventory of Washington County (Inventory) in the mid-1990s (Wagner, 1994). This inventory included "natural heritage areas" identified by the Conservancy and located on USGS quadrangle maps. These "natural heritage areas" identify important biotic and ecological resources and are categorized as Natural Areas (NA), Biological Diversity Areas (BDA), Dedicated Areas (DA), and Landscape Conservation Areas (LCA). These areas are further evaluated as exceptional, high, or notable.

NAs are defined as areas whose plant communities have flourished with little or no human disturbance, particularly recent disturbances. BDAs include those sites that are recognized as supporting special species (Special Species Habitat), relatively large numbers and kinds of species (High Diversity Area), or entire communities or ecosystems (Community/Ecosystem Conservation Areas). DAs are recognized because of the landowner's specific intention to protect their present and potential future ecological resources. LCAs include large pieces of the landscape that are of higher ecological value than other areas of similar size. Contiguous natural communities, minimal human disturbance, and often the presence of other "natural heritage areas" within the LCA allow ecological processes to function across the entire landscape.

The Inventory identifies one area on the Claysville Quadrangle that includes the Robinson Fork watershed. This area is located upstream of the study reaches near the source of Robinson Fork in State Game Lands 245. This area is categorized as the Robinson Fork Wetlands BDA. This area is evaluated as notable and consists of a beaver-influenced wetland containing a Graminoid-Robust Emergent Marsh that the Conservancy considers as a plant community that is rare in Washington County.

According to the description in the Inventory, the Robinson Fork Wetlands BDA is a large wetland complex that is recognized as a High Diversity Area. At one time, this area supported a narrow band of streamside and floodplain wetlands vegetation within a larger mesic central forest community. However, beaver have constructed several dams along the stream and created a complex of open pools, emergent marsh, and shrub wetland. Although considered a successional community because of the cyclic and temporary presence of beaver and their influence on hydrology, this area represents a unique habitat for Washington County and is, therefore, considered important for biodiversity in the county. Classified as a Mixed Graminoid-Robust Emergent Marsh, thickets of silky dogwood and black willow grow around the perimeter of the open pools while spotted touch-me-not, common elderberry, sensitive fern, and skunk cabbage (*Symplocarpus foetidus*) occupy the swampy areas between and around the pools. Duckweed float on the surface of the deeper water sections and broad-leaf cattail, bur-reed, and arrowhead (*Sagittaria latifolia*) grow in the shallow standing water areas.

8.6 Results

8.6.1 Channel Unit Classification

CUs were visually classified in the field yielding 17 CUs in the mined reach and 36 CUs in the unmined reach. Field classification is subjective and misclassification occurs especially in transitional CUs. McKenney (1997) notes that consistent separation of pool and glides is complicated by gradual and diffuse boundaries that occur not only longitudinally but laterally as well. Peterson and Rabeni (2001) found that classification in Ozarkian streams using three observers was typically 75 to 80 percent accurate; CUs within the same hierarchical level were most often misclassified, specifically glides and races.

Although this research was not designed to test classification accuracy, we cross-checked field classification by calculating and then clustering CUs using Froude numbers. The Froude number (Fr) is used by hydraulic engineers to describe types of flow (e.g., shooting or tranquil flow) and represents the ratio of inertial to gravitational forces (Panfil and Jacobson, 1999). The Froude number can be calculated from cross section data. It has been successfully used to differentiate habitats (habitats visually identified in the field tend to have similar Froude numbers) and has also been shown to correlate with benthic macroinvertebrate and fish distribution in streams (Statzner and Higler, 1986; Benbow, et al., 1997; Quinn and Hickey, 1994; Wetmore, et al., 1990; and Yu and Peters, 1997). Panfil and Jacobsen (1999) point out that an advantage of the Froude number is that it is a nondimensional number incorporating both depth and velocity and does not appear to scale with downstream changes in discharge.

Cluster analysis of Froude numbers for the 17 CUs in the mined reach produced 4 clusters while 6 clusters were produced for the 36 CUs in the unmined reach (see Figures 8-9 and 8-10 respectively). CU types were typically grouped with like CUs (i.e., pool with pools; riffles with riffles) with little mixing indicating that field classification was generally accurate. Additionally, the larger number of clusters observed in the unmined reach depicts a greater range of Froude numbers (i.e., depth/velocity combinations) and, therefore, more heterogeneity of habitat. The distance separating individual CUs in the subgroups and the Froude numbers of individual CUs also indicates greater diversity in the unmined reach and therefore more habitat complexity.

This is also illustrated by plotting CU velocity and depth for both the mined and unmined reaches (Figure 8-11). These plots show that the mined reach has most CUs located toward the tails of the plotted line (i.e., riffles and pools) and few CUs with moderate depth-velocity combinations (i.e., races and glides), whereas the plot for the unmined CUs shows depth-velocity combinations across a relatively wide range of values and hence greater habitat heterogeneity.

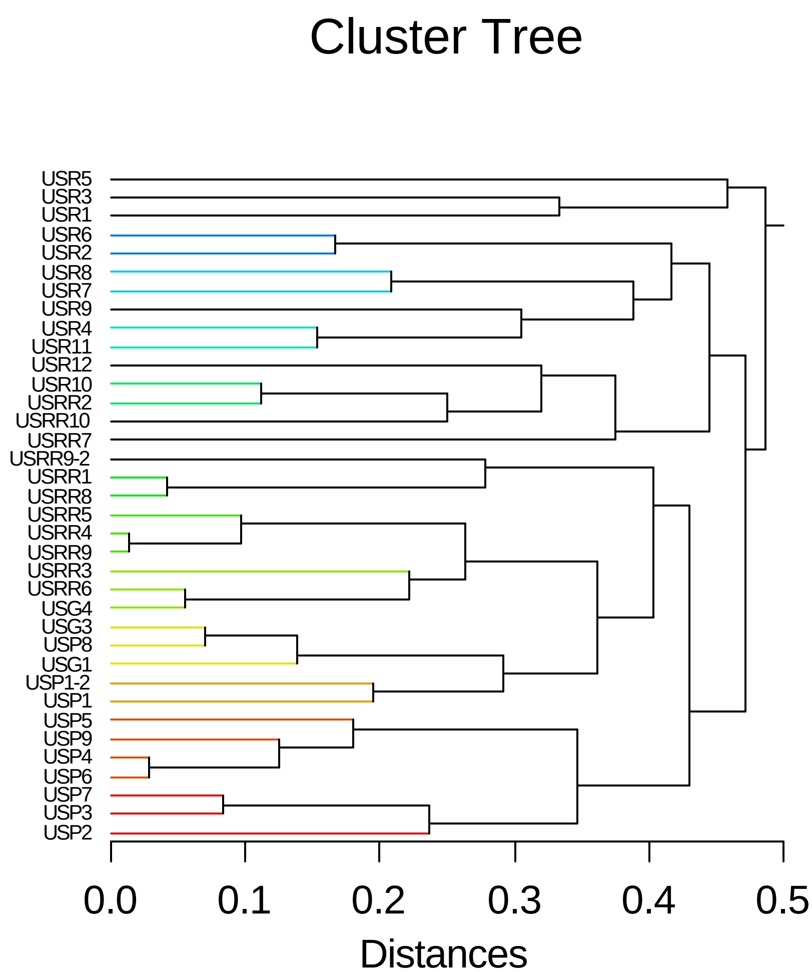


Figure 8-9. Cluster dendogram of Froude numbers for CUs in the unmined reach. Euclidian-complete cluster method.

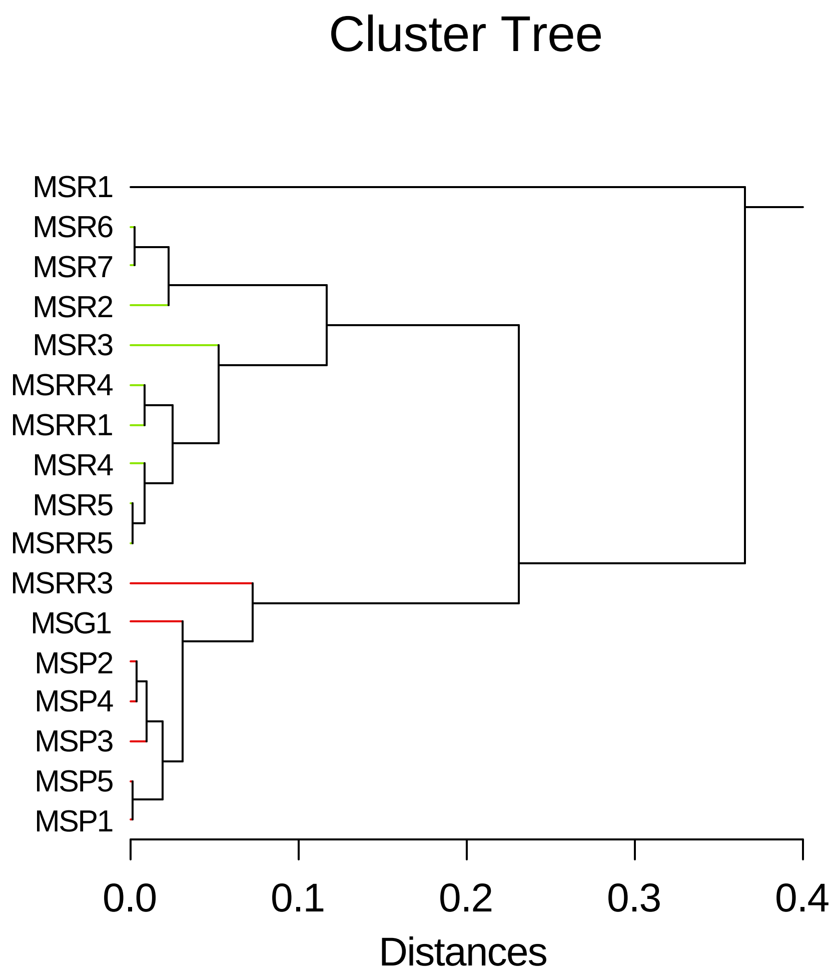
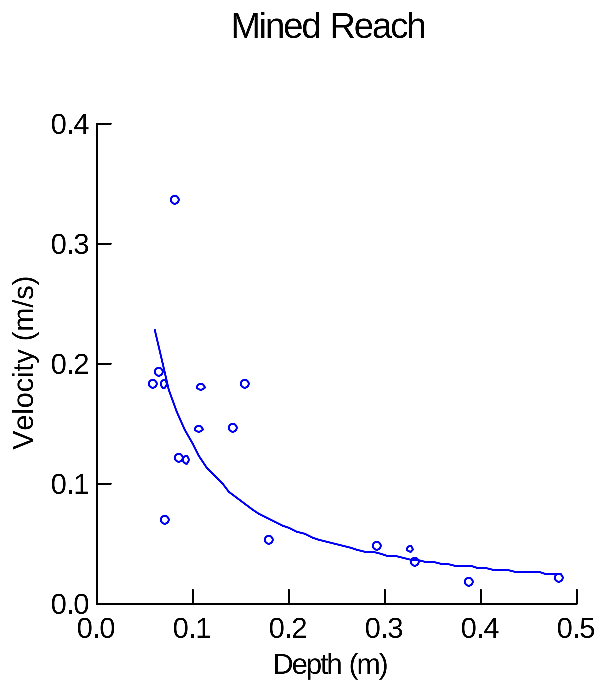


Figure 8-10. Cluster dendogram of Froude numbers for CUs in the mined reach. Euclidian-complete cluster method.



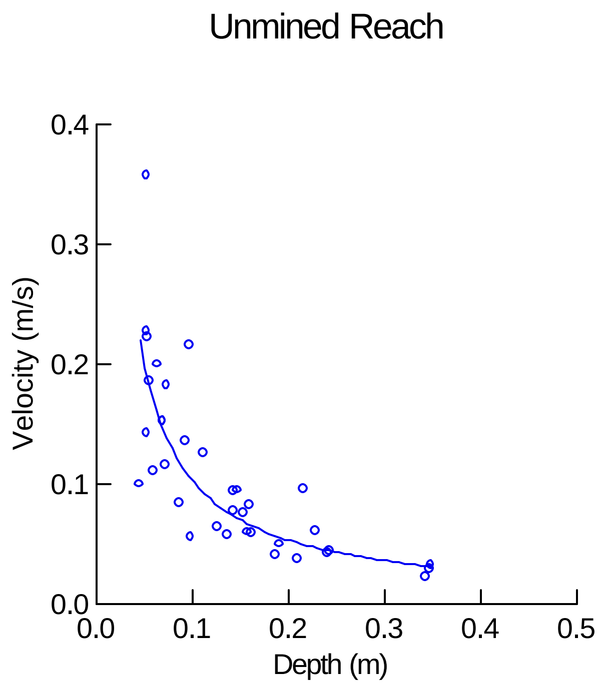


Figure 8-11. Plot of velocity v depth for CUs for the mined and unmined reaches of Robinson Fork.

8.6.2 Physical Characteristics

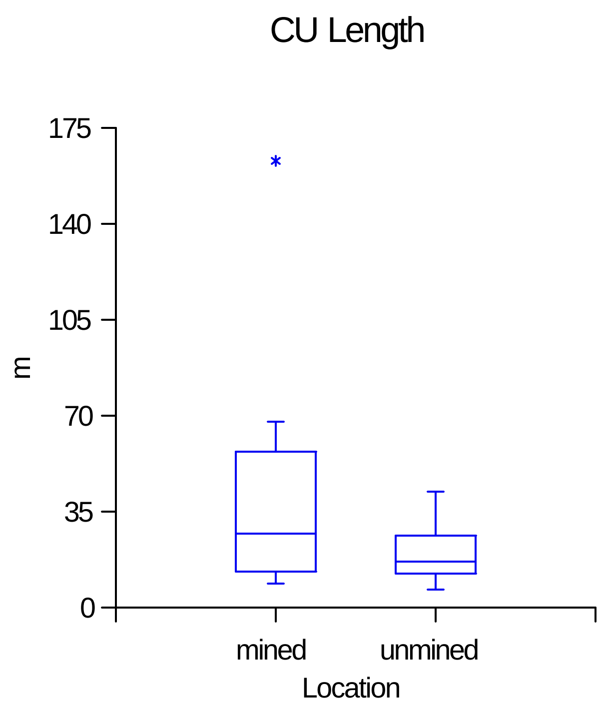
8.6.2.1 Reach Level

The unmined reach was approximately 725 meters long and contained 36 CUs (12 riffles, 11 races, 10 pools, and 3 glides); the mined reach was marginally shorter at 687 meters with 17 CUs (7 riffles, 4 races, 5 pools, and 1 glide) (see Table 8-3). CUs in the unmined reach averaged 20.2 meters in length with an average wetted width of 4.47 meters, surface area averaged 88.4 square meters, and volume averaged 11.6 cubic meters. Bank stability rating in the unmined reach averaged 6.7 (scale 0 to 10) with channel fill averaging 87.8 percent. Mined reach CUs were on average 40.4 meters long with a wetted width of 6.49 meters, surface area of 302.5 square meters, and volume of 72.8 cubic meters. Bank stability rating in the mined reach averaged 7.54 (scale 0 to 10) with channel fill averaging 77.2 percent of capacity. Box plots of CU attributes for the mined and unmined reaches are presented in Figures 8-12, 8-13, 8-14, and 8-15.

Table 8-3

Total number of CUs and average length (m), wetted width (m), percent channel fill, surface area (m^2), volume (m^3), and bank stability rating for the mined and unmined study reaches of Robinson Fork.

	CUs	Length	Wetted Width	% Channel Fill	Surface Area	Volume	Bank Stability
Unmined Reach	36	20.2	4.47	87.8	88.4	11.6	6.70
Mined Reach	17	40.4	6.49	77.2	302.5	72.8	7.54



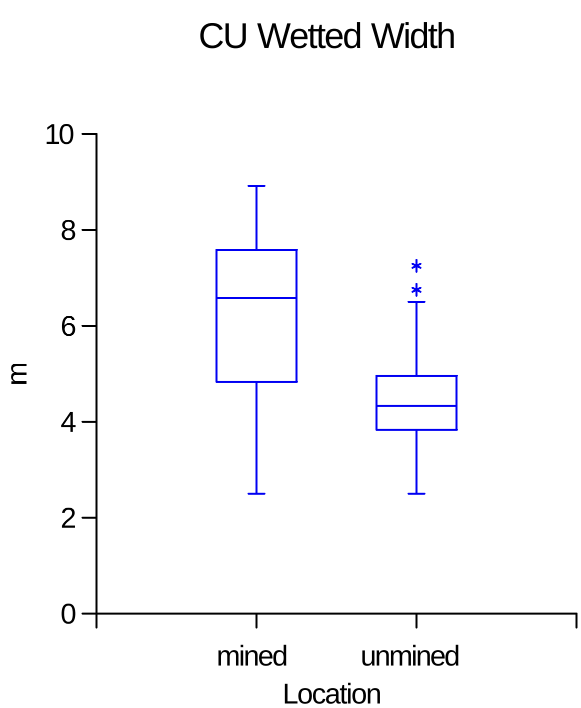
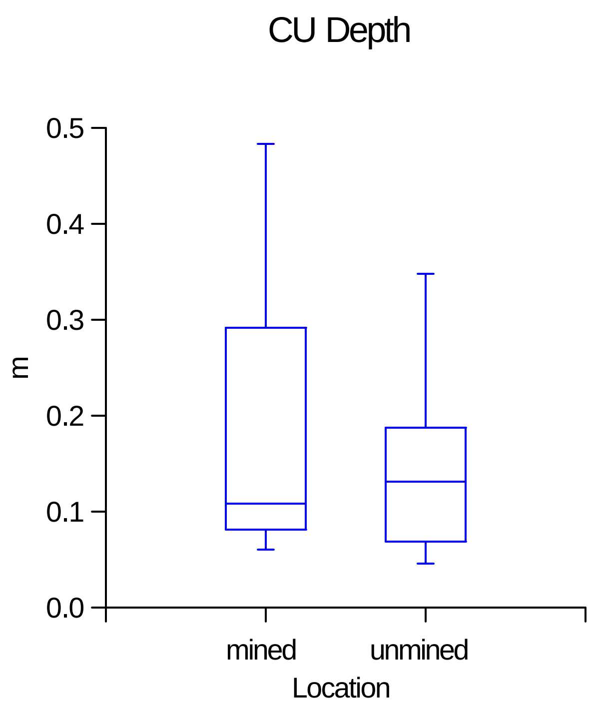


Figure 8-12. Box plot of length (m) and wetted width (m) for CUs for the mined and unmined reaches of Robinson Fork.



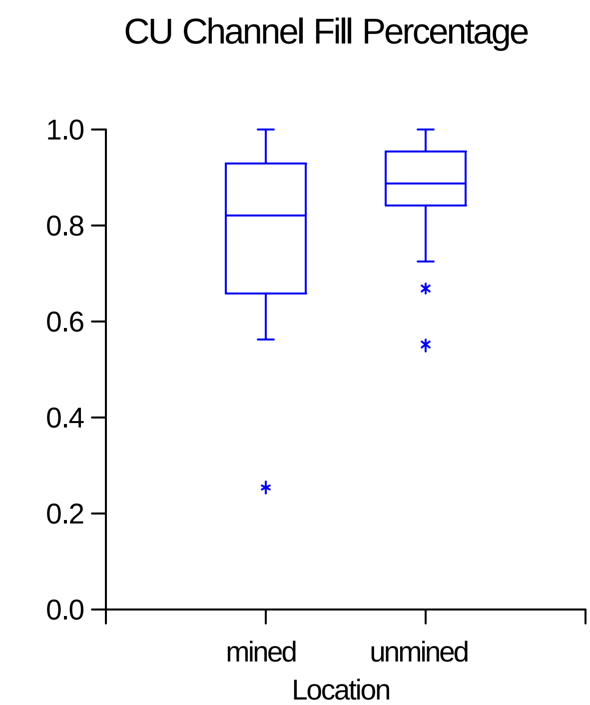


Figure 8-13. Box plot of depth (m) and channel fill percentage (%) for CUs for the mined and unmined reaches of Robinson Fork.

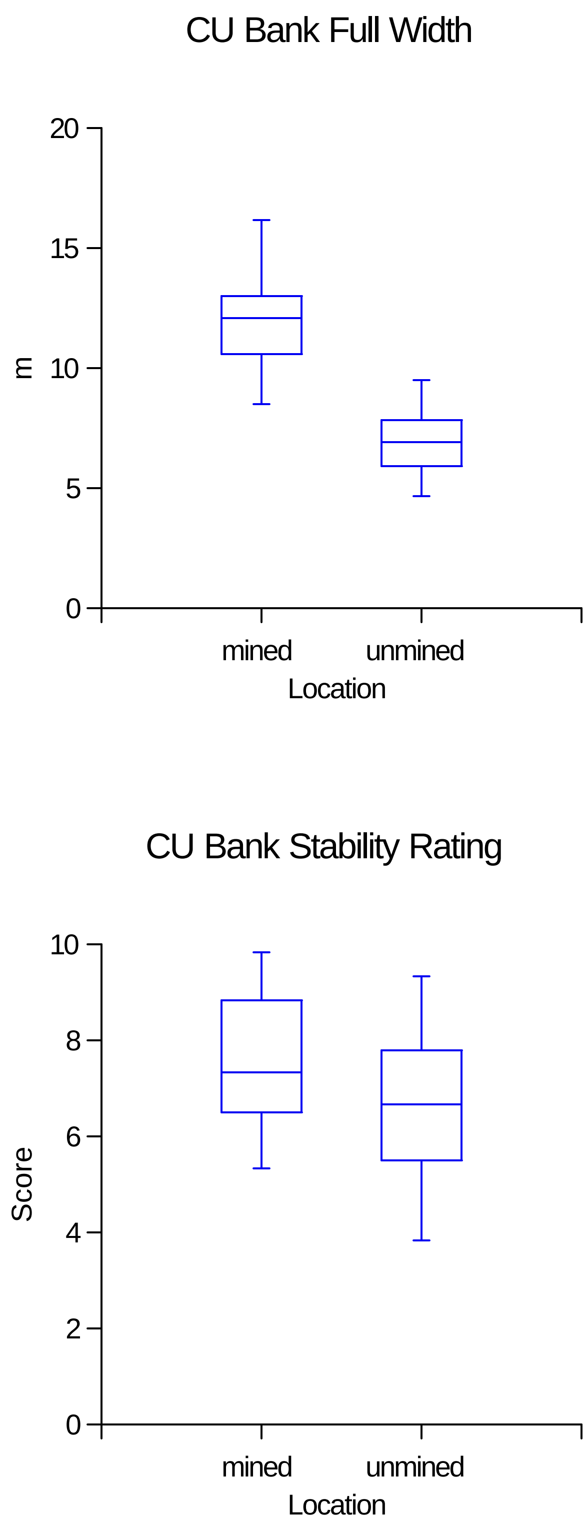
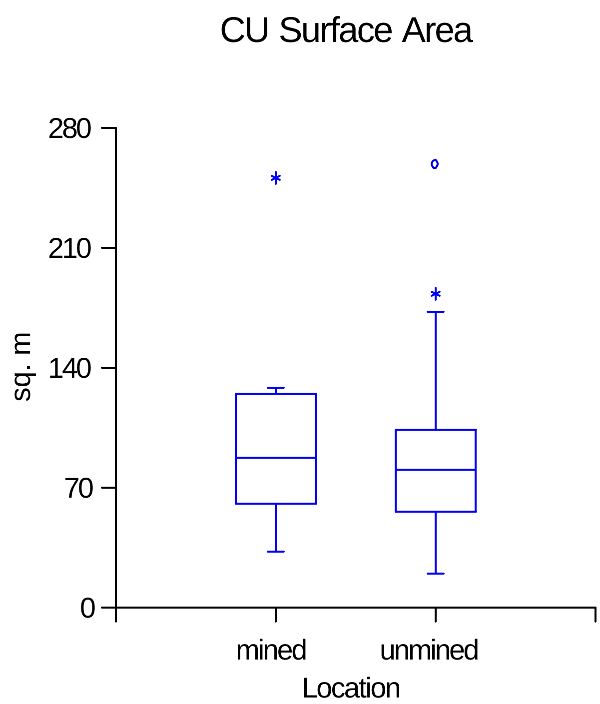


Figure 8-14. Box plot of bank full width (m) and bank stability rating for CUs for the mined and unmined reaches of Robinson Fork.



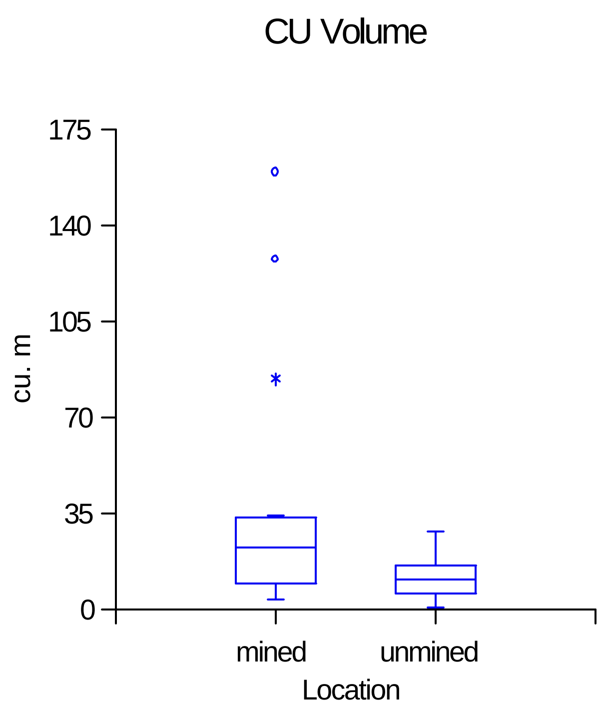


Figure 8-15. Box plot of surface area (m^2) and volume (m^3) for CUs for the mined and unmined reaches of Robinson Fork.

The number, dimensions, and relative distribution of CUs is important for determining if the reaches differ from one another. In general, the unmined reach contained twice as many CUs as the mined reach. The average CU in the mined reach was roughly twice as long as those in the unmined reach, was 1.4 times wider, had 3.4 times greater surface area, and had 6.3 times more volume. Bank stability in the mined reach was slightly better than that in the unmined reach but the percentage of channel containing water (channel fill) was about 10 percent lower.

8.6.2.2 Channel Units

The physical characteristics of CU types (pools, races, riffles, and glides) were distinctly different in the mined and unmined reaches as shown in Table 8-4 (also see Figures 8-16, 8-17, 8-18, 8-19, 8-20, and 8-21). Riffles were more numerous in the unmined reach, were generally shallower and shorter in length, and had less surface area and volume. Velocity of riffle CUs was nearly identical in the mined and unmined reaches, but wetted width was roughly 1.6 times greater and volume was nearly 3.3 times greater in the mined reach. Surprisingly, riffles in both reaches comprised similar amounts of their respective reach when expressed as a percentage of total reach length and surface area, but percent volume was less even though the mined reach CUs are wider with greater depth.

Race CUs were also more numerous in the unmined reach, but unlike riffles, races were on the average slightly longer and deeper and had greater surface area and volume than those in the mined reach. When compared relative to the percentage composition of their respective reaches, total race length in the unmined location is about 3 times greater, surface area roughly 5 times greater, and volume nearly 10 times the percentages found for races in mined reaches. Velocity is substantially lower in the unmined races.

Glides were also more numerous in the unmined reach but the lack of glide CUs in the mined reach makes it impractical to attempt to make detailed comparisons. However, velocity was similar in both reaches and depth was greater in the mined reach as would be expected due to longitudinal differences in study reach locations.

Pool CUs consisted of obstruction and lateral pools (see Table 8-5) as no bluff pools were encountered in the study reaches of Robinson Fork. For the purposes of this study, obstruction and lateral pools were combined and are henceforth referred to as pool CUs and are not differentiated. Pool CUs were twice as numerous in the unmined reach but tended to be shallower with higher velocities. On average, mined pools were roughly 4 times longer with 1.4 times greater wetted width and had substantially greater surface area (6.5 times) and volume (approximately 10 times) than pools in the unmined reach. When expressed as a percentage of reach composition, pool length and surface area were nearly twice as great in the mined reach; pool volume was less than 50 percent in the unmined reach but comprised more than 75 percent in the mined reach.

Table 8-4

Average length (m), depth (m), velocity (m/s), wetted width (m), surface area (m^2), and volume (m^3) for unmined and mined reaches by CU type. Numbers in parentheses represent percentage of total reach for that parameter (length, surface area, and volume).

	N	Length (m)	Depth (m)	Velocity (m/s)	Wetted Width (m)	Surface Area (m^2)	Volume (m^3)
Unmined Reach							
CU Type							
Riffle	12	22.1 (36.6)	0.062	0.188	4.6	108.6 (41.0)	6.5 (18.8)
Race	11	21.6 (32.7)	0.131	0.095	3.9	76.4 (26.4)	9.9 (26.1)
Glide	3	20.4 (8.4)	0.132	0.057	4.5	89.0 (8.4)	12.5 (9.0)
Pool	10	16.2 (22.3)	0.249	0.042	4.9	77.2 (24.3)	19.2 (46.1)
Reach Total	**36**	**725.0**				**3,181.92**	**417.45**
Mined Reach							
CU Type							
Riffle	7	38.1 (38.8)	0.081	0.187	7.21	270.3 (36.8)	21.1 (11.9)
Race	4	15.7 (9.2)	0.120	0.136	4.52	69.1 (5.4)	8.4 (2.7)
Glide	1	57.0 (8.3)	0.181	0.053	8.14	463.8 (9.0)	83.9 (6.8)
Pool	5	60.1 (43.7)	0.364	0.033	6.75	502.0 (48.8)	194.4 (78.6)
Reach Total	**17**	**687.0**				**5,142.51**	**1,237.15**

Table 8-5

Average length (m), depth (m), velocity (m/s), Froude Number (Fr), bank stability rating, surface area (m^2), and volume (m^3) for lateral and obstruction pools in the mined and unmined reaches of Robinson Fork.

	Unmined		Mined	
CU Attribute	**Lateral**	**Obstruction**	**Lateral**	**Obstruction**
Length	16.84	14.55	82.0	27.3
Depth	0.210	0.197	0.349	0.388
Velocity	0.038	0.052	0.032	0.034
Fr	0.024	0.038	0.018	0.019
Bank Stability Rating	6.774	7.444	7.208	5.834
Surface Area	80.618	69.163	705.82	196.35
Volume	21.558	13.822	264.752	88.821

8.6.3 Biological Communities – Fish

8.6.3.1 Species Richness

Fish were collected from most CUs in the mined and unmined reaches and from five other locations in Robinson Fork. Supplemental locations were qualitative in nature and sampled to reflect fish community structure in reaches removed from the primary study reaches. Four were located downstream and one upstream of the study reaches; all sample sites with the exception of the station at the mouth of Robinson Fork are located above the flood control reservoir, PA-647 (see Figure 8-1).

A total of 30 species were collected from Robinson Fork when all sites were combined (see Table 8-1A following this chapter). Species richness was greatest at the mouth of Robinson Fork (24) and generally declined toward the headwaters (Table 8-6). Species composition was notable at the mouth due to the presence of several species that were not collected at other stations including variegate darter, spotfin shiner, banded darter, channel catfish, sand shiner, sauger, silver shiner, and smallmouth bass. In addition, significant numbers of a very intolerant species, black redhorse, and a somewhat intolerant (intermediate) species, golden redhorse, were collected from the station at the mouth. (Historical fish collections are presented in Table 8-2A following this chapter.)

Table 8-6

Sample station location, approximate length (m), proximity to study area, and fish species richness for Robinson Fork, July 2001.

Sample Station	Proximity to Study Reaches	Approx. Length Sampled(m)	Species Richness
Station 1 (mouth)	downstream	180	24
Station 2	downstream	180	14
Station 3	downstream	180	18
Station 4	downstream	180	14
Mined Reach	NA	666	19
Unmined Reach	NA	677	14
Station 5 (SGL 245)	upstream	60	7

Station 2 is within the zone influenced by periodic reservoir inundation (flood pool) during maximum stage; Station 3 is upstream of reservoir and outside of the zone of inundation.

8.6.3.2 Species Composition

ANOVA of species richness for all CUs combined by reach (i.e., mined and unmined) showed significant differences at $p = 0.039$. Mean species richness in the mined reach and unmined reach were 9.83 and 7.79 respectively. No significant differences (p less than 0.05) were detected between CUs by reach type (i.e., pools, riffles, and races in the mined and unmined reaches). Generally, creek chub, white sucker, bluntnose minnow, and blacknose dace dominate community composition at all sample locations with the exception of the station located near the mouth of Robinson Fork (see Table 8-7). Percent composition ranges from 56 to 74 percent for these species at six locations. The station at the mouth was dominated by four species (70 percent total composition): central stoneroller, spotfin shiner, striped shiner, and bluntnose minnow.

Table 8-7

Total number of individuals and percent composition of fish species collected at sample stations in Robinson Fork, July 2001. Numbers in parentheses are percent of total for that species for that station.

	Station						
Species	**1**	**2**	**3**	**4**	**Mined**	**Unmined**	**5**
Banded Darter	3 (0.65)						
Black Redhorse	19(4.10)		1 (0.24)		1 (0.03)		
Blacknose Dace			1 (0.24)	6 (1.41)	297 (8.67)	356 (10.38)	9 (16.67)
Bluegill	9 (1.94)	3 (1.69)	1 (0.24)		2 (0.06)		
Bluntnose Minnow	36 (7.78)	67 (37.64)	80 (18.96)	76 (17.80)	312 (9.11)	503 (14.66)	1 (1.85)
Central Stoneroller	167 (36.07)	1 (0.56)	59 (13.98)	39 (9.13)	317 (9.26)	206 (6.00)	
Channel Catfish	1 (0.22)						
Common Carp	9 (1.94)				3 (0.09)		
Creek Chub	4 (0.86)	1 (0.56)	34 (8.06)	137 (32.08)	846 (24.70)	1,000 (29.15)	25 (46.30)
Fantail Darter	4 (0.86)	3 (1.69)	22 (5.21)	34 (7.96)	261 (7.62)	290 (8.45)	8 (14.81)
Gizzard Shad		38 (21.35)					
Golden Redhorse	9 (1.94)	1 (0.56)	1 (0.24)	5 (1.17)	2 (0.06)		
Green Sunfish	1 (0.22)	6 (3.37)	4 (0.95)		34 (0.99)	5 (0.15)	5 (9.26)
Greenside Darter	10 (2.16)		1 (0.24)		39 (1.14)	25 (0.73)	
Johnny Darter				14 (3.28)	120 (3.50)	76 (2.22)	
Largemouth Bass		3 (1.69)	1 (0.24)		1 (0.03)		
Northern Hog Sucker	12 (2.59)	6 (3.37)	17 (4.03)	9 (2.11)	11 (0.32)	1 (0.03)	
Pumpkinseed	1 (0.22)		1 (0.24)				
Rainbow Darter	26 (5.62)	6 (3.37)	58 (13.74)	5 (1.17)	175 (5.11)	294 (8.57)	1 (1.85)
Rock Bass				1 (0.23)	2 (0.06)	3 (0.09)	
Sand Shiner	10 (2.16)						
Sauger	1 (0.22)						
Silver Shiner	3 (0.65)						
Silverjaw Minnow		1 (0.56)	1 (0.24)		30 (0.88)	99 (2.89)	
Smallmouth Bass	3 (0.65)						
Spotfin Shiner	62 (13.39)						
Striped Shiner	59 (12.74)		8 (1.90)	4 (0.94)	68 (1.99)	13 (0.38)	
Variegate Darter	1 (0.22)						
White Sucker	11 (2.38)	34 (19.10)	128 (30.33)	97 (22.72)	904 (26.39)	560 (16.32)	5 (9.26)
Yellow Bullhead	2 (0.43)	8 (4.49)	4 (0.95)				

Community composition can also be expressed as a percentage of total biomass (fish were only weighed at the primary study reaches). Creek chub and white sucker dominated community composition (see Table 8-8). In both the unmined and mined reaches, white sucker had the highest percentage of total biomass (41.58 and 41.28 percent respectively) followed by creek chub (34.67 and 20.38 respectively).

Stream longitudinal position between the two reaches places limits on comparative analyses in this assessment. However, comparison of biomass per unit volume (g/m^3) can be used to compare relative productivity between the two reaches (i.e., mined and unmined) (see Figures 8-22, 8-23, 8-24, and 8-25). ANOVA of biomass (g/m^3) for all CUs combined ($n = 37$) showed no significant differences between the unmined and mined reaches (p = 0.504). Similar findings were detected for race CUs and riffle CUs between the unmined and mined reaches (p = 0.151 and 0.826 respectively). However, differences in biomass (g/m^3) were detected for selected pools between the mined and unmined reach (p = 0.034 with unmined greater than mined) yet pool volume was significantly different (p = 0.041) with mined greater than unmined.

Table 8-8

Total biomass (gm) of individuals and percent of total biomass of fish species collected within study reaches in Robinson Fork, July 2001. Numbers in parentheses are percent of total biomass for that station.

	Station	
Species	**Unmined**	**Mined**
Black Redhorse		38.1 (0.10)
Blacknose Dace	998 (4.53)	817.7 (2.17)
Bluegill		15.3 (0.04)
Bluntnose Minnow	1,222.5 (5.54)	724.6 (1.93)
Central Stoneroller	1,022.6 (4.64)	1,794.9 (4.77)
Common Carp		7,700 (20.47)
Creek Chub	7,711.9 (34.67)	7,666.8 (20.38)
Fantail Darter	525.4 (2.38)	414.4 (1.10)
Golden Redhorse		322.2 (0.86)
Green Sunfish	69.5 (0.32)	179.9 (0.48)
Greenside Darter	94 (0.43)	154.3 (0.41)
Johnny Darter	77.3 (0.35)	106.2 (0.28)
Largemouth Bass		0.8 (0.00)
Northern Hog Sucker	70.4 (0.32)	851.6 (2.26)
Rainbow Darter	492.4 (2.23)	242.8 (0.65)
Rock Bass	214.6 (0.97)	9.9 (0.03)
Silverjaw Minnow	338.3 (1.53)	109.9 (0.29)
Striped Shiner	46.9 (0.21)	949.2 (2.52)
White Sucker	9,169.6 (41.58)	15,522.1 (41.28)

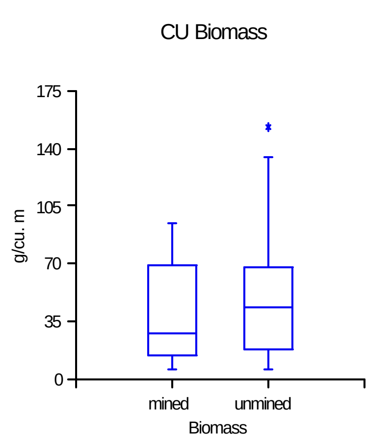


Figure 8-22. Biomass (g/m^3) for CUs in mined and unmined reaches of Robinson Fork.

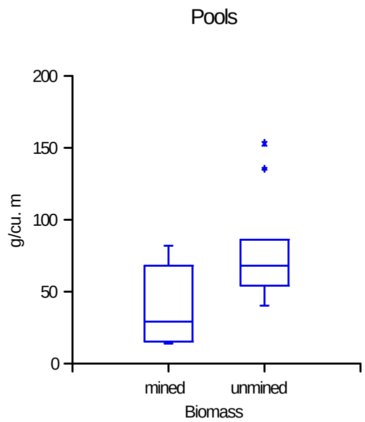


Figure 8-23. Biomass (g/m^3) for pool CUs in mined and unmined reaches of Robinson Fork.

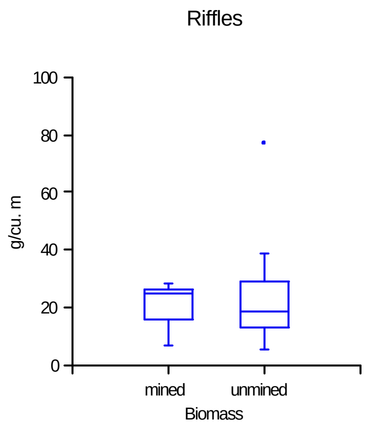


Figure 8-24. Biomass (g/m^3) for riffle CUs in mined and unmined reaches of Robinson Fork.

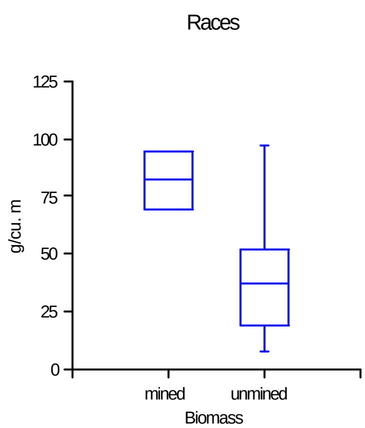


Figure 8-25. Biomass (g/m^3) for race CUs in mined and unmined reaches of Robinson Fork.

8.6.4 Benthic Macroinvertebrates

A total of 39 taxa were collected on riffle CUs in the mined study reach and a total of 33 taxa collected from riffle CUs in the unmined reach. The number of taxa collected from the three riffle CUs in the mined reach ranged from 24 to 28 with an average of 26 taxa. The number of taxa collected from the three CUs in the unmined reach ranged from 17 to 21 taxa with average of 20 taxa (Table 8-9).

A total of 12 distinct taxa were collected in the pool CUs in the mined study reach and a total of 9 distinct taxa were collected from pool CUs in the unmined reach. The number of taxa collected from the mined pool CUs ranged from 2 to 9 for an average of 5 taxa. The number of taxa collected from the unmined pool CUs ranged from 2 to 5 with and average of 4 taxa collected (Table 8-10).

The Percent EPT Taxa for both reaches (riffle CUs) were high (dominated by caddisflies–Trichoptera) exceeding 50 percent in the mined reach and approaching 50 percent in the unmined reach (Table 8-11). The Percent Dominant Taxon in both the mined and unmined riffle CUs shows uniform dominance by somewhat tolerant caddisflies and tolerant midges with codominance by somewhat tolerant mayflies and aquatic beetles. The Ratio of EPT and Chironomidae Abundance shows uniform relative abundance between these indicator groups in both the mined and unmined riffle CUs. The EPT Taxa (mayflies, stoneflies, and caddisflies) have substantial representation in each riffle CU indicating balance in the assemblages between tolerant and somewhat tolerant taxa.

A search of governmental and private sources for benthic macroinvertebrate surveys that have been made on Robinson Fork yielded three collections worth noting:

- Cooper (1975) conducted a benthic macroinvertebrate survey in conjunction with a fish survey. The report did not specify the sampling gear used but stated "representative microhabitats will be sampled quantitatively and qualitatively at each station until no new invertebrates are found in the field sorting."

  The two stations sampled by Cooper (1975) were located near the mouth of Robinson Fork and near its confluence with Beham Run. Both of these stations are located downstream of the current study area. The station near Beham Run was sampled in or near a segment of Robinson Fork that was undermined in 1993, and can be compared to the benthic macroinvertebrate sample completed in this study in the mined reach.

  The Cooper survey near Beham Run collected 16 taxa. The only taxa collected in Cooper's study that was not found in this investigation were the large stonefly, *Acroneuria* sp., and several mayflies (Hydroptilidae and *Wormaldia* sp.)

- Another collection from Robinson Fork is more recent and was conducted by Dr. Ben Stoudt of Wheeling Jesuit College. Dr. Stoudt established three stations, one near the mouth (S54), another above the zone of influence of the flood control reservoir (S68), and the third near Chapel Cemetery (S91). These stations were sampled in 1993, and S91 represents a sample area near the mined reach (current study) prior to mining. Dr. Stoudt found 24 distinct taxa which is very similar to the taxa richness in the mined reach found during this study. Dr. Stoudt also collected several large stoneflies (Perlidae) at S91 (*Acroneuria* sp., *Agnetina* sp., and *Perlesta* sp.) that were not collected in the current study, but the overall macroinvertebrate assemblage in this area had similar taxa richness as this study. The large stonefly, *Acroneuria*, was observed in the mined study reach during the electrofishing survey but was not collected during the benthic macroinvertebrate survey.

- As part of the DEP Unassessed Waters Protocol, Robinson Fork was sampled for benthic macroinvertebrates on September 8, 2000. The sampling station was located below the discharge of the dam and reservoir (PA-647) near the mouth of Robinson Fork (20000908). This sampling effort was qualitative and collected benthic macroinvertebrates were identified to the family level. Benthic macroinvertebrates collected were assigned a Hilsenhoff Index Family Score which assigns a specific family a rating of 0 to 10, with 0 being most intolerant and 10 being most tolerant.

  A total of 12 benthic macroinvertebrate families were collected which included aquatic worms, flatworms, caddisflies, damselflies, midges, blackflies, aquatic beetles, alder flies, and crayfish. The only common to abundant families were caddisflies (Hydropsychidae with a rating of 5 and Philopotamidae with a rating of 3), fingernail clams (Sphaeriidae with a rating of 8), and flatworms (Turbellaria with a rating of 9).

  Based on this information, the Unassessed Waters Field Form: Wadeable Streams for Robinson Fork determined that the stream has impaired biology because the dominant family collected (Turbellaria) had a Hilsenhoff greater than 5, and the sample was dominated by families with a mean Hilsenhoff greater than 5.

The total number of taxa collected in the pool CUs in both the unmined and mined study reaches represent assemblages with low diversity (number of taxa) and few individuals in each taxon collected. This depauperate community is often characteristic of pool areas in streams where oxygen tensions can be low and niche space (dominance of finer substrate particles) is limited.

A total of 12 taxa were collected in the pool CUs in the mined reach with the majority of these taxon and total number of individuals belonging to benthic types that are tolerant to lower dissolved oxygen tensions and have a burrowing habit or are spawlers (maintain respiratory surface free of silt). These types include aquatic worms (Oligochaeta), the mayfly (*Caenis*), bloodworms (Chironomini), freshwater limpets (*Ferrissia* sp.), and fingernail clams (*Sphaerium* sp.).

The pools CUs in the unmined reach are very similar in their benthic macroinvertebrate assemblages to the mined reach pool CUs but contain even less diversity and number of individuals. Again, the characteristic benthic macroinvertebrates of pool areas are present (bloodworms and *Caenis*) along with the tolerant aquatic sowbug (*Caecidotea* sp.).

The occurrence of primarily riffle-dwelling (clingers) species (mayflies, caddisflies, and aquatic beetles) in the pool CUs in both study reaches represent drift from upstream riffles. This drift of benthic macroinvertebrates provides a major component of the autochthonous food production in streams for fish species that prefer pool habitat.

Table 8-9

List and number of benthic macroinvertebrates (individuals) collected from riffle CUs in the mined and unmined reaches of Robinson Fork.

	Sample Location (riffle CU)					
	Unmined			**Mined**		
Taxa	**1**	**2**	**3**	**1**	**2**	**3**
Platyhelminthes						
Turbellaria (flatworms)						
Planariidae g. sp.	0	0	0	0	0	1
Annelida						
Oligochaeta g. sp. (aquatic worms)	0	1	0	4	0	0
Arthropoda						
Crustacea						
Isopoda (aquatic sow bugs)						
Asellidae						
Caecidotea sp.	1	1	0	0	1	0
Decapoda (crayfish)						
Cambaridae						
Orconectes sp.	1	0	0	0	0	0
Insecta						
Ephemeroptera (mayflies)						
Baetidae g. sp.	0	0	0	0	0	2
Baetis flavistriga	25	27	3	4	21	5
Baetis intercalaris	3	11	0	4	5	0
Baetis sp.	0	0	0	0	9	0
Centroptilum/Cloeon spp.	0	5	1	0	0	0
Diphetor hageni	0	2	0	0	0	0
Caenidae						
Caenis sp.	0	3	0	1	6	8
Heptageniidae juvenile	0	0	0	0	0	1
Leucrocuta sp.	1	0	0	1	2	0
Stenacron sp.	0	3	0	0	0	0
Stenonema spp.	3	4	1	4	6	32
Oligoneuriidae						
Isonychia sp.	0	1	1	2	2	6
Plecoptera (stoneflies)						
Leuctridae						
Leuctra sp.	0	0	0	0	1	6

Table 8-9

List and number of benthic macroinvertebrates (individuals) collected from riffle CUs in the mined and unmined reaches of Robinson Fork (cont.).

	Sample Location (riffle CU)					
	Unmined			**Mined**		
Taxa	**1**	**2**	**3**	**1**	**2**	**3**
Trichoptera (caddisflies)						
Helicopsychidae						
Helicopsyche borealis	0	0	0	1	1	0
Hydropsychidae juvenile	2	1	1	0	0	0
Hydropsychidae (Pupa)	0	2	0	1	4	1
Ceratopsyche morosa group	15	12	5	14	33	27
Cheumatopsyche spp.	32	18	14	6	17	8
Hydropsyche spp.	0	0	3	8	31	5
H. slossonae	2	0	0	8	8	2
Hydroptilidae g. sp. (Pupa)	0	0	0	1	0	0
Hydroptila sp.	0	0	0	1	0	0
Limnephilidae						
Pycnopsyche sp.	0	0	0	1	0	0
Philopotamidae						
Chimarra sp.	0	0	1	1	1	1
Dolophilodes sp.	0	0	0	0	0	1
Odonata						
Anisoptera (dragonflies)						
Gomphidae juvenile	0	0	0	1	0	0
Stylogomphus sp.	1	0	0	0	0	0
Coleoptera (aquatic beetles)						
Elmidae (riffle beetles)						
Dubiraphia sp. (Adult)	0	2	14	0	0	0
Macronychus sp. (Adult)	0	0	1	0	0	0
Optioservus sp. (Larva)	7	1	0	2	2	5
Optioservus sp. (Adult)	2	0	1	0	1	2
Stenelmis sp. (Larva)	17	25	1	6	4	5
Stenelmis sp. (Adult)	27	15	6	2	9	16
Psephenidae (water penny)						
Psephenus herricki	3	0	0	3	5	9
Megaloptera						
Corydalidae (fishflies/dobsonflies)						
Nigronia sp.	1	1	0	2	0	1
Sialidae (alderflies)						
Sialis sp.	1	0	0	1	0	0

Table 8-9

List and number of benthic macroinvertebrates (individuals) collected from riffle CUs in the mined and unmined reaches of Robinson Fork (cont.).

	Sample Location (riffle CU)					
	Unmined			**Mined**		
Taxa	**1**	**2**	**3**	**1**	**2**	**3**
Hemiptera (water bugs)						
Veliidae (broad-shouldered water striders)						
Microvelia sp.	0	0	0	1	0	0
Rhagovelia sp.	1	0	0	0	0	0
Diptera (flies and midges)						
Athericidae (watersnipe flies)						
Atherix sp.	0	0	0	1	1	0
Chironomidae (midge flies)						
Chironomidae g. spp. (Larvae)	16	46	3	19	8	14
Chironomidae g. spp. (Pupae)	2	1	0	2	0	1
Tanypodinae g. spp. (Larvae)	4	12	1	8	4	10
Empididae (dance flies)						
Hemerodromia sp.	2	3	1	0	4	1
Simuliidae (blackflies)						
Simulium sp.	0	0	1	0	3	5
Tipulidae (crane flies)						
Antocha sp.	2	2	0	0	2	0
Dicranota sp.	0	0	0	0	0	1
Hexatoma sp.	0	2	0	1	2	1
Pseudolimnophila sp.	0	0	0	0	0	1
Mollusca						
Gastropoda (snails)						
Ancylidae (freshwater limpets)						
Ferrissia sp.	6	0	1	1	0	0
Pelecypoda (clams and mussels)						
Sphaeriidae (fingernail clams)						
Sphaerium sp.	0	0	0	4	1	0
Total Number of Taxa	**21**	**21**	**17**	**28**	**26**	**24**
Total Number of Organisms	**177**	**201**	**60**	**115**	**194**	**178**

Table 8-10

List and number of benthic macroinvertebrates (individuals) collected from pool CUs in the mined and unmined reaches of Robinson Fork.

	Sample Location (pool CU)					
	Unmined			**Mined**		
Taxa	**1**	**2**	**3**	**1**	**2**	**3**
Annelida						
Oligochaeta g. sp. (aquatic worms)	0	0	0	0	0	1
Arthropoda						
Crustacea						
Isopoda (aquatic sow bugs)						
Asellidae						
Caecidotea sp.	0	4	0	0	0	0
Decapoda (crayfish)						
Cambaridae						
Orconectes sp.	0	1	0	0	1	0
Insecta						
Ephemeroptera (mayflies)						
Baetidae g. sp.	0	0	1	0	0	0
Caenidae						
Caenis sp.	1	0	0	0	2	1
Heptageniidae						
Stenacron sp.	1	0	0	0	0	0
Stenonema sp.	0	1	0	0	0	0
Trichoptera (caddisflies)						
Hydropsychidae						
Ceratopsyche morosa group	0	0	0	0	1	2
Coleoptera (aquatic beetles)						
Elmidae (riffle beetles)						
Dubiraphia sp. (Adult)	2	3	0	0	0	0
Optioservus sp. (Larva)	0	0	0	0	0	1
Stenelmis sp. (Adult)	1	0	0	0	0	0
Psephenidae (water penny)						
Psephenus herricki	0	0	0	0	1	0
Diptera (flies and midges)						
Chironomidae (midge flies)						
Chironomidae g. sp. (larvae)	0	0	0	0	1	0
Chironomini g. spp.	0	1	1	1	7	0
Tanypodinae g. spp.	0	0	0	2	2	0

Table 8-10

List and number of benthic macroinvertebrates (individuals) collected from pool CUs in the mined and unmined reaches of Robinson Fork (cont.).

	Sample Location (pool CU)					
	Unmined			**Mined**		
Taxa	**1**	**2**	**3**	**1**	**2**	**3**
Ephydridae g. sp. (pupa) (shore flies)	0	0	0	0	1	0
Mollusca						
Gastropoda (snails)						
Ancylidae (limpets)						
Ferrissia sp.	0	0	0	0	4	0
Pelecypoda (clams and mussels)						
Sphaeriidae (fingernail clams)						
Sphaerium sp.	0	0	0	0	1	0
Total Number of Taxa	**4**	**5**	**2**	**2**	**9**	**4**
Total Number of Organisms	**5**	**10**	**2**	**3**	**21**	**5**

Table 8-11

Selected metrics for assessment of the benthic macroinvertebrate community in the unmined and mined study reaches (riffle CUs) of Robinson Fork, Washington County, Pennsylvania.

Metric	MINED STATIONS			UNMINED STATIONS		
	Station 1	**Station 2**	**Station 3**	**Station 1**	**Station 2**	**Station 3**
Total Number of Taxa	28	26	24	21	21	17
Total Reach Taxa	39			33		
% EPT Taxa	50.4	75.8	59.0	46.9	44.3	50.0
Percent Dominant Taxa (1-4)*	18.3 Midge	17.0 Caddisfly (A)	18.0 Mayfly (B)	24.9 Beetle (B)	23.4 Midge	23.3 Caddisfly (D)
	12.2 Caddisfly (A)	16.0 Caddisfly (C)	15.2 Caddisfly (A)	18.1 Caddisfly (D)	20.0 Beetle (A)	23.3 Beetle (B)
	7.0 Caddisfly (B)	10.8 Mayfly (A)	11.8 Beetle (A)	14.1 Mayfly (A)	13.4 Mayfly (A)	11.7 Beetle (A)
	7.0 Caddisfly (C)	8.8 Caddisfly (D)	8.4 Midge	10.2 Midge	9.0 Caddisfly (D)	8.3 Caddisfly (A)
Ratio of EPT and Chironomidae Abundances	2.0	12.3	4.2	3.8	1.5	7.5

Mayfly (A) = *Baetis flavistringa*
Mayfly (B) = *Stenonema spp*
Caddisfly (A) = *Ceratopsyche morosa* group
Caddisfly (B) = *Hydropsyche slossonae*
Caddisfly (C) = *Hydropsyche* sp.
Caddisfly (D) = *Cheumatopsyche* spp.

Beetle (A) = *Stenelmis* sp.
Beetle (B) = *Dubiraphia* sp.
Midge = Chironomidae g. sp.

8.6.5 Riparian Vegetation

Results of the generalized survey of riparian plant species occurring along the study reaches of Robinson Fork are presented in Table 8-3A following this chapter. A total of 234 plant species comprised the riparian vegetation community in the mined reach and 246 plants species comprised the riparian community in the unmined reach. Table 8-3A also denotes whether or not a particular species was found in both reaches or found in a specific reach. The general riparian plant survey also showed that a larger proportion of plants found in the unmined reach were exotic (25 percent) compared to the mined reach (17 percent).

Land use in the study reaches was somewhat different based on use occurring at sample plots (Table 8-12). Agricultural land use was greater in the unmined reach with forested slope less prevalent. The types of agricultural practices were very similar along both the mined and unmined reaches. No active row crop agriculture or pastures were located along the study reaches. In both locations, maintenance mowing of grasses and herbaceous vegetation on relatively level areas adjacent to the stream was common. Floodplain forestland use was similar along both study reaches as was the occurrence of floodplain herbaceous (old field habitat) land use.

Stream canopy cover was also similar in the mined and unmined reaches (Table 8-12). Although agricultural land use in the unmined reach was greater, riparian trees remain along the stream margin in many locations.

Vegetative structural coverage on riparian transects for tree, shrub, and herbaceous species was very similar in the study reaches (Table 8-12). Transects typically contained significant tree coverage with understory shrubs somewhat limited. Herbaceous cover was relatively high and nearly identical for the mined and unmined reaches.

Table 8-12

Land use, canopy cover, and riparian vegetation structural coverage for the unmined and mined study reaches of Robinson Fork. All values are percentages.

	Unmined	**Mined**
Land Use		
Agriculture	45.5	27.3
Forested Slope	13.6	25.0
Flood Plain Forest	27.3	29.5
Flood Plain Herbaceous	13.6	18.2
Stream Canopy Cover	57.7	50.9
Vegetative Structural Coverage		
Tree	49.5	48.3
Shrub	29.5	21.5
Herbaceous	89.5	89.3

Additionally, the prevalence of plant species was examined to determine if the riparian communities in the study reaches were similar. Tables 8-13, 8-14, and 8-15 list the prevalent tree, shrub, and herbaceous species in each plot (i.e., greater than 20 percent coverage in plot) along with their frequency of prevalence (number of plots where they occurred) for each of the study reaches.

Generally, prevalent tree, shrub, and herbaceous plant species were very similar in both study reaches. Black maple, bitternut hickory, sycamore, American elm, slippery elm, black walnut, and basswood were codominant in both reaches with black locust, hophornbeam, white ash, and cottonwood more prevalent in the mined reach, and wild black cherry, black willow, and red oak more prevalent in the canopy layer of the unmined reach (see Table 8-13).

Table 8-13

Prevalent tree species in riparian transect plots and their occurrence in the mined and unmined study reaches of Robinson Fork.

Unmined	**Transect**	**Mined**	**Transect**
Species	**Occurrence**	**Species**	**Occurrence**
Wild Black Cherry	5	Black Maple	11
Bitternut Hickory	4	Sycamore	6
Slippery Elm	4	Bitternut Hickory	3
Sycamore	4	Black Locust	2
Black Maple	3	Hophornbeam	2
Black Willow	2	American Elm	2
American Elm	2	Slippery Elm	1
Red Oak	2	White Ash	1
Black Walnut	1	Black Walnut	1
Red Pine	1	Cottonwood	1
Basswood	1	Basswood	1

Prevalent riparian shrubs were more variable in the study reaches with only blackberry/raspberry and American crabapple being codominant in both reaches (Table 8-14). The mined reach understory contained a higher prevalence (number of sample plots) of box-elder, hornbeam, spicebush, and ninebark, while the unmined reach contained high numbers of dotted hawthorn, honeysuckles, hazelnut, dogwood, and multiflora rose.

Table 8-14

Prevalent shrub species in riparian transect plots and their occurrence in the mined and unmined study reaches of Robinson Fork.

Unmined Species	Transect Occurrence	Mined Species	Transect Occurrence
Blackberry/Raspberry	5	Blackberry/Raspberry	3
Dotted Hawthorn	4	Box-Elder	3
Honeysuckle	4	Hornbeam	2
Hazelnut	2	Spicebush	2
Dogwood	2	Ninebark	1
Multiflora Rose	2	American Crabapple	1
American Crabapple	1		

The herbaceous ground layer was diverse in both reaches with wingstem, cutleaf coneflower, riverbank rye, orchardgrass, stinging nettle, violets, and jewelweed occurring in more than two plots in both reaches. Cutgrass, waterleaf, and white wood aster were more prevalent in the mined reach (greater than two plots); and bitter dock, zig-zag aster, and cocklebur were more prevalent in the unmined reach.

Table 8-15

Prevalent herbaceous species in riparian transect plots and their occurrence (frequency) in the mined and unmined study reaches of Robinson Fork.

Unmined Species	Transect Occurrence	Mined Species	Transect Occurrence
Wingstem	18	Wingstem	14
Cutleaf Coneflower	9	Jewelweed	8
Riverbank Rye	8	Violet spp.	8
Jewelweed	6	Waterleaf	6
Orchardgrass	6	Stinging Nettle	5
Bitter Dock	5	Cutleaf Coneflower	4
Violet spp.	4	Riverbank Rye	4
Zig-Zag Aster	4	Orchardgrass	4
Common Cocklebur	3	Cutgrass	4
Stinging Nettle	3	White Wood Aster	3
Cutgrass	2	Bitter Dock	2
Lady's Thumb	2	Christmas Fern	2
Canada Clearweed	2	Maidenhair Fern	2
Crabgrass	1	Canada Clearweed	2
Simple Aster	1	Canada Goldenrod	2
Rice Cutgrass	1	Pennsylvania Smartweed	2
Virginia Creeper	1	Hog Peanut	2
Wood Fern	1	Virginia Creeper	2
Christmas Fern	1	Bee-balm	2
Jumpseed	1	Horsebalm	2
Annual Ragweed	1	Liverleaf	1
Ground-ivy	1	Common Plantain	1
Velvetleaf	1	Red Clover	1

Unmined Species	Transect Occurrence	Mined Species	Transect Occurrence
Velvetgrass	1	Wreath Goldenrod	1
Greenbrier	1	Reed Canary Grass	1
Arrowleaf tearthumb	1	Redtop	1
Deer Tongue	1	Evening Primrose	1
Common Yarrow	1	American Bugleweed	1
Canada Goldenrod	1	Common Chickweed	1
White Snakeroot	1	Purple-leaf Willow-herb	1
Honewort	1	Hooked Crowfoot	1
Tall Meadowrue	1	White Vervain	1
Garlic Mustard	1	Arrowleaf tearthumb	1
Catnip	1	Deer Tongue	1
False Nettle	1	Common Yarrow	1
Bedstraw	1	White Snakeroot	1
Blue-stem Goldenrod	1	Tall Meadowrue	1
Pokeweed	1	Spotted Joe-pye-weed	1
Agrimony	1	Boneset	1
Timothy	1	Moneywort	1
Tall Ironweed	1	Perennial ryegrass	1
Day Lily	1	Bottlebrush Grass	1
Bur Cucumber	1	Coltsfoot	1
Pale Jewelweed	1	Blue-eyed Mary	1
Devil's Beggar Tick	1	Pale Jewelweed	1
Horsebalm	1	Common Smartweed	1
Blue Lobelia	1	Blue Lobelia	1
Sensitive Fern	1	White Avens	1

8.6.6 Wetlands

A jurisdictional wetland was identified in the mined study reach area on the nearly level floodplain along the left descending bank of Robinson Fork. This wetland does not have an apparent surface hydrology connection to Robinson Fork, but may receive backwater during high discharges in the stream.

The wetland was delineated and surveyed using controls from the Robinson Fork stream survey. The wetland has been designated as the Molinari (property location) Wetland and is shown in Figure 8-1B following this chapter.

The Molinari Wetland is 0.73 acre in size and is somewhat different than other wetlands in the Robinson Fork watershed that have seasonal or temporary wetland hydrology. The soils in the wetland are saturated at or just below the soil surface (less than 6-inch depth) for most of the growing season. A shallow open water area (less than 6-inch depth of inundation) is located in the center of the wetland during wet periods. Wetland hydrology results from a prolonged high water table supplemented by seepage from the steep slope adjacent to the wetlands on the east.

The wetland plant community contains many obligate wetland species that include sweetflag, broad-leaf water-plantain, sedges (*Carex* spp.), marsh seedbox, ditch stonecrop, broad-leaf cattail, and American burreed. The prevalent plant species in the wetland (common and scientific names) along with their wetland indicator status (FAC, FACW, OBL, FACU, UPL) are listed in Table 8-4A following this chapter.

The wetland plant community in the wetland is very diverse containing 57 species of plants. This plant diversity is comparable to the diversity of emergent (herbaceous) plants in the beaver-induced wetlands that occur in the Robinson Fork watershed. The plants in the wetland exhibit zonation where the obligate species (rice cutgrass, American burreed, sweetflag, broad-leaf cattail, and marsh seedbox) are prevalent in the wetter, central portion of the wetland, and facultative wetland to facultative species are prevalent in the drier margins of the wetland.

Examination of the soils with a sharpshooter shovel and hand auger to a soil depth of 18 inches (B horizon) at numerous locations within the wetland and on the floodplain adjacent to the wetland resulted in the determination that soils in the wetland are very poorly drained to poorly drained. Soils in the field on the floodplain that surround the wetland are somewhat poorly drained to moderately well drained.

The soil color of the alluvial, Newark soil in Washington and Greene counties is very uniform in the upper B horizon being a yellowish-brown (10YR 5/4) silty clay loam with common, light gray (2.5Y 7/2) to light brownish-gray (10YR 6/2) mottles. The soil is mottled but not hydric (not poorly drained).

Soils on the floodplain adjacent to the Molinari Wetland match the typical pedon for Newark silt loam. The soils within the wetland range in color from a light brownish gray (10YR 6/1) to a very dark gray (5Y 3/1) without mottling. These soil colors indicate a mineral hydric soil (chroma equal to 1 without mottling).

The wetland hydrology in the Molinari Wetland results from a high water that is near or slightly above the soil surface for the majority of the growing season. Very poorly drained soils of this type are rare in the Robinson Fork watershed.

Figure 8-1C (following this chapter) contains ground photographs of typical floodplain wetlands on or near the study reaches on Robinson Fork and photographs of the Molinari Wetland within the mined study reach.

Figure 8-1D (following this chapter) provides low altitude, color aerial photography of the Molinari Wetland. This photography was obtained from the U.S. Department of Agriculture (USDA) – Farm Service Agency in Washington County. The Molinari Wetland is outlined on each photograph within the 3.1-acre field. The photographs show premining conditions (9/88, 9/91, and 9/94), the mining year (9/96), and postmining conditions (6/97 and 8/98).

8.7 Discussion

8.7.1 Physical Characteristics

This assessment of the effects of longwall mining on the water resources of Robinson Fork demonstrates that a habitat based system utilizing CUs originally developed and tested in Ozarkian streams (Peterson and Rabeni, 2001) is applicable to southwestern Pennsylvania. Peterson and Rabeni (2001) suggested that a simplified CU system may be useful in smaller streams with less diverse habitats and communities, and we have confirmed this assertion with the present study. We have also found that CUs can be characterized and compared to detect changes resulting from anthropogenic activities.

A primary goal of this study is to determine if channel characteristics were altered following longwall mining and subsequent surface subsidence. Results indicate that at the reach level, the number and physical characteristics (i.e., dimensions) of CUs in the mined and unmined reaches were different. There were fewer CUs in the mined reach and they were, on average, longer, deeper, and wider than their unmined counterparts. In addition, mined CUs had greater surface area and volume than unmined CUs.

Cluster dendograms show that the mined reach has less diversity of CUs (i.e., fewer cluster groups) and less inter-grading of CUs (refer to Figures 8-9 and 8-10). An examination of the plots of depth and velocity for the two reaches (refer to Figure 8-11) showed less diversity in depth-velocity combinations in mined reaches particularly for intermediate depth-velocity combinations. This reduced habitat diversity could have a subsequent impact on biological communities.

It can be expected that the CUs in the mined reach should have different dimensions than those in the unmined reach because of differences in their longitudinal position within the Robinson Fork stream network. The unmined reach drains approximately 4,384 acres or roughly 31 percent of the Robinson Run watershed. The mined reach drains 8,920 acres or approximately 62 percent of the total watershed (i.e., the total area upstream of the mined reach which includes the unmined reach).

Physical dimensions of CUs in the mined reach should be proportionally greater than those in the unmined reach based on their downstream position and associated greater water and sediment discharge. Similar differences in CUs were detected by Peterson and Rabeni (2001) in their work in the Ozarks. They attributed differences in CU physical characteristics between Fox Farm and Burnt Cabin to longitudinal position and other watershed-based factors (e.g., land use, valley physiography).

While it is reasonable to expect fewer CUs and proportionally larger dimensions in CUs downstream of the unmined reach, it is the degree of the differences in the mined reach that is of interest in this study. Over a similar total reach length, approximately one-half the number of CUs were encountered in the mined reach versus the unmined reach. Although there is no premining data, it is doubtful that the decrease in the number of CUs and their greater physical dimensions would have changed to the degree observed because of differences in discharge and/or other watershed level factors. If there was no influence associated with surface subsidence on the stream channel, then one would expect that CU occurrence (numbers and percentage of total reach length) and dimensional differences would be consistent and proportional throughout both reaches. This is not always the case.

Riffle and glide CUs are typically shorter in the unmined reach and comprise a similar amount of total reach length (refer to Table 8-4). An examination of race and pool CUs shows a different scenario. Races in the unmined reach comprised 32.7 percent of the total length, were slightly longer and deeper, and had greater surface area and volume that those in the mined reach. Mined reach races were relatively short and comprised roughly 9 percent of the total reach. Pools in the unmined reach were shorter than those in the mined reach (16.2 meters and 60.1 meters respectively) and constituted a smaller percentage of total reach length (22.3 percent and 43.7 percent respectively). Race CUs have contracted in the mined reach and pool CUs have expanded, that latter finding being similar to the results of Sidle, et al. (2000) on Burnout Creek, Utah. This is demonstrated further when volume of pool CUs is examined. More than 78 percent of the volume of the mined reach is contained within pool CUs whereas 46 percent was found for unmined pools. Furthermore, although both segments are classified as low-gradient stream segments, the mined reach has a slightly greater gradient (0.68 percent) than the unmined reach (0.36 percent).

Visual observations also support empirical findings. The occurrence of two abnormal CUs in the mined reach warrant discussion. Both are located on or near gates. The first is located at the mouth of an unnamed tributary to Robinson Fork in the lower segment of the mined reach. An elongated pool (approximately 163 meters) exists at the mouth of this tributary where a large amount of tributary-derived bedload material has been deposited in the main channel. Normally, this material would aggregate (at the tail of a pool) and form a tributary riffle immediately downstream; however, the pool continues to extend downstream 43 meters to the next CU; a cobble-boulder bedrock-riffle formed over a gradient drop. In effect, subsidence at this location has eliminated a riffle. The second location is found in a pool located near the upper limit of the mined reach. At this location, a lateral pool has formed that is effectively split into two segments by a bar that projects perpendicularly into the channel across the CU. This anomalous form interrupts the thalweg and is a location of active deposition (Figure 8-26).

Figure 8-26. Lateral pool located near a gate at the upper limit of the mined reach. Note bar in center of photograph protruding across pool.

CUs in the unmined reach typically had a greater channel fill percentage than those in the mined reach. This is influenced by longitudinal position and is generally associated with narrower channels (i.e., active channel width) in headwater areas. Conversely, bank stability ratings show that bank erosion/failure are more severe in the unmined reach. Again, this is consistent with differences in longitudinal position and because the upstream, unmined reach is located on alluvial deposits with less occurrence of bedrock and greater sinuosity.

Although no gauge data exist for Robinson Fork, it is apparent that the size and shape of the watershed influence stream hydrographs. The narrow valley floor and relatively steep basin sides produce runoff events that rapidly fill the channel to bank full stage. These bank full events are ultimately responsible for forming and modifying channel morphology.

Bank stability scores and frequent observations of bank failure point toward a basin-wide response to major precipitation events that would typically have sharply peaked, short-duration hydrographs. These events would cause constant erosion of stream banks that is exacerbated in meandering reaches and channel widening in straight segments, both of which were observed in the mined and unmined reaches of Robinson Fork. In addition, fine sediment was found on the substrate throughout both study reaches and turbidity from suspended clay particles was often observed in pools for prolonged periods following rainfall events. The source of the clay turbidity is most likely from eroding stream banks, dirt and gravel roads, and agricultural sources. Agricultural sources include overgrazed pastures, livestock degradation of stream banks, and row crops located adjacent to Robinson Fork. Dairy cattle wading in the stream channel in the headwaters area during peak midday summer temperatures also produced turbidity that affected downstream locations.

Robinson Fork above the reservoir displays a consistent pattern of channel widening and bank erosion/failure that can be attributed to a disturbance regime that has and continues to modify the stream channel. A more natural stream channel condition can be observed downstream of the flood control reservoir. A relatively narrow channel with densely vegetated banks, minimal siltation, and diverse in-stream habitats typifies this stream segment. The condition of this segment can be attributed to the mediating effect of the flood control dam on discharge and sediment and can serve as a model for potentially attainable conditions in the Robinson Fork watershed with improved agricultural practices, such as stream bank buffer strips.

8.7.2 Fish

Thirty species of fish were collected from 7 locations in the Robinson Fork watershed during this study. U.S. Fish and Wildlife Service (USFWS)/Soil Conservation Service (SCS) conducted a survey in 1975 at 2 locations (1 near the mouth) and collected 18 species. Cooper (1976) collected 25 species from 2 stations, 1 located at the mouth and the other near Beham Run. Both of the historical collections were conducted before completion of the SCS flood control dam and reservoir (PA-647).

A comparison of historical fish collections with the current study (Table 8-2A following this chapter) in Robinson Fork shows that the fish assemblage (common and abundant species) has not significantly changed in recent years. The current study had seven stations with four of the stations (Stations 1, 2, 3, and 4) in close proximity to the historical stations and three additional stations further upstream--study reaches (mined and unmined) and in headwaters (Station 5).

The USFWS/SCS survey found 12 species below the proposed reservoir and 16 species above the proposed reservoir. The Penn State survey found 22 species below the proposed reservoir and 17 species above the proposed reservoir. The current study found 25 species below the reservoir (Station 1) and 22 species above the reservoir.

A total of nine species were collected in the earlier surveys that were not collected in the recent study while 10 species were collected in the current study that were not collected in the earlier studies.

Fishes collected in the USFWS/SCS survey that were not collected in the Penn State survey or the current study include the common shiner, shorthead redhorse, and Iowa darter. The shorthead redhorse occurs in the Ohio River main stem and may occur in the Wheeling Creek watershed (Stauffer, et al., 1995). The common shiner is often confused with the striped shiner, and the occurrence of the Iowa darter in Robinson Fork or the Wheeling Creek watershed in recent times is highly unlikely. This northern species prefers lakes and slow-moving streams in glaciated areas.

Fishes collected in the USFWS/SCS and Penn State surveys not collected in the current study include the river chub, emerald shiner, rosyface shiner, stonecat, brindled madtom, and blackside darter. The emerald shiner abounds in the Ohio River main stem and is usually replaced by the closely related silver shiner and rosyface shiner in smaller streams. The river chub, blackside darter, and brindled madtom are not common in the Wheeling Creek watershed (Stauffer, et al., 1995). The rosyface shiner and stonecat were common in stations below the proposed reservoir in the earlier surveys and less common in the stations above the reservoir (rosyface shiner collected above reservoir only in USFWS/SCS survey). The absence of these two, intolerant species in Robinson Fork represent a definite loss in the fish assemblage. Both of these species remain widely distributed in the Wheeling Creek watershed.

The ten species collected in the current study that were not collected in earlier surveys include the spotfin shiner, silver shiner, common carp, gizzard shad, yellow bullhead, channel catfish, largemouth bass, green sunfish, pumpkinseed, and sauger. All of these species are common in the Ohio River main stem (channel catfish, sauger, and gizzard shad) and the Wheeling Creek watershed. The gizzard shad has apparently developed a large population in the flood control reservoir (PA-647). The yellow bullhead, green sunfish, and pumpkinseed are equally adapted to standing and flowing water habitat, and the largemouth bass (prefers standing water) often occurs as a waif in streams near impoundments.

Fish species richness in Robinson Fork was greatest near the mouth and generally declined upstream, and species richness was marginally greater in the mined reach than in the unmined reach when CUs were combined. This generally conforms to recognized ecological patterns (e.g., species area curves) and longitudinal differences in stream habitat structure. Schlosser (1987) and Peterson and Rabeni (2001) found that upstream habitats were generally shallower and less diverse than downstream reaches and contained fewer species and fewer large-sized fishes. Upstream reaches also suffer more frequent and intense disturbances that can eliminate species (black redhorse, northern hog sucker, largemouth bass, and bluegill) and favor colonizing species, such as white sucker, creek chub, and blacknose dace (Peterson and Rabeni, 2001).

Results of this study indicate that there is an adequate range of habitat types and, therefore, habitat complexity among the CUs in Robinson Fork, particularly in the unmined reach. A greater diversity of habitats (i.e., CU types and associated depth/velocity/substrate combinations) has been correlated with greater occurrence of habitat specialists (Peterson and Rabeni, 2001), yet in this study, habitat generalists are present and/or dominate in most CUs. The dominant species found at stations above the reservoir were the white sucker and the creek chub, both habitat generalists and highly tolerant to habitat degradation.

The absence or relative rarity of some species at sample reaches above the reservoir may be primarily influenced by the frequency and magnitude of hydrologic disturbances in Robinson Fork. Golden redhorse, black redhorse, and northern hog suckers were rarely collected above the reservoir but were the dominant round-bodied suckers collected below the reservoir effectively replacing the white sucker. Centrarchids rarely collected above the reservoir included bluegill, pumpkinseed, rock bass, and largemouth bass, and although habitat appeared to be suitable, no smallmouth bass were collected above the reservoir. As noted earlier, frequent and intense hydrologic disturbances may be controlling fish community structure in the segment of Robinson Fork (includes study reaches) above the flood control reservoir.

Fish biomass (g/m^3) in the mined and unmined reaches (i.e., all CUs combined) was not significantly different. However, biomass (g/m^3) in unmined pool CUs was greater than pools in the mined reach. In this low-order stream, biomass should increase incrementally in the downstream direction (the mined reach drainage area is twice as large as the unmined drainage) with pools in the mined reach having a greater productive capacity in accordance with the River Continuum Concept (Vannote, 1980) and other findings. Our result may be related to greater CU homogeneity in the mined reach (i.e., fewer riffles and races producing benthic macroinvertebrates which serve as fish food), possible lower oxygen tensions at the downstream portion of pools restricting fish utilization, higher water temperatures, and protracted turbidity (suspended clay particles) following storm events reducing primary production and feeding efficiency of sight-feeding fishes. It is also apparent from examination of the dendograms of Froude numbers that unmined pools are not nearly as homogeneous as mined reach pools.

A confounding factor in this study is the existence of the flood control dam that is effectively isolating the majority of the stream network from Enlow Fork. Many species migrate into upstream reaches to spawn and the dam prevents this activity. Species with small populations in the upstream reaches of Robinson Fork prior to construction of the flood control structure are, therefore, at greater risk of extirpation following pollution events, droughts, or other disturbances because natural recolonization is prevented.

The combination of factors previously mentioned make it difficult to determine the actual influence subsidence may exert on fish species richness and community structure. The cumulative impact of the various environmental stressors has produced a fish community in Robinson Fork that is composed of primarily tolerant, habitat generalists.

8.7.3 Benthic Macroinvertebrates

The benthic macroinvertebrate assemblages in the mined and unmined pool CUs in Robinson Fork are characteristic of a eutrophic, low-order, warm water stream in this region where species diversity is low and the number of individuals of each taxa present is reduced. The cumulative effect of anthropogenic land uses in the watershed is causing moderate impairment. Most autochthonous fish food production in small streams occurs on riffle and race CUs that generally have higher oxygen tensions resulting from water/air agitation (turbulent flow), a diversity of physical spaces (variety of substrate types ranging from gravel to cobbles to boulders), and variable depth/velocity combinations.

The riffle CUs in both study reaches have similar benthic macroinvertebrate diversity (species richness) and Percent EPT Taxa. The Percent Dominant Taxon and Ratio of EPT and Chironomidae Abundance indicate moderate impairment in both reaches. The assemblages in both reaches are dominated by somewhat tolerant caddisflies, mayflies, and riffle beetles and tolerant midges. Many of the intolerant mayflies and stoneflies are absent from both study reaches, although the highly intolerant stonefly, *Leuctra* sp., was collected in the mined reach, and the intolerant mayfly, *Leucrocuta* sp., was collected in both study reaches.

The loss of these types of CUs (riffles and races) as shown in this study can reduce food availability and quantity and can subsequently reduce fish diversity (number of species) and standing crop (biomass). The reduced level of benthic macroinvertebrate production promotes the increase and dominance of tolerant, generalist feeders such as white sucker, creek chub, blacknose dace, and bluntnose minnow that can better utilize allochthonous food sources. This increase in habitat generalists is usually inversely proportional to a decrease or extirpation of intolerant/intermediate and specialized feeders (invertivores and herbivores) such as black redhorse, golden redhorse, central stonerollers, darters, striped shiner, and silverjaw minnow.

Dissolved oxygen (DO) measurements were made in various CUs in both study reaches during the fish sampling effort (July 2001). Measurements were made with a YSI Model 85 Oxygen, Conductivity, Salinity, and Temperature Meter and the azide modification of the Winkler method (titration). Oxygen saturation and DO concentrations were adequate (greater than 5.0 milligrams per liter) in all CUs sampled in each reach. Data on DO concentrations during low-flow conditions are not available.

8.7.4 Riparian Vegetation

Land use, canopy cover, and riparian vegetation structure along with the overall riparian vegetation community were very similar between the mined and unmined reach. The riparian vegetation community in the unmined reach had a higher proportion of exotic species (25 percent) than the mined reach (17 percent). Exotic or naturalized species as a group are typically invasive and often predominate on areas where land disturbances are acute (e.g., subsidence and bank failure) or chronic (e.g., cultivation, mowing, overgrazing, logging, and flooding).

The examination of the prevalent plant species in each study reach confirmed the overall vegetation community findings where the prevalent plant species (trees, shrubs, and herbaceous) reflect the historical and current land use in the portion of the watershed containing the study reaches. As discussed in the previous section on fishes, frequent hydrologic disturbances promote and maintain the bank instability that is prevalent in both study reaches. Sloughing banks and frequent overbank flows contribute to a disturbance regime that helps maintain many of the dominant herbaceous species recorded in the mined and unmined reaches (e.g., wingstem, stinging nettle, smartweeds, and riverbank rye).

Other herbaceous species found in the riparian areas along the study reaches are there because of agricultural production (e.g., annual ragweed, cocklebur), silviculture (e.g., red pine), and the current practice of maintenance mowing in fields adjacent to the stream channel (cool season grasses and annuals). Dominant herbaceous species found in the forested riparian areas along the study reaches are somewhat limited because of heavy browsing by whitetail deer (*Odocoileus virginianus*) which are also reducing shrub/tree regeneration and diversity. Shrub cover was rather limited in the riparian transects. We observed evidence of browsing on plant species that are generally not preferred by deer (e.g., jewelweed) indicating overpopulation, and the problem of overbrowsing effects on vegetation communities.

8.7.5 Wetlands

The Molinari Wetland is a depressional area on the nearly level floodplain adjacent to Robinson Fork in the mined study reach. The wetland hydrology in the wetland is mostly permanent soil saturation with a relatively diverse wetland plant community.

An engineering survey of the area (wetland mapping – Figure 8-1B) revealed a narrow wetland buffer area where the elevation rapidly increases several feet in elevation and the prevalent vegetation changes to facultative and facultative upland species (i.e., less hydrophytic plants) in an abrupt zonation.

This wetland was probably at its present location as an isolated wet area (base of seep) long before undermining, but circumstantial evidence exists that this wetland is substantially larger following subsidence.

As late as 1990, the 3.1-acre field that contains the Molinari Wetland was listed on the USDA – Farm Service Agency roles as cropland. Examination of aerial photography of the site indicates that the field was probably most recently used as pasture (remnant cool-season grasses and invasion by wingstem, multiflora rose, and blackberry/raspberry that are common on disturbed floodplains in the region dominate on the upland portion of the field).

The rendition on the aerial photography is fair, and wetland signatures are hard to discern (Figure 8-1D) in the field where the wetland is located. The Molinari Wetland is not evident on the premining photographs (9/88, 9/91, and 9/94), although a wet spot appears to be evident in the southern portion of the field on the 9/94 photograph. The photograph taken in 9/96 (mining year) shows sparse vegetation in the portion of the field where the wetland is located. The postmining photograph (6/97) definitely shows a disturbance in the vicinity of the wetland, possibly backwater from the stream; however, the other postmining photograph (8/98) does not show a disturbance in the field, and no major signature that the wet area has expanded in size.

The Molinari Wetland was evaluated to determine its functional values as a wetland ecosystem. This assessment was based on professional judgment and did not use any of the assessment techniques currently in use.

The wetland represents a relatively large (0.73 acre) depressional area on the nearly level floodplain at the base of a steep, forested slope. The soils in the wetland are saturated or inundated by shallow surface water for a majority of the growing season. This type of wetland in the Robinson Fork watershed is not common and usually occupies smaller depressional areas in remnant stream channels and seasonal seep areas where the water table fluctuates throughout the growing season.

Because the wetland area does not have an apparent surface hydrological connection to Robinson Fork, it has low functional values for nutrient removal/transformation and sediment/toxicant retention. The wetland may have a surface water connection to the stream during occasional high flood events which would produce moderate functional values for shoreline stabilization, flood flow alteration, and production export.

The wetland has a high plant diversity. It can be classified as a palustrine emergent, persistent, saturated (PEM1B) wetland. The plant community contains many of the prevalent emergent species that are found in regional wetlands. The plant diversity certainly equals or exceeds the plant diversity in the graminoid-robust emergent marsh described and lauded by the Conservancy that occurs in the headwaters of Robinson Fork.

An unusual aspect of the wetland is the presence of three robust emergents (broad-leaf cattail, sweetflag, and American burreed) that are prevalent in the lowest portion of the wetland. These species are competitive with American burreed (located in central portion of wetland) more characteristic of stable conditions and broad-leaf cattail and sweetflag adapted to colonize areas where the hydrology has been altered.

The wetland has a high functional value for wildlife habitat because of the high plant diversity and proximity of forested slopes. The wetland is inundated in the spring providing excellent ephemeral (vernal) pool habitat for amphibians.

TABLE 8-1A

COMPREHENSEIVE LIST OF FISH SPECIES COLLECTED IN ROBINSON FORK (ENLOW FORK – WHEELING CREEK)

West Finley Township, Washington County, Pennsylvania

July 2001

COMMON NAME	SCIENTIFIC NAME
CLUPEIDAE (Herrings)	
Gizzard Shad	*Dorosoma cepedianum*
CYPRINIDAE (Carps and Minnows)	
Central Stoneroller	*Campostoma anomalum*
Spotfin Shiner	*Cyprinella spiloptera*
Common Carp	*Cyprinus carpio*
Striped Shiner	*Luxilus chrysocephalus*
Silverjaw Minnow	*Notropis buccatus*
Sand Shiner	*Notropis ludibundus*
Silver Shiner	*Notropis photogenis*
Bluntnose Minnow	*Pimephales notatus*
Blacknose Dace	*Rhinichthys atratulus*
Creek Chub	*Semotilus atromaculatus*
CATOSTOMIDAE (Suckers)	
White Sucker	*Catostomus commersoni*
Northern Hog Sucker	*Hypentelium nigricans*
Black Redhorse	*Moxostoma duquesnei*
Golden Redhorse	*Moxostoma erythrurum*
ICTALURIDAE (Bullhead Catfishes)	
Yellow Bullhead	*Ameiurus natalis*
Channel Catfish	*Ictalurus punctatus*
CENTRACHIDAE (Sunfishes)	
Rock Bass	*Ambloplites rupestris*
Green Sunfish	*Lepomis cyanellus*
Pumpkinseed	*Lepomis gibbosus*
Bluegill	*Lepomis macrochirus*
Smallmouth Bass	*Micropterus dolomieu*
Largemouth Bass	*Micropterus salmoides*
PERCIDAE (Perches)	
Greenside Darter	*Etheostoma blennioides*
Rainbow Darter	*Etheostoma caeruleum*
Fantail Darter	*Etheostoma flabellare*
Johnny Darter	*Etheostoma nigrum*
Variegate Darter	*Etheostoma variatum*
Banded Darter	*Etheostoma zonale*
Sauger	*Stizostedion canadense*

Nomenclature from: Robins, C.R., et.al. 1991. Common and Scientific Names of Fishes from the Untied States and Canada (5th Ed.). American Fisheries Society Special Publ. 20. Bethesda, Maryland. 183 pp.

TABLE 8-2A
COMPARISON OF HISTORICAL FISH COLLECTIONS (LIST OF SPECIES - OCCURRENCE [X]) AND CURRENT STUDY (PENNSYLVANIA DEPARTMENT OF ENVIRONMENTAL PROTECTION)
ON ROBINSON FORK (ENLOW FORK-WHEELING CREEK)

SPECIES	SCS-USFWS (PFBC 1975)		PENN STATE (COOPER 1976)		PENNSYLVANIA DEPARTMENT OF ENVIRONMENTAL PROTECTION 2001	
	Below Proposed Reservoir	Above Proposed Reservoir	Below Proposed Reservoir	Above Proposed Reservoir	Below Reservoir	Above Reservoir
Central Stoneroller	X	X	X	X	X	X
Striped Shiner	-	-	X	X	X	X
Spotfin Shiner	-	-	-	-	X	-
Sand Shiner	-	-	X	-	X	-
Silverjaw Minnow	X	-	-	-	-	X
Silver Shiner	-	-	-	-	X	-
Bluntnose Minnow	X	X	X	X	X	X
Blacknose Dace	-	X	-	X	-	X
Creek Chub	-	X	X	X	X	X
River Chub (*Nocomis micropogon*)	-	X	X	-	-	-
Emerald Shiner (*Notropis atherinoides)*	-	-	X	-	-	-
Rosyface Shiner (*Notropis rubellus*)	-	X	X	-	-	-
Common Shiner (*Notropis = Luxilus cornutus*)	X	X	-	-	-	-
Common Carp	-	-	-	-	X	X
Gizzard Shad	-	-	-	-	-	X
White Sucker	X	X	X	X	X	X
Northern Hog Sucker	X	X	X	X	X	X
Black Redhorse	-	-	X	X	X	X
Golden Redhorse	-	-	X	-	X	X
Northern = Shorthead Redhorse (*Moxostoma macrolepidotum*)	X	X	-	-	-	-
Stonecat (*Noturus flavus*)	-	-	X	X	-	-
Brindled Madtom (*Noturus miurus*)	-	-	X	-	-	-
Yellow Bullhead	-	-	-	-	X	X
Channel Catfish	-	-	-	-	X	-
Rock Bass	X	-	-	X	X	X
Smallmouth Bass	X	X	X	X	X	-

TABLE 8-2A
COMPARISON OF HISTORICAL FISH COLLECTIONS (LIST OF SPECIES - OCCURRENCE [X]) AND CURRENT STUDY (PENNSYLVANIA DEPARTMENT OF ENVIRONMENTAL PROTECTION)
ON ROBINSON FORK (ENLOW FORK-WHEELING CREEK)

SPECIES	SCS-USFWS (PFBC 1975)		PENN STATE (COOPER 1976)		PENNSYLVANIA DEPARTMENT OF ENVIRONMENTAL PROTECTION 2001	
	Below Proposed Reservoir	Above Proposed Reservoir	Below Proposed Reservoir	Above Proposed Reservoir	Below Reservoir	Above Reservoir
Largemouth Bass	-	-	-	-	-	X
Green Sunfish	-	-	-	-	X	X
Pumpkinseed	-	-	-	-	X	X
Bluegill	-	-	-	X	X	X
Greenside Darter	X	X	X	X	X	X
Rainbow Darter	X	X	X	X	X	X
Fantail Darter	-	X	X	X	X	X
Johnny Darter	-	X	X	X	-	X
Variegate Darter	-	-	X	-	X	-
Banded Darter	-	-	X	X	X	-
Iowa Darter (*Etheostoma exile*)	X	X	-	-	-	-
Sauger	-	-	-	-	X	-
Blackside Darter (*Percina maculata*)	-	-	X	-	-	-
Total Number of Species	12	16	22	17	25	22

TABLE 8-3A
LIST OF RIPARIAN VEGETATION OBSERVED IN THE STUDY REACHES (MINED AND UNMINED)
ON ROBINSON FORK (ENLOW FORK-WHEELING CREEK)

Common Name	Scientific Name	Occurrence (Y/N)		Exotic (Y/N)
Family		Mined Reach	Unmined Reach	
EQUISETACEAE				
Common Horsetail	*Equisetum arvense*	N	Y	N
OPHIOGLOSSACEAE				
Cut-Leaved Grape-Fern	*Botrychium dissectum*	Y	Y	N
Rattlesnake Fern	*Botrychium virginianum*	Y	N	N
ADIANTACEAE				
Maidenhair Fern	*Adiantum pedatum*	Y	Y	N
ASPLENIACEAE				
Ebony Spleenwort	*Asplenium platyneuron*	Y	N	N
Walking Fern	*Asplenium rhizophyllum*	Y	N	N
DRYOPTERIDACEAE				
Common Wood Fern	*Dryopteris intermedia*	Y	Y	N
Evergreen Wood Fern	*Dryopteris marginalis*	Y	Y	N
Sensitive Fern	*Onoclea sensibilis*	Y	Y	N
Christmas Fern	*Polystichum acrostichoicles*	Y	Y	N
PINACEAE				
Red Pine	*Pinus resinosa*	N	Y	Y
MAGNOLIACEAE				
Tuliptree	*Liriodendron tulipifera*	N	Y	N
LAURACEAE				
Spicebush	*Lindera benzoin*	N	Y	N
ARISTOLOCHIACEAE				
Wild Ginger	*Asarum canadense*	Y	Y	N
RANUNCULACEAE				
Tall Anemone	*Anemone virginiana*	Y	Y	N
Black Snakeroot	*Cimicifuga racemosa*	Y	Y	N
Virgin's – bower	*Clematis virginiana*	Y	Y	N
Dwarf Larkspur	*Delphinium tricome*	Y	N	N

TABLE 8-3A
LIST OF RIPARIAN VEGETATION OBSERVED IN THE STUDY REACHES (MINED AND UNMINED)
ON ROBINSON FORK (ENLOW FORK-WHEELING CREEK)

Common Name	Scientific Name	Occurrence (Y/N)		Exotic (Y/N)
Family		Mined Reach	Unmined Reach	
Liverleaf	*Hepatica nobilis*	Y	Y	N
Kidney-leaf Buttercup	*Ranunculus abortivus*	Y	Y	N
Allegheny Crowfoot	*Ranunculus allegheniensis*	Y	Y	N
Hairy Buttercup	*Ranunculus hispidus*	Y	Y	N
Hooked Crowfoot	*Ranunculus recurvatus*	Y	Y	N
Creeping Buttercup	*Ranunculus repens*	Y	Y	Y
Tall Meadow-rue	*Thalictrum pubescens*	Y	Y	N
Rue-anemone	*Thalictrum thalictroides*	Y	Y	N
BERBERIDACEAE				
Blue Cohosh	*Caulophylum thalictroides*	Y	Y	N
Twinleaf	*Jeffersonia diphylla*	Y	N	N
May-apple	*Podophyllum peltatum*	Y	Y	N
PLATANACEA				
Sycamore	*Platanus occidentalis*	Y	Y	N
HAMAMELIDACEAE				
Witch-hazel	*Hamamelis virginiana*	Y	Y	N
ULMACEAE				
Hackberry	*Celtis occidentalis*	N	Y	N
American Elm	*Ulmus americana*	Y	Y	N
Slippery Elm	*Ulmus rubra*	Y	Y	N
Red Mulberry	*Morus rubra*	N	Y	N
URTICACEAE				
False Nettle	*Boehmeria clylindrica*	Y	Y	N
Wood-nettle	*Laportea canadensis*	Y	Y	N
Clearweed	*Pilea pumila*	Y	Y	N
Stinging Nettle	*Urtica dioica*	Y	Y	N
JUGLANDACEAE				
Bitternut Hickory	*Carya cordiformis*	Y	Y	N

TABLE 8-3A
LIST OF RIPARIAN VEGETATION OBSERVED IN THE STUDY REACHES (MINED AND UNMINED)
ON ROBINSON FORK (ENLOW FORK-WHEELING CREEK)

Common Name	Scientific Name	Occurrence (Y/N)		Exotic (Y/N)
Family		Mined Reach	Unmined Reach	
Shagbark Hickory	*Carya ovata*	Y	Y	N
Black Walnut	*Juglans nigra*	Y	Y	N
FAGACEAE				
American Beech	*Fagus grandifolia*	Y	Y	N
White Oak	*Quercus alba*	Y	Y	N
Shingle Oak	*Quercus imbricaria*	N	Y	N
Northern Red Oak	*Quercus rubra*	Y	Y	N
Black Oak	*Quercus velutina*	Y	Y	N
BETULACEAE				
Hornbeam	*Carpinus caroliniana*	Y	Y	N
Hazelnut	*Corylus americana*	Y	Y	N
Hop-hornbeam	*Ostrya virginiana*	Y	Y	N
PHYTOLACCACEAE				
Pokeweed	*Phytolacca americana*	Y	Y	N
CHENOPODIACEAE				
Goosefoot	*Chenopodium album*	N	Y	Y
PORTULACEAE				
Spring beauty	*Claytonia virginica*	Y	Y	N
CARYOPHYLLACEAE				
Nodding Chickweed	*Cerastium nutans*	Y	Y	N
Deptford Pink	*Dianthus armeria*	N	Y	Y
Giant Chickweed	*Myosoton aquaticum*	Y	Y	Y
Common Switchwort	*Stellaria graminea*	Y	Y	Y
Common Chickweed	*Stellaria media*	Y	Y	Y
Great Chickweed	*Stellaria pubera*	Y	Y	N
POLYGONACEAE				
Common Smartweed	*Polygonum hydropiper*	Y	Y	Y
Smartweed	*Polygonum pensylvanicum*	Y	Y	N

TABLE 8-3A
LIST OF RIPARIAN VEGETATION OBSERVED IN THE STUDY REACHES (MINED AND UNMINED)
ON ROBINSON FORK (ENLOW FORK-WHEELING CREEK)

Common Name	Scientific Name	Occurrence (Y/N)		Exotic (Y/N)
Family		Mined Reach	Unmined Reach	
Lady's-thumb	*Polygonum persicaria*	N	Y	N
Arrow-leaved Tearthumb	*Polygonum sagittatum*	Y	Y	N
Climbing false-buckwheat	*Polygonum scandens*	Y	Y	N
Jumpseed	*Polygonum virginianum*	Y	Y	N
Sheep Sorrel	*Rumex acetosella*	N	Y	Y
Curly Dock	*Rumex crispus*	Y	Y	Y
Bitter Dock	*Rumex obtusifolius*	Y	Y	Y
TILIACEAE				
Basswood	*Tilia americana*	Y	Y	N
MALVACEAE				
Butter-print	*Abutilon threophrastii*	N	Y	Y
Cheeses	*Malva neglecta*	N	Y	Y
VIOLACEAE				
Canada Violet	*Viola canadensis*	Y	N	N
Blue Marsh Violet	*Viola cucullata*	Y	Y	N
Smooth Yellow Violet	*Viola eriocarpa*	Y	Y	N
Common Blue Violet	*Viola sororia*	Y	Y	N
Striped Violet	*Viola striata*	Y	Y	N
CUCURBITACEAE				
Bur Cucumber	*Sicyos angulatus*	N	Y	N
SALICACEAE				
Cottonwood	*Populus deltoides*	Y	N	N
Heart-leaved Willow	*Salix eriocephala*	Y	Y	N
Sandbar Willow	*Salix exigua*	Y	Y	N
BRASSICACEAE				
Garlic-mustard	*Alliaria petiolata*	Y	Y	Y
Winter-cress	*Barbarea vulgaris*	Y	Y	Y
Shepherd's-purse	*Capsella bursa-pastoris*	N	Y	Y

TABLE 8-3A
LIST OF RIPARIAN VEGETATION OBSERVED IN THE STUDY REACHES (MINED AND UNMINED)
ON ROBINSON FORK (ENLOW FORK-WHEELING CREEK)

Common Name	Scientific Name	Occurrence (Y/N)		Exotic (Y/N)
Family		Mined Reach	Unmined Reach	
Toothwort	*Cardamine angustata*	Y	Y	N
Bitter-cress	*Cardamine bulbosa*	Y	Y	N
Cut-leaved Toothwort	*Cardamine concatenata*	Y	Y	N
Pennsylvania Bitter-cress	*Cardamine pensylvanica*	Y	Y	N
Dames-rocket	*Hesperis matronalis*	N	Y	Y
Charlock	*Sinapsis arvensis*	N	Y	N
PRIMULACEAE				
Fringed Loosestrife	*Lysimachia ciliata*	N	Y	N
Moneywort	*Lysimachia nummularia*	Y	Y	Y
Whorled Loosestrife	*Lysimachia quadriflora*	Y	Y	N
HYDRANGEACEAE				
Wild Hydrangea	*Hydrangea arborescens*	Y	Y	N
GROSSULARIACEAE				
Prickly Gooseberry	*Ribes cynosbati*	Y	Y	N
CRASSULACEAE				
Wild Stonecrop	*Sedum ternatum*	Y	N	N
ROSACEAE				
Southern Agrimony	*Agrimonia parviflora*	Y	Y	N
Shadbush	*Amelanchier arborea*	N	Y	N
Goat's-beard	*Aruncus dioicus*	Y	Y	N
Dotted Hawthorn	*Crataegus punctata*	Y	Y	N
Wild Strawberry	*Fragaria virginiana*	Y	Y	N
White Avens	*Geum canadense*	Y	Y	N
Spring Avens	*Geum vernum*	Y	Y	N
Ninebark	*Physocarpus opulifolius*	Y	Y	N
Strawberry-weed	*Potentilia norvegica*	Y	Y	N
Old-field Cinquefoil	*Potentila simplex*	Y	Y	N
Wild Black Cherry	*Prunus serotina*	Y	Y	N

TABLE 8-3A
LIST OF RIPARIAN VEGETATION OBSERVED IN THE STUDY REACHES (MINED AND UNMINED)
ON ROBINSON FORK (ENLOW FORK-WHEELING CREEK)

Common Name	Scientific Name	Occurrence (Y/N)		Exotic (Y/N)
Family		Mined Reach	Unmined Reach	
Pasture Rose	*Rosa carolina*	Y	N	N
Multiflora Rose	*Rosa multiflora*	Y	Y	N
Common Blackberry	*Rubus allegheniensis*	Y	Y	N
Black Raspberry	*Rubus occidentalis*	Y	Y	N
Blackberry	*Rubus pensilvanicus*	Y	N	N
FABACEAE				
Hog-peanut	*Amphicarpaea bracteata*	N	Y	N
Sticky Tick-clover	*Desmodium glutinosum*	Y	Y	N
Bird's-foot Trefoil	*Lotus corniculatus*	N	Y	Y
Black Locust	*Robinia pseudoacacia*	Y	Y	N
Red Clover	*Trifolium pratense*	Y	Y	Y
ONAGRACEAE				
Enchanter's Nightshade	*Ciraea lutetiana*	Y	Y	N
Purple-leaved Willow-herb	*Epilobium coloratum*	Y	Y	N
Evening Primrose	*Oenothera biennis*	Y	Y	N
CORNACEAE				
Kinnikinik	*Cornus amomum*	N	Y	N
Flowering Dogwood	*Cornus florida*	Y	Y	N
VITACEAE				
Virginia-creeper	*Parthenocissus quinquefolia*	Y	Y	N
Frost Grape	*Vitis riparia*	Y	Y	N
ACERACEAE				
Box-elder	*Acer negundo*	Y	Y	N
Black Maple	*Acer nigrum*	Y	Y	N
Red Maple	*Acer rubrum*	Y	Y	N
Sugar Maple	*Acer saccharum*	Y	Y	N
ANACARDIACEAE				
Smooth Sumac	*Rhus glabra*	N	Y	N

TABLE 8-3A
LIST OF RIPARIAN VEGETATION OBSERVED IN THE STUDY REACHES (MINED AND UNMINED)
ON ROBINSON FORK (ENLOW FORK-WHEELING CREEK)

Common Name	Scientific Name	Occurrence (Y/N)		Exotic (Y/N)
Family		Mined Reach	Unmined Reach	
Poison-ivy	*Toxicodendron radicans*	Y	Y	N
OXALIDACEAE				
Common Yellow-wood Sorrel	*Oxalis stricta*	Y	Y	N
GERANIACEAE				
Wood Geranium	*Geranium maculatum*	Y	Y	N
LIMNATHACEAE				
False-mermaid	*Floerkea proserpinacoides*	Y	Y	N
BALSAMINACEAE				
Jewelweed	*Impatiens capensis*	Y	Y	N
Pale Jewelweed	*Impatiens pallida*	Y	Y	N
APIACEAE				
Poison Hemlock	*Conium maculatum*	Y	Y	Y
Honewort	*Cryptotaenia canadensis*	Y	Y	N
Queen-Anne's-lace	*Daucus carota*	Y	Y	Y
Sweet-cicely	*Osmorhiza claytonil*	Y	Y	N
Anise-root	*Osmorhiza longistylis*	Y	Y	N
Wild Parsnip	*Pastinaca sativa*	N	Y	Y
APOCYNACEAE				
Indian Hemp	*Apocynum cannabinum*	Y	Y	N
ASCLEPIADACEAE				
Swamp Milkweed	*Asclepias incarnata*	Y	Y	N
Common Milkweed	*Asclepias syriaca*	N	Y	N
SOLANACEAE				
Horse-nettle	*Solanum carolinense*	Y	Y	N
Trailing Nightshade	*Solanum dulcamara*	N	Y	Y
CUSCUTACEAE				
Dodder	*Cuscuta gronovii*	Y	Y	N

TABLE 8-3A
LIST OF RIPARIAN VEGETATION OBSERVED IN THE STUDY REACHES (MINED AND UNMINED)
ON ROBINSON FORK (ENLOW FORK-WHEELING CREEK)

Common Name	Scientific Name	Occurrence (Y/N)		Exotic (Y/N)
Family		Mined Reach	Unmined Reach	
POLEMONIACEAE				
Wild Blue Phlox	*Phlox divaricata*	Y	Y	N
Summer Phlox	*Phlox paniculata*	Y	Y	N
HYDROPHYLLACEAE				
Waterleaf	*Hydrophyllum appendiculatum*	Y	Y	N
Canadian Waterleaf	*Hydrophyllum canadense*	Y	Y	N
Miami-mist	*Phacelia purshii*	Y	N	N
BORAGINACEAE				
Viper's Bugloss	*Echium vulgare*	N	Y	Y
Virginia Bluevells	*Mertensia virginica*	Y	Y	N
Forget-me-not	*Myosotis scorpioides*	N	Y	Y
VERBENACEAE				
Blue Vervain	*Verbena hastata*	Y	Y	N
White Vervain	*Verbena urticifolia*	Y	N	Y
LAMIACEAE				
Horse-balm	*Collinsonia canadensis*	Y	Y	N
Ground-ivy	*Glecoma herderacea*	Y	Y	Y
Wood Mint	*Blephilia hirsuta*	Y	N	N
Purple Dead-nettle	*Lamium purpureum*	Y	Y	Y
Water-horehound	*Lycopus americanus*	Y	Y	N
Field Mint	*Mentha arvensis*	Y	Y	N
Bee-balm	*Monarda clinopoda*	Y	Y	N
Purple Bergamot	*Monarda media*	Y	N	N
Catnip	*Nepeta cataria*	N	Y	Y
Heal-all	*Prunella vulgaris*	Y	N	N
Downy Skullcap	*Scutellaria incana*	Y	N	N
Creeping Hedge-nettle	*Stachys tenuifolia*	N	Y	N

TABLE 8-3A
LIST OF RIPARIAN VEGETATION OBSERVED IN THE STUDY REACHES (MINED AND UNMINED)
ON ROBINSON FORK (ENLOW FORK-WHEELING CREEK)

Common Name	Scientific Name	Occurrence (Y/N)		Exotic (Y/N)
Family		Mined Reach	Unmined Reach	
PLANTAGINACEAE				
English Plantain	*Plantago lanceolata*	Y	Y	Y
Broadleaf Plantain	*Plantago major*	Y	Y	Y
OLEACEAE				
White Ash	*Fraxinus americana*	Y	Y	N
SCROPHULARIACEAE				
False-foxglove	*Agalinis tenuifolia*	Y	N	N
Blue-eyed-Mary	*Collinsia verna*	Y	N	N
Allegheny Monkey-flower	*Mimulus ringens*	Y	Y	N
Bird's-eye Speedwell	*Veronica persica*	N	Y	Y
CAMPANULACEAE				
Tall Bellflower	*Campanula americana*	Y	Y	N
Indian-tobacco	*Lobelia inflata*	Y	Y	N
Great Blue Lobelia	*Lobelia siphilitica*	Y	Y	N
RUBIACEAE				
Bedstraw	*Galium aparine*	Y	Y	N
Rough Bedstraw	*Galium asperellum*	Y	Y	N
White Bedstraw	*Galium mollugo*	Y	Y	Y
Bluets	*Hedyotis caerulea*	Y	Y	N
CAPRIFOLIACEAE				
Morrow's Honeysuckle	*Lonicera morrowii*	N	Y	Y
Tartanan Honeysuckle	*Lonicera tatarica*	Y	Y	Y
American Elder	*Sambucus canadensis*	N	Y	N
Coralberry	*Symphoricarpus orbiculatus*	N	Y	N
Maple-leave Viburnum	*Viburnum acerifolium*	Y	Y	N
Black-haw	*Viburnum prunifolium*	N	Y	N
DIPSACACEAE				
Teasel	*Dipsacus sylvestris*	Y	Y	Y

TABLE 8-3A
LIST OF RIPARIAN VEGETATION OBSERVED IN THE STUDY REACHES (MINED AND UNMINED)
ON ROBINSON FORK (ENLOW FORK-WHEELING CREEK)

Common Name	Scientific Name	Occurrence (Y/N)		Exotic (Y/N)
Family		Mined Reach	Unmined Reach	
ASTERACEAE				
Common Yarrow	*Achillea millefolium*	Y	Y	Y
Common Ragweed	*Ambrosia artemisiifolia*	Y	Y	N
Giant Ragweed	*Ambrosia trifida*	Y	Y	N
Pussytoes	*Antennaria neodioica*	Y	Y	N
Common Burdock	*Arctium minus*	Y	Y	Y
Blue Wood Aster	*Aster cordifolius*	Y	Y	N
White Wood Aster	*Aster divaricatus*	Y	Y	N
Simple Aster	*Aster lanceolatus*	Y	Y	N
Heath Aster	*Aster pilosus*	Y	Y	N
Zig-zag Aster	*Aster prenanthoides*	Y	Y	N
Beggar-ticks	*Bidens frondosa*	Y	Y	N
Great Indian-plantain	*Cacalia muhlenbergii*	Y	Y	N
Ox-eye Daisy	*Chrysanthemum leucanthemum*	Y	Y	Y
Blue Chicory	*Cichorium intybus*	N	Y	Y
Tall Thistle	*Cirsium altissimum*	Y	Y	N
Canada Thistle	*Cirsium arvense*	Y	Y	Y
Horseweed	*Conyza canandensis*	Y	Y	N
Daisy Fleabane	*Erigeron annuus*	Y	Y	N
Joe-pye-weed	*Eupatorium fistulosum*	Y	Y	N
Boneset	*Eupatorium perfoliatum*	Y	Y	N
Joe-pye-weed	*Eupatorium purpureum*	Y	Y	N
White-snakeroot	*Eupatorium rugosum*	Y	Y	N
Grass-leaved Goldenrod	*Euthamia graminifolia*	Y	Y	N
Common Sneezewood	*Helenium autumnale*	Y	Y	N
Thin-leaved Sunflower	*Helianthus decapetalus*	Y	Y	N
Rough-leaved Sunflower	*Hellianthus strumosus*	Y	Y	N
Jerusalem Artichoke	*Helianthus tuberosus*	Y	Y	Y

TABLE 8-3A
LIST OF RIPARIAN VEGETATION OBSERVED IN THE STUDY REACHES (MINED AND UNMINED)
ON ROBINSON FORK (ENLOW FORK-WHEELING CREEK)

Common Name	Scientific Name	Occurrence (Y/N)		Exotic (Y/N)
Family		Mined Reach	Unmined Reach	
Blue Lettuce	*Lactuca biennis*	Y	Y	N
Cutleaf Coneflower	*Rudbeckia laciniata*	Y	Y	N
Golden Ragwort	*Senecio aureus*	Y	N	N
Blue-stem Goldenrod	*Solidago caesia*	Y	N	N
Canada Goldenrod	*Solidago canandensis*	Y	N	N
Zigzag Goldenrod	*Solidago flexicaulis*	Y	N	N
Gray Goldenrod	*Solidago nemoralis*	Y	N	N
Elm-leaved Goldenrod	*Solidago ulmifolia*	Y	N	N
Coltsfoot	*Tussilago farfara*	Y	Y	Y
Wingstem	*Verbesing alternifolia*	Y	Y	N
Ironweed	*Vernonia gigantea*	Y	Y	N
Common Cocklebur	*Xanthium strumarium*	Y	Y	N
ARACEAE				
Green-dragon	*Arisaema dracontium*	Y	N	N
Jack-in-the-pulpit	*Arisaema triphyllum*	Y	N	N
JUNCACEAE				
Soft Rush	*Juncus effusus*	Y	Y	N
Path Rush	*Juncus tenuis*	Y	Y	N
Field Wood-rush	*Luzula multiflora*		Y	N
CYPERACEAE				
Sedge	*Carex blanda*	Y	Y	N
Sedge	*Carex laxiflora*	Y	Y	N
Sedge	*Carex prasina*	Y	Y	N
Sedge	*Carex vulpinoidea*	Y	Y	N
Yellow Nutsedge	*Cyperus esculentus*	Y	Y	N
False Nutsedge	*Cyperus strigosus*	Y	Y	N
POACEAE				
Hairgrass	*Agrostis hyemalis*	Y	Y	N

TABLE 8-3A
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ON ROBINSON FORK (ENLOW FORK-WHEELING CREEK)

Common Name	Scientific Name	Occurrence (Y/N)		Exotic (Y/N)
Family		Mined Reach	Unmined Reach	
Autumn Bent	*Argostis perennans*	Y	Y	N
Hairy Chess	*Bromus commutatus*	Y	Y	Y
Smooth Brome	*Bromus inermis*	Y	Y	Y
Wood Redgrass	*Cinna arundinacea*	Y	Y	N
Orchard Grass	*Dactylis glomerata*	Y	Y	Y
Smooth Crabgrass	*Digitaria ischaemum*	Y	Y	Y
Barnyard Grass	*Echinochloa crusgalli*	Y	Y	Y
Bottlebrush Grass	*Elymus hystrix*	Y	Y	N
Riverbank Wild-Rye	*Elymus riparius*	Y	Y	N
Virginia Wild-rye	*Elymus virginicus*	Y	Y	N
Meadow Fescue	*Festuca pratensis*	Y	Y	Y
Velvetgrass	*Holcus lanatus*	Y	Y	Y
Cutgrass	*Leersia virginica*	Y	Y	N
Perennial Ryegrass	*Lolium perenne*	Y	Y	Y
Panic-grass	*Panicum acuminatum*	Y	Y	N
Witch Grass	*Panicum capillare*	Y	Y	N
Deer-tongue Grass	*Panicum clandestinum*	Y	Y	N
Reed Canary-grass	*Phalaris arundinacea*	Y	Y	Y
Timothy	*Phleum pratense*	Y	Y	Y
Annual Bluegrass	*Poa annua*	N	Y	Y
Rough Bluegrass	*Poa trivialis*	Y	Y	Y
Kentucky Bluegrass	*Poa pratensis*	Y	Y	Y
Yellow Foxtail	*Setaria pumila*	Y	Y	Y
Purple-top	*Tridens flavus*	Y	Y	N
LILIACEAE				
Wild Onion	*Allium canadense*	Y	Y	N
Field Garlic	*Allium vineale*	N	Y	Y
Trout-lily	*Eyrthronium americanum*	Y	Y	Y

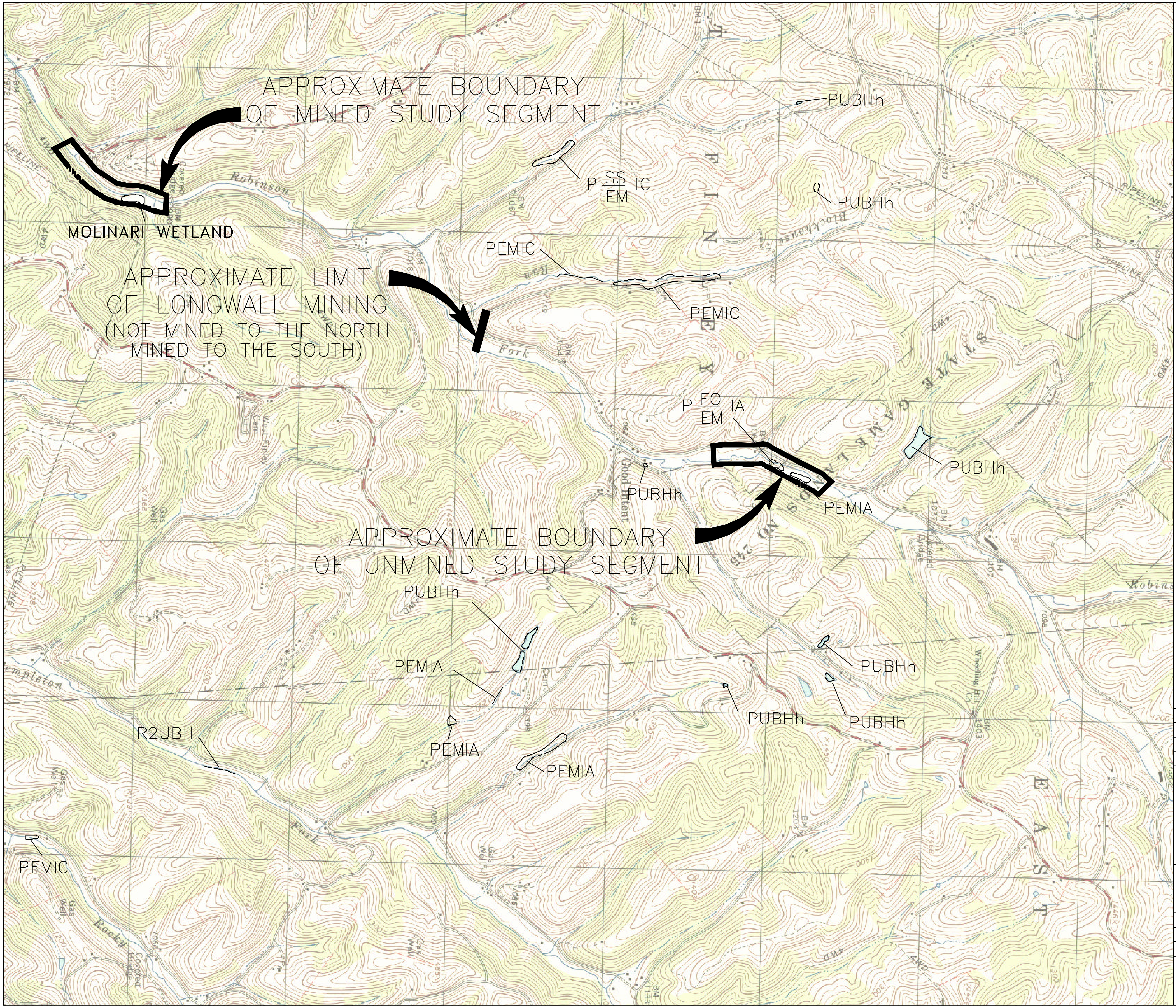
TABLE 8-3A
LIST OF RIPARIAN VEGETATION OBSERVED IN THE STUDY REACHES (MINED AND UNMINED)
ON ROBINSON FORK (ENLOW FORK-WHEELING CREEK)

Common Name	Scientific Name	Occurrence (Y/N)		Exotic (Y/N)
Family		Mined Reach	Unmined Reach	
Orange Day-lily	*Hemerocallis fulva*	Y	Y	Y
Star-of-Bethlehem	*Ornithogalum umbellatum*	N	Y	Y
False Solomon's-seal	*Smilacina racemosa*	Y	Y	N
White Trillium	*Trillium grandiflorum*	Y	Y	N
Toadshade	*Trillium sessile*	Y	N	N
IRIDACEAE				
Blue-eyed-grass	*Sisyrinchium angustifolium*	Y	Y	N
SMILACEAE				
Bristly Greenbrier	*Smilax hispida*	Y	N	N
Total Number of Species		234	246	
Total Number of Exotic Species (%)		42 (17)	61 (25)	

- Riparian area constitutes a distance of 10 m (30 feet) perpendicular to the wetted width on each bank of the stream in each study reach
- Occurrence (Y/N) is Y = presence and N = absence
- Exotic (Y/N) is N = indigenous or native and Y = introduced or naturalized
- Plant nomenclature (common and scientific names) follows sources cited in Rhoads, A.F., and W.M. Klein, Jr. 1993. *The Vascular Flora of Pennsylvania: Annotated Checklist and Atlas.* Am. Philosophical Soc. Philadelphia, PA. 636 pp.

TABLE 8-4A
LIST OF PREVALENT PLANT SPECIES IN MOLINARI WETLAND ON FLOODPLAIN OF ROBINSON FORK WITHIN MINED STUDY REACH

Common Name	Scientific Name	Indicator Status
Sweetflag	*Acorus calamus*	OBL
Tall Hairy Groovebur	*Agrimonia gryposepala*	FACU
Broad-leaf Water-plantain	*Alisma plantago-aquatica*	OBL
Clasping-leaf Dogbane	*Apocynum cannabinum*	FACU
Swamp Milkweed	*Asclepias incarnatum*	OBL
Panicled Aster	*Aster simplex*	FACW
Devil's Beggar-ticks	*Bidens frondosa*	FACW
Small-spike False-nettle	*Boehmeria cylindrica*	FACW+
Shallow Sedge	*Carex lurida*	OBL
Drooping Sedge	*Carex prasina*	OBL
Woodland Sedge	*Carex blanda*	FAC
Smooth-sheath Sedge	*Carex laevivaginata*	OBL
Creeping Thistle	*Cirsium arvense*	FACU
False Nutsedge	*Cyperus strigosus*	FACW
Orchard Grass	*Dactylis glomerata*	FACU
Deer-tongue Witchgrass	*Dichanthelium clandestinum*	FAC+
Barnyard Grass	*Echinochloa crusgalli*	FACU
Riverbank Wild-rye	*Elymus riparius*	FACW
Purple-leaf Willow-herb	*Epilobium coloratum*	OBL
Hollow Joe-pye-weed	*Eupatoriadelphus fistulosus*	FACW
Rough Bedstraw	*Galium asprellum*	OBL
Spotted Touch-me-not	*Impatiens capensis*	FACW
Soft Rush	*Juncus effusus*	FACW+
Canada Wood-nettle	*Laportea canadensis*	FACW
Rice Cutgrass	*Leersia oryzoides*	OBL
Great Blue Lobelia	*Lobelia siphilitica*	FACW+
Marsh Seedbox	*Ludwigia palustris*	OBL
Creeping Jennie	*Lysimachia nummularia*	OBL
American Bugleweed	*Lycopus americanus*	OBL
Peppermint	*Mentha x piperita*	FACW+
Allegheny Monkeyflower	*Mimulus ringens*	OBL
Field Mint	*Mentha arvensis*	FACW
Sensitive Fern	*Onoclea sensibilis*	FACW
Virginia Creeper	*Parthenocissus quinquefolia*	FACU
Ditch-stonecrop	*Penthorum sedoides*	OBL
Reed Canary Grass	*Phalaris arundinacea*	FACW+
Canada Clearweed	*Pilea pumilea*	FACW
Rough Bluegrass	*Poa trivialis*	FACW



SCALE - FEET

0 2000

REFERENCE

USGS 7.5-MIN TOPOGRAPHIC QUADRANGLE
CLAYSVILLE, PENNSYLVANIA
DATED 1998

REVISION	DESCRIPTION	APPVD.	DATE

FIGURE 8-1A
NATIONAL WETLANDS INVENTORY (NWI) MAPPING
MINED AND UNMINED STUDY REACHES
ROBINSON FORK
WEST FINLEY TWP, WASHINGTON COUNTY, PA

PREPARED FOR
PENNSYLVANIA BUREAU OF MINING AND RECLAMATION
HARRISBURG, PENNSYLVANIA

APPROVED	
CHECKED	
DRAWN	DEB 11/21/01
DRAWING NUMBER	
5904205	

Earth Sciences Consultants, Inc.


PANEL B-8 (4/18/96)
N
GATE
GATE
AREA 0.73 ACRES
TRIBUTARY
BEGINNING OF SURVEYED REACH
ROBINSON FORK
RIFFLE (MSR7)
POOL (MSP5)
RIFFLE (MSR6)
RUN (MSRR5)
RIFFLE (MSR5)
RUN (MSRR4)
POOL (MSP3)
RUN (MSRR3)
GLIDE (MSG1)
RUN (MSRR2)
RIFFLE (MSR3)
BASE MAPPING PROVIDED BE EARTH SCIENCE CONSULTANTS
T-360
LEGEND
DELINEATED WETLAND (MOLINARI PROPERTY)
SCALE: 1"= 50'
0
100
200
300
THIS DRAWING IS CORRECT TO THE BEST OF MY KNOWLEDGE AND BELIEF
SCI-TEK
PADEP LONGWALL MINING STUDY
WETLAND DELINEATION
ON FLOODPLAIN OF MINED
REACH OF ROBINSON FORK
MOLINARI WETLAND
WEST FINLEY TOWNSHIP, WASHINGTON COUNTY, PA
BY DATE
DESIGN
DRAWN TJV 11/16/01
CKD PSB 11/19/01
APP
CLIENT
REV DATE DESCRIPTION BY CKD APP
1
2
3
ISSUE DATE 11/16/01
PROJECT NUMBER NA
SCALE AS NOTED
FIGURE NO. 8-1B

TABLE 8-4A
LIST OF PREVALENT PLANT SPECIES IN MOLINARI WETLAND ON FLOODPLAIN OF ROBINSON FORK WITHIN MINED STUDY REACH

Common Name	Scientific Name	Indicator Status
Arrow-leaf Tearthumb	*Polygonum sagittatum*	OBL
Climbing False-buckwheat	*Polygonum scandens*	FAC
Virginia Knotweed	*Polygonum virginianum*	FAC
Marshpepper Smartweed	*Polygonum hydropiper*	OBL
Pennsylvania Smartweed	*Polygonum pensylvanicum*	FACW
Multiflora Rose	*Rosa Multiflora*	FACU
Allegheny Blackberry	*Rubus allegheniensis*	FACU
Bitter Dock	*Rumex obtusifolius*	FACU
Sandbar Willow	*Salix exigua*	OBL
Common Greenbrier	*Smilax rotundifolia*	FAC
American Burreed	*Sparganium americanum*	OBL
Broad-leaf Cattail	*Typha latifolia*	OBL
Wingstem	*Verbena alternifolia*	FAC
Tall Ironweed	*Vernonia gigantea*	FAC
Woolly Blue Violet	*Viola sororia*	FAC -
Cut-leaf Coneflower	*Rudbeckia laciniata*	FACW
Columbia Water-meal	*Wolffia columbiana*	OBL
Horse-nettle	*Solanum carolinense*	UPL
Clammy Ground-cherry	*Physalis heterophylla*	UPL

Plant nomenclature follows the convention in Reed, P.B. 1988. *National List of Plant Species That Occur in Wetlands: Pennsylvania*. National Wetlands Inventory, U.S. Fish Wildlife Service, NERC-88/18.38, St. Petersburg, FL. and Tiner, R. et.al. 1995. *Supplement to the List of Plant Species That Occur in Wetlands: Northeast (Region 1)*. National Wetlands Inventory, U.S. Fish Wildlife Service. 8 pp.

W:\5904\rpt\table8-4a.doc

Photograph 8-1C1 - Typical view of depressional wetland (remnant stream channel)
located on floodplain within unmined study reach.

Photograph 8-1C2 - Typical view of depressional wetland on floodplain of
Robinson Fork at base of forested slope where seepage occurs.

Figure 8-1C
Photographs of Molinari Wetland

Photograph 8-1C3 - View of Molinari Wetland from main stem of Robinson Fork.

Photograph 8-1C4 - North view of Molinari Wetland.
Reddish plants in center of photograph are Ditch Stonecrop.

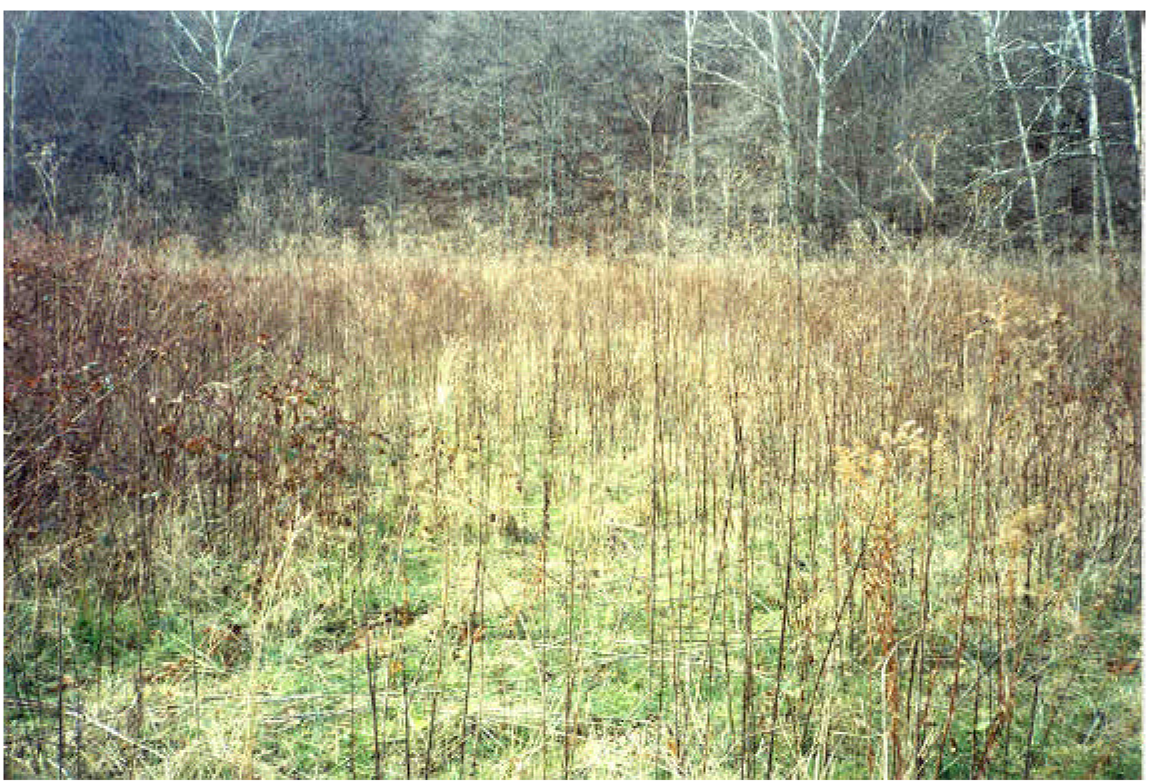
Figure 8-1C
Photographs of Molinari Wetland

Photograph 8-1C5 - Central portion of Molinari Wetland with forested slope along eastern edge of the wetland.

Photograph 8-1C6 - View west of Molinari Wetland (Robinson Fork in background) showing zonation where wingstem is dominant on the higher areas between the wetland and stream.

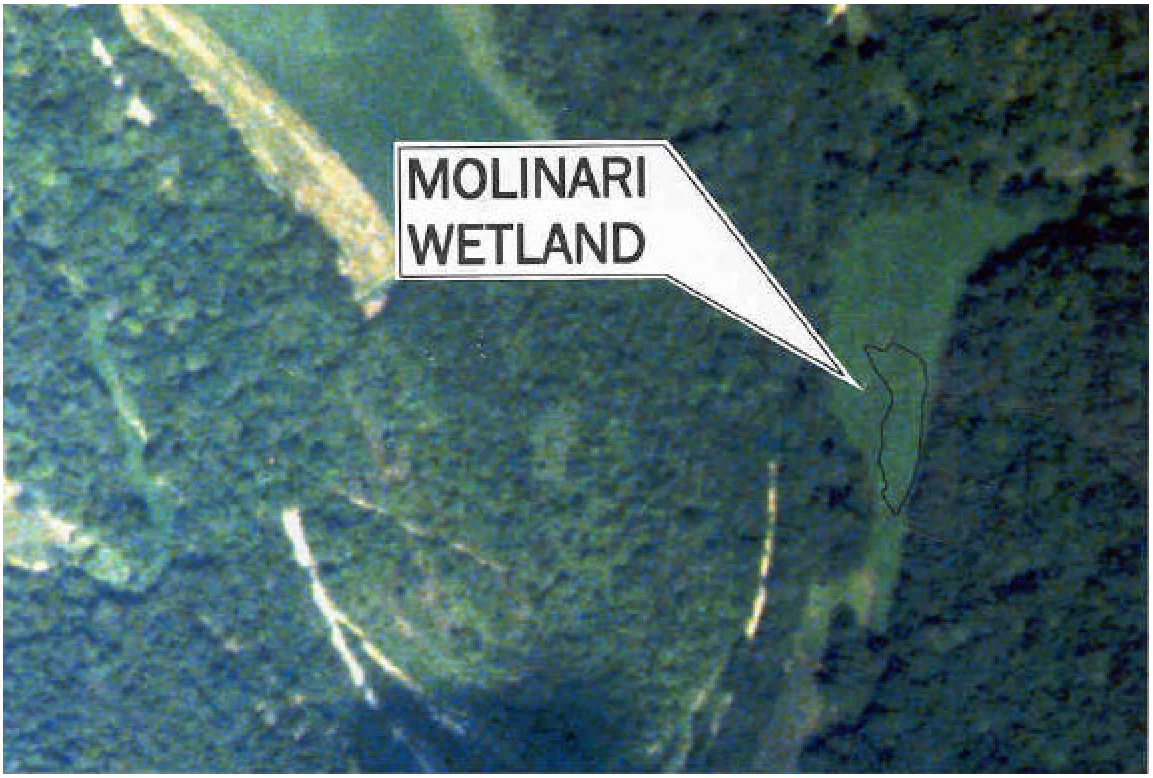
Figure 8-1C
Photographs of Molinari Wetland

Photograph 8-1C7 - View south from interior portion of Molinari Wetland
showing narrow floodplain of Robinson Fork Valley.

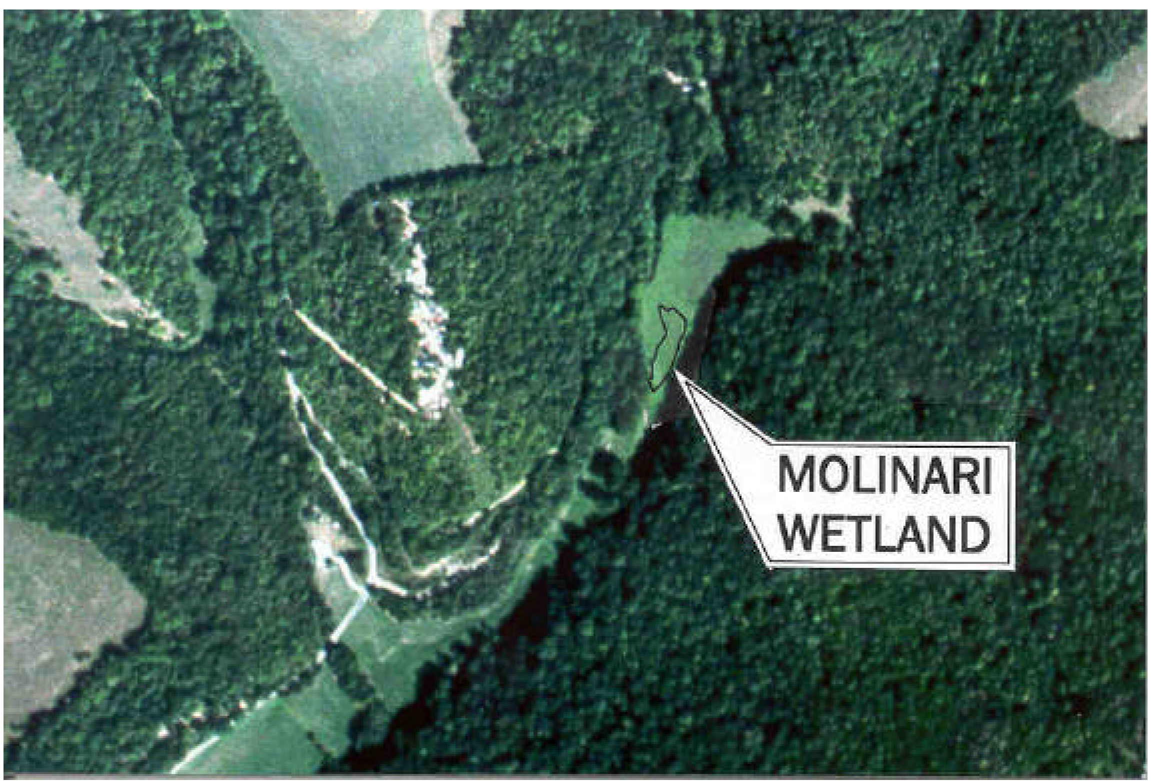


Photograph 8-1C8 - Typical view of upland area in field where Molinari Wetland is situated.
Remnant cool-season grasses and wingstem dominate upland areas adjacent to wetland.

Figure 8-1C
Photographs of Molinari Wetland



Photograph 8-1D1 - September 1988 Premining



Photograph 8-1D2 - September 1991 Premining

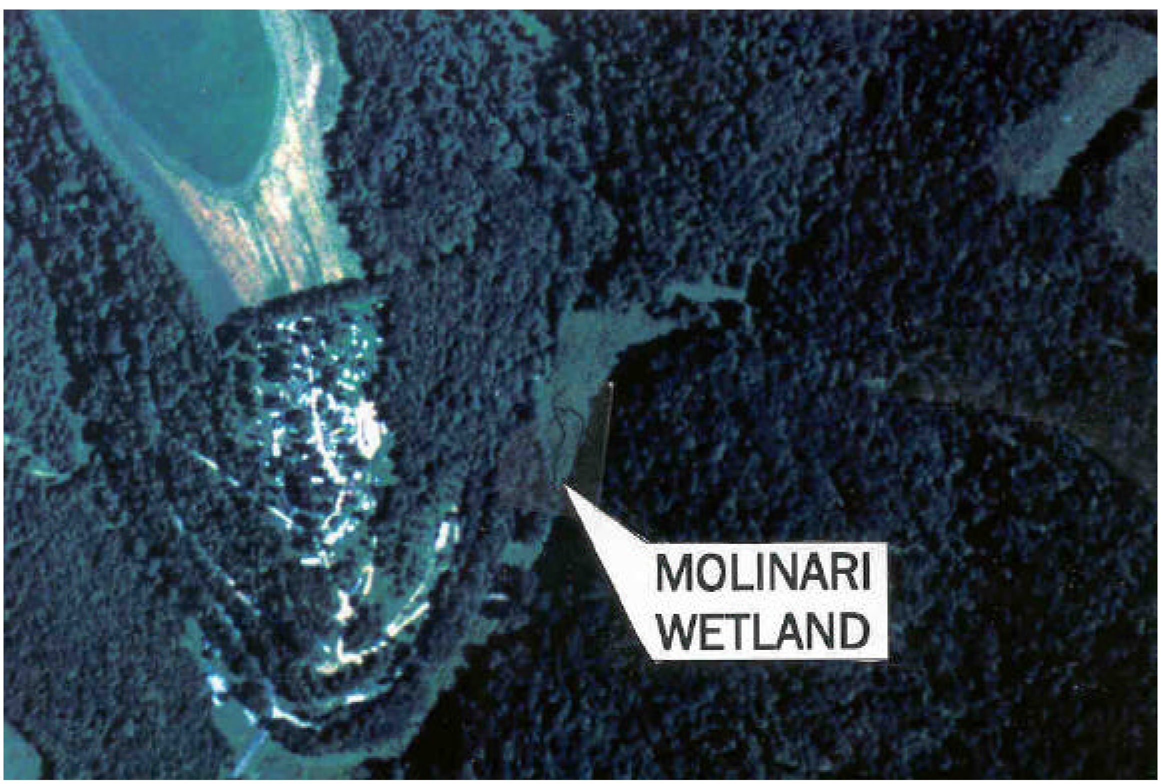
Figure 8-1D
Aerial Photographs of Molinari Wetland

Photograph 8-1D3 - September 1994 Premining

Photograph 8-1D4 - September 1996 Year of Mining (April 1996)

Figure 8-1D
Aerial Photographs of Molinari Wetland

Photograph 8-1D5 - June 1997 Postmining



Photograph 8-1D6 - August 1998 Postmining

Figure 8-1D
Aerial Photographs of Molinari Wetland