

Upper Unami Creek

Aquatic Resources Assessment and Conservation Plan



2005



Introduction



In the Upper Unami Creek watershed of northern Bucks County, and everywhere on Earth, water is the lifeblood of the land. The heavily forested portion of this watershed, known as the Unami Forest, includes some of the highest quality streams, wetlands, and groundwater aquifers in the Philadelphia region, and represents the second largest contiguous forest in southeast Pennsylvania. These ecological attributes are a testimony to the stewardship of landowners, municipalities, county and state agencies, and environmental organizations who have worked to protect local landscapes and water supplies. To date, over 1,000 acres of land in the Upper Unami Creek watershed have been permanently protected by landowners working with state and county agencies, municipal governments, and non-profit conservation groups (or combinations of these).

Natural Lands Trust has prepared this *Upper Unami Creek Aquatic Resource Assessment and Conservation Plan* (the Assessment) for the purpose of identifying parcels of land that provide the most effective natural buffer and ecological enhancement to the healthiest stream reaches in the Upper Unami Creek watershed. The upper, Bucks County portion of the watershed was selected since its headwaters streams represent the transition from an agricultural/suburban landscape, and associated non-point source pollutants, to one that is primarily forested. It is in these streams that biological monitoring

can demonstrate the stream quality improvements provided by forests. The decision to sample bottom-dwelling aquatic insects and worms (or benthic macroinvertebrates) was made because of they tend to be common, diverse, readily accessible aquatic organisms that offer a relatively sensitive measure of environmental change and stress.

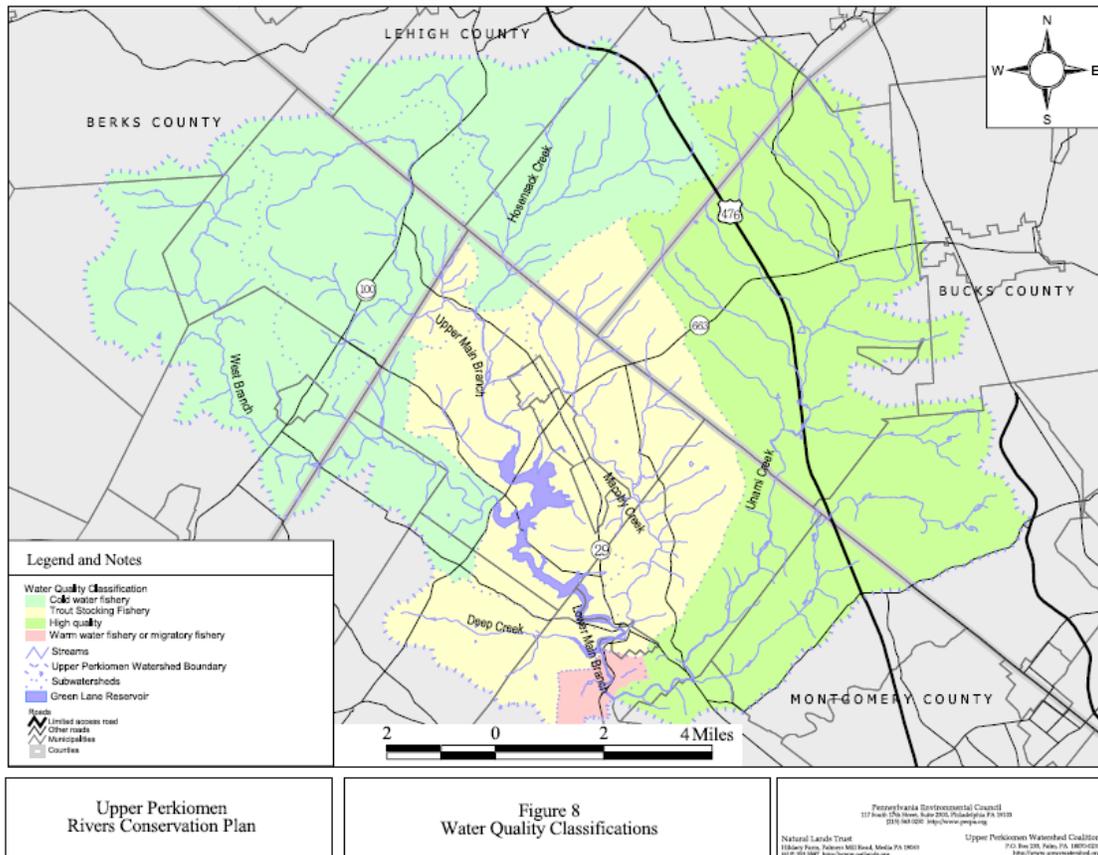


Figure 1 – Unami Creek location within the Upper Perkiomen Creek Watershed (source: Upper Perkiomen Creek Watershed Conservation Plan – UPWC, 2001)

The findings of this Assessment are intended to further refine the Conservation Priorities established by the Trust in its publication, *Upper Unami Creek Watershed: Landscape Conservation Plan* (NLT, 2002). The sampling stations are also intended to serve as a network for long-term volunteer monitoring of biological conditions on the Unami Creek and its tributaries, as a supplement to data collected by the Pennsylvania Department of Environmental Protection (PA DEP).

As development pressures and land values increase throughout southeastern Pennsylvania, the importance of prioritizing the “right” land to protect also increases. What is “right” is based on several factors:

- the conservation values (or regional public benefits) of the program area,
- the mission of the organization protecting land, and
- the priorities of the entity funding land protection projects in a given program area.

Natural Lands Trust has defined the right land to protect in its *Upper Unami Creek Watershed: Landscape Conservation Plan*, identifying properties as landscape conservation priorities based on their role in providing “landscape-scale networks of forest-interior habitat and forested riparian corridors” (NLT, 2002). The Unami Creek is a tributary of the Perkiomen Creek, a source the water supplier Aqua Pennsylvania draws from to serve over 700,000 customers at a surface intake near the confluence with the Schuylkill River (Upper Perkiomen Watershed Coalition, 2001). To ensure that the Unami Creek watershed continues to support biologically-diverse forests and clean, plentiful water supplies, the Trust and other conservation partners, using funds from state and county agencies, municipal governments, and private foundations, are working to protect large, forested parcels and parcels with extensive forested stream frontage.

This Assessment is designed to answer an important question: Which forested streamfront parcels in this program area are doing the best job of buffering and filtering high quality stream reaches (or segments)? The answer to that question is provided herein through the identification of the healthiest stream reaches and associated parcels of land in the Upper Unami Creek watershed as priorities for conservation.

In light of recent Stroud Water Research Center findings that riparian forests play a critical role in cleaning up our streams and rivers, this question and its answers have taken on new relevance to land protection programs in the Unami and throughout the Eastern Deciduous Forest biome. The Stroud study, reported in the *Proceedings of the National Academy of Sciences* (Vol. 101, no. 39), documented that streamside forests “prevent nonpoint source pollutants from entering small streams, they also enhance the in-stream processing of both nonpoint and point source pollutants, thereby reducing their impact on downstream rivers and estuaries.” (Sweeney, et al, 2004). In its Schuylkill River Project, Stroud monitored biological communities at 2 sites in the lower reaches and 6 sites in the upper reaches of Unami Creek from 1996 to 2005 and found that water quality was “fair” based on an analysis of benthic macroinvertebrate populations, with one site ranking as “poor”. A number of these sites are in or

near open farmland and downstream of newly developing areas. The Unami was given a grade of a C based on comparison to 19 other stream reaches monitored in the Schuylkill basin (SWRC, 2005).

This Assessment provides an overview of water quality assessments previously prepared for the Unami Creek, outlines the United States Environmental Protection Agency Rapid Bioassessment Protocols used for data collection and analysis, and summarizes the findings for 12 stream reaches in the 6 subbasins sampled. The final section, entitled Riparian Land Protection Priorities, identifies and prioritizes streamside parcels found to contribute the most direct filtration of overland flow, in-stream purification, and aquatic and riparian habitat benefits to stream reaches with healthy benthic macroinvertebrate communities.

With the knowledge offered by this Assessment in hand, conservation partners can act strategically to save land that ensures the land-water link is maintained for the ongoing benefit of healthy aquatic life and clean, plentiful water supplies in the Unami Creek watershed.

Overview of Unami Creek Water Quality Assessments

The water quality and biology of the Unami Creek has been the subject of ongoing study since at least the 1980's, with studies by the Pennsylvania Department of Environmental Protection, Marlborough Township, and the Stroud Water Research Center.

PA DEP Impaired Streams Assessment/Watershed Restoration Action Strategy

The Pennsylvania Department of Environmental Protection has surveyed the Unami Creek as part of its evaluation of the Perkiomen Creek under the Unassessed Waters Program. Nearly the entire Unami Creek stream network is rated as "Attaining" water quality parameters established by the United States Environmental Protection Agency. The exception is one half-mile reach of the Licking Creek on the Lehigh/Bucks County border rated as Impaired due to impacts associated with agricultural runoff. This Impaired reach is well upstream of the nearest sampling station (UC1) established for this Assessment.

PA DEP biologists rely on data collection strategies similar to those used for this Assessment, evaluating aquatic habitat and stream biology at multiple stream sites chosen to reflect land use impacts in each subbasin. Biological surveys include kicknet sampling and identification of benthic macroinvertebrates to the family level in the field, and evaluation of their pollution tolerance. Habitat assessments include: embeddedness of stream substrate; degree of streambank erosion; condition of riparian vegetation; and amount of sedimentation (PA DEP, 2003). PA DEP assessments in the streams of the Upper Unami were postponed during the summer of 2002 due to a number of dry or pooled streambeds. Within the study area for this Assessment, Butter Creek was dry and Hazelbach Creek was pooled that year (Kimberly Long, personal communication).

Marlborough Township Nomination to Upgrade Unami Creek to Exceptional Value (PA Code, Title 25, Chapter 93 Water Quality Standards)

In 1995, Marlborough Township petitioned the Environmental Quality Board (EQB) for Pennsylvania to upgrade Chapter 93 Protected Use Designation for the Unami Creek from Cold Water Fishery to Exceptional Value. The EQB voted in

1997 to redesignate the Unami to High Quality, affording the stream with Special Protection Waters status to limit potential degradation from proposed land development projects. The Unami did not achieve the extra level of protection afforded by an Exceptional Value designation due in part to its water chemistry, physical condition, and stream biology, including lack of a reproducing native brook trout population. PA DEP testimony to the EQB noted that it changed its recommendation from Exceptional Value to High Quality since the reference streams to which the Unami samples were compared were High Quality streams. "This circumstance makes it necessary to evaluate how much better than the reference station a candidate stream must be, rather than whether it compares equivalently to the reference stream. Scores for the sampling stations ranged from 59% to 112% of the reference station scores." (PA Bulletin, 1997)

Data collection for the nomination included benthic macroinvertebrate sampling performed by George Christian of Normandeau Associates, the same biologist contracted for labwork on this study. Sampling data from the EV nomination for reference sites on Cooks Creek and Unami Creek (UC2, UC3) was utilized to enlarge the data sets for this Assessment (Unami Creek) and to serve as a baseline data set (Cooks Creek).

Schuylkill River Project – Stroud Water Research Center

The Stroud Water Research Center recently completed a study of benthic macroinvertebrates, habitat conditions, and water quality for 19 sites along the major tributaries of the Schuylkill River, including 8 sites in the Unami Creek watershed with field work done between 1996 and 2005.

The goals of the Schuylkill River Basin Project are:

- 1) To establish baseline data that can be used to describe and evaluate water and habitat quality (current and long-term) in the Schuylkill River basin based on aquatic macroinvertebrates collected from numerous locations distributed throughout the basin,
- 2) To make this assessment available to local education outreach and community groups in order to encourage efforts to assess, improve, and/or protect water quality in these streams and rivers, and
- 3) To provide local college students experience in a long-term scientific study, collecting and processing scientific data that will be compared to past data and used in future studies.

“Our Schuylkill River project provides the information and tools needed to encourage citizens (children, adolescents, and adults) to interface with local organizations and governments, and with state and federal agencies.” (Stroud, 2005)

The findings for the Unami are average compared to those of other sites, achieving a Macroinvertebrate Aggregate Index for Streams (MAIS) score of 6.6 for the main station on the lower Unami, for a grade of “C” and a water quality rating of “fair”. Another station in the lower portion of the Unami Creek watershed, along Ridge Valley Creek at Rostkowski Road, rated as “fair” with a MAIS score of 11.2. MAIS scores for sampling stations in the Upper Unami ranged from a low of 5.3 on Molasses Creek (ranking as “poor”) to a high of 17.0 on Licking Creek. The study sampled 6 sites in the Upper Unami watershed: Unami Creek above Kumry Road both below and the Milford-Trumbauersville Wastewater Treatment Plant; Unami Creek at Allentown Road; Licking Creek at Allentown Road; Molasses Creek above Rosenberger Road; and Butter Creek below Allentown Road.

The primary data used to summarize the Unami Creek conditions was collected at a long-term sampling station below Swamp Creek Road bridge in Marlborough Township. The site selected for the study is below a series of impoundments associated with the Musser Scout Reservation and a community of early 20th-century summer cabins. As is true of other sampling stations in this Assessment, benthic macroinvertebrate communities below impoundments tend to include greater representation of pollution-tolerant species, reflecting the increased temperatures and sediment loads and lack of in-stream food and habitat. These sampling results reflect some of the realities of land use in the Unami, for while its large network of forested streams may help to offset agricultural and development impacts from the upper watershed, the scenic and recreational uses along the lower main stem can undo these gains.

The macroinvertebrates identified in the study for each site are summarized in **Appendix C** of this report.

Study Design and Rapid Bioassessment Methodology



The *Upper Unami Creek Aquatic Resource Assessment and Conservation Plan* is unlike other watershed plans in that it links strategic land conservation planning based on GIS prioritization of tax parcels, with aquatic resource assessments based on macroinvertebrate sampling. The study design and methodology used for the project are summarized in this section.

Overview of Study Design

In fall and winter of 2003 and 2004, the Trust conducted kick-net sampling for benthic macroinvertebrates at 12 sampling stations along the Unami Creek and its major wooded tributary streams in Bucks County, Pennsylvania – 3 stations along the main stem of Unami Creek, 2 each on Ridge Valley Creek, Hazelbach Creek, Schmoutz Creek, and Butter Creek, and 1 station on Molasses Creek. Sampling was also conducted at reference stations on Cooks Creek, a nearby stream characterized by similar geology and land use patterns.

Sampling stations were selected based on several factors:

- 1) achieving a representative sample of subbasins in the diabase forest portion of the Upper Unami Creek watershed.
- 2) presence of habitat conditions conducive to diverse, abundant benthic macroinvertebrate populations (cobble substrate with riffle/run habitat).

- 3) upstream proximity of a series of relatively large (>10 acres), unprotected, privately owned properties.
- 4) ease of access from public roads, but distance from road impacts.

Data collection and analysis followed Rapid Bioassessment III protocols established by the United States Environmental Protection Agency (Plafkin et al, 1989), described in summary sheets in **Appendix B**. Stream monitors from Natural Lands Trust (David Harper, Clare Billett), Normandeau Associates (George Christian), and a consultant (Megan D'Arcy) used a D-frame Kick Net to collect samples of at least 200 specimens at each station. Samples were taken twice at each station between the months of September and February.

Data analysis for each site provided a Total Score based on three criteria:

- 1) Biological Score: the diversity and type of macroinvertebrates present
- 2) Percent Comparison to Reference Station Score (Cooks Creek)
- 3) Habitat Score (both in-stream and riparian, based on Field Data Sheets)

Rapid Bioassessment

Each sampling station and associated stream reach was assessed using Field Data Sheets for: Habitat Assessment; and, Physical Characterization and Water Quality. These forms are based on the US EPA Rapid Bioassessment III protocols (Plafkin, et al, 1989), and samples can be found in Appendix B.

Physical Characterization and Water Quality data sheets were used to provide detailed site assessment data, but did not factor directly into the scoring for the stream reach. Site assessment data includes:

- a specific location map for the sampling station,
- detailed measurements of stream dimensions,
- visible water quality conditions,
- riparian vegetation descriptions,
- instream habitat and substrate descriptions, and
- weather conditions within the week prior to the sampling.

Habitat Score

Field data sheets for Habitat Assessment were used to generate the Habitat Score for each stream reach. A stream reach is defined as a roughly 100 meter (330 feet) stream segment associated with the sampling station. Habitat Assessment forms were used to evaluate the following parameters for each stream reach:

Epifaunal Substrate/Available Cover -- a measure of stationary in-stream woody debris and rocks/stones available for fish and aquatic insects. Low-scoring sites lack such features.

Pool Substrate – measures the stream bottom in pools, ranging from low-scoring conditions with uniform bedrock or silt/sand to high-scoring gravels and submerged vegetation.

Pool Variability – a measure of how diverse the pools are, with a combination of large and small, deep and shallow pools favored over reaches with only small, shallow pools or no pools.

Sediment Deposition – a measure of how much silt, sand, and gravel is deposited in the stream bottom, with heavy deposition scoring lower than little or no deposition.

Channel Flow Status – measures the amount of exposed stream bottom and whether the water is standing or flowing. A flowing stream with little or no exposed substrate is scored higher than a slow or standing stream with very little water in the channel.

Channel Alteration – a measure of manmade alterations such as channelization, stabilization and flood control structures, alteration of instream habitat. Stream reaches without these impacts score higher than those that have been altered.

Channel Sinuosity – a measure of stream meandering, with greater bends scoring higher than straight channels.

Bank Stability – a measure of streambank erosion, with no erosion scoring high and much erosion scoring low.

Vegetative Protection (each bank) – measures the amount of native vegetation anchoring each streambank. Sites with little or no vegetation (including lawns and pastures) score low compared to native woody vegetation.

Riparian Vegetative Zone Width – a measure of natural riparian buffers (no lawn or crops), with zones 50 feet or wider favored, and those less than 20 feet scoring lowest.

Each reach was scored for these parameters, and rated as Optimal, Suboptimal, Marginal, or Poor. These scores were summed as a Habitat Score for the reach, which was then combined with the Biological Score to reach a Total Score.

Biological Score

The benthic macroinvertebrate samples collected for the 12 stream reaches in the Upper Unami were assessed and scored based on 7 metrics described in the first edition of the US EPA Rapid Bio-assessment Protocols (EPA/444/4-89-001).

These are:

- Richness (total taxa)
- Hilsenhoff Biotic Index (water quality rating)
- Scraper/Filtering Collector Ratio
- Ratio of EPT and Chironomid Abundances
- Percent Contribution of Dominant Taxon
- EPT Index
- Community Loss Index

Collection procedures

Stream monitors in hip or chest waders stood in a riffle section of the stream, holding a D-frame Kick Net with a 500mm opening mesh. With the flat part of the frame level with the stream bottom, and the opening facing upstream. The monitor kicked the streambed just upstream of the Kick Net for approximately 1 to 2 minutes, making sure to capture any macroinvertebrates that may be in that section of the riffle by stirring up silt, gravel and sand, rubbing cobbles, logs and tree roots, and breaking up leaf packs.

Stream monitors then did a visual check of the net to estimate that at least 200 individual organisms had been collected. If the sample appeared smaller than that, the monitor would repeat the procedure in or close to the first collection area. When at least 200 organisms were present, the stream monitor emptied the net into a large (1 gallon) freezer-type zip-lock plastic food storage bag, being sure to do this over a 5-gallon plastic bucket to avoid accidental loss of sample specimens and material. Samples were double-bagged to avoid leakage.

A permanent marker pen was used to label the outside of the bag with the stream reach ID code (e.g. RV2, SC1), date, and initials of stream monitor. The same information was written in pencil on a water-safe paper inserted in the bag. The entire sample was then flooded with denatured alcohol to preserve it for transport and laboratory analysis. Samples were then analyzed by George

Christian, an aquatic biologist at Normandeau Associates, the data presented in summary forms provided to Natural Lands Trust and included in **Appendix A** of this report.

Percentage Comparison to Reference Score

These Biological Scores were then compared to the Biological Score for the reference samples taken on Cooks Creek. Cooks Creek has protected use status as an Exceptional Value stream in the Chapter 93 Water Quality Standards (PA Code, 2005). The Percentage Comparison to Reference Score was then used to determine the Biological Condition Category for each stream reach. Those 2 sites that ranked greater than 83% of the Reference Score (UC2 and SC2) are considered “Nonimpaired”, meaning they are among the best conditions possible in southeastern Pennsylvania. 75% of the Upper Unami sites had Biological Scores between 54% and 79% of the Reference Score. These are “Slightly Impaired”, with some of the more pollution-tolerant species replacing intolerant ones. One site in the study area (RV1 – below a dam near Allentown Road) scored 21% to 50% of the Reference Score, meaning it is “Moderately Impaired”, with fewer species present and mostly pollution-tolerant species. None of the Upper Unami reaches are rated as “Severely Impaired”, a term generally used to describe sites with little or no species diversity.

The sampling stations were then classified based on these criteria as either Class I, II, or III, as a measure of their relative ecological health. Class I sites represent the highest diversity of pollution-sensitive aquatic life and the healthiest habitat conditions relative to the other sites. Class II sites are characterized by a moderate balance of pollution-sensitive and pollution-tolerant species, and moderate habitat conditions. Class III sites are those with the highest concentration of pollution-tolerant species and poor habitat conditions.

By combining this biological data with Geographic Information System (GIS) computer mapping analysis of tax parcels adjacent to these sampling sites, a series of priority properties could then be linked to the stream reaches associated with Class I, II, and III sampling sites (generally 500 to 1,000 feet upstream. The extent of stream frontage considered to be beneficial to healthy stream reaches is based on a number of factors, including in-stream purification of contaminants (Stroud, 2005), filtration and habitat functions of riparian forest buffers, and stream baseflow contributions from seeps, springs, wetlands and hydric soils. By assessing the size of the parcel, the extent of stream frontage (in linear feet), and the percentage of woodland, a score for each parcel was generated to determine the acquisition priority of the parcels associated with Class I, II, and III sites.

Benthic Macroinvertebrates

Benthic macroinvertebrates are organisms that dwell in the streambed and include aquatic insects (often nymphs and larval stages), aquatic worms, snails, mussels, clams, beetles, and crayfish. They are essential links in the food web of streams, acting as consumers of aquatic plants and microbes, and providing food for fish and other secondary consumers.

Benthic macroinvertebrates are a form of “canary in the coal mine” for stream ecosystems in that the type and number of these organisms present in a given stream reach indicate its chemical and physical properties, and help to measure the presence of pollutants or other stresses on aquatic life. Each stream reach may contain between 100 and 200 species of these organisms and hundreds of individuals. “Because each species potentially has different tolerances of environmental change and stress, this diversity can result in hundreds of independent environmental measures that, taken together, provide a relatively sensitive measure of environmental change and stress” (Stroud, 2005).

These species are generally stationary, readily collected and have a relatively long life cycle (up to 1 year). This means they may provide a more accurate picture of long-term stream water quality than the snapshot results of chemical sampling. Macroinvertebrates have for years been the most commonly used group of organisms for water quality assessments, and are increasingly used for volunteer stream monitoring and environmental education.

Pollution Tolerances

A series of different groups of insects are found in southeastern Pennsylvania Piedmont streams, and are potentially represented in the samples collected in the Upper Unami. Aquatic organisms comprise a gradient of pollution tolerances. **Intolerant** species live only in very clean water. **Facultative** species can live in most water conditions, clean or polluted. **Tolerant** species are generally found in polluted water. The orders are listed and described by their pollution tolerance in the following pages, with photographs courtesy of the Stroud Water Research Center’s Schuylkill Project (www.stroudcenter.org). Three of the more pollution-sensitive (intolerant) taxonomic groups are mayflies (Ephemeroptera), stoneflies (Plecoptera), and caddisflies (Trichoptera). Rapid bioassessment protocols call for analyzing data for these groups as a metric, or measurement, of stream water quality known as EPT Richness.

Intolerant



Ephemeroptera (mayflies) –

Mayflies are generally sensitive to pollution, may be facultative (can live in clean or polluted water). Nymphs dwell on rocks and in gravel.



Plecoptera (stoneflies) –

Stonefly nymphs are pollution sensitive species dwelling in rocks and gravel.



Trichoptera (caddisflies) –

Caddisflies larvae are sensitive to pollution and environmental changes, and are important indicators of stream health. Some species construct shelters out of sands and gravels attached to larger stones.

Facultative



Coleoptera (beetles)

Riffle beetles are considered to be facultative pollution indicators.



Water Penny Beetle is a common facultative species for pollution sensitivity.



Crustaceans

Aquatic sow bugs are crustaceans that are facultative indicators of pollution.



Odonata (dragonflies/damselflies)

Damselfly and dragonfly nymphs are generally facultative indicators of pollution.

Tolerant



Diptera (true flies)

Larvae of flies such as black flies are pollution tolerant.



Midge larvae (also true flies) are worm-like reddish or greenish organisms known to be relatively tolerant of pollution.



Aquatic Worms

Aquatic earthworms and other worms are pollution tolerant species found in stream sediments.

Nonpoint Source Pollution

The health of biological communities in each stream reach may be affected by the pattern of adjacent and upstream land uses, and by the size and ownership of parcels associated with them. The term nonpoint source pollution describes a group of water contaminants carried in runoff from agricultural lands and suburban/urban landscapes with paved areas, lawns, construction sites, and septic systems. Common contaminants and sources are listed in the following table:

<i>Contaminant</i>	<i>Possible Sources</i>
Fecal coliform bacteria	Septic systems/livestock feces/Canada Goose feces
Total suspended solids (TSS)	Soil erosion (construction/farming)/road runoff
Phosphates (PO ₄)	Septic systems/fertilizers (lawns and farms)
Ammonia (NH ₃)/Nitrate, Nitrite (NO ₃ , NO ₂)	Septic systems/fertilizers/livestock feces/Canada Goose feces
Metals (lead, cadmium, zinc)	Road & parking lot runoff/dumps/water lines

Table 1 -- Non-point Source Pollution Parameters and Possible Sources

These examples of non-point source pollution are associated with typical land uses in a rural/residential watershed. The significance of each contaminant is summarized below. This information has been extracted from the *Pennsylvania Citizens' Volunteer Monitoring Program Technical Handbook* (River Network and PA DEP, 2001):

Fecal coliform bacteria (of which *E. coli* is a species) is a *biological* contaminant that reaches surface and groundwater as a result of waste from warm-blooded animals, including wildlife, livestock and humans. This bacteria is associated with leachate from failing septic systems, livestock such as horses or cattle grazing in or near streams (or manure piles), and concentrations of wildlife such as large resident Canada goose populations. High levels of these bacteria can present health risks for water supply, swimming and other recreational uses of water, and can degrade conditions for aquatic life.

Total Suspended Solids (TSS) are undissolved materials or particles that will float in the water column. They can include soils, organic matter, and man-made substances. Suspended solids affect water clarity and can reduce photosynthesis and cause higher water temperatures, inhibiting aquatic plant and animal life. Suspended solids are generally attributed to soil erosion associated with development sites, road runoff or farm fields lacking conservation practices. Visibly brown water after a heavy rain is the most obvious example of TSS, however they may be present in less noticeable concentrations that still degrade stream quality.

Phosphates (PO₄) are a form of phosphorus, an essential nutrient for plant growth and metabolic reactions in plants and animals. Together with nitrogen, it is a key element in the aquatic ecosystem. The main artificial sources of phosphate are septic systems (household detergents), and chemical fertilizers used for lawns and farm fields. Too much phosphorus can cause excessive biological activity and lead to problems such as unnatural algae blooms (eutrophication), which degrade water quality for fish and other aquatic life by consuming dissolved oxygen as plant material decomposes. The Green Lane Reservoir, just upstream from the confluence of Unami Creek with the main stem Perkiomen Creek, has been listed as Impaired by PA DEP due to high phosphate levels. Under the terms of the Clean Water Act, a Total Maximum Daily Load (TMDL) strategy has been developed and will be implemented upstream of the reservoir to reduce phosphate levels and achieve compliance with US EPA standards.

Ammonia (NH₃) and Nitrate/Nitrite (NO₃, NO₂) are forms of nitrogen, a naturally occurring gas in the atmosphere that combines with oxygen or hydrogen to provide vital nutrients for plant growth and metabolic reactions in plants and animals. Nitrogen and phosphorus are the primary sources of food energy in the aquatic ecosystem. Ammonia (NH₃) is a byproduct of organic decomposition, and is usually associated with human sewage, livestock, or Canada goose populations. Nitrates and nitrites may be found in fecal matter or in chemical fertilizers applied to lawns and farm fields. Excessive Ammonia, Nitrate or Nitrite can cause too much biological activity and can be toxic to aquatic life. High concentrations in drinking water can be toxic to infants (“blue baby syndrome”).

Metals (lead, cadmium, zinc) are all naturally occurring elements that can be toxic to aquatic life and humans. They become concentrated by human activities associated with automobiles (brake dust in road and parking lot runoff), manufacturing, dumps and landfills, and even household plumbing and water system supply lines. Lead is used in older plumbing and household paints. Cadmium occurs with zinc and lead, and is used in metal plating, batteries, and paints. Zinc is common in galvanized plumbing pipes. Exposure to lead, cadmium, and zinc can cause numerous serious health impacts to humans and other animals.

Point Source Pollutants

Discharge from industrial facilities and wastewater treatment plants are a less common source of water quality impacts in the Upper Unami. The main point source discharge is from the Milford Township Wastewater Treatment Plant. Potential contaminants from effluent include nutrients such as nitrates and phosphates.

Riparian Buffers and Stream Restoration



Courtesy: Heritage Conservancy Riparian Buffer Assessment

The Stroud Water Research Center has recently documented that riparian forest buffers provide in-stream benefits by processing water moving through the buffered stream reach, not just overland flow through the buffer, as had been previously documented. Researchers documented that stream reaches flowing through forested areas are wider, shallower, with rougher beds and more habitat than streams flowing through open herbaceous cover types. Riparian forest buffers provide greater variety of organic food and more natural temperature patterns. The increased abundance of bacteria, algae, invertebrates, and fish are all benefits of forested streams -- and it is this abundance that enables streams to better process certain pollutants (National Science Foundation, 2005)

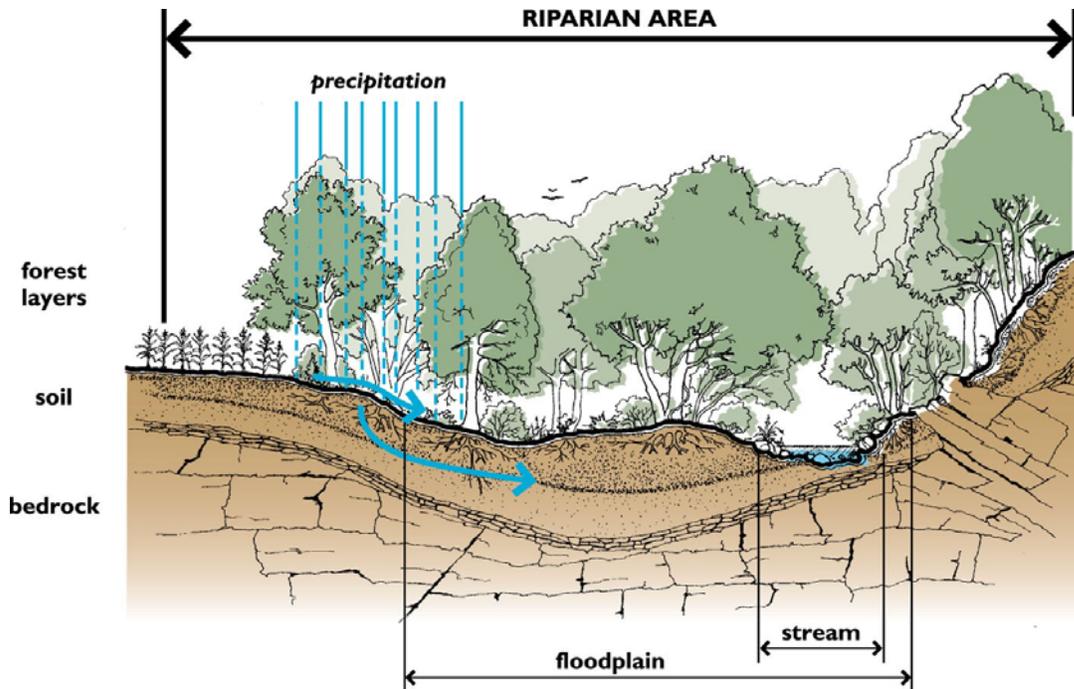


Figure 2 -- Riparian Forest Buffer Crosssection.

Riparian buffers are defined in this Assessment as wooded corridors paralleling streams and extending outward at least 100 feet from the tops of both banks of a stream. They provide numerous community benefits, and are often the first line of defense for non-point source surface water quality concerns such as sediment, erosion, nutrients and other pollutants. The roots of trees, shrubs and herbaceous vegetation help to anchor streamside soils and reduce flooding. The leaves, twigs, branches and logs of trees provide food and habitat on which the entire food web of a healthy stream ecosystem is based, and tree canopies provide shade to maintain cooler water temperatures necessary for many native aquatic organisms, including native brook trout.

The vast majority of the streams in the southern half of the Upper Unami Creek watershed are bordered by forest, however, the northern half includes numerous stream reaches with “gaps” in riparian buffer coverage due to clearing for agriculture and other uses. The Riparian Forest Buffer manual prepared by the US Forest Service recommends a minimum of 75 feet of forest cover on each side of a stream (Welsch, 1991). Portions of the study area have the potential for significantly wider buffers that would benefit the health of the stream ecosystem.

The *Riparian Buffer Assessment of Southeastern Pennsylvania* (the Assessment) prepared by the Heritage Conservancy in 2001, includes a detailed analysis of riparian buffer coverage and gaps in the Unami Creek watershed as shown in

Figure 3 - Riparian Forest Buffer Assessment Map. The map highlights the extent of stream reaches lacking buffer in the agricultural landscape at the headwaters of the Unami Creek watershed. The goal of the Assessment is “to promote non-point source (NPS) pollution prevention and mitigation.” This study involved helicopter flights and video assessments of riparian corridors along the main stem Perkiomen Creek, and aerial photograph evaluation and field verification of riparian corridors throughout the watershed.

The results include documentation of 4 categories: “full” riparian forest buffers (at least 50 feet of woodland on each side of a stream); “partial” riparian forest buffers (less than 50 feet of woodland on one or both sides of a stream); streams “lacking buffer on one side”; and stream segments “lacking buffers on both sides”, where riparian forest buffers are missing.

The results of the Assessment and subsequent analysis provide important guidance for ongoing riparian buffer conservation and restoration activities in the Upper Unami Creek valley. Perhaps the most important factor about the Unami Creek is that it has the highest amount of stream buffering relative to other subbasins in the Perkiomen Creek watershed, and one of the highest in the Schuylkill River basin. (NLT, 2002)

Areas with full riparian buffers are good candidates for voluntary protection agreements such as conservation easements. Partial buffers can be expanded with tree planting efforts and by fencing streams in areas where floodplain meadows or fields exist, extending the width of existing riparian buffers to, ideally, at least 100-feet on either side of the stream, as recommended by the Chester County Water Resources Authority (CCWRA, 2003). Missing buffers, areas where streams flow unprotected through fields or lawns, are “opportunities” for reforestation. The only exceptions to this recommendation apply in areas where native herbaceous wetlands (i.e. sedge marshes and wet meadows) provide important habitats for native plants and wildlife. Headwaters streams (1st and 2nd Order) are among the most important locations for reducing NPS pollution through riparian buffer protection. Small streams represent the greatest stream miles and the narrowest widths in any watershed – therefore, they expose surface water to a broad area of potential land use impacts to water quality.

	Total Stream Length	Lacking Buffer Both Sides (12.8%)	Lacking Buffer One Side (7.5%)	Partial Forest Buffer (0.74%)	Full Forest Buffer (79%)	% Total in Full Forest Buffer
<i>Unami Creek</i>	411,296 ft.	52,819 ft.	30,810 ft.	3,051 ft.	324,615 ft.	79%

Table 2 – Riparian Buffer Summary

As identified in the *Upper Perkiomen Creek Watershed Conservation Plan*, the Unami Creek rises to the top of the riparian buffer conservation priorities list of 7 subwatersheds for several reasons:

- *It has the greatest linear stream miles (62 miles) in Full Forest Buffer coverage;*
- *With 62 out of its 78 stream miles in Full Forest Buffer coverage, the Unami has the greatest percentage (79%) of total stream miles bordered by forest.*
- *At 31,998 acres, the Unami is also the largest subwatershed in the Upper Perkiomen Valley, measuring over twice as large as the West Branch (14,768 acres), and it contains the highest percentage of forested cover. It provides full buffering of 27% of the total stream miles in the Upper Perkiomen watershed.*

The contribution of this nearly contiguous forested stream frontage to the overall health and quality of the Upper Perkiomen watershed cannot be overestimated (UPWC, 2001).

Riparian and Wetland Vegetation

In discussing the interrelationships between riparian forests and wetlands and stream quality, it is important to understand the native vegetative communities that characterize the Unami Creek watershed.

Successional Red Maple Forest

This forest type is typically found in low-lying areas along streams, floodplains and headwaters areas with hydric soils, particularly those that have been logged or abandoned from farming within the last 20 to 30 years. Dominant species are:

- | | |
|------------------|--------------------------------|
| Eastern redcedar | <i>Juniperus virginiana</i> |
| Red maple | <i>Acer rubrum</i> |
| Tuliptree | <i>Liriodendron tulipifera</i> |
| White ash | <i>Fraxinus Americana</i> |

Bottomland Oak-Hardwood Palustrine Forest

Forested areas along broader floodplains bordering the Unami and Ridge Valley Creeks mature to this forest type. Dominant species include:

Black walnut	<i>Juglans nigra</i>
Box elder	<i>Acer negundo</i>
Hop hornbeam	<i>Ostrya virginiana</i>
Pin oak	<i>Quercus palustris</i>
River birch	<i>Betula nigra</i>
Shagbark hickory	<i>Carya ovata</i>
Silver maple	<i>Acer saccharinum</i>
Sycamore	<i>Platanus occidentalis</i>

Silver Maple and Sycamore-River Birch-Box Elder Flood Plain Forest

Alluvial soils in the watershed may support forest stands dominated by fast-growing silver maple, sycamore, or river birch, each a pioneer species adapted to streamside habitats.

Buttonbush Wetland and Alder-Ninebark Wetland

Shrubby wetland communities in the study area are known to support the following species:

Alder	<i>Alnus spp.</i>
Arrowwood	<i>Viburnum dentatum</i>
Buttonbush	<i>Cephalanthus occidentalis</i>
Elderberry	<i>Sambucus canadensis</i>
Red-osier dogwood	<i>Cornus amomum</i>
Silky dogwood	<i>Cornus racemosa</i>
Spicebush	<i>Lindera benzoin</i>
Swamp Rose	<i>Rosa palustris</i>
Willow	<i>Salix spp.</i>
Winterberry holly	<i>Ilex verticillata</i>

Tussock Sedge Marsh and Mixed forb Marsh

Openings in shrubby wetlands, and broader wet meadow areas support these communities, including species such as tussock sedge, sweet flag iris, sensitive fern and skunk cabbage.

The *Unami Creek Valleys: Vegetation Survey, Bucks and Montgomery Counties* prepared for Natural Lands Trust by Claudia Steckel in 2001, includes a survey of woodland trees along the Upper Unami Creek just above the Bucks-

Montgomery County line. This site was noted as including a “young to maturing forest community that is an intermediate form between a red oak – mixed hardwood forest and sugar maple – basswood forest, with noted locations for herbaceous vernal ponds and seeps.” Upper slopes support a mature mix of oak, beech and hickory, while slower slopes are dominated by red maple and tulip poplar. Sugar maple and beech are noted as dominant saplings. “A broadleaf palustrine forest, consisting of a mix of red maple, red ash, white oak or possibly swamp white oak (*Quercus bicolor*), shagbark hickory, black cherry, slippery elm, red-cedar, hawthorn (*Crataegus* sp.) and young sugar maple” was documented along Unami Creek, with a diverse mix of herbaceous wildflowers, ferns, sedges and grasses. “Occasional seeps and ephemeral pools occur throughout the property at all elevations; the floodplain area contains deeper (up to 24” deep) ephemeral pools, filled in April with salamander and frog egg masses (Steckel, 2001)

Land Use

The Upper Unami Creek watershed is still largely rural compared to other areas of Bucks and Lehigh counties. Due to its relatively remote location from population centers and the building constraints posed in part of the area by the underlying diabase geology, the Upper Unami has largely escaped the rapid rates of population growth and land consumption impacting other municipalities in central and northern Bucks County. Farming and rural residential communities still dominate the northern half of the watershed, while woodlands and scattered homes in wooded settings characterize the southern half. While the rate of growth has been relatively slow, the number of current and pending subdivision applications in municipalities such as Milford and West Rockhill indicates that the pattern of land use and ownership is starting to shift toward a more suburban residential and commercial scenario.

The Upper Unami area has, until recently, not supported large-scale residential or commercial development. Historically, the populations of local municipalities have been located in villages such as Trumbauersville and Milford Square, and larger towns such as Perkasio and Quakertown. Most residents lived in single-family homes on small lots. In the mid- to late 20th century, many individual road-front lots and large lots were sold off for custom homes and cabins – a trend which continues today. A number of large residential subdivisions of 50 or more homes at varying densities are proposed or are being constructed in Milford Township in the vicinity of the Quakertown exit of the Northeast Extension of the PA Turnpike. Route 663 in this area is becoming a corridor for commercial and light industrial development.

The study area for this project is the largely forested ridges and valleys of the southern portion of the Upper Unami Creek watershed in Bucks County, below Route 663 and above the county line. The land use pattern in this area is markedly different from the rapidly developing agricultural landscape of the northern portion of the watershed. The land use pattern in both areas is closely linked to the ownership pattern, the natural constraints of the land, demographic trends, local land use regulations, and the central Bucks County real estate market.

The southern area can generally be described as a second-growth forested landscape of wooded diabase ridges, steep wooded valleys with scattered 19th century mill sites, summer camp properties, with small-scale suburban residential and commercial development slowly encroaching from nearby villages of Trumbauersville, Tylersport, and Sellersville, along major roads such as Ridge Road (Route 563) and Allentown Road. Parcel sizes tend to be smaller in this area, with many averaging between 10 and 50 acres. While there are generally no direct routes in or out of the Unami Forest, major roads in the area such as Route 663, Route 563 and Allentown Road are all serving as conduits for new development.

As reported in the *Upper Unami Creek Landscape Conservation Plan*, “(t)here are no major industrial or commercial land uses present in the study area, other than small businesses and light industrial facilities. The only large-scale recreational uses in the study area are the Fox Hollow Golf Course, the Great Swamp sportsmen’s club, and several camp properties, including Camp Men-O-Lan. Community facilities are limited to municipal buildings and parks. Public utilities include at least 4 major corridors: PECO Energy transmission lines and, AT&T fiber optic lines, and gas pipelines that pass through the area from west to east. The history of large camps in the area is symbolic of its presence in the region as a relatively remote, natural getaway.” (NLT, 2002)

For its relatively low population, the study area supports a relatively high density of roads, a pattern shared across much of Pennsylvania. The forested landscape is crisscrossed by major highways, state arterial roads, local paved and dirt roads, and an increasing number of internal road networks and cul-de-sacs, with very few roadless areas of 1,000 acres or more. Natural Lands Trust documented these conditions in its *Unami Restoration of Human Made Improvements and Disturbance Report* (NLT, 2003). Figure 4, below, illustrates the scattered blocks of forest-interior habitat in the lower and upper sections of the Unami Forest. The NLT report concludes that forest-interior wildlife can be protected in the region if quantitative criteria for habitat connectivity can be developed and applied in the area. The study specifically recommends quantitative mapping and protection of forest-interior habitat and linkages between forest blocks. The Report recommends “de-fragmentation” of habitat through removal of certain structures and working to reduce utility and roadway fragmentation, and promoting adequate bridge crossings to allow wildlife underpasses along streams.

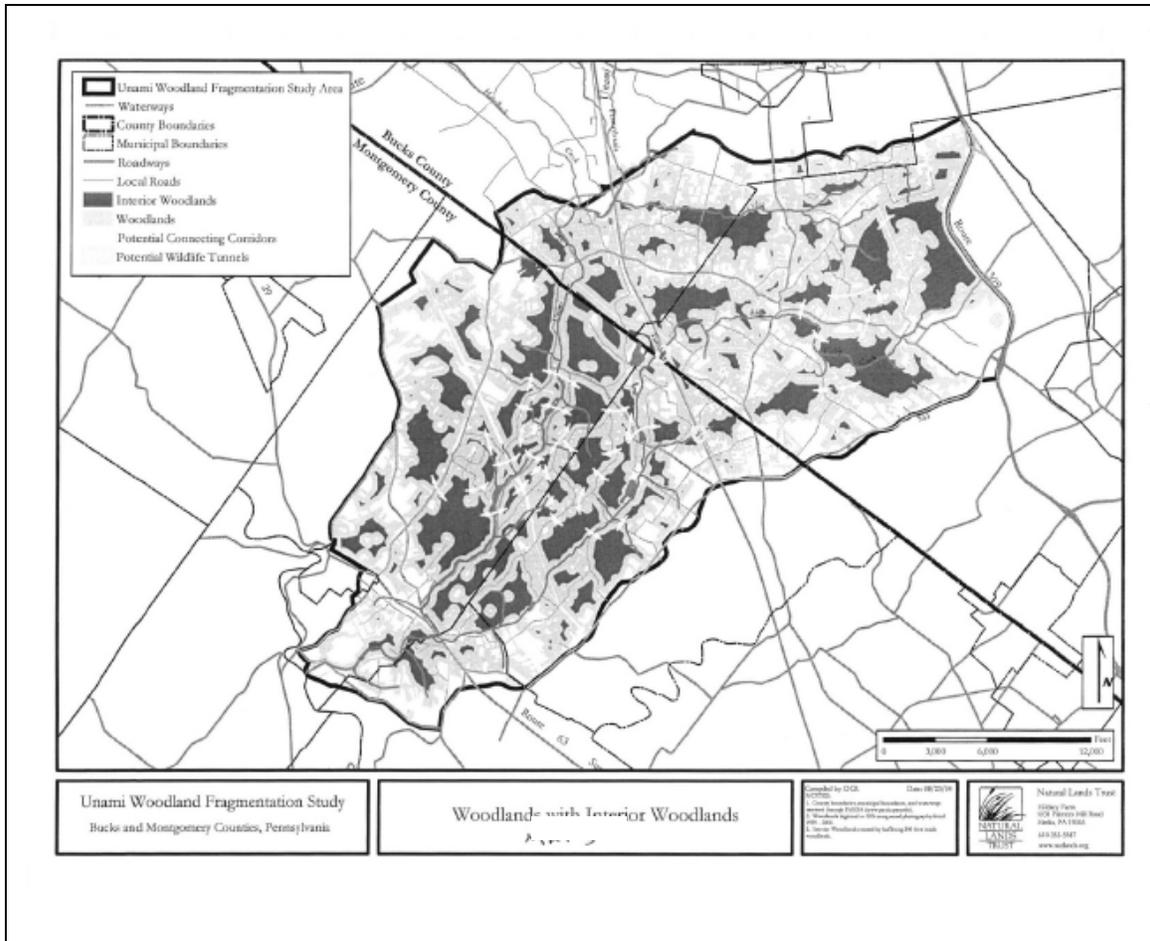


Figure 4 -- Forest Interior Habitat Blocks.

The *Schuylkill Watershed Conservation Plan* identified a moderate amount of road/stream crossings relative to other watersheds in the Schuylkill River basin (NLT et al, 2001). Within the forested study area, at least 25 points have been identified where roads cross streams, not including driveways and crossings over unmapped tributaries. The Academy of Natural Sciences has documented the ways in which road and road/stream crossings – particularly full-pipe culverts -- can have a significant impact on the hydrology and water quality of rivers and streams (NLT et al, 2001). Where roads cross streams, culverts or bridges can alter the channel size, shape, and/or gradient leading to channel erosion and scour. Numerous sampling stations for this study include reaches downstream of culverts which clearly channelize water and cause a gouging effect in streambeds.

Roads in the study area are a measure of habitat/open space fragmentation for terrestrial and aquatic wildlife, increased mortality rates among wildlife populations, and an indicator of the intensity of existing or potential land use. A

particularly detrimental pattern in the Upper Unami watershed is the close proximity of roads (both paved and gravel) to small headwaters streams – often unmapped first order streams that simply follow roadside ditches constructed for drainage. Stormwater runoff from roads adjacent to streams can transport contaminants such as sediment, salts, oils and pesticides used along the road edges. The impacts of this man-made infrastructure on aquatic life is evident in the results from certain sampling stations in this Assessment. It should be noted that the Stroud Water Research Center and other watershed organizations emphasize the importance of reducing these fragmentation effects by replacing full-pipe culverts with half-pipe culverts or bridges, either of which allow for a more natural streambed and floodplain.

Stream Reaches and Subbasin Land Use

The biological assessment data collected for the Upper Unami Creek watershed is organized by 6 subwatersheds or subbasins. The 12 sampling stations and associated stream reaches surveyed are mapped in **Figure 5 – Prioritized Stream Reaches and Parcels**, and ranked by total score in **Table 1**. The subbasin descriptions in this section characterize the land uses and ownership pattern associated with each stream reach.

Table 1 and Figure 5 both employ a color-coded system for classifying stream reaches and sampling stations in terms of their Total Score (Biological Score + Habitat Score). Green represents Class 1 reaches with Total Scores of 179 or greater. Yellow represents Class 2 reaches with Total Scores of between 155 and 178. Orange represents Class 3 reaches with Total Scores below 155. The Stream and Reach ID column on the table corresponds by color and code (RV1, SC2, etc.) with the colored dots and colored tax parcels on Figure 5.

Unami Creek (UC1, UC2, UC3)

The three stream reaches sampled on the main stem of Unami Creek include two Class I reaches which are among the highest ranking sites in the Assessment (UC1 and UC2), and a Class II reach (UC3).

The main stem Unami above the study area flows through a relatively flat, mostly agricultural landscape with a rapidly expanding area of intensive development centered around the Quakertown Exit of the Northeast Extension of the Pennsylvania Turnpike. Several large nursery, greenhouse and poultry operations are located in this area, and some are near small headwaters tributaries.

The majority of the woodlands and wetlands in this area tend to be concentrated along steep, wet, or flood-prone areas associated with streams. Forested uplands in the watershed that are not associated with stream corridors are typically small (<20 acres) isolated woodlots and hedgerows. Riparian woodlands of up to 300 feet in width (150 feet on each side of the stream) can be found along some of these headwaters streams, however, streams in this area are shown as having two of the largest gaps for riparian buffer coverage (i.e. both sides lacking) in the Heritage Conservancy's Riparian Buffer Assessment (Heritage Conservancy, 2001).

A 100-year floodplain is associated with all but the uppermost reaches of the Unami Creek and its tributaries. Many sections of floodplain average between 200 and 400 feet in width, with broader sections reaching up to 2,000 feet wide.

The presence of forested wetlands and hydric soils in and near the study area is evidenced by the frequent use of the word "swamp" in local road names, place names, and the former name for the Unami Creek itself. Swamp Creek Road which follows the lower main stem of the stream in Montgomery County south of the study area. The name appears frequently to the north of the study area, as described in the *Upper Unami Creek Watershed: Landscape Conservation Plan*:

"(t)he local name Swamp Church is used for a Mennonite church on Rosedale Road just west of Rosedale, while West Swamp Church is on nearby West Swamp Road and East Swamp Church is also on Swamp Road in the village of Brick Tavern located nearby...The "swamp" may describe a woodland patch of 25 acres or so that adjoins an extensive wooded/successional wetland area... is located at the hamlet of Steinsburg on the north side of Rosedale Road... (a) major forest/stream/wetland complex of

nearly 200 acres is situated at the hamlet of Brick Church, where four of the Unami Creek tributaries merge. This area is underlain by hydric ... & alluvial soils.... The area is crossed by two roads (Brick Tavern Road and Mill Pond Road), but otherwise represents a relatively unbroken block of forest and wetland extending for nearly one mile along the Unami Creek above the village of Milford Square. The 100-year floodplain in this area is unusually broad, reaching almost 2,000 feet in width. " (NLT, 2002)

This area adjoins the Milford Middle School property, which is specifically listed as a priority area for protection in the *Upper Perkiomen Creek Watershed: Landscape Conservation Plan*. Implementation Action #2.C. in the Plan reads: "Protect land along the Unami Creek adjacent to Milford Middle School in Milford Township." (NLT, 2002)

UC1



Figure 6 -- Upper Unami Creek Subbasin Land Use Pattern Above UC1.

Milford Square is a growing village center upstream of UC1 at Route 663, where the Unami merges with Licking Creek, which flows in from the northwest. The reach of the Unami in which both the UC1 and UC2 sampling stations are located, between Milford Square and the NE Extension, is characterized by over 2 miles of riparian forest buffer of at least 300 feet in width, with only 2 road crossings. South of the village, the stream then flows through a 50+ acre wooded area and merges with a second order tributary that flows through the 153-acre Quakertown Airport property to the east.

The Unami Creek crosses under an old stone bridge at Allentown Road and continues flowing in a southwesterly direction through a wooded corridor, then along the eastern edge of a 150 acre forest block. This forested tract borders the stream for approximately 1 mile above the UC1 sampling station, and is fragmented by two roads and a utility line. Molasses Creek merges with the Unami in this area. The riparian forest buffer in this reach is at least 300 feet on each side of the stream, and is much greater on the west bank. The UC1 sampling station is at Kumry Road just downstream of the Milford-Trumbauersville Wastewater Treatment Plant.

The area within one mile upstream of UC1 is listed in the Bucks County Natural Areas Inventory as a Priority 3 Site, and is described as follows:

Unami Creek in the vicinity of Allentown Road including Milford Township Park

This stretch of the Unami Creek includes forested floodplain and other scoured areas along the creek. Wooded slopes occur below Allentown Road. The geology is a combination of diabase and hornfels. A 1997 survey of fish documented high native fish diversity (15 species) in this section of the Unami Creek (Criswell 1998). “ Notable features of this area include tuliptree-beech-maple forest, Sycamore-river birch-box elder floodplain forest, and high native fish diversity (Rhoads and Block, 1999).

UC2

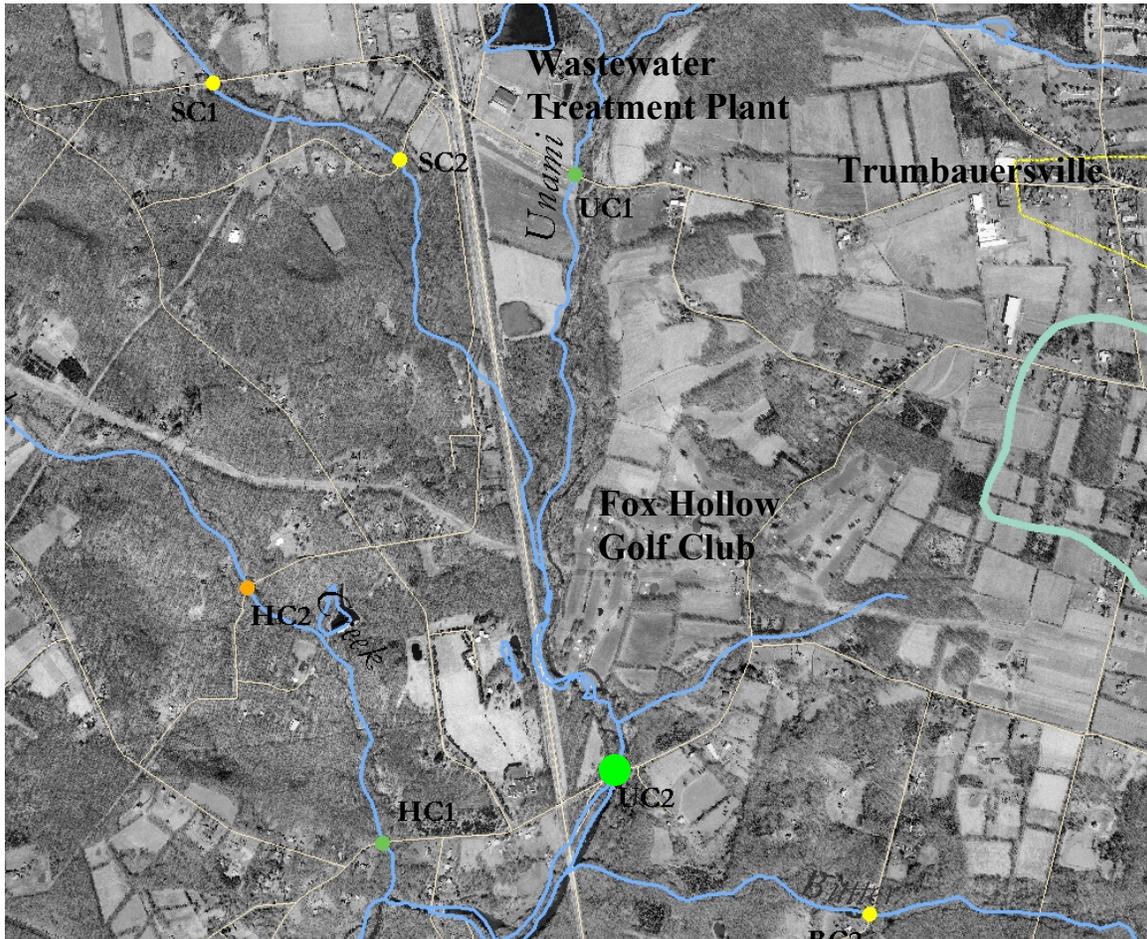


Figure 7 -- Upper Unami Creek Subbasin Land Use Pattern Above UC2.

As described in the *Landscape Conservation Plan*, “the 3,500 foot stretch of the Unami between Kumry Road and the confluence with Schmoltz Creek includes a broad alluvial forest (at least 30 acres) averaging 500 feet in width, with a number of small streams and sloughs. Two small tributaries flow into this natural area from the east, and the entire floodplain is underlain by alluvial soils. Farm fields border the forest on both sides, and the NE Extension is just to the west.” (NLT, 2002)

The Unami continues flowing south past its confluence with Schmoltz Creek (also from the northwest), and enters the Fox Hollow Golf Club, a golf course with over 2,000 feet of stream frontage, little or no riparian buffer, extensive mowed streambanks and a large island for one of its holes. The Unami in this section is buffered from the Turnpike by less than 200 feet of woodlands, with one 500-foot reach bordering the embankment of the highway. An unnamed tributary stream less than a mile in length flows through a partly wooded

corridor to the east near Esten Road and joins the Unami approximately 500 feet upstream of the sampling station. A narrow crop field borders the riparian corridor. Below Trumbauersville Road, the Unami flows past a neighborhood of older summer camps before crossing under the Turnpike and merging with Butter Creek.

The Assessment ranking for this stream reach is the highest Total Score (190) out of all of the assessed reaches. Its Biological Score was especially high, achieving 90.5% of the Reference Score for Cooks Creek. This score is unexpected given the elevated potential for non-point source pollution from golf course, highway, and lack of a substantial riparian forest buffer and natural wetlands. The stream flows through nearly one half mile of substantial riparian buffer before reaching the sampling station, this high score may be an example of the in-stream pollution processing function of riparian forest buffers documented by the Stroud Water Research Center (NSF, 2004). Dilution of pollutants with higher quality surface and ground water may also be a factor. Schmoltz Creek and unnamed tributary flow into the Unami above the sampling station, and the area also supports one of the greatest concentrations of hydric soils in the Upper Unami Creek watershed, an indicator of seeps and springs.

UC3

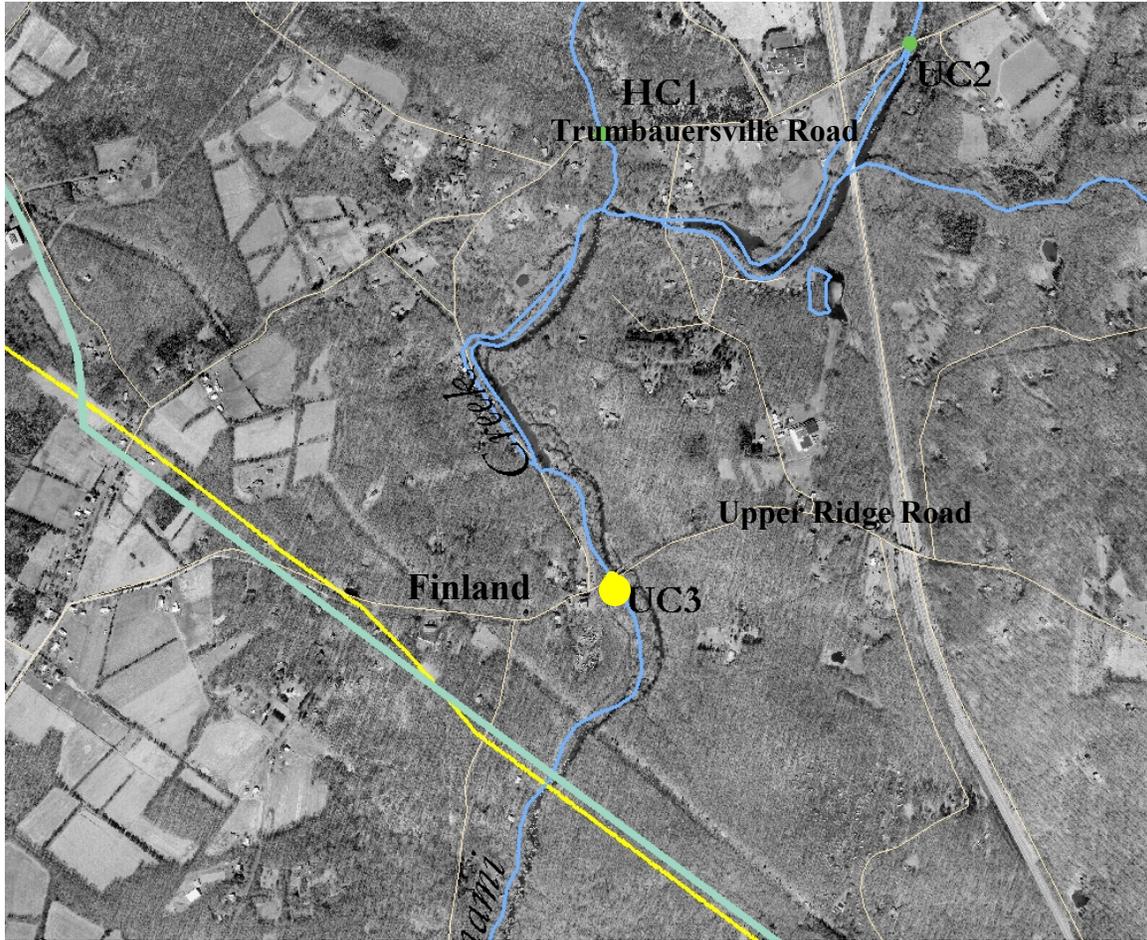


Figure 8 -- Upper Unami Creek Subbasin Land Use Pattern Above UC3.

The third sampling station on the main stem of Unami Creek is situated in a wooded area at the Upper Ridge Road bridge at the hamlet of Finland. This site is just downstream of an impounded area where Milford Township has been removing residences from the floodplain due, in part, to lack of proper sewerage facilities and flooding problems.

Molasses Creek
MC1



Figure 9 -- Molasses Creek Subbasin Land Use Pattern Above MC1.

Molasses Creek is a major headwaters tributary of the Unami which has its source in a partly wooded, partly agricultural area on the Lehigh/Bucks County line. Molasses Creek flows for nearly 4 miles in a southeasterly direction, through a primarily agricultural landscape, before reaching its confluence with the Unami above Kumry Road. Its watershed area is 3.4 square miles.

The watershed of Molasses Creek includes two of the most intensive uses within the entire Upper Unami watershed: the Quakertown exit of the Northeast Extension of the Pennsylvania Turnpike, and the Milford-Trumbauersville Wastewater Treatment Plant at Rosenberger Road, which features the largest pond in the Unami Creek watershed (over 5 acres) and a stream discharge.

The biological sampling station on Molasses Creek (MC1) was established at the bridge beside Rosenberger Road, near its intersection with Umbright Road. This MC1 and its associated reach is situated within a forested section of the Molasses

Creek watershed identified as a Priority 2 Conservation Area in the Landscape Conservation Plan (NLT, 2003). This reach has a substantial riparian forest buffer of over 200 feet at its narrowest point extending for over one half mile upstream of MC1, with only 3 houses situated within this zone. A young stand of Eastern Redcedar (*Juniperus virginiana*) borders the stream for about ¼ mile upstream of MC1. The ownership pattern along this reach includes 10 unprotected, mostly undeveloped wooded parcels of between 10 and 60 acres in size, with an average parcel size of about 30 acres. The prevalence of hydric soils and a broad 100-year floodplain in this area may help to explain its undeveloped condition.

The Northeast Extension of the Pennsylvania Turnpike is a major land use with the potential to influence stream quality for approximately 1 mile upstream of the site. At Spinnerstown, Molasses Creek flows for approximately ½ mile along the edge of a woodland, with the Turnpike approximately 400 feet from its east bank, passing under another major road, Route 663, and adjacent to the Milford Township Building and Park on Krammes Road. The turnpike crosses the stream over a culvert approximately ½ mile upstream of the MC1 site, and follows within 600 to 800 feet of its west bank, flowing through mostly alluvial soils. PennDot maintains stormwater outlets which deposit runoff from the Turnpike into alluvial forest along Molasses Creek. The Quakertown exit of the turnpike along Route 663, located within 1 mile upstream of the MC1, is experiencing rapid and widespread commercial and residential development.

The upper reaches of Molasses Creek, above the village of Spinnerstown, are bordered by a riparian buffer averaging 300 feet wide and hydric soils. The stream segment that flows past Spinnerstown is mapped as a “gap” in the Riparian Buffer Assessment.

Schmoltz Creek
SC1, SC2



Figure 10 -- Schmoltz Creek Subbasin Land Use Pattern Above SC1 and SC2.

Schmoltz Creek is a headwaters tributary of the Unami Creek that parallels Molasses Creek and flows to the southeast for nearly 3 miles through an agricultural and rural residential landscape before reaching its confluence with the Unami. The stream drains an area of 3.79 square miles. Two first order streams form the upper reaches of Schmoltz Creek north of Route 663, south and west of Spinnerstown. These streams drain a relatively level area of active farmland, with a scattered mix of low-density residential properties. Of all streams in the Upper Unami Creek watershed, the upper Schmoltz Creek has the greatest stream length lacking forest buffer on both sides (Heritage Conservancy, 2004). Much of the area without riparian buffer coverage is in farmland reverting to old field and shrub wetland. A narrow, forested ridge forms the drainage divide to the south.

After the headwaters tributaries merge and flow through a culvert under Route 663, Schmoltz Creek enters the northern limit of the diabase woodland. It is here, along Kumry Road and Walnut Road west of the PA Turnpike, that the sampling stations SCI and SC2 are located. These sites both rank as Class II in terms of aquatic resources.

Hazelbach Creek

HC1, HC2



Figure 11 -- Hazelbach Creek Subbasin Land Use Pattern Above HC1 and HC2.

Hazelbach Creek is a fairly short but ecologically important stream valley originating in an agricultural and rural residential area and then flowing through a large block of diabase woodland. Its watershed is the smallest in this Assessment, at 2.15 square miles in area. While the upper reach of Hazelbach Creek is bordered closely by Saw Mill Road and a number of residential lots, the lower half below Fennel Road flows through a relatively rural, forested landscape with only 2 additional road crossings before it merges with the Unami Creek near Finland. Several large landholdings and protected lands in this diabase portion provide a core area for protection of the contiguous diabase forest block west of the PA Turnpike.

Butter Creek
BC1, BC2

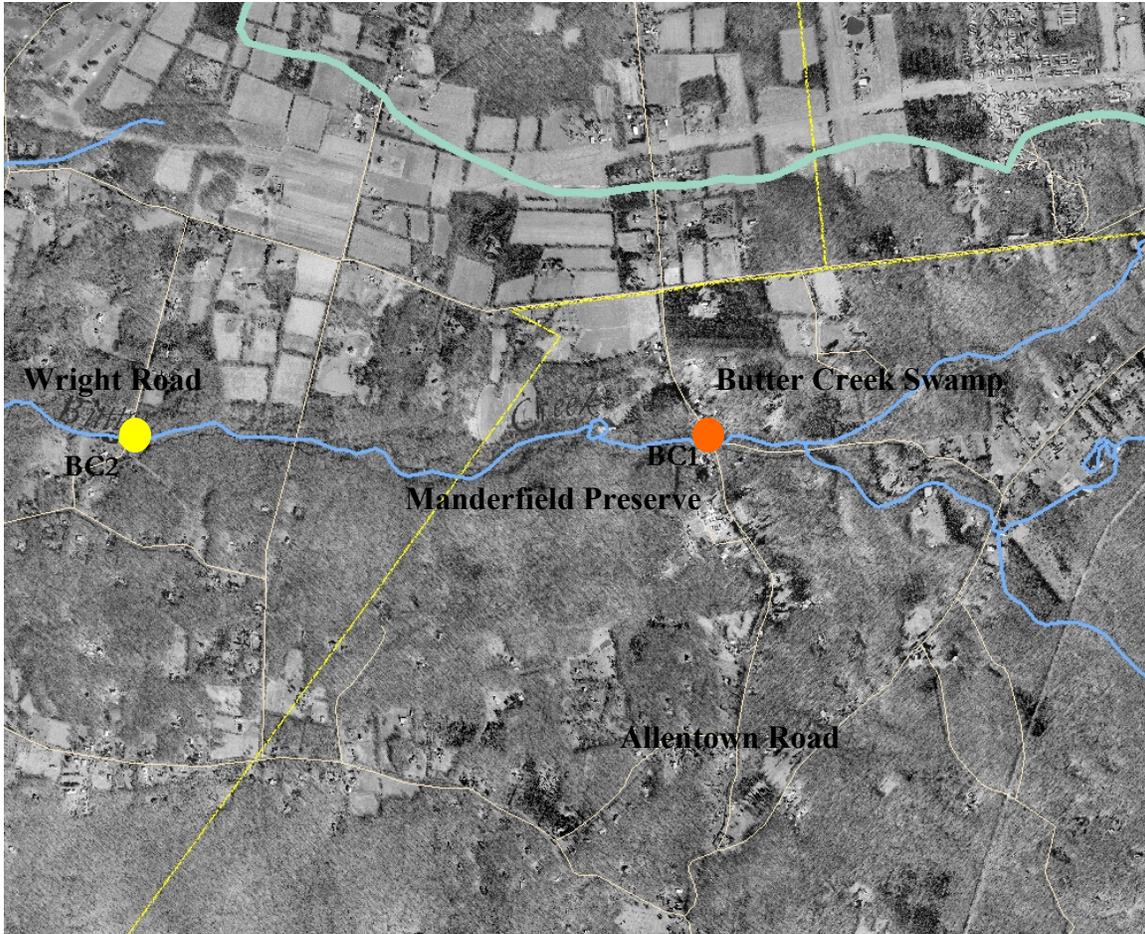


Figure 12 -- Butter Creek Subbasin Land Use Pattern Above BC1 and BC2.

Butter Creek is the second most heavily forested subwatershed in the upper portion of the Unami Creek watershed. Land use is generally limited to large lot rural residential with custom homes (no large subdivisions) along the network of 5 local roads. The stream originates in two small forks and flows from east to west, from Route 309 near its source to the Northeast Extension of the PA Turnpike at its confluence with the Unami Creek. The quality and quantity of water in the stream benefits from its extensively forested watershed and undisturbed wetlands and the lack of impervious surfaces and resulting stormwater runoff. Runoff from Route 309 does not drain to the headwaters of Butter Creek, and the only road runoff to the creek comes from the network of 5 local roads in the subwatershed.

The 1,500+ acre (4.35 square mile) stream valley averages approximately 1 mile wide and three miles in length, and includes approximately 60% forest, 30%

agricultural, and 10% residential. Livestock and agricultural uses in the area appears to be limited to a few small scattered farms and small sheep flocks and horse stables along Butter Creek Road, Schukraft Road, and Camp Rock Hill/Esten Roads. The northern fork includes a portion of a mobile home park and also a series of in-stream ponds maintained by the Great Swamp Fish, Game and Forestry Association.

The southern fork of the stream is almost entirely forested, and has its source in forested seeps and wetlands in State Game Lands #196 just east of Schukraft Road. A smaller rivulet rises to the south in a red maple wetland "saddle" along Schukraft Road. All three tributaries merge along Butter Creek Road in the Butter Creek wetland. Most of the diabase woodland here appears to be 50 to 75 years in age, with a mixture of oaks, hickories and red maple. From here, the stream flows to the west for approximately one-half mile through an unusually large (500+ acre), undeveloped area of dense forest with buffers averaging at least 1,000 feet on each side. Several homes are located approximately 1,000 feet from the source, along a dead end road called Tower Road which leads to a radio tower on a knoll at an elevation of about 730 feet above sea level. Newer homes on Schukraft Road are constructed within 100 feet of small tributary streams. Several other homes are located at least 2,000 feet to the south. This upper reach of the stream is crossed by at least 2 utility corridors (including an Interstate Energy gas/petroleum pipeline and a fiber optic cable) and a gravel road.

The next 1,700 feet of this upper reach of Butter Creek is impounded to form 3 large ponds, with a second road crossing. Several farmfields and a road border the north side of the stream in this area, though the majority of the landcover is still forested. Just downstream from the ponds, a large mobile home park straddles the Unami watershed boundary and includes over 75 units in the Butter Creek subwatershed. The wastewater treatment system for this community does not appear to discharge to Butter Creek, however, stormwater runoff drains toward Butter Creek, with the closest units and internal roads located only 700 feet from the stream. Butter Creek flows for another half mile through a densely wooded valley with large lots along the south side within 300 feet of the stream, and a large lot subdivision on the north side with a home 200 feet from the stream. The main stem then flows within 100 feet of the north side of Butter Creek Road for over 1,600 feet before crossing under Allentown Road. This section is mostly wooded, with several mature pine plantations and residential clearings.

At this point, a second headwaters tributary merges with the main stem. This second tributary includes two forks that rise in the same large forested patch as the main stem. They then pass through large rural lots along Cedar Hollow Road, where they merge and flow north through a mostly wooded landscape

before merging with the main stem. This tributary is impounded at two locations to create large ponds.

Just west of Allentown Road, Butter Creek flows through the Manderfield Preserve managed by Heritage Conservancy, and passes within 600 feet of a large campground (with a number of camper trailers scattered in woodland clearings). At this point, the stream flows for approximately one mile through a forested landscape unbroken by roads or clearings, and with one large acre pond. The forest patch on the south side of the stream is several hundred acres in area. The north side of the stream includes forested riparian buffers of at least 150 feet in width, with a number of agricultural fields further upslope along Camp Rock Hill/Estes Road. West of the closed section of Bennetts School Road, Butter Creek flows through a similar landscape for another 2,000 feet before passing under Wright Road, then another 3,500 feet through less densely forested landscape before reaching its confluence with the Unami Creek under the overpass of the Northeast Extension of the Pennsylvania Turnpike. This final lower segment of Butter Creek includes a mix of agricultural and forested residential properties, with full-to-partial riparian buffers.

Ridge Valley Creek

RV1, RV2



Figure 13 -- Ridge Valley Creek Subbasin Land Use Pattern Above RV1 and RV2.

The Bucks County portion of Ridge Valley Creek is the most forested subwatershed of the upper Unami Creek valley, flowing for over 4 miles through over 1,100 acres of relatively dense diabase forest with only small clearings and scattered custom homes. This is the largest subbasin of the Unami Creek, at 11.1 square miles (including a major portion in Montgomery County). Ridge Valley Creek includes the southern half of State Game Lands #196, which, at 348.52 acres, is the largest protected area in the upper Unami Creek watershed. While the majority of SGL #196 is managed as forest, the Game Commission manages a series of fields along Ridge Valley Road with feed crops and habitat for game birds.

Two broad swaths of agricultural land can be found in this subwatershed, the largest following the drainage divide along Ridge Road (Route 563) and the

second centered around the hamlet of Argus along Allentown Road and Thousand Acre Road. A large landfill under construction near the top of the subwatershed at Shady Lane and County Line Roads appears to be impacting a small headwaters tributary through filling of wetlands and siltation.

This reach of Ridge Valley Creek is roughly 1 mile wide, and is crossed by roads passing over culverts in 5 places along small headwaters tributaries. The three main roads bisecting the valley are Allentown Road, Twin Lows Road, and the Northeast Extension of the Pennsylvania Turnpike. The main stems passes under larger bridges at each of these crossings. An electric utility line parallels the creek along the ridge to the south, crossing several headwaters wetlands. Two other utility corridors cross the stream valley in a north-south direction.

Ownership Patterns



Ownership Patterns

What is most noticeable, and concerning, about the pattern of ownership in the Upper Unami is its fragmented nature. The large parcels of 250 to 1,250 acres or even 100 to 250 acres present in the Montgomery County portion of the watershed are not present in the Upper Unami in Bucks County. The fragmented nature of land ownership simply means that large scale protection efforts must incorporate the agreement of many landowners.

Largest Parcels (50 to 100 acres)

In NLT's earlier *Upper Unami Creek Watershed: Landscape Conservation Plan*, the largest properties identified as Conservation Priorities in the Upper Unami Creek are *24 parcels of between 50 and 100 acres in size*. Some of these are larger farm properties in the northern portion of the Upper Unami, identified for their wetlands and riparian corridors rather than their total acreage. Only *three parcels of just over 100 acres in size* were identified as Conservation Priorities, and two of these are owned by the Pennsylvania Game Commission as part of State Game Lands #196. The goal of the ongoing conservation efforts in the area is to secure all the Conservation Priority Parcels with permanent protection from future development and to promote ecological land management. They represent true "anchors" of biodiversity in the region.

Second-Tier Parcels (25 to 50)

The next level of parcel sizes in the *Upper Unami Creek Watershed: Landscape Conservation Plan* study area are those in the 25 to 50 acre range. Several institutional and commercial owners (i.e. camps, golf courses) each own a series of individual parcels which, when combined, total over 100 acres.

Approximately 31 of the largest parcels are concentrated in the 25 to 50 acre range. Roughly 97 parcels fall within this size category. These include properties such as parks, hunting clubs, nature preserves and private holdings scattered throughout the area, but they are often contiguous with other parcels in this size class or the Largest Parcels. They often include significant woodlands, steep slopes, hydric soils and riparian corridors. These parcels, if not already protected, are generally listed as conservation priorities to secure conservation and sound land management.

Third-Tier Parcels (10 to 25)

The next level of open space parcels fall in the *Upper Unami Creek Watershed: Landscape Conservation Plan* in the 10 to 25 acre range. These are scattered widely throughout the Upper Unami area, often in contiguous blocks adjoining larger parcels. Properties in this size category are important priorities for “infill” conservation between larger tracts.

Small Individual Parcels and Subdivisions

Approximately 47 parcels of less than 10 acres are included as Conservation Priorities, only in cases where the majority of the parcel contributes to an important block of habitat as part of a mosaic of larger contiguous parcels. Many of these also appear to be vacant with difficult access, and a number are owned by a single party as multiple parcels. Most of the largest parcels are situated along the streams and wooded slopes in the area, while the smaller parcels are more randomly located. Numerous parcels below 10 acres in size can be found along nearly every road throughout the study area. An increasing number of large-lot subdivision (3 to 5 acres or more per lot) are being developed, and custom homes are becoming more prevalent in the diabase woodlands.

The prioritized parcels identified in Figure 5 of this *Aquatic Resource Assessment and Conservation Plan* are drawn from the ownership pattern analysis data developed for the two conservation plans prepared for the Unami Forest by Natural Lands Trust, as described on the following page.

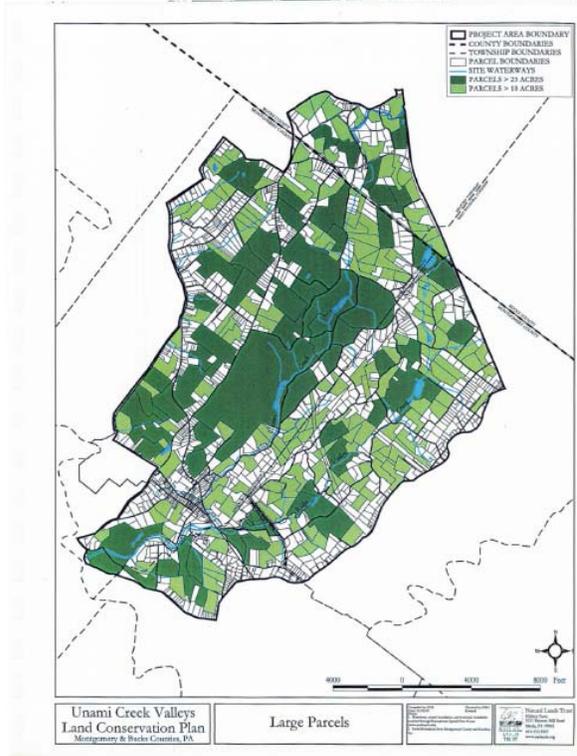


Figure 14 -- Unami Creek Valleys Landscape Conservation Plan (NLT, 2001) Large Parcels map. This map depicts the ownership pattern of the lower (Montgomery County) portion of the watershed, with larger parcels (25 acres or greater) shown in dark green).

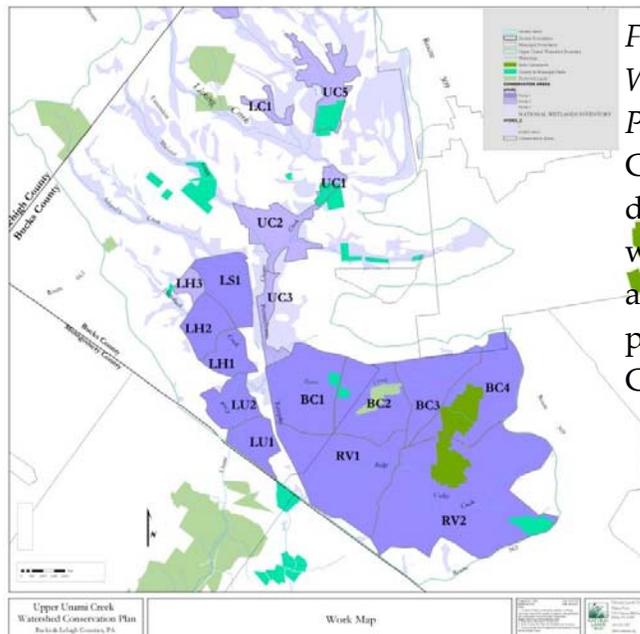


Figure 15 - Upper Unami Creek Watershed: Landscape Conservation Plan (NLT, 2002) Priority Conservation Areas map. This map depicts groups of priority tax parcels within the largest blocks of forest and corresponds to ownership pattern data for the upper (Bucks County) portion of the watershed.

Existing Protected Riparian Open Space

The Upper Unami Creek watershed currently supports nearly 2,000 acres of land protected by private landowners working with state and county agencies, local municipalities, and land trusts. Protection methods utilized in the upper Unami include: State Game Land acquisition; purchase of state and county-funded agricultural easements; municipal acquisition of land and conservation easements through the subdivision process; municipal park acquisition, and; land trust acquisition of preserves and conservation easements.

Milford Township Open Space Plan and Milford Township Park and Recreation Plan (2003)

The Milford Township Open Space Plan and Milford Township Park and Recreation Plan provides detailed assessments of “Permanently Preserved Areas” and “Temporarily Preserved Areas”. As of 2002, the Preserved Areas map and table show the following breakdown:

A number of these areas are near or adjacent to lands identified as Riparian Land Protection Priorities in this Plan, particularly along Butter Creek, where both Milford and West Rockhill Township are working closely with the County, Natural Lands Trust, and the Heritage Conservancy to establish a protected greenway link between the Unami Creek and the Quakertown Swamp.

“There are over 900 acres of permanently preserved land in Milford. The township owns 23 parcels totaling over 475 acres. Molasses Creek Park (63 acres) and Unami Creek Park (73 acres) are Milford’s developed community parks. The balance of township-owned acreage is in undeveloped open space parcels. Permanently preserved land in Milford includes homeowner association property and lands under various types of conservation easements, such as agricultural preservation easements, among others.” (Milford, 2003)

An additional 749.32 acres are mapped as Temporarily Preserved Areas, including land owned by churches, public utilities, private recreational groups (i.e. camps, sportsmen’s clubs) and schools. Due to their size, location and the uncertainty of their protected status, a number of these parcels are important candidates for protection.

Tract	Owner/Status	Area	Priority Area Location
Molasses Creek Park	Milford Township	22.47 ac	Molasses Creek, south side of Rte. 663 near MC1.
Unami Creek Park	Milford Township	72.77 ac	Near UC1, a Priority 2 area on the Unami at Allentown Road s. of Milford Square.
Lands along Barrel Run Creek	Milford Township	50.91 ac	Barrel Run Creek, n. of Trumbauersville.
Rosenberger tract	Milford Township	95.68 ac	Near UC1 adjoining east side of 38.87 ac Milford Middle School tract.
Wise tract	Milford Township	14.95 ac	Near BC2, lower Butter Creek
Wheelin tract	Milford Township	15.65 ac	Near BC2, lower Butter Creek
Shelps tract	Milford Township	26.81 ac	Near BC2, lower Butter Creek
Willow Stream Condo.	Homeowners Association (HOA)	38.68 ac	Barrel Run Creek, n. of Trumbauersville.
Willow Stream	HOA	18.64 ac	Barrel Run Creek, n. of Trumbauersville.
Tollgate Landing	HOA	13.85 ac	Barrel Run Creek, n. of Trumbauersville.
Woodlands Creation	HOA	9.27 ac	Near SC2, Lower Schmoltz Creek, Walnut Lane
Mood tract	Agricultural Easement	110.00	Licking Creek headwaters, Meyers Road
Sutton tract	Conservation Easement	9.56 ac	Near HC2, Hazelbach Creek n. of Fennel Road.
Heinrich	Conservation Easement	31.11 ac	Near HC2, Hazelbach Creek s. of Fennel Road.
Camburn	Conservation Easement	22.65 ac	Near HC2, n. side of Doerr Road
Williams	Conservation Easement	32.31 ac	Near HC2, n. side of Doerr Road
Blattner	Conservation Easement	24.22 ac	Near HC2, n. side of Doerr Road
PA Turnpike Commission	State Land	29.36 ac	Near UC2, e. side of Turnpike, confluence of Schmoltz/Unami Creeks

TABLE 2 – Protected Lands in Milford Township (continued)

<i>Tract</i>	<i>Owner/Status</i>	<i>Area</i>	<i>Priority Area Location</i>
Milford-Trumbauersville Sewer Authority	Public Utility Land	32.85 ac	Near UC2, e. side of Rosenberger Rd, confluence Molasses/Unami Creeks.
Quakertown Airport	Public Utility Land	153.75 ac	Extensive frontage on Unami tributary.
Camp Men-O-Lan	Private Recreational Land	156.18 ac	Near HC2 along lower Hazelbach Creek.
Fox Hollow Golf Course	Private Recreational Land	136 ac	Near UC2 along Unami, n. side of Trumbauersville Road.
Milford Township Fish and Game	Private Recreational Land	91.45 ac.	Near SC2, lower Schmoltz Creek, between Canary Road and Turnpike.

Protected lands in West Rockhill portion of the study area include the 350-acre State Game Lands #196, the 54-acre Manderfield Preserve managed by Heritage Conservancy, easement land along Butter Creek, and the West Rockhill Township park property.

Natural Lands Trust is negotiating several additional conservation easements to protect hundreds of additional forested acres in the Upper Unami in or near Priority Stream Reaches. As incompletd projects, these parcels were not mapped as part of this Assessment.

Riparian Land Protection Priorities



For the twelve assessed stream reaches, a total of 72 parcels totaling 1,220 acres are identified on Figure 5 as Priority Parcels for acquisition. Stream reaches on the Molasses, Unami, Hazelbach, and Ridge Valley Creeks are identified in the Upper Unami Creek project area as high priorities for conservation based on their proximity upstream of five Class 1 sampling stations. A total of forty-two parcels totaling over 750 acres of land upstream of these stations are shown as Class 1 Priority Parcels on the map titled Prioritized Stream Reaches and Parcels (Figure 5). *These properties were identified as a result of the detailed GIS analysis, with an emphasis on protecting large parcels with extensive stream frontage located within 3,000 feet upstream of the five Class 1 sampling stations.*

Stream reaches on the Unami, Butter and Schmoltz Creeks are identified as medium priorities for conservation based on their proximity upstream of four Class 2 sampling stations. A total of nineteen parcels associated with Class 2 reaches are identified in Figure 5, encompassing an area of over 325 acres. Class 3 stream reaches can be found in the upper Ridge Valley, Butter, and Hazelbach Creeks. Eleven parcels totaling over 145 acres are identified in Figure 5 as lower priorities for acquisition – however, these areas warrant further study as potential restoration sites. *Class 2 Properties are identified through GIS analysis and include large parcels with extensive stream frontage located within 2,000 feet upstream of*

the four Class 2 sampling stations. Class 1 Properties are identified as those within 1,000 feet of the three Class 3 sampling stations.

The goal of this parcel-based analysis is to protect landscape-scale networks of forested riparian corridors providing buffering and in-stream filtration for water quality and healthy communities of aquatic organisms. The properties identified are a minimum of 5 acres or greater in size, and are situated in Milford and West Rockhill Townships.

The Priorities are listed in the following sections by municipality and watershed, with description of important features and potential conservation status where possible. The parcels' identifying number does not indicate its priority. Certain listings are a series of contiguous parcels under single ownership. Others are listed as proposed for subdivision, with potential protection of key resources. Lands that are already protected are listed and mapped as such based on current information.

Class 1 Stream Reach Parcels

The following sections of the upper Unami Creek watershed are identified in this Plan as *Class I Priority Parcels* due to their multiple benefits for protection and enhancement of biodiversity and water quality and quantity:

Molasses Creek Corridor

Ridge Valley Creek Corridor

Unami Creek

Hazelbach Creek Corridor

A total of forty-two parcels are identified as Class 1 Priority Parcels, encompassing an area of over 750 acres (see Figure 5).

Molasses Creek Corridor (MC1)

This area includes an extensive alluvial forest and adjacent uplands just east of the Pennsylvania Turnpike and south of Route 663. A total of 8 parcels encompassing 118 acres) are identified as Class 1. Parcel ID #s 8 and 9 are counted together as one parcel.

Description: A relatively large subwatershed with an agricultural headwaters and heavily forested floodplain at its lower end near the sampling station. Molasses Creek reaches the Unami just upstream of the Milford-Trumbauersville Wastewater Treatment Plan.

Nearest Roads: Rosenberger, Umbright, and Kumry Roads. Northeast Extension of PA Turnpike.

Municipality: Milford Townships.

Label #	Parcel ID #	Acres
1	23010031	15.810
2	23010029	2.183
3	23010030	1.319
4	23010012	9.321
5	23010011	7.901
6	23010183	47.229
7	23010033	23.063
8	23010032	10.595
9	23010032-001	0.633
Total		118.054 total acres

Ridge Valley Creek Corridor (RV2)

A total of 9 parcels encompassing 116 acres are identified as Class 1(see Figure 5).

Description: The reach south of Allentown Road flows through extensive woodlands and is fed by seeps, rivulets and wetlands. Several homes are situated close to the stream. The middle and lower sections of Ridge Valley Creek in Bucks County flow to the west through dense forest and is impounded in several locations near the hamlet of Ridge Valley on Allentown Road.

Nearest Roads: Allentown Road, Ridge Valley Road, Thousand Acre Road

Municipality: West Rockhill Township

Label #	Parcel ID #	Acres
92	52001025-004	9.602
93	52001025-003	10.164
94	52001025-007	2.973
95	52001025-006	1.977
96	52001017-003	8.757
97	52003086	27.326
98	52001025-002	12.239
99	52003085-001	4.099
100	52003083	38.992
Total		116.129 Total acres

Unami Creek

Unami Creek includes two Class 1 reaches.

Unami Creek below Milford Square (UC1)

A total of 8 parcels (217.03 acres) are identified as Class 1 (see Figure 5).

Description: Forested slopes, floodplain and stream frontage on Unami Creek and a large tributary downstream of Milford-Trumbauersville Wastewater Treatment Plant. Wooded stream corridor is listed as a Priority 3 site in Bucks County Natural Areas Inventory due to relatively high diversity of native fish species (15). Includes over 4,000 feet of full riparian buffer.

Nearest Roads: Allentown Road, Mill Road, Hillcrest Road

Municipality: Milford Township

Label #	Parcel ID #	Acres
27	23010060	56.468
28	23010061-002	33.019
29	23010061	20.881
30	23010048	19.067
31	23010047	20.458
32	23010053	28.397
33	23010044	10.648
34	23010054	28.088
Total		217.03 total acres

Unami Creek (UC2)

A total of 12 parcels are identified as Class 1, totaling 167 acres.

Description: Extensive forested floodplain and wetlands at confluence of Molasses Creek, Unami Creek, and an unnamed tributary from the east. Adjoins UC1 to north and UC3 to south. Includes over 2.5 miles of full or partial riparian buffer. Milford Township Wastewater Treatment Plant is situated just to the west and discharges to Molasses Creek at this point. Kumry Road forms

southern boundary, and Umbright Road bisects the area. Downstream of Fox Hollow Golf Club. Partly impounded.

Nearest Roads: Trumbauersville Road, PA Turnpike.

Municipality: Milford Township

Label #	Parcel ID #	Acres
35	23020052	34.475
36	23007195	11.458
37	23020051	12.775
38	23007187	17.257
39	23007188	23.822
40	23020157	25.497
41	23007193	10.415
42	23007194	16.901
43	23020159-002	6.443
44	23020156	3.006
45	23020158	0.475
46	23020052-001	4.776
Total		167.3 total acres

Hazelbach Creek Corridor (HC1)

A total of 4 parcels (141 acres) are identified as Class 1 (see Figure 5).

Description: Extensive forested stream valley with alluvial forest and shrub/sedge marsh seeps. Camp Men-O-Lan is major landowner. Listed as a Priority 3 site in Bucks County NAI as a characteristic diabase stream “with extensive wooded, shrubby, and herbaceous wetlands forming a mosaic of habitats which includes amphibian and reptile habitat.” Natural Lands Trust’s Klaber preserve is situated at the headwaters of the Hazelbach at Saw Mill and Spinnerstown Roads.

Nearest Roads: Canary Road, Doerr Road, Fels Road, Trumbauersville Road.

Municipality: Milford Township

Label #	Parcel ID #	Acres
23	23007128	43.271
24	23007130	17.353
25	23007126	60.083
26	23007127	20.056
Total		140.763 total acres

Class 2 Stream Reach Parcels

A total of 19 parcels in the Upper Unami are identified as Class II priorities, encompassing an area of over 325 acres.

Schmoltz Creek Corridor, Lower (SC1, SC2)

A total of 9 parcels (151 acres) are identified as Class 2. These reaches are contiguous and are listed here together (see Figure 5).

Description: Extensive forested stream valley with alluvial forest, forested wetlands and adjacent diabase woodlands, adjoins lower Hazelbach Creek woodlands. An agricultural easement protects a farm along both sides of the headwaters portion of Schmoltz Creek in Lower Milford Township, Lehigh County.

Nearest Roads: Kumry Road, Walnut Road, Canary Road.

Municipality: Milford Township

Label #	Parcel ID #	Acres
10	23007140	17.387
11	23007139	20.180
12	23007138-005	10.369
13	23007138	65.119
14	23007150	16.489
15	23007149	14.415
16	23007151	2.422
17	23007151-001	2.194
18	23007151-002	2.685
Total		151.260 total acres

Unami Creek at confluence of Molasses (UC3)

A total of 3 parcels (60 acres) are identified as Class 2 priorities. A number of small < 2 acres developed parcels are found in this area.

Description: Forested area at Finland, includes impounded stream with summer camps.

Nearest Roads: Upper Ridge Road, Trumbauersville Road.

Municipality: Milford Township

Label #	Parcel ID #	Acres
70	23008003-002	4.769
72	23020011	31.463
77	23020012	23.773
Total		60.05 total acres

Butter Creek at Wright Road (BC2)

A total of 7 parcels (116 acres) are identified as Class 2 priorities (see Figure 5).

Description: Forested area between protected open space owned by Milford Township – important growing greenway corridor with extensive alluvial forest, shrub wetland habitat.

Nearest Roads: Wright Road, Old Woods Road.

Municipality: Milford Township

Label #	Parcel ID #	Acres
81	23020137	12.203
82	23020147	14.330
83	23020127-002	5.676
84	23020136	22.797
85	23020127	41.560
86	23020128	9.467
87	23020127-001	9.829
Total		115.862 total acres

Class 3 Stream Reach Parcels

A network of 145 acres of land on 11 parcels along the upper Hazelbach, Ridge Valley, and Butter Creeks has high value for protection and restoration of water resources and biological diversity, even where sampling scores were relatively low. These areas are shown on Figure 5 as Class 3 Priority Parcels, and include riparian corridors, floodplains, wetlands and hydric soils within 1,000 feet upstream of Class 3 sampling stations. These reaches are small enough that some go dry or are pooled in summer (Butter and Hazelbach), while Ridge Valley is influenced by impoundments.

These networks are valuable habitats in their own right and in terms of their proximity to higher-ranking blocks, and may be considered high priorities for *restoration* of riparian buffers, wetlands, and streambanks (including dam removal). With gradual restoration of riparian forests and wetlands through a combination of municipal ordinances and landowner initiatives, the aquatic health of these Class III reaches will become the “green infrastructure” that ensures the long term health of the Unami Creek watershed, the quality and quantity of its water, and the habitat it provides for people, plants and wildlife.

Butter Creek at Allentown Road (BC1)

A total of 3 parcels (35 acres) are identified as Class 3 priorities (see Figure 5).

Description: Butter Creek Swamp and adjacent forested headwaters areas upstream of bridge at Allentown Road. Adjoins east side of Manderfield Preserve – important growing greenway corridor with extensive alluvial forest, shrub wetland habitat.

Nearest Roads: Allentown Road, Butter Creek Road.

Municipality: West Rockhill Township

Label #	Parcel ID #	Acres
78	52002002	23.017
79	52002001	7.317
80	52001058-002	4.723
Total		35.057 total acres

Ridge Valley Creek Corridor (RV1)

A total of 4 parcels encompassing 53 acres are identified as Class 3 (see Figure 5).

Description: The reach north of Allentown Road flows through an impounded area at the village of Ridge Valley, but upstream areas support extensive woodlands adjacent to and including State Game Lands. The area is fed by forested headwaters seeps, rivulets and wetlands.

Nearest Roads: Allentown Road, Ridge Valley Road, Thousand Acre Road

Municipality: West Rockhill Township

Label #	Parcel ID #	Acres
88	52003098	28.344
89	52003109	8.456
90	52003109-005	14.089
91	52003097	1.857
Total		52.746 total acres

Hazelbach Creek Corridor (HC2)

A total of 4 parcels (56 acres) are identified as Class 3 (see Figure 5).

Description: Extensive forested stream valley with alluvial forest and shrub/sedge marsh seeps. Upstream of Camp Men-O-Lan, with larger residential properties. Listed as a Priority 3 site in Bucks County NAI as a characteristic diabase stream “with extensive wooded, shrubby, and herbaceous wetlands forming a mosaic of habitats which includes amphibian and reptile habitat.” Natural Lands Trust’s Klaber preserve is situated at the headwaters of the Hazelbach at Saw Mill and Spinnerstown Roads.

Nearest Roads: Canary Road, Doerr Road, Fels Road.

Municipality: Milford Township

Label #	Parcel ID #	Acres
19	23007106-003	33.495
20	23007110	13.008
21	23007112	4.443
22	23007111	5.332
Total		56.278 total acres

Restoration Priorities

Waterways lacking riparian forest buffers in the Upper Unami Creek watershed are fully exposed to erosion, pollutants and sunlight, and are listed in the Assessment (see Figure 3) as Lacking Buffer on Both Sides. The location and extent of these gaps is critically important in terms of impacts to otherwise healthy stream segments and valuable community water supplies. These areas are prime candidates for restoration efforts such as those that have been underway in the watershed through streambank fencing and tree planting projects. The amount of effort to reforest this relatively small percentage of stream miles can produce major benefits for stream quality and result in major cost savings by reducing future flood damage, dredging frequency and water treatment procedures.

In addition, the Assessment noted 26 stream miles (11% of the total in the watershed) as Lacking Buffer on One Side but having a full 50' buffer on one side. The Unami supports the greatest number of segments with these characteristics. A total of 2.7 miles of streams are mapped as having Partial Forest Buffers of less than 50' on both sides.

Approximately ten miles of the Upper Unami watershed lacks riparian buffer coverage. While this is only about 13% of the total stream miles in the Unami (UPWC, 2001), it occurs in headwaters areas where streams are small and sensitive to pollution and heating that accompanies lack of wooded buffers.

Conclusion

This *Upper Unami Creek Aquatic Resource Assessment and Conservation Plan* combines field-collected data on aquatic life with GIS-based parcel analysis. It takes a valuable first step toward understanding how specific parcels of land, based on their management and ecological health, may directly benefit the habitat and water quality conditions supporting benthic macroinvertebrate communities – the canaries in the coal mine for stream health in the region. It incorporates assessments of land use and land ownership patterns affecting each subbasin and the stream reaches where monitoring stations are established.

This Plan also provides *knowledge* to assist in carrying forward the ongoing effort to identify and protect those land parcels which have the greatest potential for protecting, or enhancing, the health of the stream ecosystems and water quality that are the basis for reliable drinking water supplies in the region. The GIS-based analysis provided in the Plan has generated a detailed listing of Riparian Land Protection Priorities, adding an aquatic resource component to the terrestrial resource-based Conservation Priorities provided in the *Upper Unami Creek Watershed: Land Conservation Plan* (NLT, 2002).

This Assessment and Plan are offered as a guidebook for Trust staff and local conservation leaders to use in charting the water future for communities in the Upper Unami and around the region. It also points toward possible future projects that meld the goals of strategic conservation planning with accurate field data on stream ecosystem health. By expanding data sets to include rapid bioassessment and long-term biological data collected by PA DEP, Stroud Water Research Center, volunteer monitors, and others, the parcel-based analysis demonstrated here can help to focus on protecting high quality land to protect high quality streams in the lower Delaware Valley.

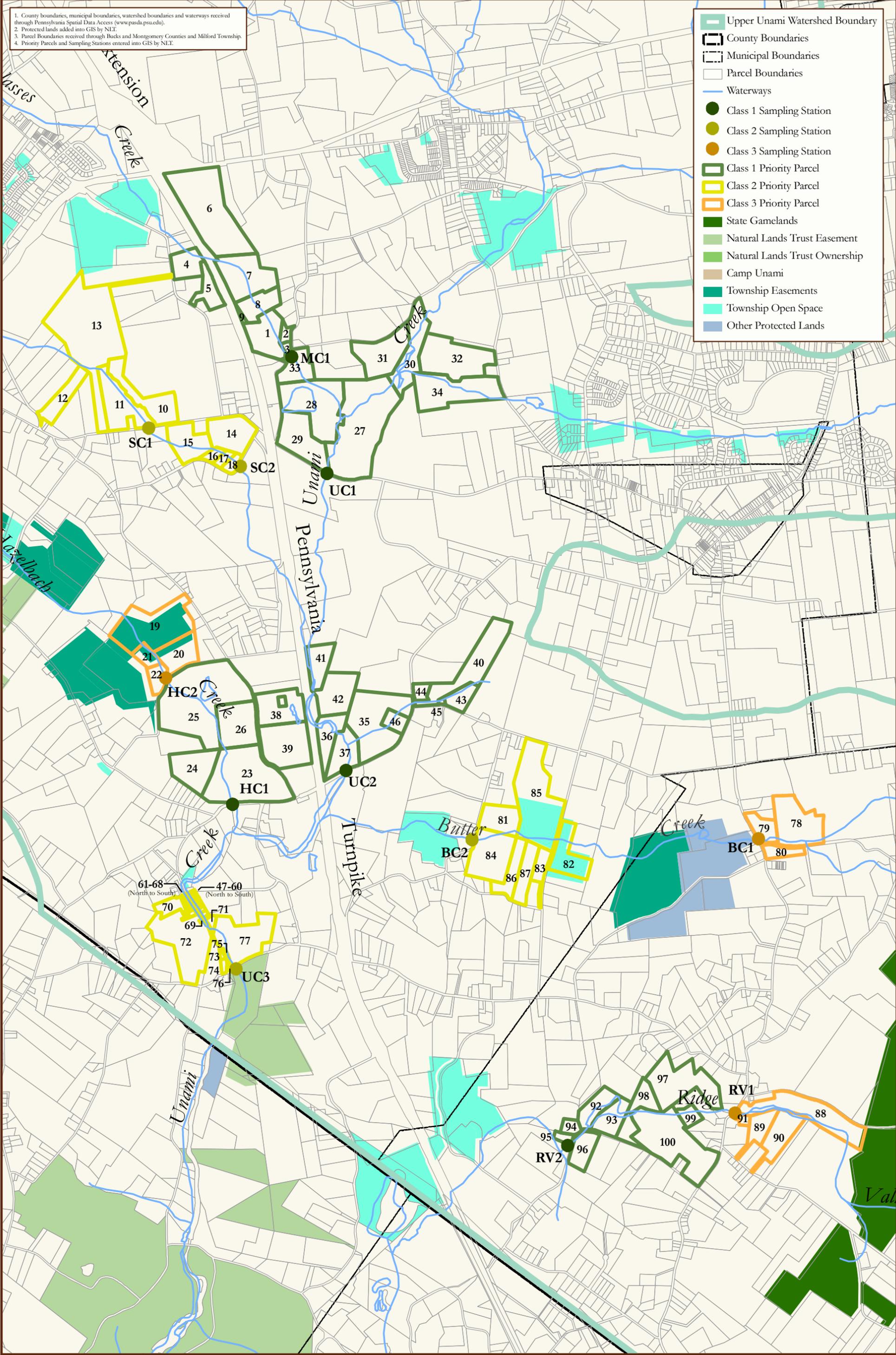
With increasing understanding of the land-water link, conservation partners may act with care for protecting riparian lands providing ecosystem services resulting in clean, plentiful water for people, plants and animals.

TABLE 3 – Stream Reaches Ranked by Total Score (Green = Class I, Yellow = Class II, Orange = Class III)

Stream and Reach ID	Stream Reach:	Biological Score	% Reference Score	Biological Condition	Habitat Score	Total Score
Cooks Creek	multiple	42	n/a	n/a	157	199
Unami Creek						
UC1	Kumry Road (downstream)	30	71.4%	Slightly Impaired	153	183
UC2	Trumbauersville Road	38	90.5%	Non-Impaired	152	190
UC3	Upper Ridge and Trumbauersville Roads	34	80.9%	Slightly Impaired/Non-Impaired	143	177
Ridge Valley Creek						
RV1	Allentown Road (upstream of road, downstream of dam)	20	47.6%	Moderately Impaired	129	149
RV2	Rocky Dale Road (downstream)	24	57.1%	Slightly Impaired	155	179
Butter Creek						
BC1	Manderfield Preserve (downstream of Allentown Road)	26	61.9%	Slightly Impaired	128	154
BC2	Wright Road (downstream)	24	57%	Slightly Impaired	154	178
Hazelbach Creek						
HC1	Trumbauersville Road	28	66.7%	Slightly Impaired	158	186
HC2	Doerr Road (upstream)	32	76.2%	Slightly Impaired	122	154
Schmoltz Creek						
SC1	Kumry Road	32	76.2%	Slightly Impaired	139	171
SC2	Walnut Lane	40	95.2%	Non-Impaired	134	174
Molasses Creek						
MC1	Rosenberger and Umbright Rds.	28	66.7%	Slightly Impaired	151	179

1. County boundaries, municipal boundaries, watershed boundaries and waterways received through Pennsylvania Spatial Data Access (www.pasda.psu.edu).
 2. Protected lands added into GIS by NLT.
 3. Parcel Boundaries received through Bucks and Montgomery Counties and Milford Township.
 4. Priority Parcels and Sampling Stations entered into GIS by NLT.

- Upper Unami Watershed Boundary
- County Boundaries
- Municipal Boundaries
- Parcel Boundaries
- Waterways
- Class 1 Sampling Station
- Class 2 Sampling Station
- Class 3 Sampling Station
- Class 1 Priority Parcel
- Class 2 Priority Parcel
- Class 3 Priority Parcel
- State Gamelands
- Natural Lands Trust Easement
- Natural Lands Trust Ownership
- Camp Unami
- Township Easements
- Township Open Space
- Other Protected Lands



PRIORITIZED STREAM REACHES AND PARCELS

Upper Unami Aquatic Resource Assessment and Conservation Plan
 Milford and West Rockhill Townships, Bucks County, Pennsylvania

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 Media, PA 19063
 610-353-5587
www.natlands.org

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