Coldwater Conservation Plan
Bertsch & Hokendauqua Creek Watersheds

2012

"Indian Creek in Winter"

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for the Bertsch-Hokendauqua-Catasauqua
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Coldwater Heritage Partnership***

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Table of Contents

REPORT

MAPS

APPENDICES

Acknowledgements and Funding

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Introduction & Purpose of Study

This Coldwater Conservation Plan for the Bertsch and Hokendauqua Creek Watersheds was developed to document and assemble baseline data for these two coldwater ecosystems, provide recommendations for water resource protection within these watersheds, increase community awareness of these watersheds and their natural resources and petition the Commonwealth of Pennsylvania for special protection designation for streams within these two watersheds. This plan is the first conservation plan developed for these watersheds focused specifically on water resources. This plan was prepared by the Northampton County Conservation District for the Bertsch-Hokendauqua-Catasauqua Watershed Association (BHCWA), whose mission is to promote stewardship of, preserve, protect, enhance and restore watersheds that are tributary to the Lehigh River from the east, between Catasauqua Borough and Lehigh Gap, in the uppermost reach of the Lower Lehigh River Basin. The implementation of this plan is a priority for BHCWA.

This Coldwater Conservation Plan provides a description of the study area and background information; reviews the cultural history, land use practices and conservation planning efforts in the study area; addresses challenges and resource protection opportunities in the study area; summarizes the biological and thermal studies conducted on streams in the study area as part of this planning project; and provides conclusions of the study and recommendations for implementing this plan. The plan will be used as a basis for watershed restoration project funding and implementation, more detailed watershed studies and conservation education and outreach initiatives by BHCWA and its community partners.

Description of the Study Area

General Description

The headwaters of the Bertch and Hokendauqua Creek Watersheds originate on the forested southern slopes of the Kittatinny Ridge, locally known as Blue Mountain, in Northampton County, PA. Together, these adjacent watersheds encompass 50.55 square miles of northwestern Northampton County, and include nearly 200 miles of streams. See Map 1, Aerial Photo. The Bertsch and Hokendauqua Creeks are both tributaries to the Lehigh River. The Bertsch Creek Watershed encompasses 9.6 square miles, with 4.5 stream miles on its main stem and 30.4 miles of tributaries. The Hokendauqua Creek Watershed encompasses 40.95 square miles, with 18 stream miles on its main stem and 143.5 miles of tributaries, including waterways within the Indian Creek sub-basin; the largest and only named tributary to Hokendauqua Creek. The Indian Creek sub-basin encompasses 13.46 square miles of the greater Hokendauqua Creek Watershed, with eight stream miles on its main stem and 59 miles of tributaries.

The Bertsch Creek Watershed is situated wholly in Lehigh Township, a predominantly rural agricultural municipality with a few small historical village centers, many more

modern residential communities and subdivisions and a population of 10,526 (2010 Census figures). Bertsch Creek empties into the Lehigh River in Lehigh Township, just south of the Borough of Walnutport, which is located just outside the study area. The Hokendauqua Creek Watershed encompasses much of Lehigh Township and Northampton Borough, and the majority of Allen and Moore Townships. Like Lehigh Township, Moore and Allen Townships are also mostly rural agricultural municipalities with a few small old village centers, a number of more modern residential subdivisions and populations of 9,198 and 4,269 respectively (2010 Census figures). The Borough of Northampton is the only urban center in the study area, with a population of 9,926 (2010 Census figures). Hokendauqua Creek empties into the Lehigh River in Northampton Borough.

Elevations in the study area range from 1,610 feet above sea level in the uppermost headwater reach of the Hokendauqua Creek Watershed on top of Blue Mountain at Smith Gap in Moore Township, to 290 feet above sea level at the confluence of Hokendauqua Creek and the Lehigh River in the Borough of Northampton. See Map 2, Surface Terrain and Map 3, Contours. The majority of the slopes in the study area are well under 15%, with some steeper slopes of 15%-25%, and some very steep slopes of over 25% on Blue Mountain and in local stream valleys. See Map 4, Steep Slopes.

Under 25 PA Code, Chapter 93, Water Quality Standards Regulations, all of the streams in the Bertsch and Hokendauqua Creek Watersheds are listed as Cold Water Fisheries (CWF). See Map 5, Stream Designations & Impairments. While streams in both watersheds are listed as Naturally Reproducing Wild Trout Waters by the PA Fish & Boat Commission (PFBC), none of the streams in these two watersheds are listed as Class A Wild Trout Waters by the agency. Nevertheless, Hokendauqua Creek and Indian Creek are popular trout fishing streams, and every year both waterways are stocked by PFBC both before and during trout season.

Geology

The landscape of a watershed, the characteristics of the water and the form that streams take are all influenced by the underlying geology of the region. For the most part, the Bertsch and Hokendauqua Creek Watersheds are located in the northern half of the Great Valley Physiographic Section of the Ridge and Valley Physiographic Province, which is underlain with shale, sandstone and slate. See Map 6, Geology. The lowest-most reach of the Hokendauqua Creek Watershed extends into the southern half of the Great Valley Physiographic Section of the province, which is underlain by limestone and dolomite, which gave rise to the cement industry in and around the Borough of Northampton. The Kittatinny Ridge, in the highest elevations and uppermost reaches of the two watersheds, is situated in the southernmost extent of the Blue Mountain Physiographic Section of the Ridge and Valley Physiographic Province. Here, the underlying rock type is predominately sandstone and conglomerate.

The Minsi and Lizard Creek members of the Shawangunk Formation are the underlying bedrock across the crest of the Kittatinny Ridge, or Blue Mountain, in a narrow band in

the uppermost reach of the Bertsch and Hokendauqua Creek Watersheds. These Silurian geologic members are composed primarily of sandstone and conglomerate. With its Pen Argyl, Ramseyburg and Bushkill Members, the Martinsburg Formation underlies the vast majority of the two watersheds. These Ordovician bedrock members are composed of shale, sandstone and slate, which gave rise to the slate industry here in the middle 19th through late 20th centuries. In the lowermost reach of the Hokendauqua Creek Watershed, Jacksonburg Limestone, also of the Ordovician period, is the underlying bedrock, which gave rise here to the cement industry from the middle 19th through late 20th centuries.

Soils

The specific soil characteristics of a watershed are important in determining local land use and overland runoff patterns. Soils have widely varying characteristics in factors, such as nutrient levels and drainage rates. These soil characteristics help determine what types of local land use are suitable, i.e., agricultural field crops, pasture, athletic fields, residential or commercial development, etc. The rate at which water infiltrates into soils also has a significant impact on runoff patterns. Soils with high infiltration rates, like sandy soils, produce less surface runoff, while soils high in clay content are typically less permeable and will produce more runoff. See Map 7, Soils for the soil types of the Bertch and Hokendauqua Creek Watersheds.

Throughout the study area, the immediate stream corridors are composed of Brinkerton-Comly/Comly soils. These soil types are typical of soils found in and along streams and drainage ways.

Hazleton/Hazleton-Rubble and Laidig/Laidig-Rubble soils cover the crest and steep slopes of Blue Mountain in the extreme headwater reaches of the two watersheds. These soils and land types have an extremely stony or gravelly surface layer and a firm, cobbly and gravelly subsoil. They are poorly suited for most land uses.

Just off the toe of Blue Mountain, a more gently sloping landscape is covered in deeper soils with a shaly surface layer underlain by shale and slate. Allenwood, Andover-Buchanan, Buchanan and Bedington-Berks compose most of the soil types in this relatively narrow belt across the Bertch and Hokendauqua Creek Watersheds. These soils and land types are used for pastureland, hay crops and home sites, although slow permeability and high water tables, especially in the Andover-Buchanan soils, are limiting factors for many land uses.

A little further down in these watersheds and extending to the very bottom and near bottom of the Bertsch Creek and Hokendauqua Creek Watersheds respectively, Berks-Weikert soils cover the majority of the landscape in the area. These are fairly deep, well drained, shaly soils on gently sloping uplands. These soils and land types are common across the northern tier of Northampton County, where the Bertsch and Hokendauqua Creek Watersheds are situated. In the study area, these soils are suitable for all agricultural field crops typically grown in the county. Many homes and small residential communities are also found throughout this large section of both watersheds.

The Borough of Northampton is situated in the lowest-most reach of the Hokendauqua Creek Watershed, the most highly urbanized landscape in the study area. Here, in many places, human land use has completely destroyed the original soil profile. But in a few scattered areas, Weikert-Berks soils (described above) and Duffield/Duffield-Ryder soils remain intact. Duffield/Duffield-Ryder soils formed in material weathered mostly from impure limestone, commonly called cement rock. Northampton Borough is underlain with limestone and was once a center of the cement industry in the Lehigh Valley, with many limestone quarries and cement plants in operation. Today, no cement plants operate anywhere in the study area, and just one limestone quarry remains in part-time operation in the Borough of Northampton. Another urban-related soil type, Udorthents, can be found in and around the borough. This term applies to areas where the original soils have been cut away or covered with fill, like in abandoned limestone quarry landscapes. Fill materials often consist of a mixture of stones, boulders and rubble. The original soil type is no longer identifiable. These soils and land types are used for urban development, like roads, schools and shopping centers.

Woodlands & Vegetation

Farmlands, with woodlots of varying sizes, compose much of the landscape in both the Bertsch and Hokendauqua Creek Watersheds. A fairly extensive tract of woodlands is located in the lower reach of the Bertsch Creek Watershed, in one of the natural areas described later in this report. And while not continuous along all the streams in either watershed, there are a fair amount of riparian woodland buffers along local waterways, especially in the steeper creek valleys and in the headwater reaches of both watersheds. However, Blue Mountain, which straddles the northern tier of both the Bertch and Hokendauqua Creek Watersheds, as well as that of Northampton County and the entire Lehigh Valley, is the most extensive and relatively contiguous woodland in the region. See Map 8, Woodlands.

With its extensive forests, streams, seeps, vernal pools, rock outcrops and boulder fields, Blue Mountain is definitely the wildest area in the two watersheds, and probably the wildest area remaining in all of southeastern Pennsylvania. It has long been recognized as one of the major east coast fall flyways for migrating birds of prey, and the rock outcrops at Little Gap in Lehigh Township provide a station for observing and collecting data on these migrations. It is also a migration corridor for neotropical songbirds, like warblers, vireos and thrushes, which require large forested habitats. The extensive, relatively unfragmented forests include habitat for larger mammals, like black bear and bobcat, as well as for numerous smaller mammals, including the PA-Threatened Allegheny woodrat. Although Blue Mountain is primarily an upland forest, it includes streams, seeps, springs and vernal pools that serve as the headwaters of both the Bertch and Hokendauqua Creek Watersheds. These features are more common on lower slopes, as well as in areas at the base of the mountain, where drainage is poor. These riparian and wetland areas are critical habitat for a wide diversity of plant species, as well as for many groups of animals, including birds, reptiles, amphibians, Odonates (dragonflies & damselflies) and other aquatic insects.

The study area is located in the Mixed Oak Forest Region of the eastern United States. White, red, scarlet and chestnut oaks are the primary species in both watersheds, with white oaks found growing in moist stream valley soils, and scarlet and chestnut oaks found growing in better drained soils on slopes and ridges. Here, tulip poplar, pitch pine, red maple, sassafras and black gum are common associates. In the lower woodlands and floodplains, there is a well-developed understory of dogwood, spicebush, witch hazel, hop hornbeam and musclewood. A mixed mesic (middle moisture) forest containing hemlock and white pine occurs in the watersheds' steep ravines and narrow valley floors. In these places, beech, red maple, tulip poplar and red oak are common associates. Pin oak, swamp white oak, red maple, river birch, sycamore and willows are found growing along streams and in floodplain soils throughout both watersheds, especially in the lower elevations.

Exotic & Invasive Plant Species

A number of exotic invasive plant species have been identified in the Bertsch and Hokendauqua Creek Watersheds. An exotic species is one that is not native, but has been introduced and has become established. The PA Department of Conservation & Natural Resources (DCNR) has identified some 1,300 species of exotic plants in the Commonwealth, and more introduced plant species are identified every year. By comparison, according to DCNR, there are some 2,100 species of native plants known in Pennsylvania. A native plant is defined as one that occurred within the state before European settlement. Over 36% of the vascular plant species now growing within the borders of Pennsylvania are not native.

An invasive plant not only becomes established, but spreads aggressively into other areas and environments. Most invasive plants are introduced from other continents, leaving behind in their native homeland natural controls, like pests, diseases and predators which serve to keep these species in check. Due to this absence of natural controls, invasive plants reproduce rapidly and can form stands that exclude nearly all other plants. In the process, they damage natural areas, altering ecosystem processes and displacing desirable native plant species. Invasive species may pose a serious threat to the abundance and diversity of native vegetation in the Bertsch and Hokendauqua Creek Watersheds. Invasive species usually establish themselves first in disturbed areas, and then quickly spread out across the surrounding landscape. They threaten the ecology of naturally vegetated areas, as they do not provide appropriate food or habitat for native insects and wildlife.

Some invasive plant species that have been identified in the two watersheds include Norway maple, Norway spruce, Russian olive, autumn olive, bamboo, Tartarian honeysuckle, multiflora rose, Japanese barberry, Japanese honeysuckly, purple loosestrife, Japanese knotweed, Japanese stiltgrass, Canada thistle and garlic mustard. Some of these species can pose a severe problem because there are limited means of effectively controlling their spread. The primary means of control for most all of these invasive species is manually or mechanically removing them from the landscape. Invasive tree species may first require girdling, while some of the vines and herbaceous

plants may require herbicide applications either before or after manual or mechanical removal. After removing invasive plants, care should be taken to adequately treat and replant the disturbed soil with native seeds or native plant stock so that the invasive plants do not reseed the treated areas.

Superfund Site

Several hundred acres of the 3,000-acre Palmerton Zinc Pile Superfund site are located on the crest and upper slopes of Blue Mountain, in the uppermost headwater reaches of the Bertsch Creek Watershed. This land includes portions of State Game Lands 168, which is owned by the PA Game Commission, and the Appalachian National Scenic Trail Corridor, which is owned by the federal government. The core area of this superfund site is located in and around the Borough of Palmerton, just north of the study area in Carbon County. The affected lands within the study area are in the southeastern section of the Blue Mountain Operable Unit, one of five Operable Units within the Palmerton Zinc Pile Superfund Site that are being remediated through the superfund process. The other four Operable Units are located in Carbon and Lehigh Counties to the north and west of the study area.

This superfund site, which was designated as such in 1983, has been undergoing decades-long cleanup and revitalization in an effort to restore thousands of acres of barren wasteland. Zinc smelting operations initiated in Palmerton in the late 1800s through 1980 produced emissions fallout of sulfur dioxide and heavy metals across the surrounding landscape at concentrations that resulted in ecosystems collapse and prevented plant growth across a 3,000-acre area. These metals include zinc, lead and cadmium. Without vegetation to keep soil in place, erosion of contaminated soil impacted the nearby Lehigh River in the westernmost reach of the study area, and Aquashicola Creek to the north of the study area in Carbon County. Streams in the Bertsch Creek Watershed were not impacted by contaminated soil erosion, as heavy metal fallout avoided the lower slopes of Blue Mountain, which remained forested throughout the time period of zinc smelting operations in Palmerton; a classic example of the filtering powers of forested headwater areas and riparian buffers.

However, the crest and upper slopes of Blue Mountain in the uppermost headwater reaches of the Bertsch Creek Watershed were impacted by metals, resulting in a denuded landscape of rocks and boulders. Revegetation was the treatment technology selected on Blue Mountain to address the heavy metal contamination. In 2009, the upper slopes of Blue Mountain in the Bertsch Creek Watershed were revegetated via aerial applications of native warm season prairie grass seeds and seeds of native trees, like pitch pine and black gum. Soil amendments used in the process included mushroom compost, municipal sewage sludge, power plant fly ash and agricultural limestone. Revegetation has stabilized the treated area, reduced soil erosion and improved water quality by decreasing soluble metals contaminant concentrations associated with runoff from the site. The plan is to revegetate the crest of Blue Mountain via the same aerial application technique in 2012. As a result of these treatments, the threat of metals migrating downslope into the Betsch Creek Watershed should be completely removed.

Sport Fishing

Because the PA Fish & Boat Commission and the PA Council of Trout Unlimited are two of the four organizational partners that comprise the Coldwater Heritage Partnership, which funded this project—the other two organizational partners are the PA Department of Conservation & Natural Resources and the Foundation for Pennsylvania Watersheds—it is relevant to take into account the role of trout fishing in the Bertch and Hokendauqua Creek Watersheds in this Coldwater Conservation Plan.

While some of Northampton County's trout waters are well known outside the region—most notably limestone or partial limestone streams, like Bushkill, Monocacy and Saucon Creeks—others, like the mostly freestone Hokendauqua Creek and Indian Creek (a major, freestone tributary to Hokendauqua Creek), are hardly known outside their immediate neighborhoods. And while neither stream is listed as Class A Wild Trout Waters by the PA Fish & Boat Commission (PFBC), both Hokendauqua and Indian Creeks are home to stocked and naturally reproducing wild trout populations. The freestone Bertsch Creek is also home to a naturally reproducing wild trout population. But with very limited public access, Bertsch Creek is not presently stocked by PFBC.

Some of the more popular and publicly accessible trout fishing areas along Hokendauqua Creek are found along Kreidersville Road and Covered Bridge Road in Allen Township, and along Creek Road near the Petersville Rod & Gun Club in Moore Township.

In Allen Township, Hokendauqua Creek, at the Kreidersville Covered Bridge on Covered Bridge Road, contains a nice short run, and nice pocket water can be found just upstream of the covered bridge. A little further upstream, on Kreidersville Road, the stream flows under the highway bridge, where some of the widest and deepest water on Hokendauqua Creek can be found. Substantial pools can be found just upstream and downstream of this bridge crossing.

Further north and upstream in Moore Township, along Creek Road, near the Petersville Rod & Gun Club, Hokendauqua Creek contains a low dam with a substantial plunge pool. There are also some fine fishing waters at Birch and Walker Roads, just upstream of the club, which includes a series of small pools.

Indian Creek, which is the largest and only named tributary to Hokendauqua Creek, is accessible to the public at select points along Indian Trail Road in Lehigh Township. The creek contains a lot of fine pocket water, with some deep sycamore pools and a channelized section of stream that is very popular with anglers.

Cultural History & Land Use

Cultural History

While the many historical village names, like Apps, Arndts, Beersville, Berlinsville, Benningers, Bossard's Corner, Danielsville, Delps, Emmanuelsville, Harpers, Howersville, Klecknersville, Kreidersville, Laubachsville, Lockport, Pennsville, Petersville, Point Phillips, Pomfret, Stemton and Stone Church attest to the very steeped European-American history of the Bertsch and Hokendauqua Creek Watersheds, local place names like Hokendauqua Creek, Indian Creek, Indianola Lake, Indian Ford, Indianland and Indianland Tract also attest to the region's rich Native American history. Further testament to this history is found in the place names of the larger geographic setting and headwaters backdrop of these two watersheds: the Lehigh Valley and the Kittatinny Ridge, more locally known as Blue Mountain. The name Lehigh is believed to be a corruption of the Lenape or Delaware Indian word Lechauwekink, which may mean "where there are forks in the stream," perhaps referring to the fact that the Lehigh is a major tributary, or fork, of the Delaware River. And the name Kittatinny is believed to be a corruption of either the Lenape word Kantatinchunk, which may mean "principal or main mountain," or Kekachtauanim, which may mean "endless mountains."

When European settlers first arrived in these two watersheds in the early 18th century, the area was already well settled by American Indians. In 1735, Thomas Penn set aside 6,500 acres in the Hokendauqua Creek Watershed called Indian Tract Manor, which was to be a place for the resettlement of the Indians of the region who were being displaced by European settlers. The plan didn't succeed, but if it had, Indian Tract Manor would have qualified as one of the earliest Indian reservations in the country. The area today is known as Indianland Tract in Lehigh Township.

Two major historical Indian paths and the route of the infamous Walking Purchase crossed through the Bertsch and Hokendauqua Creek Watersheds; a French and Indian War-era Frontier Fort was located in the Hokendauqua Creek Watershed; and the remains of a historically-documented Native American petroform site (manmade stone works) are located in the extreme headwaters of the Bertsch Creek Watershed, on the steep slopes of Blue Mountain.

The Nescopeck Path ran from Bethlehem through Indian Tract Manor, and north through Lehigh Gap to Nescopeck in Luzerne County. During the French and Indian War, it was widely used by Indian traders and missionaries. And settlers fleeing the Wyoming Massacre to the north in 1778 used the path to reach safety in Bethlehem. The Wechquetank Path ran north from Bethlehem across Blue Mountain through Smith Gap, in the uppermost reach of the Hokendauqua Creek Watershed, to the Wyoming Valley in the Susquehanna River Basin. Moravian missionaries from Bethlehem used the path extensively to minister to Indian converts in villages north of Blue Mountain.

The route of the 1737 Walking Purchase, that objectionable land survey in which the Lenape or Delaware Indians were swindled out of 1,200,000 acres of land, ran north from

Wrightstown in Bucks County, through the Bertsch and Hokendauqua Creek Watersheds and Lehigh Gap, to Broad Mountain near Jim Thorpe in Carbon County. This notorious act resulted in local Indians being forced west into the Susquehanna, Allegheny and Ohio River Basins, and the fallout from the Walking Purchase was felt for generations. During the French and Indian War, Delaware Indians who raided Pennsylvania frontier farms and villages cited the Walking Purchase as one of their grievances. During this time, Peter Doll's Blockhouse, one of the many "Indian Forts" that were established by the Provincial Government along Blue Mountain as a refuge for frontier families from hostile Indian attacks, was located along Hokendauqua Creek, near the base of Blue Mountain in Moore Township.

An article in an 1887 issue of the **American Antiquarian & Oriental Journal** describes two ancient parallel stone walls about one mile in length and situated on either side of a natural gully on the steep southern slopes of Blue Mountain, in the extreme headwaters of the Bertsch Creek Watershed. The author of the article believed the walls were constructed as a "game weir" by American Indians in which wild game was driven into the stone corralled gully, and then ambushed by Indian hunters. In 2001, about 3/10ths of a mile of the uppermost sections of the walls were relocated on the steep slopes of Blue Mountain on State Game Lands 168; the lower sections having long-been destroyed in the construction of a residential subdivision and gas pipeline near the base of the mountain.

At the time European settlers arrived in the area, Hokendauqua was an Indian village at the mouth of Hokendauqua Creek on the Lehigh River, in what is today the Borough of Northampton. The name of the village and the creek are believed to have been derived from the Indian word Hackiundochwe, which may mean "stream searching for land." This implies that the village took its name from the creek. Hokendauqua was the village of the famous 18th century Unami Delaware Indian Chief, Lappowinzo, who was a signatory of the 1757 Treaty of Easton, and well respected by his own Native American people and European-American leaders alike.

Indian Creek, the largest and only named tributary to Hokendauqua Creek, most likely takes its name from the Indian residents who once lived in the area, or because it flowed through the famous Indian Tract Manor, known today as Indianland Tract. And Bertsch Creek most likely takes its name from Christian Bertsch, who received a patent of 222 acres of land at the mouth of the creek on the Lehigh River in 1793. The name Bertsch Creek appears on maps since that time.

Land Use History

Agriculture was naturally one of the first industries in the Bertsch and Hokendauqua Creek Watersheds when it was settled by Europeans in the early 1700s, and it is still very prominent today. At about that same time and continuing into the early 20th century, many low-head milldams were constructed on streams in these watersheds to power saw mills, grist mills, tanneries and distilleries. Each dam formed a slackwater millpond that trapped sediment over a period of decades and even centuries. Today, most of these

milldams and millponds are long gone, but obsolete derelict dams gradually breached or were removed, releasing these sediments and attached nutrients to be carried downstream, resulting in thick accumulations of fine-grained sediment on streambeds and stream banks known as "legacy sediment." In many waterways throughout the Lehigh Valley, including reaches of streams in the Bertsch and Hokendauqua Creek Watersheds, legacy sediments have buried pre-European settlement streambeds, floodplains, wetlands and valley bottoms. These legacy sediments have altered and continue to impair the hydrologic, biologic, aquatic and riparian functions and water quality of local streams. Widespread indicators of impaired streams and watersheds due to legacy sediments include high banks, rapid rates of bank erosion, high in-stream sediment loads and habitat degradation; all of which have been observed in the study area.

The upper Bertsch and Hokendauqua Creek Watersheds are part of the region's Slate Belt, which forms the northern tier of Northampton County, extending from Delaware Water Gap in the northeastern corner of the county to Lehigh Water Gap in the northwestern corner of the county. In the mid-19th century and continuing well into the 20th century, a booming slate industry grew across the northern tier of the county. In the upper Bertsch and Hokendauqua Creek Watersheds, communities like Rockville, Slate Valley and Slatefield were established around this industry. Dozens of slate quarries and slate finishing mills once operated here, producing slate roofing shingles, floor tiles, chalk boards, sinks and sink tops, toilet partitions and shower stalls, wainscots, window sills, stairways, electrical conduits, fence posts, vaults, headstones and crypts. Today, only two slate quarries operate anywhere in Northampton County, and neither one is located in the study area. However, along with towering heaps of slate waste and the remains of mills and outbuildings, many slate quarries, some of them several hundred feet deep and most of them filled with groundwater, dot the landscape in the upper Bertsch and Hokendauqua Creek Watersheds. Generally, the water quality in these abandoned quarry holes is good, with cold temperatures and little in the way of pollutants. However, it is not known if the water in these quarry holes diverts base flow from local streams.

The lowest-most reach of the Hokendauqua Creek Watershed dips into the region's Cement Belt, which extends across a broad section of the center of Northampton County, from the Delaware River in the east to the Lehigh River in the west. Pennsylvania's cement industry was established in and around the Borough of Northampton. Here, the first limestone quarry and kilns for making cement were opened in the 1830s. Many more quarries and kilns followed and by 1900, this area was a global center for the manufacturing of cement. The famous Atlas Portland Cement Company was established here in 1901, where it operated until it closed in 1982. The Atlas Portland Cement Company supplied most of the cement that was used in the building of the Panama Canal. Today, only one active limestone quarry remains in operation in the study area, which supplies limestone for cement manufacturing outside the area; no cement manufacturing occurs in the study area today.

The main line of the 170-mile Lehigh & New England Railroad (1895-1961) ran along the base of Blue Mountain across the study area in both the Bertsch and Hokendauqua

Creek Watersheds. This railroad was likely the least known of the great anthracite coal lines of the Northeast. It also served the local slate and cement industries in the study area and across the northern tier of Northampton County. In the study area, railroad stations were located at Danielsville and Berlinsville, although rail stops were also located at Delps, Arndts, Slatefield, Slate Junction and Edgemont. The rails have long been removed and most of the old railroad right-of-way today is in private ownership across the study area. Lehigh Township owns some of the old railroad right-of-way in the Bertsch Creek Watershed, which it is trying to develop into a recreational rail-trail. About 1855, the Lehigh Valley Railroad was built along the Lehigh Canal in the westernmost reach of the study area (see next paragraph) from Easton to Mauch Chunk (today's Jim Thorpe). It was later purchased by the Central Railroad of New Jersey and later by the Consolidated Rail Corporation (Conrail). Today, the railway is owned and operated by the Norfolk Southern Corporation.

The very tail end of both the Bertch and Hokendauqua Creeks flow through the narrow historical landscape of the Lehigh Canal before both streams empty into the Lehigh River. Completed in 1829, the Lehigh Canal was five feet deep, 60 feet wide and 46 miles long, extending from near the Borough of White Haven in Luzerne County to the City of Easton in Northampton County, where it joined the Delaware Canal running south to Philadelphia and the Morris Canal running east across New Jersey. A towpath for mules to tow coal-laden canal boats ran alongside the canal.

The Lehigh Canal was built and maintained by the Lehigh Coal & Navigation Company to transport coal downriver from the anthracite coal mines of northeastern Pennsylvania to urban centers in the Lehigh and Delaware Valleys and beyond. The company built five aqueducts to carry the canal over intersecting streams, and 56 locks to compensate for differences in elevation from the upper to lower reaches of the canal. Aqueducts spanned both the Bertsch and Hokendauqua Creeks, and locks were located very near the canal intersections of both streams. In 1942, most of the Lehigh Canal was destroyed by a flood, which ended its 113-year history of commercial transportation use.

Today, many sections of the canal have been breached and no longer carry water. Many of these sections have naturally grown in with vegetation or have been filled in by man. However, certain sections of the canal have been restored, and many sections of the towpath remain intact and provide local recreational trails for public use. A 4.5-mile section of restored canal and a maintained towpath extends from the Borough of Walnutport, just north of the study area, downriver to Bertsch Creek. In the Borough of Northampton, the canal has been filled in, but the towpath is paved and provides for a recreation trail along the Lehigh River in the borough. Stone and timber remains of the aqueduct and lock at Bertsch Creek can be seen near the stream's confluence with the Lehigh River. The Lehigh River and its historic canal system today are part of the Delaware & Lehigh National Heritage Corridor & State Heritage Park, a partnership of private groups and interested citizens, county and municipal governments, the Commonwealth of Pennsylvania and the federal government working together to conserve cultural and natural resources in the five-county region of Pennsylvania that traverses the historic Delaware and Lehigh Canals.

Residential housing and agriculture make up the majority of land use in the Bertsch and Hokendauqua Creek Watersheds today, with some retail, commercial, manufacturing and industrial land uses in a few areas of both watersheds, particularly in the Borough of Northampton at the bottom of the Hokendauqua Creek Watershed. See Map 9, Existing Land Use. Generally, the majority of the Bertch and Hokendauqua Creek Watersheds are zoned for rural land use, with suburban residential zoning districts in and around some of the historical village centers in both watersheds, like Danielsville, Klecknersville and Pennsville, and just north of the Borough of Northampton in the Hokendauqua Creek Watershed. Light industrial and heavy industry zoning districts are also located in and around Northampton Borough, the only urban center in either watershed. The PA Route 248 corridor across the Bertsch Creek Watershed is zoned for commercial retail use, and most of Blue Mountain is zoned for environmental protection throughout the study area. See Map 10, Generalized Zoning.

The following table shows that some of the four municipalities in the study area regulate, to some degree, the protection and preservation of natural features through municipal ordinances.

Local Municipal Natural Resource Protection Ordinances*

Municipality	Riparian Buffers	Floodplains	Wetlands	Steep Slopes	Forestry	Woodlands Preservation	Natural Areas
Allen Township	No	Yes	Yes	Yes	Yes	No	No
Lehigh Township	No	Yes	No	Yes	Yes	No	No
Moore Township	No	Yes	No	Yes	Yes	Yes	Yes
Northampton Borough	No	Yes	No	No	No	No	No

***It is possible that these ordinances may not reflect recent amendments.**

It should be noted that, according to the Lehigh Valley Planning Commission's History & Official Forecast of Population by Municipality, the four municipalities that encompass the Bertsch and Hokendauqua Creek Watersheds—Allen, Lehigh and Moore Townships and Northampton Borough—are expected to see a combined increase of 70% in residential population by 2030; from a combined current residential population of 33,919 (2010 Census figures) to a projected combined population of 48,352. An increase in residential population of this magnitude will mean far more demand on local land and water resources in the region, and the very real potential for negative environmental impacts if this projected growth is not carefully planned for and managed by municipal leaders.

Agricultural Security Areas & Preserved Farmland

Many Agricultural Security Areas (Ag Areas) have been established and 13 farms have been permanently preserved in the study area. See Map 11, Agricultural Easement Purchases/Security Areas. Ag Areas are established by local municipalities in cooperation with individual landowners who agree to place at least 10 acres in an Ag

Area. Farm tracts needed to create Ag Areas do not have to be contiguous, but the properties must be zoned to permit agricultural uses. In designated Ag Areas, municipalities agree to support agriculture by not passing nuisance ordinances that would restrict normal farming operations, and limitations are placed on the ability of government to condemn farmland for new schools, highways, parks or other projects. Additionally, landowners in Ag Areas may be eligible to sell their development rights by way of a perpetual agricultural conservation easement through their local Agricultural Land Preservation Program. In Northampton County, this program is administered by the county's Farmland Preservation Office.

An Agricultural Conservation Easement is an interest in farmland, less than a fee simple purchase, which represents the right to prevent development or improvement of a parcel of land for any purpose other than agricultural production. The farmland must be in a designated Ag Area in order to be eligible for preservation under an Agricultural Conservation Easement Program. In Northampton County, this program, like the Agricultural Land Preservation Program, is administered by the county's Farmland Preservation Office.

Selling a conservation easement can permanently protect a family's farmland from being lost to future non-agricultural development, help pay off debt, expand or improve farm operations and help family's successfully pass farms on to the next generation. Thirteen farms totaling nearly 1,156 acres have been permanently preserved in the Bertsch and Hokendauqua Creek Watersheds; two farms totaling about 143 acres in the Bertsch Creek Watershed, and 11 farms totaling about 1,013 acres in the Hokendauqua Creek Watershed. These preserved farmlands help protect these watersheds from future development.

Greenways

The Lehigh Valley Planning Commission's **Lehigh Valley Greenways Plan: A Regional Greenways Plan for Lehigh & Northampton Counties**, published in 2007, identifies one multi-use/scenic greenway, one cultural/recreational greenway and three conservation greenways in the study area. See Map 12, Greenways. A greenway, regardless of type, is defined as a corridor of open space that may vary greatly in scale from narrow strips of green that run through urban, suburban and rural areas to wider corridors that incorporate diverse natural, cultural and scenic features. Greenways are a critical component of any landscape. They protect the environment and water quality, provide recreational opportunities and connect natural and cultural areas to one another, providing a linear resource for a variety of users. Connectivity is the defining characteristic that distinguishes greenways from isolated paths and pockets of open space. While individual parks, preserved lands, undisturbed natural areas and waterways are valuable resources in and of themselves, their conservation and recreation value is compounded when they are linked together. Permanently protecting environmentally sensitive, historically important and/or culturally significant lands from undesirable development is the ultimate goal identified in the Lehigh Valley Greenways Plan.

Greenways come in a variety of forms and serve many functions. The Lehigh Valley Greenways Plan identifies four types of greenways in the Lehigh Valley, all of which are found in the study area. Cultural/recreational greenways provide people with an array of low-impact recreational activities and quality of life benefits. Conservation greenways exist primarily to protect natural resources, like water quality. They are undisturbed corridors that fulfill their ecological potential by serving as habitat, buffers, filters and wildlife corridors. Conservation greenways represent the majority of greenways in the Lehigh Valley and in the study area. Many of these corridors follow streams and rivers and associated riparian buffers and woodlands. Multi-use greenways accommodate a multitude of recreational activities and provide cultural and/or conservation opportunities. Multi-use greenways are multipurpose since they serve both human and wildlife interests. Scenic greenways enhance the quality of life by providing scenery for residents and visitors to enjoy. Greenways provide connections by linking origins to destinations, and scenic greenways provide visual connections across the landscape so people can enjoy the natural environment around them. Currently, none of the four municipalities in the study area—Allen, Lehigh and Moore Townships and Northampton Borough—have enacted local zoning ordinances to protect greenways within their borders that have been identified in the Lehigh Valley Greenways Plan. The following five greenways in the Bertsch and Hokendauqua Creek Watersheds are identified in the Lehigh Valley Greenways Plan.

Blue Mountain/Kittatinny Ridge Multi-Use/Scenic Greenway
Lehigh & Moore Township

The PA Department of Conservation & Natural Resources has identified the Kittatinny Ridge, locally known as Blue Mountain, and the Appalachian National Scenic Trail, which follows the Blue Mountain ridgeline, as one of 34 major greenways throughout Pennsylvania. This 160-mile corridor across Pennsylvania frames the northern backdrop and encompasses the uppermost headwater reaches of the Bertsch and Hokendauqua Creek Watersheds. It is one of the major East Coast flyways for migrating birds of prey and neotropical songbirds. The outcrops at Little Gap in Lehigh Township have long been a major resource as an observation and research station for collecting data on these migrations. Pennsylvania Audubon has designated the Blue Mountain as one of 81 Important Bird Areas (IBA) in Pennsylvania; to date, it is the only IBA in the Lehigh Valley.

The Nature Conservancy, whose mission is to conserve the lands and waters on which all life depends, has identified Blue Mountain as one of two exceptional natural features in the Lehigh Valley; the other is the Delaware River. Blue Mountain is the most extensive, relatively contiguous area of natural habitat in Lehigh and Northampton Counties. It is also one of the major corridors for the movement of biota in eastern Pennsylvania. With its extensive forests, streams, seeps, vernal pools, rock outcrops and boulder fields, Blue Mountain is definitely the wildest area in the Bertsch and Hokendauqua Creek Watersheds, and probably the wildest area in all of southeastern Pennsylvania. Many natural areas of statewide or local significance are found on Blue Mountain or at its base. Excellent local examples include Little Gap and Neff's Ponds Natural Areas in the

Hokendauqua Creek Watershed in Lehigh Township, which are described in the next section of this report.

Locally significant recreation areas along Blue Mountain include portions of the 5,168-acre State Game Lands 168, which spans both the Bertsch and Hokendauqua Creek Watersheds in Lehigh and Moore Townships. Additionally, the U.S. Government holds acreage along the Appalachian Trail on the Kittatinny Ridge in both watersheds, which provides hiking, nature study and sightseeing opportunities for the public. The Blue Mountain/Kittatinny Ridge Greenway connects with ten other greenways in Lehigh and Northampton Counties, including the Bertsch, Indian and Hokendauqua Creek Greenways in the study area, making it a significant cultural, recreational and scenic resource worthy of further study and preservation.

Bertsch Creek Conservation Greenway
Lehigh Township

This six-mile conservation greenway extends along Bertsch Creek from its mouth on the Lehigh River northeast to the base of Blue Mountain. Most of the stream valley is wooded with adjacent lands in agricultural or residential development. The greenway includes one identified natural area; the Bertsch Creek Seep, which is a seep-fed tributary to Bertsch Creek that supports a population of rare plant species. This natural area is described in the next section of this report. This greenway's primary function is to establish a conservation corridor and riparian buffer along Bertsch Creek, between the Lehigh River and the extensive woodlands along Blue Mountain, where it connects with the Blue Mountain/Kittatinny Ridge Greenway.

Recreational opportunities along the Bertsch Creek Greenway include access to the Walnutport Canal Park Trail adjacent to the Lehigh River, which continues north into the Borough of Walnutport, just outside the study area. This greenway also provides access to Blue Mountain Fish & Game Association lands for hunting opportunities, when so permitted by the Association.

Hokendauqua Creek Conservation Greenway
Lehigh, Moore & Allen Townships & Northampton Borough

This 16-mile conservation greenway follows the main stem of Hokendauqua Creek from the base of Blue Mountain in Moore Township, southwest to the Lehigh River in Northampton Borough. The lower reaches of the stream pass through an urban environment of residential and industrial landscapes in the Borough of Northampton, and should be carefully monitored for degradation. Further upstream, this greenway connects with the Indian Creek Greenway before the Hokendauqua Creek flows under the historic Kreidersville Covered Bridge in Allen Township. Built in 1839 and known for its history and serene setting in a municipal park, it is the only covered bridge left standing in Northampton County. The upper reaches of the greenway pass through mixed farmland and rural development before connecting with the forested Blue Mountain/Kittatinny

Ridge Greenway. Despite the many agricultural lands throughout this corridor, many of the riparian areas remain wooded.

Parks and other outdoor recreation sites in this greenway include Canal Street Park in Northampton Borough, Lappawinzo Fish & Game Protective Association lands and the Bodnarczuk Tract Recreation Easment in Allen Township, and the Petersville and Point Phillips Rod & Gun Clubs in Moore Township.

Indian Creek Conservation Greenway
Lehigh, Moore & Allen Townships

This eight-mile conservation greenway follows the main stem of Indian Creek, from the base of Blue Mountain in Moore Township, where it connects with the Blue Mountain/Kittatinny Ridge Greenway, to its confluence with Hokendauqua Creek in Allen Township, where it connects with the Hokendauqua Creek Greenway. Most riparian lands in this greenway are wooded as the creek passes through rolling hills of mixed farmland and forest. Rural residential development increased significantly in this greenway during the 2000s, and efforts should be made to ensure its protection as a conservation corridor.

Parks and other outdoor recreation sites in this greenway include the 200-acre Woodstone Golf Club and the 50-acre Delps Road Tract, which was acquired by Lehigh Township for use as a municipal park.

Nor-Bath Trail Cultural/Recreational Greenway
Northampton Borough & Allen Township

This seven-mile cultural/recreational greenway is a rail-trail that follows the abandoned right-of-way of the Northampton-Bath Railroad, and extends from Northampton Borough across Allen Township to East Allen Township, which is east of and outside the study area. Only a relatively short reach of this greenway is in the study area. The Nor-Bath Trail is owned and maintained by Northampton County. The Nor-Bath Trail connects with the Hokendauqua Creek Greenway in the Borough of Northampton.

Natural Areas

As noted in **A Natural Areas Inventory of Lehigh and Northampton Counties, Pennsylvania – Update 2005**, *"In order to plan development and ensure the protection of critical natural areas, county and municipal governments, the public and developers must know the location and importance of these sites. This knowledge can help prevent conflicts over land use and direct protection efforts and limited conservation dollars to the most vulnerable sites."* The Lehigh and Northampton County Natural Areas Inventory (NAI) was first produced in 1999, and subsequently updated in 2005 by the PA Office of The Nature Conservancy for the Lehigh Valley Planning Commission. The NAI is a useful guide for planning developments and parks, conserving natural areas and

setting priorities for the preservation of the most vulnerable natural resources in Lehigh and Northampton Counties that have been identified in the NAI. The counties, local municipalities, land trusts and other conservation organizations can use the NAI to identify potential projects that may be eligible for funding through state or community grant programs.

According to the 2005 NAI Update, two sites of Statewide Significance for the protection of biological diversity exist in the Hokendauqua Creek Watershed, and one such site exists in the Bertsch Creek Watershed. The presence of species of special concern and/or exemplary natural communities have been documented at all three sites. Future land development at these sites should be carefully assessed to determine the impact of the project on the species or communities before construction approval is granted. Additionally, the NAI includes one site of Local Significance in the Bertsch Creek Watershed, and another that spans both the Bertsch and Hokendauqua Creek Watersheds. Locally significant natural areas are based on size, diversity of wildlife and plant life, water quality protection value and recreational potential. These sites do not include high quality natural communities and no species of special concern have been documented at the sites, although they may have the potential for rare species to occur. See Map 13, Natural Areas for the locations of all five sites. Currently, only one of the four municipalities in the study area—Moore Township—has enacted a local ordinance to protect important natural areas within its borders that have been identified in the NAI. See Local Municipal Natural Resource Protection Ordinances Table on Page 12.

At the time this Coldwater Conservation Plan was written, the Western Pennsylvania Conservancy was in the process of preparing a second update of the Lehigh and Northampton County NAI for the Lehigh Valley Planning Commission. When completed, this second NAI Update may reflect changes from the 2005 NAI Update, which were not yet available at the time this report was written. The following natural area sites in the Bertsch and Hokendauqua Creek Watersheds and recommendations for conserving the natural resources at each site are described in the 2005 NAI Update.

Blue Mountain

Lehigh and Moore Townships

This area of Local Significance is also described as an Exceptional Natural Feature in the NAI because of its extensive physical scale. Blue Mountain forms the northern backdrop for and spans both the Bertsch and Hokendauqua Creek Watersheds in the extreme headwaters of both. It is the most extensive, relatively contiguous area of natural habitat in both watersheds, as well as in Northampton County and the entire Lehigh Valley. It includes extensive forests, headwater streams, seeps, springs, vernal pools, rock outcrops and boulder fields in both watersheds. It is one of the major east coast flyways for migrating raptors and neotropical songbirds. Conserving sites on the mountain as listed in the NAI must be considered as part of the effort to conserve the greater natural functional value of the mountain ridge. Preserving the ecological integrity of Blue Mountain will be an important component in protecting water quality in both the Bertsch and Hokendauqua Creek Watersheds, and in preserving the biodiversity of the entire region.

Bertsch Creek Seep

Lehigh Township

This area of Local Significance at the bottom of the Bertsch Creek Watershed is a seep-derived tributary of Bertsch Creek that supports a fair quality population of goldenclub *(Orontium aquaticum)*, a plant species delisted as a species of special concern. This species is still on the "watch list," however. Therefore, this site deserves locally significant status. Here, the lower reaches of Bertsch Creek run along the bottom of a moderately steep forested slope, and contain segments of rock outcrops and groves of eastern hemlock. Disturbances at the site are minimal. Leaving this site in its current condition will help protect water quality in Bertsch Creek, and help the rare goldenclub persist here.

Little Gap

Lehigh Township

This area of both Statewide and Local Significance in the uppermost headwaters of the Hokendauqua Creek Watershed is a notch in the Kittatinny Ridge, or Blue Mountain. The area is dominated by a xeric (dry habitat) hardwood forest community with black gum, red maple, sassafras, oaks and sweet birch as the most common overstory species. Heaths, like mountain laurel and blueberry, dominate the understory. The world-famous Appalachian Trail bisects the site. A small, but expanding population of Hartford fern *(Lygodium palmatum)*, a PA-Rare plant species, and a small, but diverse acidic shrub marsh occurs at the site. The shrub marsh is a several-acre, perched wetland and is dominated by highbush blueberry and hardhack, with scattered red maple and black gum. Interspersed among the shrubs and trees are marshy openings dominated by strict sedge and grasses. Both the species of concern and the wetland occur in the saddle of the gap. At the western end of the site is a boulder field of significant size locally known as the "Devil's Potato Patch." Sandstone and conglomerate rock of the Shawangunk Formation was broken off of Blue Mountain by repeated freeze-thaw cycles during glacial times. Gravity moved the boulders to where they rest today. Similar boulder fields of periglacial origin are found along the length of Blue Mountain. Boulder fields may be used as habitat by certain rare reptiles, mammals and insects.

Neff's Ponds

Lehigh Township

This area of Statewide Significance is located near the base of Blue Mountain in the Hokendauqua Creek Watershed. It supports a small cluster of vernal pools located mostly under a canopy of chestnut oak, red maple, sassafras and black gum. Water levels and vegetation vary greatly between the pools at this site. Vegetation cover is greatest in the pools with higher water levels. One pool has vegetation comparable to a shrub swamp, with arrow-wood, highbush blueberry, royal fern, bur-reed and sedges being common plant species. Another pool has shrubs growing only on its margins, with herbs like knotweed, pondweed and pale meadow grass growing scattered over the pond. The majority of the pools lack vegetation and are lined only with decaying leaves. Several of the pools support fair to good quality populations of spotted pondweed *(Potomogeton pulcher)*, a PA-Endangered plant species. These pools are also important to amphibians for reproduction. The vernal pools are located on State Game Lands 168 and possibly

private property. Some of the pools have been manipulated and the surrounding forest is crisscrossed with ATV trails. Limiting further disturbance around the pools, to include forbidding logging and ATVs from riding through the pools, will help preserve these natural areas and allow the PA-Endangered pondweed to persist at this site. Locating and posting the game lands boundary may prevent potential encroachment from further degrading the site.

Walnutport Canal Site

Lehigh Township (and other municipalities outside the study area)

In the study area, this site of Statewide Significance is located at the bottom of the Bertsch Creek Watershed, at the confluence of Bertsch Creek and the Lehigh River. The site consists of the Walnutport Canal and adjacent banks, and a strip of woods between the canal towpath and the river. The site extends well beyond the study area; upriver and downriver in Northampton County, and across the river into Lehigh County. In the study area, this site contains a fair population of Virginia rose *(Rosa virginiana)*, a PA-Tentatively Undetermined plant species that is believed to be in decline. Associated species include sensitive fern, southern arrow-wood, Virginia creeper and wild grape. Historical records of autumn willow *(Salix serissima)*, a PA-Threatened plant species; waterhemp ragweed *(Amaranthus cannabinus)*, a PA-Rare plant species; and narrow false oats *(Trisetum spicatum)*, a PA-Endangered plant species also exist for this site. Mowing the towpath and seemingly benign low impact recreational activities, like simply walking the path and fishing, can result in disturbances and threats to this site. It is recommended that maintenance workers that mow the path be made aware of these plant species of concern and the threats associated with them.

Wetlands

Wetlands are areas where water covers the soil or is present either at or near the surface of the soil all year, or for varying periods of time during the year, including during the growing season. Regulatory agencies define wetlands as, *"Those areas that are inundated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs and similar areas."* The three major characteristics of wetlands are hydrology, soils and vegetation. Water saturation (hydrology) largely determines how soils develop in wetlands. Wetland or hydric soils have characteristics that indicate they developed in conditions where soil oxygen is limited due to water saturation for long periods of time during the growing season. Wetland, or hydrophytic, vegetation are plants that have adapted to environments where the soil is either permanently saturated, or saturated enough of the year to exert a controlling influence on the plant species and plant communities present in wetlands. Cattail, highbush blueberry and swamp white oak are examples of wetland plants.

Many wetlands in the Bertsch and Hokendauqua Creek Watersheds are connected to floodplains along streams in the study area. Other wetlands are found isolated from

waterways in upland areas, especially along the lower slopes and base of Blue Mountain, where drainage is poor. See Map 14, Floodplains, Wetlands and Hydric Soils for the location of many of the larger wetlands in the Bertsch and Hokendauqua Creek Watersheds.

Much like riparian buffers, which are described in the next section of this report, wetlands filter runoff from surrounding uplands before the runoff reaches streams or rivers, maintain stream flow during periods of drought and help replenish groundwater supplies. They also serve an important role in flood management, since the capacity of wetlands to hold back water can lessen the human impacts of flooding. Currently, only one of the four municipalities in the study area—Allen Township—has enacted a local ordinance to protect wetlands. See Local Municipal Natural Resources Protection Ordinances Table on Page 12. Because most of the natural areas in the Bertch and Hokendauqua Creek Watersheds (which are described in this report in the section immediately above) include wetlands, a note about the ecological functions and values of these unique ecosystems follows.

Wetlands are among the most productive ecosystems in the world, comparable to rain forests and coral reefs. They are also a source of substantial biodiversity in supporting numerous species from all of the major groups of organisms—from microbes to mammals. Physical and chemical features, such as climate, topography, geology, nutrients and hydrology, help to determine the plant and animal species that inhabit different kinds of wetlands.

Wetlands can be thought of as "biological supermarkets." They produce great quantities of food that attract many animal species. The combination of shallow water, high levels of organic nutrients and high rates of primary productivity in many wetlands is ideal for the development of organisms that form the base of the food web, like insects, mollusks and crustaceans. Some animals consume live vegetation; others utilize dead plant leaves and stems, which break down in the water to form small nutrient-enriched particles of organic material called detritus. As the plant material continues to break down into smaller and smaller pieces, it becomes increasingly enriched due to bacterial, fungal and protozoan activity. This enriched material, including the many microbes that colonize it, feeds many small aquatic invertebrates and fish. Many of these organisms then serve as food for larger predatory amphibians, reptiles, fish, birds and mammals.

Fish and wildlife use wetlands to varying degrees, depending on the species. Some live in wetlands their entire lives; others require wetland habitat for at least part of their life cycle; still others use wetlands much less frequently, generally for feeding or breeding. According to the Alliance for the Chesapeake Bay, nearly 70% of Pennsylvania’s threatened and endangered wildlife species rely directly or indirectly on wetlands for their survival.

Biochemical cycling is another important function of wetlands. This process involves the biological, physical and chemical transformations of various nutrients within the biota, soils, water and air. Wetlands are very important in this regard, particularly in relation to

nitrogen, sulfur and phosphorous. Upon death and decay, the nitrogen and sulfur in plant and animal biomass is released through mineralization. Much of this is then made available to certain plants and their associated nitrogen-fixing bacteria in soil. In conjunction with various microbes, the anaerobic and chemically reducing conditions in wetland substrates ensure the gaseous release of nitrogen and sulfur. Phosphorous, on the other hand, does not have a gaseous form. But vascular plants in wetlands transform inorganic forms of phosphorous that might otherwise be shunted into undesirable algal blooms, into organic forms in their biomass as they grow. Thus wetlands provide the conditions needed for the removal of both nitrogen and phosphorus from surface water.

Riparian Buffers

A riparian or streamside buffer is the land and vegetation next to a river or creek, extending outward from the waterway from several feet to several hundred feet. In its natural state, it has native trees, shrubs and grasses growing in it. As the term suggests, these plants " buffer" streams from pollutants that would otherwise flow into them; things like sediment (the #1 pollutant in Lehigh Valley streams) and nutrients from agricultural and lawn care practices, and toxics and other contaminants from stormwater runoff from roadways, sidewalks, parking lots and rooftops (the #2 pollutant in Lehigh Valley streams). Science has proven that pollution removal is maximized when buffers are at least 100 feet wide. While not continuous or always 100 feet wide along waterways in the Bertsch and Hokendauqua Creek Watersheds, there are a fair amount of forested riparian buffers along streams in both watersheds, especially in the steeper creek valleys and upper headwater reaches along Blue Mountain. See Map 15, Riparian Woodland Buffers.

In many ways, riparian buffers provide many of the same ecological services as do wetlands, which are described in the previous section of this report. In addition to buffering streams from stormwater pollution as just described, riparian buffers also provide the following benefits:

- **Reduce flood damage.** The vegetation and soils in riparian buffers reduce flooding impacts by increasing storage and infiltration of floodwaters and slowing floodwater velocities, protecting riverfront and streamside properties from maximum damage.
- **Decrease costs of storm water management.** The use of riparian buffers, especially in new land development designs, can reduce or eliminate the need for large and expensive stormwater infrastructure, like storm sewers and detention basins.
- **Protect drinking water.** The vegetation and soils in riparian buffers filter out pollution, as mentioned above, and battle drought by retaining vast amounts of water, protecting both water quality and quantity—a fact that should prove crucial in future water management plans.
- **Improve in-stream pollution removal.** Streams protected by riparian buffers break down and remove 200-800% more nitrogen pollution than streams without

buffer protection—a finding that should prove vital to regional water quality improvement programs.

- **Reduce streambank erosion.** The root systems of trees, shrubs and other vegetation in riparian buffers stabilize streambank soils and slow down stormwater runoff to prevent erosion, reducing sediment pollution.
- **Cool waters.** The shade of forested riparian buffers can cool streams by 4-9^{O}F. Shaded and cooler water means healthier streams, particularly for temperature sensitive fish, like trout, for which waterways in the Bertsch and Hokendauqua Creek Watersheds are locally well known.
- **Enhance stream habitat for fish and other aquatic life.** Leaves, sticks and other natural debris that end up in streams from riparian buffers provide food, shelter and habitat, increasing biological diversity from the bottom of the food chain on up.

Science has proven that riparian buffers are the most natural and inexpensive systems for protecting natural resources and human health, life and property from pollution and flood damage. Community planners, local officials and natural resource agencies are now heeding this science and advocating for the establishment and enhancement of riparian buffers as best management practices for protecting water quality and mitigating flood damage. In 2008, the Lehigh Valley Planning Commission published a science-based guide for municipal officials to use in creating riparian buffer regulations. More recently, knowing that riparian buffers have an enormous effect on decreasing nonpoint source pollution to waters of the Commonwealth, the PA Department of Environmental Protection adopted new riparian buffer requirements for earth disturbance activities under its Chapter 102, Erosion & Sediment Control Regulations in Title 25 of the PA Code. Currently, none of the four municipalities in the Bertsch and Hokendauqua Creek Watersheds have enacted local ordinances to protect riparian buffers. See Local Municipal Natural Resource Protection Ordinances Table on Page 12.

Water Quality Concerns & Impairments

Water Quality

Recognizing the importance of water quality to the preservation of Pennsylvania's water supply and wildlife, the PA Department of Environmental Protection (DEP) established a Water Quality Standards program in 25 PA Code, Chapter 93, as required by the federal Clean Water Act. The standards are based upon water use: 1) Designated Use — specified for each water body or segment (reach) whether or not the use is being attained (met), and 2) Existing Use — the use actually attained or met in the water body, whether or not the use is included in the water quality standards. All Commonwealth waters are protected for a designated aquatic life use as well as a number of water supply and recreational uses. At a minimum, waters of the Commonwealth must be "fishable and swimmable." To achieve this standard, water must not be too polluted for the fish that live in the water to be edible, and it must not have bacteria levels too high to make it unsafe for swimming or wading.

However, most of the streams in Pennsylvania have other stricter water quality standards associated with them, such as being clean and cold enough to support cold water fishes (Cold Water Fishery or CWF), or being able to support an exceptional ecological community (Exceptional Value or EV). Each different use designation has different water quality standards association with it. These standards are found in 25 PA Code, Chapter 93, Water Quality Standards Regulations. These designations are based on DEP's evaluation of historical and current stream quality data. The present designation for all streams in the Bertsch and Hokendauqua Creek Watersheds is Cold Water Fishery (CWF). See Map 5, Stream Designations & Impairments. The DEP defines CWF as a stream or watershed that is capable of the *"Maintenance or propagation, or both, of fish species including the family Salmonidae* (including trout species) *and additional flora and fauna which are indigenous to cold water habitats."* Generally, cold water habitats are capable of supporting trout fisheries.

The DEP determines stream quality through sampling of benthic macroinvertebrates; the aquatic insects that live in streams and on rocks, woody debris and leaves in streams. Fly fishermen are familiar with these insects because the artificial flies they use imitate these insects, hoping to "fool" the fish into biting what looks like familiar prey. Aquatic macroinvertebrate species have very different tolerances for habitat and water quality. Some, like leeches and black fly larvae, are very tolerant of polluted and poor quality water. Others, like mayfly and stonefly larvae, are more sensitive to water quality, and require clean water and good habitat to survive. Therefore, DEP determines water quality by sampling the aquatic insects and identifying which species are living in a stream. Because these macroinvertebrates live in the water for long periods of time, this is a more accurate way to measure stream health than by taking water samples, which only reveal the water quality at the time samples are taken.

For this study, benthic macroinvertebrate sampling was conducted at six sites in the study area following DEP protocols. See Biological Studies section of this report beginning on Page 33. As a result of these sampling surveys, streams in the upper reaches of the Bertsch and Hokendauqua Creek Watersheds—and possibly other sites downstream—appear capable of supporting high quality stream communities. Therefore, consideration for High Quality (HQ) special protection antidegradation water uses is warranted for both watersheds. Streams designated HQ are considered special protection waters. Construction projects occurring in watersheds of special protection waters are reviewed to a higher standard, following antidegradation guidelines. Generally, the antidegradation policy limits new permitted discharges to protected waters, and requires impacts to be minimized as much as possible to both streams and wetlands.

There are six public drinking water supply wells in the study area: three in the Bertsch Creek Watershed and three in the Hokendauqua Creek Watershed. The Lehigh Township Municipal Authority provides drinking water to approximately 250 people through 105 domestic, commercial, industrial and institutional connections, with an average daily water use of 33,791 gallons per day. The authority's main well is located in the Bertsch Creek Watershed and its backup well is located in the Hokendauqua Creek Watershed. The Whispering Hollow Mobile Home Park spans both Allen and Moore Townships in

the Hokendauqua Creek Watershed. The mobile home park has two public drinking water wells: one in Allen Township that serves approximately 400 people through 136 domestic connections, with an average daily water use of 23,383 gallons per day; and one in Moore Township that serves approximately 240 people through 79 domestic connections, with an average daily water use of 15,926 gallons per day. The Mountainveiw Mobile Home Park is located in the Bertsch Creek Watershed in Lehigh Township with one well that serves approximately 360 people through 185 domestic connections, with an average daily water use of 43,987 gallons per day. The Heritage Village Mobile Home Park is also located in the Bertsch Creek Watershed in Lehigh Township with one well that serves approximately 400 people through 158 domestic connections, with an average daily water use of 21,988 gallons per day. Combined, these four public water systems draw an average daily water use of 139,075 gallons per day from groundwater reserves in the study area. The Northampton Borough Municipal Authority operates a public water system outside the study area, in Lehigh County, which provides drinking water for approximately 15,000 customers in the borough and in neighboring municipalities, both in and outside the study area. All other residents and businesses in the study area rely on private wells for their drinking water sources.

None of the four public water systems in the study area have a Wellhead Protection Program Plan in place through the PA Source Water Protection Program, which is administered by DEP. Through the program, DEP conducts assessments of the susceptibility of pubic water system water sources to potential sources of contamination. The purpose of conducting the assessments is to educate the public and promote the development of local, voluntary source water protection plans and programs. DEP offers a variety of support for municipalities, water suppliers and the public to develop these local source water protection program plans.

There are three permitted municipal wastewater treatment plant discharge points in the study area: one each on Bertsch, Hokendauqua and Indian Creeks. The Lehigh Township Municipal Authority operates two wastewater treatment plants (WWTP) that serve about 900 customers in the areas of Danielsville, Pennsville and Walnutport. The Danielsville WWTP serves about 800 customers in the Danielsville and Walnutport areas. It is located behind the Lehigh Township Municipal Building on Municipal Road. This WWTP discharges between 110,000-120,000 gallons of treated wastewater daily into Bertsch Creek. The Pennsville WWTP serves about 100 customers in the Pennsville area. It is located on Indian Trail Road and discharges between 7,000-8,000 gallons of treated wastewater daily into Indian Creek. The Northampton Borough Municipal Authority operates one WWTP, which is located at Lerch and Miller Streets in the borough. The Northampton Borough WWTP serves about 15,000 customers in the borough and in nearby Allen Township. This WWTP discharges between 800,000-1.2 million gallons of treated wastewater daily into Hokendauqua Creek. Combined, these three municipal wastewater treatment plants discharge between 917,000-1,328,000 gallons of treated wastewater daily into streams in the study area.

The Atlas Dam Removal & Fish Passage Project on Hokendauqua Creek in the Borough of Northampton has been a plan in progress since about 2005. The project involves the

survey, design, permitting and removal of the Atlas Dam and meets all the criteria outlined in the Open Rivers Initiative, which was created in 2005 by the National Oceanic & Atmospheric Administration to provide communities with funding and technical guidance to carry out dam removal projects that restore local rivers and streams. The initiative is focused on community driven dam removal, with the goal of enhancing watershed health and fostering sustainable populations of migratory fish. Open Rivers Initiative projects also aim to improve public safety and enhance community vitality, while encouraging economic growth. Removing outdated, nonfunctional dams—like the Atlas Dam—provides significant environmental improvements, such as opening access to spawning habitat and improving water quality. Dam removals also offer economic and societal benefits, such as decreased dam maintenance and liability costs, improved recreational opportunities and the elimination of safety hazards.

The Atlas Dam is located about ¾-miles upstream of the mouth of Hokendauqua Creek at its confluence with the Lehigh River. The dam was constructed in 1898 to provide water for the Atlas Portland Cement Company, which ceased operations in 1982. It is approximately 600 feet wide and 12 feet high. Storage behind the dam is approximately 40 acre-feet. The length of the impoundment behind the dam is about 4,000 feet. The impoundment is filled with 114 years-worth of sediments. The removal of the Atlas Dam will restore fish passage to the upper 25 miles of streams on Hokendauqua Creek and its largest and only named tributary, Indian Creek. It will also enhance the existing cold water fishery through improved aquatic habitat and thermal qualities. Once the dam is removed, the property owner has offered to donate approximately 30 acres of land to the borough as a public recreational park. At the present time, all the project field surveying, analysis and design work has been completed and regulatory agency permits are pending before the project can be bid, and removal of the dam can begin.

Impairments

A water body is considered "impaired" when it does not meet the water quality standards associated with its designated use. When a stream is listed as impaired, there is a federal requirement under the Clean Water Act for the state in which the impaired stream is located to develop a plan to return the stream to its designated use. This plan is called a Total Maximum Daily Load or TMDL. A TMDL plan locates the source of the impairment and calculates what pollutant load reductions are required in order to return the stream to its designated use.

In 2010, DEP designated a 5.36-mile reach of Hokendauqua Creek in Northampton Borough as impaired for aquatic life use due to suspended solids from municipal point source discharges, and siltation from urban runoff and storm sewer discharges. See Map 5, Stream Designations & Impairments. Point source pollution is pollution that comes from a single source, such as a factory, wastewater treatment plant or municipal stormwater sewer system. Point source discharges are permitted under the National Pollutant Discharge Elimination System (NPDES) program, which is discussed in the next section of this report. The DEP must pinpoint the pollution sources and develop a

TMDL for this impaired reach of Hokendauqua Creek within 13 years of its 2010 listing, or by the year 2023.

Concurrent with this study, bacteria sampling was conducted at four sites on the Hokendauqua and Indian Creeks to assess these streams for DEP's recreational use standards, like swimming and wading. The recreational use standard for Pennsylvania is that a five sample, geometric mean cannot exceed 200cfu/100mL, and 10% of the samples collected in a 30 day period cannot exceed 400cfu/100mL. In 2010, water samples were taken on these two streams by volunteers from the Bertsch-Hokendauqua-Catasauqua Watershed Association on behalf of DEP. The downstream sampling sites on both the Hokendauqua and Indian Creeks produced attaining results for recreational use; meaning that they were within acceptable limits of bacteria. However, the upstream sampling sites on both waterways produced inconclusive results for bacteria; with one assessment at each site attaining and one impaired for recreational use. Therefore, no assessment was rendered by DEP for these two upstream sites. These same sampling sites should be tested again to conclude a final assessment for recreational use.

Stormwater & Nonpoint Source Pollution

Stormwater

Stormwater is water that originates when rain or snowmelt flows over the ground. It is defined by the Pennsylvania Stormwater Management Act as *"Drainage runoff from the surface of the land resulting from precipitation or snow or ice melt."* Precipitation that falls on the natural landscape is managed by a natural system of vegetation, soil, groundwater and surface waters that have formed over time. Natural events shape this system through infiltration, evaporation and runoff. When less precipitation is infiltrated into the soil or evaporated, either directly to the air or through trees and other plants, there is an increase in the volume and rate, or acceleration, of stormwater runoff.

As changes to the landscape alter the balance of the natural water cycle, accelerated stormwater causes further impacts to the landscape. High volumes and rates of stormwater runoff cause increased soil erosion, greater and more frequent flooding and reshape surface water channels through scour and erosional deposition. It also reduces groundwater levels because less precipitation ends up there, and this in turn reduces dry weather stream flows that are fed by groundwater. More soil and other water pollutants are picked up and carried further with accelerated stormwater runoff. Depending on the extent of these impacts, serious safety, property and environmental risks can also result.

Changing the soil cover by building impervious surfaces, like driveways, parking lots and buildings; removing vegetation, like trees and shrubs; and changing the shape of the land and the way water flows across it can all accelerate stormwater runoff. During construction, vegetation is removed, soil is exposed, the landscape is graded and reshaped, and impervious surfaces are installed. Following construction, the impervious surface cover prevents infiltration and may attract new pollution sources, like motor

vehicle fluids, road salt and cinders, and the reshaped landscape alters the flow and destination of stormwater runoff.

Stormwater can pick up debris, chemicals, soil and other pollutants and flow into a storm sewer system or directly into surface waters, like streams and rivers. Anything that enters a storm sewer system is ultimately discharged untreated into the surface waters we use for swimming, fishing and providing drinking water. Pollutants entering surface waters during precipitation events is called "polluted runoff." Daily human activities result in deposition of pollutants on roads, parking lots, lawns, roofs, farm fields and more. When it rains, polluted runoff ultimately makes its way to a water body. While there is some attenuation of these pollutants before entering receiving waters, the scale of human activity can result in large enough quantities of pollutants to impair these waters; as is the case with the impairment of a lower reach of the Hokendauqua Creek (see Water Quality Concerns & Impairments section of this report immediately above).

Sources vary as to the exact figure, but there is general agreement that when a watershed reaches certain threshold percentages of imperious surface cover, the quality of local streams declines rapidly. At approximately 10% impervious cover, streams tend to loose sensitive aquatic organisms. At about 20-30% impervious cover, most stream indicators drop to poor conditions, and this percent of impervious cover is generally recognized as a critical threshold for impairment. Knowing the percent of impervious surface area in a watershed allows municipal managers to make informed decisions about what types of future land development may negatively impact water quality. An estimate of impervious surface cover in the Bertsch and Hokenduaqua Creek Watersheds was not made as part of this study, nor is it believed that such cover is presently at or near the threshold to threaten water quality in either of these watersheds. However, land use has changed substantially in both watersheds over the past decades, and residential populations in the study area are projected to increase by 70% from the 2010 Census figures by the year 2030; therefore, estimating impervious surface cover in both watersheds for future planning purposes is a recommendation of this Coldwater Conservation Plan (see Recommendations & Next Steps section of this plan beginning on Page 41).

Stormwater Management

Managing the quantity and quality of stormwater is called "stormwater management." The Pennsylvania Stormwater Management Act, Act 167 of 1978, was enacted in response to the impacts of accelerated stormwater runoff resulting from land development in the state. It requires counties to prepare and adopt watershed based stormwater management plans. It also requires municipalities to adopt and implement ordinances to regulate development consistent with these plans. In Lehigh and Northampton Counties, the Lehigh Valley Planning Commission is responsible for preparing these watershed based stormwater management plans on behalf of both counties. Under Act 167, the PA Department of Environmental Protection (DEP) provides technical, administrative and financial assistance to counties or, in the case of Lehigh and Northampton Counties, the Lehigh Valley Planning Commission, in preparing stormwater management plans.

Watershed based stormwater management plans provide municipalities with a framework, including model ordinances and management practices, to control stormwater runoff from new development in a watershed. These plans include standards for managing the quantity and quality of stormwater runoff given the characteristics of the watershed, including current and future development plans. The goal is to control post-development stormwater runoff rate, volume and quality to replicate predevelopment conditions. This is to prevent additional downstream flooding and to protect water resources and their uses. Each municipality in the watershed covered by the plan must adopt ordinances consistent with the plan. This includes zoning, subdivision and land development, building code, erosion and sedimentation, and post-construction stormwater management requirements in the municipality. This process is also consistent with municipal obligations under federal National Pollutant Discharge Elimination System (NPDES) permitting requirements for municipal separate storm sewer systems (MS4s), which are described later in this section of the report.

In order to implement the provisions of a stormwater management plan, municipalities in the watershed are divided and mapped into stormwater management districts consistent with stormwater release rates that are presented in the stormwater management plan. The four municipalities in the study area include the Townships of Allen, Lehigh and Moore and the Borough of Northampton. The western half of Lehigh Township falls under the **Trout/Bertsch Creeks Watershed Stormwater Management Plan**, which was first developed in 1995. The eastern half of Lehigh Township and the remainder of the study area—Allen and Moore Townships and Northampton Borough—fall under the **Hokenduaqua Creek Watershed Stormwater Management Plan**, which was first developed in 1997. The boundaries of the stormwater management districts are illustrated on an official map, which can be viewed at the offices of each municipality.

Act 167 also requires periodic updates of stormwater management plans in order to guarantee a dynamic system of runoff controls sensitive to changing land use characteristics and changing regulatory requirements. At the present time, the Lehigh Valley Planning Commission and its municipal partners are in the process of updating all the stormwater management plans in Lehigh and Northampton Counties, including those for the Bertsch and Hokendauqua Creek Watersheds. When these updated plans are finally completed, each updated plan will require adoption by the appropriate county and approval by DEP. Municipalities in the two counties will then ultimately be required to adopt ordinances to implement the adopted and approved Act 167 Stormwater Management Plan updates.

The National Pollutant Discharge Elimination System (NPDES) program regulates stormwater and wastewater discharges from municipal separate storm sewer systems (MS4s), construction sites and industrial sites. NPDES permits are a requirement of the federal Clean Water Act of 1972, and most states—including Pennsylvania—are authorized to implement the NPDES program. This permitting mechanism is designed to prevent the discharge of pollutants into local surface waters, like streams and rivers. Polluted stormwater is commonly transported through municipal separate storm sewer systems (MS4s), from which it is usually discharged untreated into local water bodies.

An MS4 is a conveyance or system of conveyances designed or used to collect or convey stormwater, including storm drains, pipes, ditches, etc. It is not part of a combined sewer system and it is not part of a sewage treatment plant. To prevent harmful pollutants from being washed or dumped into an MS4, operators must obtain an NPDES permit and develop a stormwater management plan of best management practices to reduce the discharge from MS4s of pollutants into local waterways. MS4s are permitted and regulated in all four municipalities in the Bertsch and Hokendauqua Creek Watersheds: Allen, Lehigh and Moore Townships and Northampton Borough.

Nonpoint Source Pollution

With most point source pollution, or end-of-pipe discharges, already regulated by state and federal laws, it is nonpoint source pollution—water pollution that comes from many difference sources, like roads, highways, sidewalks, parking lots, lawns, gardens, farm fields and leaking septic systems—that is the larger concern for water quality degradation. Nonpoint source pollution (NPS) does not have one specific source, like a factory or sewage treatment plant discharge pipe. NPS comes from the cumulative effect of a region's residents and workers going about their everyday activities, like fertilizing the lawn or changing the oil in the car. NPS is triggered when rainwater or snowmelt washes road salts, vehicle fluids, fertilizer, herbicides, pesticides, manure, litter and soil off the land and into waterways. As surface runoff moves over land, it picks up and moves these pollutants into streams, rivers, lakes, wetlands and reservoirs. NPS is the biggest source of pollution to Lehigh Valley streams and rivers.

Because there are so many sources of NPS, it is difficult to isolate and regulate. Therefore, it is really incumbent upon individuals to each do their part to help minimize NPS. Best management practices (BMPs) refer to a wide variety of practices that serve to minimize pollution, including NPS. There are a great number of BMPs and they are generally categorized by the type of land use or activity to which they refer. Therefore, there are agricultural BMPs, urban BMPs, construction BMPs, golf course BMPS and even residential BMPs for homeowners. Following BMPs is the cornerstone of any good watershed protection activity.

It is the job of water resource professionals, municipalities and community conservation organizations to educate their constituencies about NPS and make sure that BMPs are followed wherever possible. Therefore, one of the recommendations of this report is educate residents and business owners about BMPs that apply to their situations. However, creating an exhaustive list of BMPs is outside the scope of this report. Such lists do exist and the federal Environmental Protection Agency (EPA) highlights some of the best NPS materials that the EPA's Nonpoint Source Control Branch is aware of for both professionals and the public. A brief list of some BMPs follows.

- Employ soil conservation practices on farms to keep soil from eroding.
- Apply appropriate erosion and sediment control practices to active construction sites.
- Use the minimum amount of road salt needed.

- Do no dump plowed snow into streams.
- Label storm drains with markers or plaques that read "No Dumping, Drains To Waterway" to discourage oil and other toxics from being disposed of inappropriately.
- Encourage the public to pick up animal waste.
- Ensure that private septic systems are cleaned according to a regular schedule.
- Do not apply excessive amounts of fertilizers or herbicides.
- Do not wash vehicles on pavement where detergents can run off into waterways.
- Store chemicals away from water bodies in elevated sealed containers.
- Pick up trash before it washes into streams.

There are lists of BMPs for most industries and land uses, including residential stormwater management. Best management practices represent the first line of defense in the battle against nonpoint source pollution everywhere.

Conservation Planning Efforts

While this Coldwater Conservation Plan for the Bertsch and Hokendauqua Creek Watersheds is the first plan developed for these watersheds focused specifically on water resources, it is not the first plan, study or effort developed or initiated for the conservation of natural resources in these two watersheds. Over the years, local, county and state governments; regional planning agencies; and community partnership organizations have conducted studies and developed plans and initiatives for the conservation of natural resources in the study area.

Municipal Planning Efforts

Of the four municipalities in the Bertsch and Hokendauqua Creek Watersheds—Allen, Lehigh and Moore Townships and Northampton Borough—Allen and Moore Townships are currently engaged in conservation planning. Allen Township is in the process of developing an open space plan to guide the township in protecting and preserving its open spaces, while Moore Township has an open space plan; an Environmental Advisory Council to assist township supervisors with the protection and conservation of local natural resources; a farmland preservation board to assist township supervisors and farmers with preserving local farms; and a dedicated open space tax used to help preserve both open space and farmland.

County Planning Efforts

Northampton County administers both a Farmland Preservation Program and an Open Space & Natural Areas Program. The Farmland Preservation Program provides county funds to match state and local funds for the purchase of agricultural conservation easements in townships across the county. Presently, 13 farms totaling nearly 1,156 acres have been preserved in the Bertsch and Hokendauqua Creek Watersheds. See Map 11, Agricultural Easement Purchases/Security Areas. The Open Space & Natural Areas Program serves to protect the county's important natural features by assisting

municipalities and nonprofit organizations in the acquisition and preservation of lands where these resources are located. To date, no properties have been preserved through the Northampton County Open Space & Natural Areas Program in either the Bertsch or Hokendauqua Creek Watersheds.

State Study Efforts

Both the PA Department of Environmental Protection and the PA Fish & Boat Commission occasionally conduct studies of streams in the Bertsch and Hokendauqua Creek Watersheds, typically surveying for fish and benthic macroinvertebrate species (aquatic insects). See Biological Studies in the next section of this report.

Regional Planning Efforts

The Lehigh Valley Planning Commission (LVPC) and the Nazareth Area Council of Governments (Naz COG) have each produced conservation plans that are relevant to the Bertsch and Hokendauqua Creek Watersheds. The LVPC, whose mission is to provide comprehensive planning to guide orderly growth in Lehigh and Northampton Counties, has produced a number of such conservation planning documents, including a **Natural Resources Plan** (part of LVPC's **Lehigh Valley Comprehensive Plan**), which includes an evaluation of important natural resources in the Lehigh Valley—including the Bertsch and Hokendauqua Creek Watersheds—and what should be done to protect them; **Lehigh Valley Greenways Plan** (see Greenways section of this report beginning on Page 13); **A Natural Areas Inventory of Lehigh & Northampton Counties, Pennsylvania** (see Natural Areas section of this report beginning on Page 16); and **Northampton County 21st Century Open Space Initiative Guidelines**, which provides information necessary to implement the county's Open Space & Natural Areas Program (see County Planning Efforts in this section of the report immediately above). The Naz COG, a council of ten municipalities in the greater Nazareth Area, including Moore Township in the Hokendauqua Creek Watershed, developed a **Natural Resources Plan** as part of its **Nazareth Area Multimunicipal Comprehensive Plan**, a vision of the future of the Nazareth Area that places special importance on the preservation of natural features, farmland, open space and historic resources.

Community Partnership Planning Efforts

Many nonprofit community partnership organizations have developed conservation plans that are relevant to the Bertsch and Hokendauqua Creek Watersheds. The Kittatinny Ridge Conservation Project, led by Audubon Pennsylvania, developed a **Conservation Plan for the Kittatinny Ridge in Pennsylvania** as an overview of what is currently known about the cultural and natural resources of the Kittatinny Ridge through Pennsylvania, with recommended strategies and priorities for protecting the ridge corridor—which includes the upper headwater reaches of both the Bertsch and Hokendauqua Creek Watersheds—for people and for ecological integrity. The Wildlands Conservancy, a Lehigh Valley land trust whose mission is to protect and restore critical natural areas and waterways, produced the **Lehigh River Watershed Conservation Management Plan** as a comprehensive plan for maintaining and remediating the health of the Lehigh River Basin, which includes the Bertsch and Hokendauqua Creek Watersheds. The Delaware & Lehigh National Heritage Corridor, whose mission is to

enrich communities through actions and partnerships that conserve the resources, tell the stories and enhance the quality of life for Corridor residents, developed the **Delaware & Lehigh Canal National Heritage Corridor & State Heritage Park Management Action Plan**, which serves as a guide for enhancing the quality of life—including the conservation of natural resources—for residents who live in the Corridor, including the Bertsch and Hokendauqua Creek Watersheds. The Lehigh Valley Greenways Conservation Landscape Initiative is a partnership of nearly 25 state, local and regional organizations collaborating to advance a vision of conservation—including watershed protection—across Lehigh and Northampton Counties, including the Bertsch and Hokendauqua Creek Watersheds. The Hokendauqua Chapter of Trout Unlimited, whose mission is to conserve, protect and restore the Hokendauqua Creek Watershed and its coldwater fishery, regularly partners with other community organizations and conservation agencies in the planning and implementation of local watershed restoration projects and stream and streambank cleanups. Lastly, the Bertsch-Hokendauqua-Catasauqua Watershed Association, whose mission is to protect and restore the land and water resources in eastern Lehigh and northwestern Northampton Counties, developed a **Strategic Plan** that identifies the Association's project and program goals and objectives for protecting and restoring the streams and natural resources in the Bertsch-Hokendauqua-Catasauqua Watershed Region.

Education & Outreach

In order to effectively address issues concerning local natural resources, the appropriate knowledge base must exist within all sectors of the watershed community. Residents; government officials and staff; business owners and employees; and school students, teachers, faculty and staff all play essential roles in protecting and conserving local natural resources. It is not enough for a few natural resource professionals to understand the problems and potential solutions; those problems and solutions must be conveyed to and adopted by the people best able to make the necessary changes at the local level. It is public works staff who are able to keep salt-laden snow from being dumped into streams by stockpiling plowed snow in fields. It is private homeowners who must keep their septic systems working properly. It is government elected officials who must enact and enforce local ordinances that protect natural resources. And for any of these actions to take place, the appropriate individuals or organizations must understand the issues, accept solutions and then act upon them.

Fortunately, the Bertsch-Hokendauqua-Catasauqua Watershed Association (BHCWA) was established in 2009 to help facilitate natural resource conservation, education and outreach in eastern Lehigh and northwestern Northampton Counties; including the study area. The vision of this community watershed organization is to be the region's leader and chief advocate for conservation; inspiring residents, businesses and local governments to value their natural resources, engage in conservation practices and work collaboratively with the Association to protect and restore the region's watersheds and water quality. To help fulfill this vision, BHCWA developed and approved a strategic plan that defines the purposes of the Association, identifies its goals and helps determine

funding needs and project and program priorities. The plan is to be used to communicate the Association's goals and objectives to its constituency, and to ensure that the most effective use is made of BHCWA's limited resources by focusing those resources on key priorities.

The very first goal in the Association's Strategic Plan is Education and Outreach. It states that the Association will *"Develop and deliver educational programs on watershed conservation and protection."* Under this goal, the Association defines five objectives and 13 activities to achieve its goal of education and outreach, including reaching out to all sectors of the watershed community: school teachers and students, youth and civic organizations, municipal officials, businesses and industry, residents and the general public.

Community watershed organizations across the Commonwealth of Pennsylvania have taken a leading role in protecting the land and water resources within their watershed boundaries for many years. It is a recommendation of this plan that BHCWA be a lead proponent of this Coldwater Conservation Plan, and actively reach out to and share this plan's recommendations with all the watershed stakeholder groups the Association is already targeting in its strategic plan, in order to fulfill these recommendations to protect and improve the water quality and natural resources in the Bertsch and Hokendauqua Creek Watersheds.

Biological Studies

For this study, benthic macroinvertebrate (aquatic insects) sampling was conducted in April 2011 at four survey sites in the upper Hokendauqua Creek Watershed and at two sites in the upper Bertsch Creek Watershed, for a total of six macroinvertebrate survey sampling sites. See Map 16, Survey Sites for the locations of all six macroinvertebrate sampling sites in the study area. In the Hokendauqua Creek Watershed, two sites were sampled on the main stem of upper Hokendauqua Creek and two sites were sampled on the main stem of upper Indian Creek, the largest and only named tributary to Hokendauqua Creek. These upper reaches on the Bertsch, Hokendauqua and Indian Creeks were selected because they represent some of the most contiguously forested corridors along these streams. Using macroinvertebrates as an assessment tool, a primary goal of this study was to determine whether sections of Bertsch, Hokendauqua and Indian Creeks might qualify for a change in designation from Cold Water Fisheries (CWF), which all three streams are currently designated as under 25 PA Code, Chapter 93, Water Quality Standards Regulations, to either High Quality (HQ) or Exceptional Value (EV) designation under these same water quality regulations. The HQ and EV status affords increased legal protection of stream sections so designated. Forested headwater reaches of streams in both the Bertsch and Hokendauqua Creek Watersheds afford the best possibilities for achieving stream designation upgrades.

Macroinvertebrate sampling and assessment followed PA Department of Environmental Protection (DEP) protocols using the agency's evaluation tool, **A Benthic Index of**

Biotic Integrity (IBI) for Wadeable Freestone Streams in Pennsylvania. Using this scientifically credible indicator, macroinvertebrate assemblages collected and subsampled at one site on each of the three streams (Bertsch, Hokendauqua and Indian Creeks) had IBI scores above the benchmark to qualify for consideration for special protection High Quality/Exceptional Value (HQ/EV) antidegradation water uses under 25 PA Code, Chapter 93, Water Quality Standards Regulations. As mentioned above, the Bertsch and Hokendauqua Creek Watersheds are currently designated as Cold Water Fisheries (CWF) under these same water quality standards regulations.

Sensitive macroinvertebrates are less tolerant of the effects of human-associated disturbances, like warming water, stormwater runoff and dissolved manufactured chemicals. These factors increase with decreasing forested stream corridors, and result in population declines of sensitive macroinvertebrate species. Because sensitive macroinvertebrate species are associated with generally healthy forested streams, they can be used as indicators of a stream's biological condition and integrity. The presence or absence of sensitive macroinvertebrate species in proportion to the abundance of more pollution tolerant macroinvertebrate species are data that can be used in a biotic index. A biotic index is made up of several metrics or ecological descriptions, each providing a score based on the macroinvertebrate assemblage sampled. The metric scores are summed for a total score, which determines the biotic integrity and the appropriate aquatic life use designation and protection status for that section of stream. The DEP uses an index of biotic integrity for macroinvertebrate species to help determine the aquatic life use designations for streams, such as Cold Water Fisheries (CWF), and qualifications for special protection antidegradation water uses, like High Quality (HQ) and Exceptional Value (EV).

Forested stream corridors are ecologically important links to sustaining biological diversity and water quality within and between watersheds, and are often considered conservation priorities. As a result of the macroinvertebrate surveys that were conducted as part of this study, streams in the upper Bertsch and Hokendauqua Creek Watersheds—and possibly other sites downstream—appear capable of supporting high quality stream communities. Therefore, consideration for High Quality (HQ) special protection antidegradation water use is warranted for both watersheds. See Appendix A, Macroinvertebrate Survey Report & Appendices for the full survey methodology, data results and discussion.

In addition to the six macroinvertebrate surveys that were conducted using DEP protocols in the upper Bertsch and Hokendauqua Creek Watersheds as part of this study in 2011, water quality biologists with DEP conducted 15 such surveys in upper, middle and lower reaches of the Bertsch and Hokedauqua Creek Watersheds in 2005 and 2008. In 2005, four surveys were conducted by DEP in the Hokendauqua Creek Watershed. In 2008, DEP conducted six more macroinvertebrate surveys in the Hokendauqua Creek Watershed, and five such surveys were conducted by DEP in the Bertsch Creek Watershed that same year. See Appendix B, DEP Sampling Locations & Macroinvertebrate Sampling Summaries for the results of these surveys.

In July 2011, three fish surveys were also conducted as part of this study using a concentrated single pass electrofishing protocol in pools and riffles to assess for species abundance and fish communities. One site was surveyed on the upper Hokendauqua Creek in Moore Township, and two sites were surveyed near the confluence of Indian and Hokendauqua Creeks in Allen Township; one site on Indian Creek just upstream of the confluence, and one site on Hokenduaqua Creek just downstream of the confluence. See Map 16, Survey Sites for the locations of these three fish sampling sites. (Note that, due to their very close proximity, the two sampling sites at the confluence of Indian and Hokendauqua Creeks are represented by just one fish sampling site symbol on the map.) Altogether, 14 fish species were documented in the three survey samples. See Appendix C, Fish Species Collection Table & Sampling Site Maps for the fish species, relative sample abundance and sampling site locations.

In addition to the three fish surveys that were conducted in the upper Hokendauqua Creek Watershed as part of this study in 2011, biologists with the PA Fish & Boat Commission (PFBC) conducted 21 other fish surveys in both the Bertsch and Hokendauqua Creek Watersheds in 1976, 1978, 1999 and 2006. Altogether, 24 fish species were documented in these surveys. See Appendix D, PFBC Species Collection Matrix Tables for the fish species and stream section and mile locations of these 21 survey sites.

Thermal Studies

Temperature monitoring was conducted at eight stations throughout the Bertsch and Hokendauqua Creek Watersheds from early January through early November 2011 using in-stream dataloggers to collect hourly water temperature readings. Onset HOBO Pendant Loggers were installed and anchored in-stream at each station and temperature data were downloaded quarterly. Two temperature dataloggers were installed on the main stem of Bertsch Creek, four dataloggers were installed on the main stem of Hokendauqua Creek and two were installed on the main stem of Indian Creek, the largest and only named tributary to Hokendauqua Creek. See Map 6, Survey Sites for the locations of all eight datalogger stations. The datalogger at Station 6, on Indian Creek at Cedar Road, was lost sometime after April 27.

The data indicate that temperatures were generally sufficient for coldwater fish and benthic macroinvertebrate species, and especially so at those stations further upstream in both watersheds. Lower in the watersheds, temperatures were still generally within ranges that coldwater fishes like brook trout will survive, but commonly exceeded 66.2^{O}F in the summer months, at which point reproducing populations of brook trout have been known to decline. In some instances, dataloggers recorded station temperatures that exceeded 75^{O}F in the summer months, at which point trout mortality increases substantially. The increased water temperatures in the lower reaches of the watersheds may be a result of decreasing forested riparian buffers and increasing impervious surface cover in these lower reaches. See Appendix E, Temperature Data Graphs for average daily and maximum daily temperature readings from early winter to early fall 2011.

Conclusions

The following conclusions have been made as a result of this Coldwater Conservation Planning Project.

1. Streams in the Bertsch Creek and Hokendauqua Creek Watersheds are currently designated as Cold Water Fisheries (CWF) under PA Code, Title 25, Chapter 93, Water Quality Standards Regulations. The upper reaches of the Bertsch, Hokendauqua and Indian Creeks appear to meet the regulatory criteria and definitions for special protection waters designation of either High Quality (HQ) or Exceptional Value (EV) under Chapter 93. One of the two macroinvertebrate sampling sites on each of the three streams sampled in this study yielded results which met or exceeded the biological standards required for HQ designation.

   In addition to the six sites sampled for macroinvertebrates in this 2011 study (two in the Bertsch Creek Watershed and four in the Hokendauqua Creek Watershed), all of which were in headwater stream reaches, biologists with the PA Department of Environmental Protection (DEP) sampled 15 other sites for macroinvertebrates in these two watersheds in 2005 and 2008, including sites in upper, middle and lower stream reaches. Because of the results of this most recent study, additional sampling by DEP at all sites previously sampled is warranted in order to make a final determination on the appropriate Chapter 93 stream designations for these waterways.

2. The vision of the all-volunteer Bertsch-Hokendauqua-Catasauqua Watershed Association (BHCWA), founded in 2009, is to be the region's leader and chief advocate for conservation; inspiring residents, businesses, and local governments to value their natural resources, engage in conservation practices and work collaboratively with the Association to protect and restore the region's watersheds and water quality. To help fulfill this vision, BHCWA developed and approved a Strategic Plan in 2011 that defines the purpose of the Association, identifies its goals and helps determine funding needs and project and program priorities in a methodical and tactical way. The plan is to be used to communicate the Association's goals and objectives to its constituency, and to ensure that the most effective use is made of BHCWA's limited resources by focusing those resources on key priorities.

   The Strategic Plan includes five goals (Education & Outreach; Planning & Programming; Policy & Advocacy; Fundraising, Membership & Operations; and Marketing & Communications), each with a set of objectives and activities designed to achieve those goals. Along with this Coldwater Conservation Plan, which was prepared for BHCWA by the Northampton County Conservation District, the Association should actively reach out to and share its Strategic Plan with local municipalities, businesses, industry, civic organizations, school districts and other community stakeholder groups to help build capacity for effectively

fulfilling its vision and meeting its mission to protect and preserve the watersheds and water resources of eastern Lehigh and northwestern Northampton Counties.

3. Several hundred acres of the Palmerton Zinc Pile Superfund Site are located on the crest and upper slopes of Blue Mountain, in the uppermost headwater reaches of the Bertsch Creek Watershed. Zinc smelting operations initiated in the Borough of Palmerton (located just outside the study area) in the late 1800s through 1980 produced emissions fallout of sulfur dioxide and heavy metals across the surrounding landscape at concentrations that resulted in ecosystems collapse and prevented plant growth across a 3,000-acre area, resulting in contaminated soil erosion to the Lehigh River in the westernmost reach of the study area, and to Aquachicola Creek to the north of the study area. Streams within the Bertsch Creek Watershed were not impacted by contaminated soil erosion, as heavy metal fallout avoided the lower slopes of Blue Mountain, which remained forested throughout the time of zinc smelting operations; providing testament to the filtering powers of forested headwater areas and riparian buffers.

   In recent years, revegetating the affected areas in and outside the study area has reduced soil erosion on the upper slopes of Blue Mountain, and improved water quality by decreasing soluble metals contaminant concentrations associated with stormwater runoff from the site. As a result of these treatments, the threat of metals migrating downslope into the Bertsch Creek Watershed should be completely removed.

4. Natural resources within the Bertsch and Hokendauqua Creek Watersheds are not well protected by local land use regulations, like municipal ordinances. Of the four municipalities in the study area—Allen, Lehigh and Moore Townships and Northampton Borough—none protect riparian buffers or greenways (greenways that have been identified in the Lehigh Valley Greenways Plan), only Allen Township protects wetlands and only Moore Township protects woodlands and natural areas (natural areas that have been identified in the Lehigh and Northampton County Natural Areas Inventory) by way of local municipal natural resource protection ordinances.

5. Through the Northampton County Farmland Preservation Office, 13 farms totaling nearly 1,156 acres have been permanently preserved in the Bertsch and Hokendauqua Creek Watersheds; two farms totaling about 143 acres in the Bertsch Creek Watershed, and 11 farms totaling about 1,013 acres in the Hokendauqua Creek Watershed. These preserved farmlands help protect these watersheds from future development.

6. Temperature data collected during thermal studies for this project indicate that water temperatures were generally sufficient for coldwater fish and benthic macroinvertebrate species, and especially so at those temperature monitoring stations further upstream in both the Bertsch and Hokendauqua Creek Watersheds. The increased water temperatures in the lower reaches of the

watersheds may be a result of decreasing forested riparian buffers and increasing impervious surface cover in these lower reaches.

7. The Lehigh Valley Greenways Plan identifies five greenways in the Bertsch and Hokendauqua Creek Watersheds: the Blue Mountain/Kittatinny Ridge Multi-Use/Scenic Greenway, Bertsch Creek Conservation Greenway, Hokendauqua Creek Conservation Greenway, Indian Creek Conservation Greenway and the Nor-Bath Trail Cultural/Recreational Greenway. A greenway, regardless of type, is defined as a corridor of open space that may vary greatly in scale from narrow strips of green that run through urban, suburban and rural areas to wider corridors that incorporate diverse natural, cultural and scenic features. Greenways protect the environment and water quality, provide recreational opportunities and connect natural and cultural areas to one another.

   Three of the five greenways in the study area are considered "conservation greenways," which exist primarily to protect natural resources, like water quality. Permanently protecting environmentally sensitive, historically important and/or culturally significant lands from undesirable development is the ultimate goal identified in the Lehigh Valley Greenways Plan. Currently, none of the four municipalities in the study area—Allen, Lehigh and Moore Townships and Northampton Borough—have enacted local ordinances to protect greenways that have been identified in their municipal boundaries in the Lehigh Valley Greenways Plan.

8. The Lehigh and Northampton County Natural Areas Inventory (NAI) identifies five natural areas in the Bertsch and Hokendauqua Creek Watersheds: the Blue Mountain, Bertsch Creek Seep, Little Gap, Neff's Pond and Walnutport Canal Site Natural Areas. These natural areas include sites of both local and statewide significance. Statewide significant natural areas include the presence of plant or animal species of special concern and/or exemplary natural communities. Locally significant natural areas do not include high quality natural communities or species of special concern, although they may have the potential for rare species to occur.

   The NAI is a useful guide for planning developments and parks, conserving natural areas and setting priorities for the preservation of the most vulnerable natural resources in Lehigh and Northampton Counties that have been identified in the NAI. Currently, only one of the four municipalities in the study are—Moore Township—has enacted a local ordinance to protect natural areas within its borders that have been identified in the NAI.

9. There are six public drinking water supply wells in the study area: three in the Bertsch Creek Watershed and three in the Hokendauqua Creek Watershed. The Lehigh Township Municipal Authority provides drinking water to approximately 250 people with an average daily water use of 33,791 gallons per day. The authority's main well is located in the Bertsch Creek Watershed and its backup

well is located in the Hokendauqua Creek Watershed. The Whispering Hollow Mobile Home Park spans both Allen and Moore Townships in the Hokendauqua Creek Watershed. The mobile home park has two public drinking water wells: one in Allen Township that serves approximately 400 people with an average daily water use of 23,383 gallons per day; and one in Moore Township that serves approximately 240 people with an average daily water use of 15,926 gallons per day. The Mountainview Mobile Home Park is located in the Bertsch Creek Watershed in Lehigh Township with one well that serves approximately 360 people with an average daily water use of 43,987 gallons per day. The Heritage Village Mobile Home Park is also located in the Bertsch Creek Watershed in Lehigh Township with one well that serves approximately 400 people with an average daily water use of 21,988 gallons per day. Combined, these four public water systems draw an average daily water use of 139,075 gallons per day from groundwater reserves in the study area. The Northampton Borough Municipal Authority operates a public water system outside the study area, in Lehigh County, which provides drinking water for its customers. All other residents and businesses in the study area rely on private wells for their drinking water sources. None of the four public water systems in the study area have a Wellhead Protection Program Plan in place through the PA Source Water Protection Program, which is administered through the PA Department of Environmental Protection.

10. There are three permitted municipal wastewater treatment plant discharge points in the study area: one each on Bertsch, Hokendauqua and Indian Creeks. The Lehigh Township Municipal Authority operates two wastewater treatment plants (WWTPs): the Danielsville WWTP and the Pennsville WWTP. The Danielsville WWTP serves about 800 customers and discharges between 110,000-120,000 gallons of treated wastewater daily into Bertsch Creek. The Pennsville WWTP serves about 100 customers and discharges between 7,000-8,000 gallons of treated wastewater daily into Indian Creek. The Northampton Borough Municipal Authority operates one WWTP, which serves about 15,000 customers in the borough and nearby Allen Township. This WWTP discharges between 800,000 and 1.2 million gallons of treated wastewater daily into Hokendauqua Creek. Combined, these three municipal wastewater treatment plants discharge between 917,000-1,328,000 gallons of treated wastewater daily into streams in the study area.

11. The defunct Atlas Dam on Hokendauqua Creek in the Borough of Northampton is planned for removal. The dam was constructed in 1898 to provide water for the Atlas Portland Cement Company, which ceased operations in 1982. It is approximately 600 feet wide and 12 feet high, with 40-acre feet of storage in a 4,000-foot long impoundment behind the dam. The removal of the Atlas Dam, as outlined in the Atlas Dam Removal & Fish Passage Project, will restore fish passage to the upper 25 miles of streams on Hokendauqua and Indian Creeks. It will also enhance the existing cold water fishery through improved aquatic habitat, water quality and water temperatures. At the present time, all the project

field surveying, analysis and design work has been completed, and regulatory agency permits are pending before the project can be bid, and removal of the dam can begin.

12. In 2010, the PA Department of Environmental Protection (DEP) designated a 5.36-mile reach of Hokendauqua Creek in Northampton Borough as impaired for aquatic life use due to suspended solids from municipal point source discharges, and siltation from urban runoff and storm sewer discharges. The DEP must pinpoint the pollution sources and develop a Total Maximum Daily Load (TMDL) plan for this impaired reach of Hokendauqua Creek within 13 years of its 2010 listing, or by the year 2023.

13. In 2010, the Bertsch-Hokendauqua-Catasauqua Watershed Association conducted bacteria sampling at four sites on Hokendauqua and Indian Creeks to assess these streams for the PA Department of Environmental Protection's recreational use standards, like swimming and wading. The downstream sites at both the Hokendauqua and Indian Creek sampling points produced attaining results for recreational use; meaning that they were within the acceptable limits of bacteria. However, the upstream sites at the two sampling points on both waterways produced inconclusive results for bacteria; with one assessment at each site attaining and one impaired for recreational use. Therefore, no assessment was rendered by DEP for these two upstream sites. These same sampling sites should be tested again to conclude a final assessment for recreational use.

14. In the study area, the western half of Lehigh Township falls under the **Trout/Bertsch Creeks Watershed Act 167 Stormwater Management Plan** and the remainder of the study area—the eastern half of Lehigh Township, all of Allen and Moore Townships and Northampton Borough—falls under the **Hokendauqua Creek Watershed Act 167 Stormwater Management Plan**. At the present time, the Lehigh Valley Planning Commission and its municipal partners are in the process of updating all the Act 167 Stormwater Management Plans in Lehigh and Northampton Counties, including those for the Bertsch and Hokendauqua Creek Watersheds. When these updated stormwater management plans for the Bertsch and Hokendauqua Creek Watersheds are finally completed, each updated plan will require adoption by Northampton County. The four municipalities in the study area will then ultimately be required to adopt ordinances to implement the adopted and approved Act 167 Stormwater Management Plan updates.

15. Through the National Pollutant Discharge Elimination System (NPDES) program, municipal separate storm sewer systems (MS4s) are permitted and regulated in all four municipalities in the study area: Allen, Lehigh and Moore Townships and Northampton Borough. An MS4 is a conveyance or system of conveyances designed or used to collect or convey stormwater, including storm drains, pipes, ditches, etc. Polluted stormwater is commonly transported through MS4s, from which it is usually discharged untreated into local waterways. This NPDES

permitting mechanism is designed to prevent the discharge of polluted stormwater into local surface waters, like streams and rivers. To prevent harmful pollutants from being washed or dumped into an MS4, operators in the four townships in the study area must obtain an NPDES permit and develop a stormwater management plan of best management practices to reduce the discharge from MS4s of pollutants into waterways within the Bertsch and Hokendauqua Creek Watersheds.

16. Of the four municipalities in the study area—Allen, Lehigh and Moore Townships and Northampton Borough—only Moore Township at the present time has an approved open space plan to guide the municipality in protecting and preserving its open spaces; Allen Township is in the process of developing an open space plan. Similarly, only Moore Township has an Environmental Advisory Council to assist township supervisors with the protection and conservation of local natural resources; a farmland preservation board to assist township supervisors and farmers with preserving local farms; and a dedicated open space tax used to help preserve both open space and farmland.

17. While this Coldwater Conservation Plan for the Bertsch and Hokendauqua Creek Watersheds is the first plan developed for these watersheds focused primarily on water resources, it is not the first plan, study or effort developed or initiated for the conservation of natural resources in these two watersheds. Over the years, local, county and state governments; regional planning agencies; and community partnership organizations have conducted studies and developed many plans and initiatives for the conservation of natural resources in the study area. Municipalities and stakeholder groups in the Bertsch and Hokendauqua Creek Watersheds should work together to implement existing conservation plans and continue natural resource protection efforts.

Recommendations & Next Steps

The following recommendations of this Coldwater Conservation Plan are made as next steps for the Bertsch-Hokendauqua-Catasauqua Watershed Association (BHCWA) and its community partners to take in order to best preserve and protect the coldwater streams in the Bertsch and Hokendauqua Creek Watersheds. The first three recommendations are priorities of this plan. The remaining recommendations are in no particular order of priority, but will likely be pursued as conservation issues, public interest and organizational capacity arise, and project funding is sought after and acquired.

1. Conduct additional macroinvertebrate surveys at all stations monitored on the Bertsch, Hokendauqua and Indian Creeks in 2005, 2008 and 2011 in order to make a final determination on the appropriate Chapter 93 water quality designations at each station and its associated stream reach. Upgrades from Cold Water Fisheries (CWF) to High Quality (HQ) or Exceptional Value (EV) special protection waters classification should be made as provided by 25 PA Code,

Chapter 93, Water Quality Standards Regulations. *This task should be pursued by the Northeast Regional Office of the PA Department of Environmental Protection, in cooperation with the Northampton County Conservation District.*

2. Upgrade stream segments in the Bertsch and Hokendauqua Creek Watersheds, including the Indian Creek sub-basin of the Hokendauqua Creek Watershed, from their current Cold Water Fisheries (CWF) classification to special protection waters classification (either High Quality [HQ] or Exceptional Value [EV]) under 25 PA Code, Chapter 93, Water Quality Standards Regulations. This classification upgrade will best protect these streams from both point and nonpoint source discharges, and better control land development encroachments on stream channels in these watersheds. BHCWA, in cooperation with local municipalities and the Hokendauqua Chapter of Trout Unlimited, should support any qualifying upgrade measures as may be necessary or requested. *This task should be pursued by the Northeast Regional Office of the PA Department of Environmental Protection.*

3. BHCWA should reach out to local municipalities, businesses, industry, civic organizations, school districts and other community stakeholder groups throughout the region, and work with each one to effectively meet its mission of protecting and restoring the watersheds and water resources of eastern Lehigh and northwestern Northampton Counties. BHCWA's programming and operation goals and associated objectives and activities for achieving its mission are spelled out in the association's recently approved Strategic Plan, copies of which are available through BHCWA and the Northampton County Conservation District. BHCWA should request time on the agendas of regularly scheduled meetings of local municipalities, businesses, industry, schools and civic organizations to share its vision and mission and to nurture partnerships for accomplishing the goals and objectives in its Strategic Plan, and the recommendations in this Coldwater Conservation Plan. *This task should be pursued by the BHCWA Board of Directors, in cooperation with community stakeholder groups throughout the Bertsch-Hokendauqua-Catasauqua Watershed Region.*

4. Assess targeted stream reaches in the Bertch and Hokendauqua Creek Watersheds to determine their candidacy as Class A Wild Trout Streams. Class A Wild Trout Streams are defined by the PA Fish & Boat Commission (PFBC) as streams that support a population of wild, naturally reproducing trout of sufficient size and abundance to support a long term and rewarding sport fishery. The PFBC does not stock these streams. Class A Wild Trout Stream status can afford special protection waters designation, like High Quality (HQ), by the PA Department of Environmental Protection to waterways so designated by PFBC. *This task should be pursued by the Southeast Regional Fisheries Management Area Office of PFBC, in cooperation with the Northampton County Conservation District.*

5. Utility line corridors should be monitored for exotic and invasive plant species. Any and all occurrences of such species should be promptly treated using

acceptable best management practices. *This task should be pursued by Allen and Lehigh Township supervisors and the Moore Township Environmental Advisory Council, the Bertsch-Hokendauqua-Catasauqua Watershed Association and utility companies.*

6. Protect wetlands and forested riparian lands in the study area through municipal tools, like zoning ordinances, subdivision and land development ordinances and official map ordinances. Municipal officials should consider the Lehigh Valley Planning Commission's Riparian and Wetland Buffers Model Regulations as a guide. Technical Assistance is available from the Lehigh Valley Planning Commission. *This task should be pursued by Allen, Lehigh and Moore Township supervisors, with assistance from the Moore Township Environmental Advisory Council.*

   An educational campaign on the value of wetlands and forested riparian buffers for protecting and improving water quality should first be developed and implemented throughout the region, targeting municipal officials, riparian landowners and the general public. Technical Assistance for educational program development is available through the Northampton County Conservation District. Potential funding sources for such educational outreach include the Water Resources Education Network, Lehigh Valley Greenways Landscape Conservation Initiative, PA Association of Conservation Districts, PA Department of Environmental Protection Environmental Education Grants Program and others. *This task should be pursued by BHCWA in partnership with the Northampton County Conservation District.*

7. Protect the five greenways in the study area that have been identified in the Lehigh Valley Greenways Plan, and the five natural areas in the study area that have been identified in the Lehigh and Northampton County Natural Areas Inventory through municipal tools, like zoning ordinances, subdivision and land development ordinances and official map ordinances. Technical Assistance is available from the Lehigh Valley Planning Commission. *This task should be pursued by Allen, Lehigh and Moore Township supervisors, with assistance from the Moore Township Environmental Advisory Council.*

8. Where feasible, work with private landowners (local residents and businesses) and public landowners (local governments) to enhance and restore riparian buffers along local streams by planting native vegetation to filter stormwater runoff and improve water quality. Identify sites in need of riparian buffer restoration and reach out to appropriate landowners to work with them to expand existing riparian buffers or replant riparian areas that have been cleared of vegetation, like utility line stream crossings. Potential funding sources include the PA Growing Greener Grants Program, Lehigh Valley Greenways Conservation Landscape Initiative, Coldwater Heritage Partnership, private utility companies and others. *This task should be pursued by BHCWA in cooperation with local residents, businesses and governments.*

9. Where feasible, work with private landowners (local residents and businesses) and public landowners (local governments) to stabilize and restore eroding streambanks in order to reduce in-stream and stream bed siltation. Identify eroding streambanks and reach out to appropriate landowners to work with them to stabilize and restore these sites using structural and bioengineering best management practices. Re-grade eroding streambanks, where feasible, to create shallow vegetated banks to add additional floodplain capacity. Technical Assistance is available through the PA Fish & Boat Commission and the Northampton County Conservation District. Potential funding sources include the Pennsylvania Growing Greener Grants Program, Lehigh Valley Greenways Conservation Landscape Initiative, Coldwater Heritage Partnership and other sources. *This task should be pursued by BHCWA, in cooperation with private landowners and local municipalities.*

10. Work with local farmers and the Lehigh Valley District Office of the Natural Resources Conservation Service (NRCS) to identify farms most in need of agricultural best management practices (Ag BMPs) to control soil erosion and water pollution, and design and implement appropriate Ag BMPs to reduce stormwater and nutrient runoff, and protect surface waters from livestock impacts. Depending on site conditions, constructing manure storage facilities, planting cover crops or installing streambank fencing or stabilized livestock stream crossings could be appropriate Ag BMPs. Technical Assistance is available through NRCS. Potential funding sources for developing and implementing Ag BMP projects include the U.S. Department of Agriculture, PA Growing Greener Grants Program, PA Infrastructure Investment Authority and others. *This task should be pursued by the Northampton County Conservation District and NRCS.*

11. Conduct a stormwater basin survey to identify commercial, industrial, residential and other sites that have outdated or inadequate stormwater best management practices in place to effectively manage and treat water entering streams during storm events. The survey should then be used to develop watershed wide stormwater retrofit plans to reconstruct or modify existing stormwater basins, where presently uncontrolled runoff would be treated and infiltrated into the ground. Stormwater retrofits can also significantly improve the quality of stormwater as well, by planting wetland vegetation in stormwater basins that uptake water and help remove pollutants. Potential funding sources for retrofitting stormwater basins include the PA Growing Greener Grants Program, PA Infrastructure Investment Authority and others. *This task should be pursued by BHCWA, in cooperation with local municipalities and the Northampton County Conservation District.*

12. Support the Atlas Dam Removal & Fish Passage Project on Hokendauqua Creek in the Borough of Northampton. The removal or partial breaching of the 600-foot wide, 12-foot high obsolete dam will restore fish passage to the upper 25 miles of stream on Hokendauqua and Indian Creeks. It will also enhance the existing coldwater fishery through improved aquatic habitat, water quality and water

temperatures. Technical Assistance is available through American Rivers and the Open Rivers Initiative. *This task should be pursued by the Atlas Dam property owner, the Borough of Northampton, project applicants and permitting agencies.*

13. Work with municipal and state road departments to identify road-stream crossings and roadside ditches draining to streams and gullies that accelerate runoff to waterways, and design and implement best management practices (BMPs) to protect surface waters from road discharges, which can cause erosion and carry sediment and road-associated chemicals, like spills, oil and salt, directly to stream channels. Depending on site conditions, the use of curbing, berms, check dams in vegetated ditches, geotextile on vegetated embankments, or raising roadbeds or realigning ditches to drain onto forestland, where stormwater can infiltrate before reaching a stream, could be appropriate BMPs. Potential funding sources include the PA Growing Greener Grants Program, PA Department of Transportation (PA DOT), municipalities and other sources. *This task should be pursued by BHCWA, in cooperation with local municipalities and PA DOT.*

14. Using geographic information systems (GIS) software and present and historical aerial photography, estimate the percent of impervious surface cover (roads, parking lots, buildings, etc.) in the Bertsch and Hokendauqua Creek Watersheds for current reference data and for future land use planning efforts. Sources vary as to the exact figure, but there is general agreement that when a watershed reaches certain threshold percentages of impervious surface cover, the quality of local streams declines rapidly. At approximately 10% impervious cover, streams tend to loose sensitive aquatic organisms. At about 20-30% impervious cover, most stream indicators drop to poor conditions, and this percent of impervious cover is generally recognized as a critical threshold for impairment. Residential populations in the study area are projected to increase by 70% by 2030. Knowing the percent of impervious surface area in the Bertsch and Hokendauqua Creek Watersheds will allow municipal managers to make informed decisions about what types of future land development may negatively impact water quality. *This task should be pursued by municipal planners in all four municipalities in the study area: Allen, Lehigh and Moore Townships and Northampton Borough.*

15. Develop a Watershed Conservation Management Plan for the Bertsch and Hokendauqua Creek Watersheds to assess the past and present state of the watersheds' natural resources, and to provide a comprehensive, inter-municipal approach to conserving and improving the Bertsch and Hokendauqua Creeks, their tributaries and landscapes. This plan should include an inventory of existing natural resources; analysis of the issues, concerns and threats to watershed resources; and specific recommendations that set forth priorities and actions leading to the development of a long-term, prioritized Watershed Management Program. Products of this planning project should include extensive geographic information systems (GIS) mapping and a database, a prioritized list of watershed problem areas and extensive water quality data. The Watershed Management Plan should be developed by a professional planner experienced in developing

watershed conservation plans. Potential funding sources include the PA Growing Greener Grants Program, the U.S. Environmental Protection Agency and others. *This task should be pursued by BHCWA, in cooperation with local municipalities.*

16. Develop a Wellhead Protection Program Plan for each of the four public water systems in the study area: the Lehigh Township Municipal Authority, Whispering Hollow Mobile Home Park in Allen and Moore Townships, Mountainview Mobile Home Park in Lehigh Township and Heritage Village Mobile Home Park in Lehigh Township. These plans can be developed through the PA Source Water Protection Program, which is administered through the PA Department of Environmental Protection (DEP). Through the program, DEP conducts assessments of the susceptibility of public water systems water sources to potential sources of contamination. The purpose of conducting the assessments is to educate the public and promote the development of local, voluntary source water protection plans and programs. DEP offers a variety of support for municipalities, water suppliers and the public to develop these local source water protection program plans. *This task should be pursued by the owners of the four public water systems in the study area, in cooperation with DEP.*

17. Work in cooperation with municipal and state road departments to purchase and install stream identification signs at targeted road-stream crossings in the Bertsch and Hokendauqua Creek Watersheds. The signs will provide visual identification of local waterways so residents become more aware of, connected to and concerned about their local streams. Potential funding sources include the PA Southeastern Resource Conservation & Development Council, PA Department of Transportation (PA DOT) and others. *This task should be pursued by BHCWA, in cooperation with local municipalities and PA DOT.*

18. Allen Township should consider and Lehigh Township should reconsider forming an Environmental Advisory Council (EAC) to assist township supervisors and planners with the protection, conservation, management, promotion and use of local natural resources. Both Township EACs would naturally work with the established and neighboring Moore Township EAC, which was formed in 2010, to protect the water quality and natural resources of the Hokendauqua Creek Watershed, which encompasses the majority of and is shared by all three municipalities. The PA Environmental Council produced **The EAC Handbook: A Guide for PA's Environmental Advisory Councils** as a resource for municipal leaders who seek to establish EACs in their communities. Technical Assistance is available through the Lehigh Valley Planning Commission and the EAC Network of the PA Environmental Council. *This task should be pursued by Allen and Lehigh Township supervisors, with support from the Moore Township Board of Supervisors and its EAC.*

19. Northampton Borough should establish an Environmental Advisory Council (EAC) to assist the borough's mayor, manager, councilmembers and planners with the protection, conservation, management, promotion and use of natural

resources in the borough's reach of the Hokendauqua Creek Watershed. The PA Environmental Council produced **The EAC Handbook: A Guide for PA's Environmental Advisory Councils** as a resource for municipal leaders who seek to establish EACs in their communities. Technical Assistance is available through the Lehigh Valley Planning Commission and the EAC Network of the PA Environmental Council. *This task should be pursued by the Northampton Borough Council, with support from established urban EACs, like those in the Cities of Easton or Bethlehem.*

20. Northampton Borough and Allen, Lehigh and Moore Townships should adopt the most feasibly stringent stormwater management regulations as part of each municipality's Act 167 Stormwater Management Plan to control stormwater runoff from new development in order to protect local streams, residents and businesses from water quality and water quantity degradation, as well as from downstream flooding. Technical Assistance is available from the Lehigh Valley Planning Commission and the PA Department of Environmental Protection. *This task should be pursued by local municipal officials.*

21. Northampton Borough and Allen, Lehigh and Moore Townships should work toward full compliance with the requirements of the MS4 Program to develop and implement a stormwater management program of best management practices to reduce the discharge of pollutants into local waterways from each municipality's regulated municipal separate storm sewer system (MS4). Technical Assistance is available from the PA Department of Environmental Protection. *This task should be pursued by local municipal officials.*

22. Allen, Lehigh and Moore Townships should conduct a comprehensive review of their zoning and land development ordinances, and update these local land use regulations to ensure maximum protection of each municipality's natural resources, and particularly in the case of Lehigh and Moore Township, the forest and water resources on the wooded slopes of Blue Mountain, in the headwater reaches of the Bertsch and Hokendauqua Creek Watersheds. For Moore Township, which is a member of the Nazareth Area Council of Governments, ordinance changes should be consistent with the Nazareth Area Multimunicipal Comprehensive Plan. *A professional, certified planner should conduct this review for each municipality and develop a report of findings, with detailed recommendations and sample ordinances to illustrate the recommended changes.*

23. Lehigh and Moore Townships should adopt ordinances protecting the Appalachian Trail as required under the PA Appalachian Trail Act, which would not only preserve the trail corridor as a natural and recreational resource along the spine of Blue Mountain, but would also serve to protect the headwater springs, streams, wetlands and woodlands in the uppermost reaches of both the Bertsch and Hokendauqua Creek Watersheds on the slopes of Blue Mountain. For municipal guidance on the subject, the PA Department of Community & Economic Development produced an **Appalachian Trail Conservation**

Guidebook and Implementation Program, with model regulations and suggested municipal strategies for protecting the Appalachian Trail and natural resources within the trail corridor. And the Lehigh Valley Planning Commission produced a handbook titled **Protect the Trail: A Guide to Protecting the Appalachian Trail for Lehigh Valley Municipalities**, which also provides guidance to this end. Technical Assistance is available through the PA Department of Community & Economic Development and the Lehigh Valley Planning Commission. *This task should be pursued by Lehigh and Moore Township supervisors, with assistance from the Moore Township Environmental Advisory Council.*

24. Allen, Lehigh and Moore Townships should adopt an Official Map Ordinance and establish an Official Map that includes all the stream corridors and riparian woodlands throughout each municipality, as well as other environmentally sensitive natural resources and conservation areas of concern; like the Blue Mountain, Bertsch Creek, Indian Creek and Hokendauqua Creek Greenways, and the Bertsch Creek Seep, Blue Mountain, Neff's Pond, Little Gap and Walnutport Canal Site Natural Areas. An Official Map greatly increases the likelihood that key conservation resources will be protected by enabling municipalities to reserve them for conservation purposes, without having to immediately commit to purchasing them. The PA Land Trust Association, PA Department of Transportation, PA Department of Conservation & Natural Resources and the PA Department of Community & Economic Development produced a handbook titled **The Official Map: A Handbook for Preserving and Providing Public Lands & Facilities** as a resource for municipal leaders who seek to establish an Official Map. *This task should be completed by Allen, Lehigh and Moore Township supervisors, with assistance from Moore Township and its Environmental Advisory Council (EAC), and neighboring Bushkill Township and its long-established EAC, which has had an Official Map since 2005.*

25. Lehigh Township should develop an Open Space Plan—like Allen Township is presently doing and like Moore Township already has done—to guide the municipality in protecting and preserving its green infrastructure, like waterways, woodlands, farmlands, wildlife habitat, parks, recreation areas, trails and greenways, which is as important to the economic future of a community as is planning for schools, roads, drinking water and wastewater infrastructure. Open space plans are one more tool these municipalities can use to conserve and enhance the natural resources of the Bertsch and Hokendauqua Creek Watersheds. Potential funding sources to develop open space plans include the PA Department of Conservation & Natural Resources, Lehigh Valley Greenways Conservation Landscape Initiative and others. *A professional, certified planner experienced in developing municipal open space plans should work with township supervisors to develop these plans, spelling out where, why and how open space will be protected.*

26. Where feasible, Allen, Lehigh and Moore Townships should procure from willing landowners, private property parcels along streams (especially headwater streams), greenways (Blue Mountain, Bertsch Creek, Indian Creek and Hokendauqua Creek Greenways) and natural areas (Bertsch Creek Seeps, Blue Mountain, Neff's Pond, Little Gap and Walnutport Canal Site Natural Areas) as public open space, either through fee simple purchases or conservation easements. Preserving these environmentally sensitive areas as open space will further protect local natural resources and water quality in Allen, Lehigh and Moore Townships. Potential funding sources include the Northampton County and Moore Township Open Space Programs, PA Department of Conservation & Natural Resources and others. *This task should be pursued by Allen, Lehigh and Moore Township supervisors, in cooperation with the Northampton County Open Space Program and with partners from the Lehigh Valley Greenways Conservation Landscape Initiative.*

27. Allen, Lehigh and Moore Township officials should actively promote the Northampton County Farmland Preservation Program to farmers in designated Agricultural Security Areas in their municipalities. Preserved farmland can help protect rural municipalities from future development. Presently, 13 farms totaling nearly 1,156 acres have been permanently preserved in the Bertsch and Hokendauqua Creek Watersheds. *This task should be pursued by Allen and Lehigh Township supervisors, and by Moore Township supervisors and its farmland preservation board.*

28. Conduct bacteria sampling on the Bertsch, Hokendauqua and Indian Creeks for the purposes of assessing these streams for the PA Department of Environmental Protection's (DEP) Recreational Use Standards, like swimming, wading, boating and fishing. Water samples taken on Hokendauqua and Indian Creeks by BHCWA on behalf of DEP in 2010 produced inconclusive results for bacteria, with one sampling location on each stream producing geometric means for fecal coliforms that varied on assessments, with one assessment at each site attaining and one impaired for recreational use. These same sampling sites on Hokendauqua and Indian Creeks should be tested again to conclude a final assessment for recreational use. Additionally, sampling sites on Bertsch Creek should also be identified and tested for bacteria, including sites immediately upstream and downstream of the Danielsville Wastewater Treatment Plant. *This task should be pursued by BHCWA in coordination with DEP, which provides technical assistance, training and supplies.*

29. The PA Department of Environmental Protection (DEP) must develop a TMDL (Total Maximum Daily Load) plan by 2023 to address water quality impairment issues on Hokendauqua Creek. A TMDL is the calculation of how much pollution loading needs to be decreased so that a waterway can meet the water quality standards appropriate for its designated use. In 2010, DEP listed a 5.36-mile reach of Hokendauqua Creek in Northampton Borough as impaired for aquatic life use due to suspended solids and siltation from municipal point source and urban

runoff and storm sewer discharges. This TMDL is scheduled to be completed within 13 years of the 2010 impairment listing, or by 2023. *This task should be pursued by DEP, in cooperation with Northampton Borough Council and other community stakeholder groups in the Hokendauqua Creek Watershed.*

Maps

MAP 1
AERIAL PHOTO
- 2010 -

Bertsch/Hokendauqua Creek Watershed Boundaries

Major Roads

Minor Roads

Other Roads

Municipal Boundaries

Streams

N

0 5,250 10,500 Feet

Source: Lehigh Valley Planning Commission, 2010

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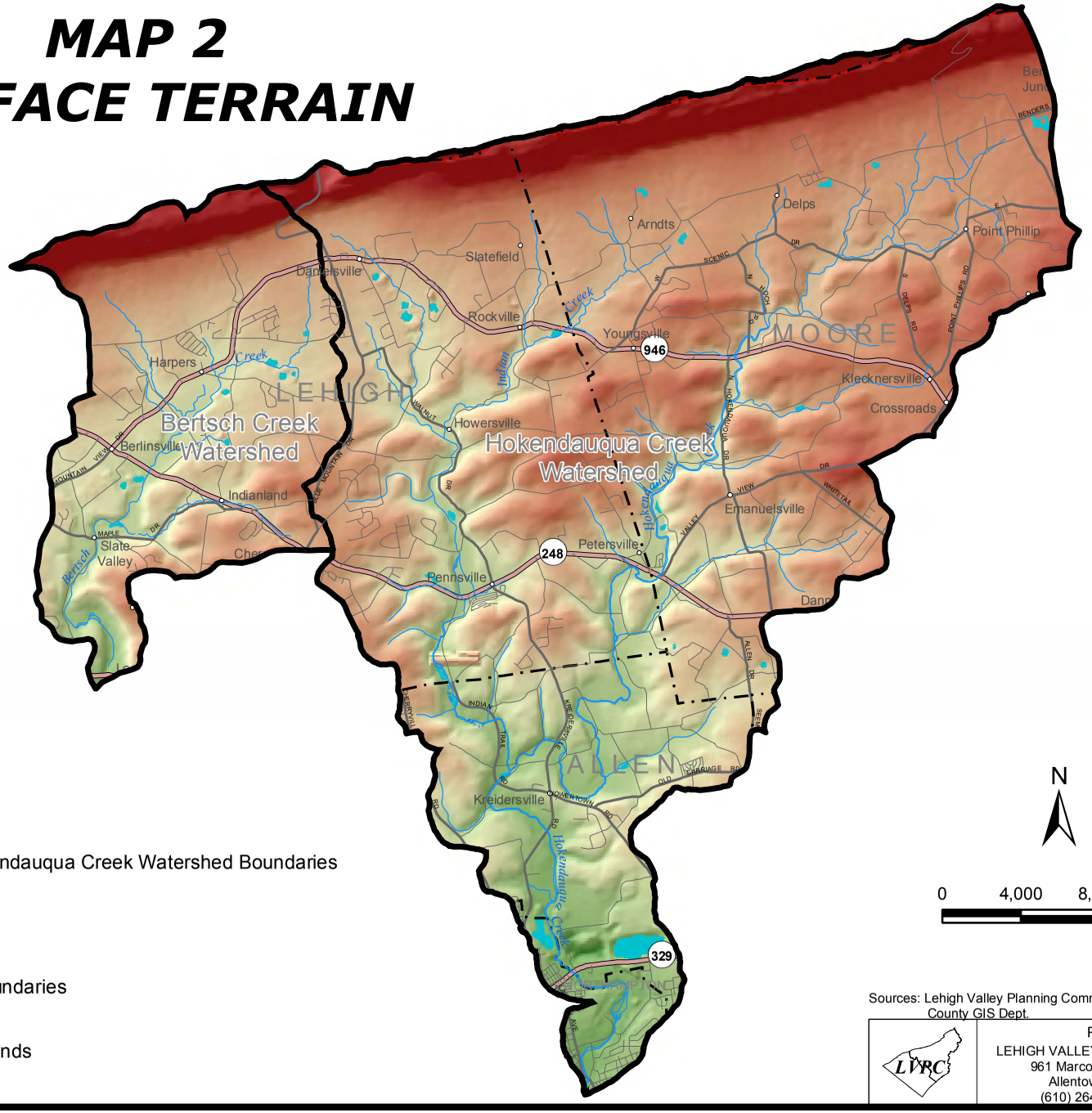
MAP 2
SURFACE TERRAIN



Elevation

- High
- Low

- Bertsch/Hokendauqua Creek Watershed Boundaries
- Major Roads
- Minor Roads
- Other Roads
- Municipal Boundaries
- Streams
- Lakes and Ponds

N

0 4,000 8,000 12,000 Feet

Sources: Lehigh Valley Planning Commission, 2005; Northampton County GIS Dept.

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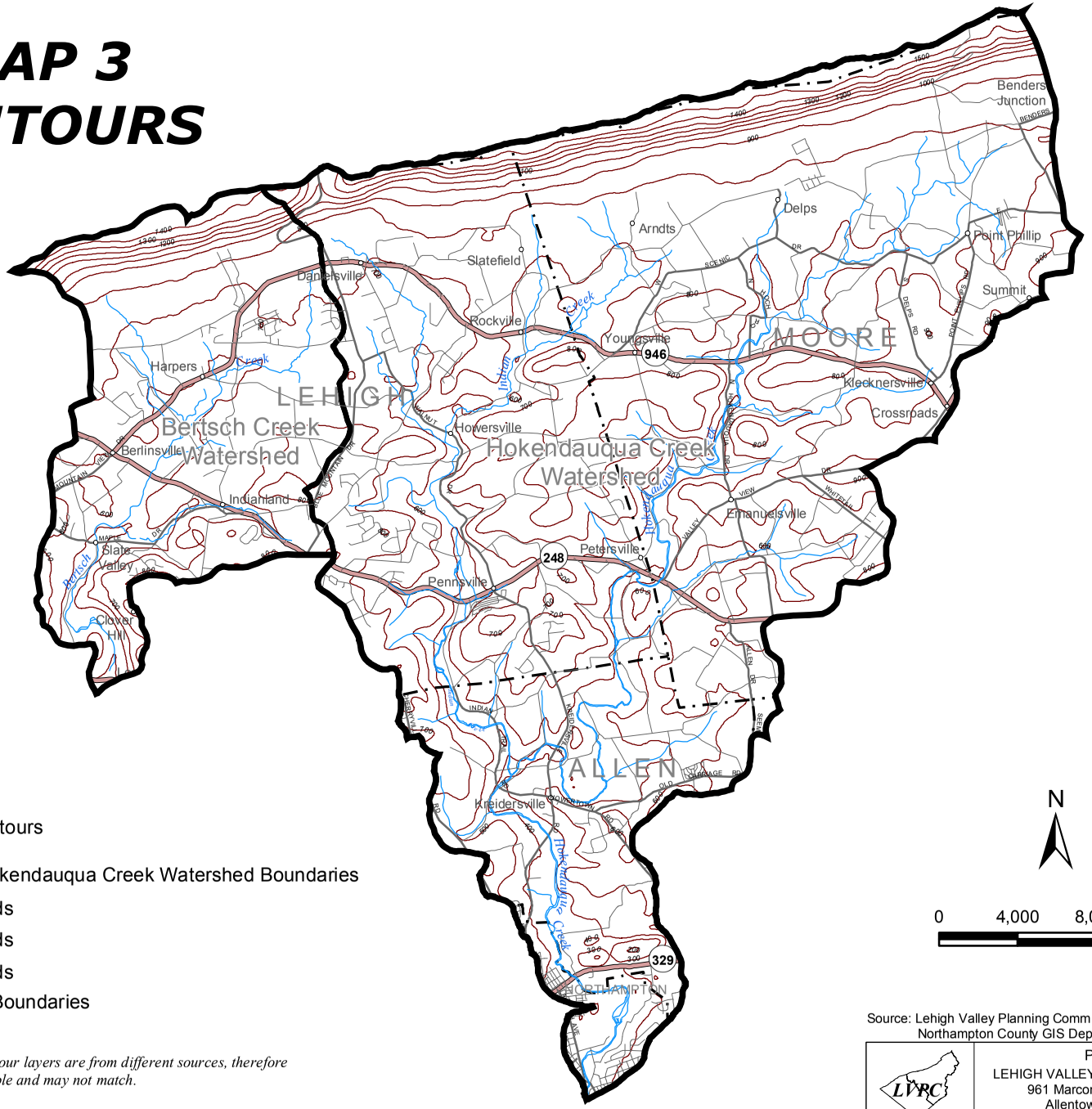
MAP 3
CONTOURS



Elevation

- 100 ft. Contours
- Bertsch/Hokendauqua Creek Watershed Boundaries
- Major Roads
- Minor Roads
- Other Roads
- Municipal Boundaries
- Streams

**The streams and the contour layers are from different sources, therefore they are not fully compatible and may not match.*

N

0 4,000 8,000 12,000 Feet

Source: Lehigh Valley Planning Commission; USGS DEMs, 2000; Northampton County GIS Dept.

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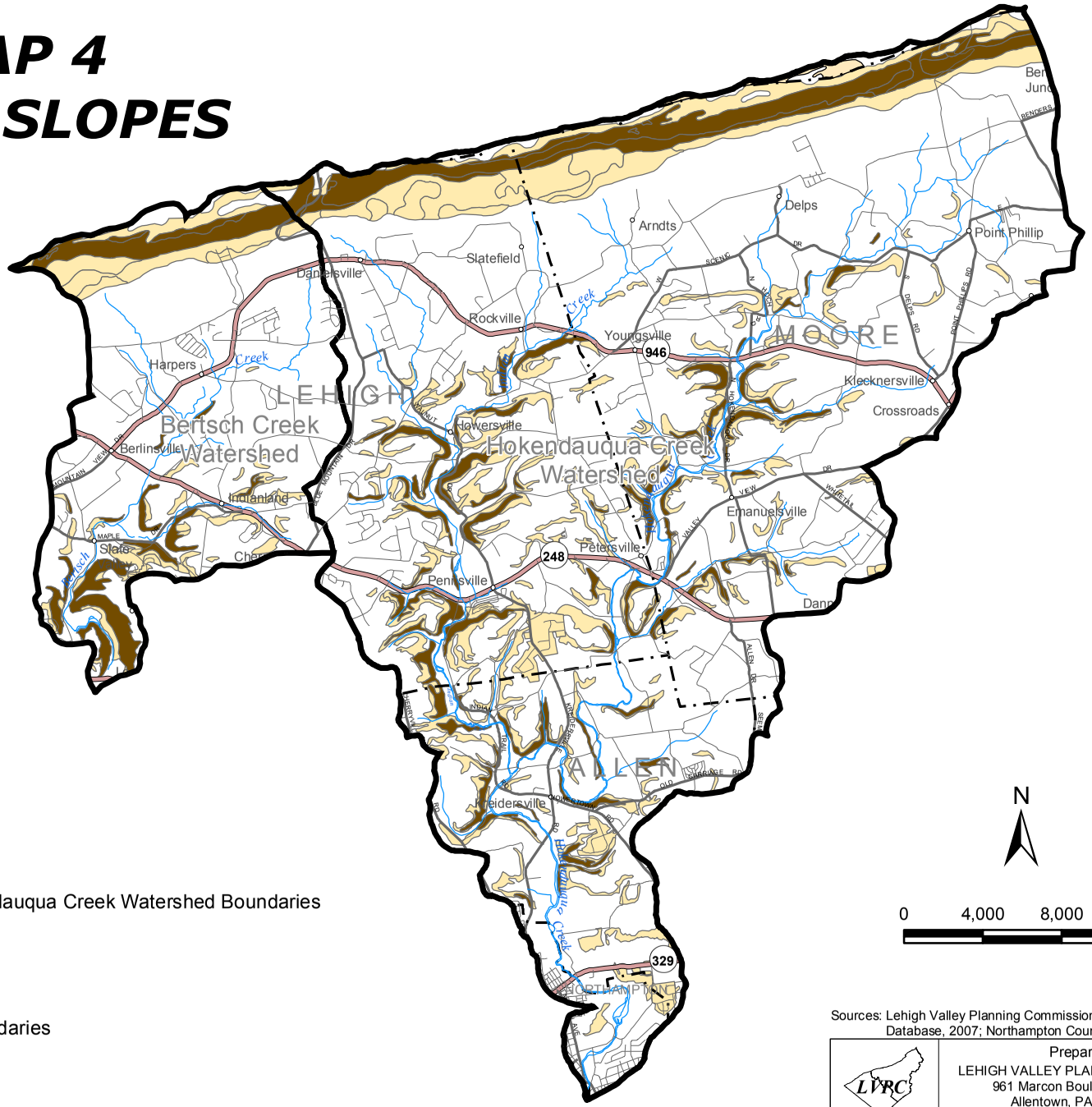
MAP 4
STEEP SLOPES



SLOPE

- 15 - 25% Slope
- > 25% Slope
- Bertsch/Hokendauqua Creek Watershed Boundaries
- Major Roads
- Minor Roads
- Other Roads
- Municipal Boundaries
- Streams

N

0 4,000 8,000 12,000 Feet

Sources: Lehigh Valley Planning Commission; NRCS, SSURGO Database, 2007; Northampton County GIS Dept.

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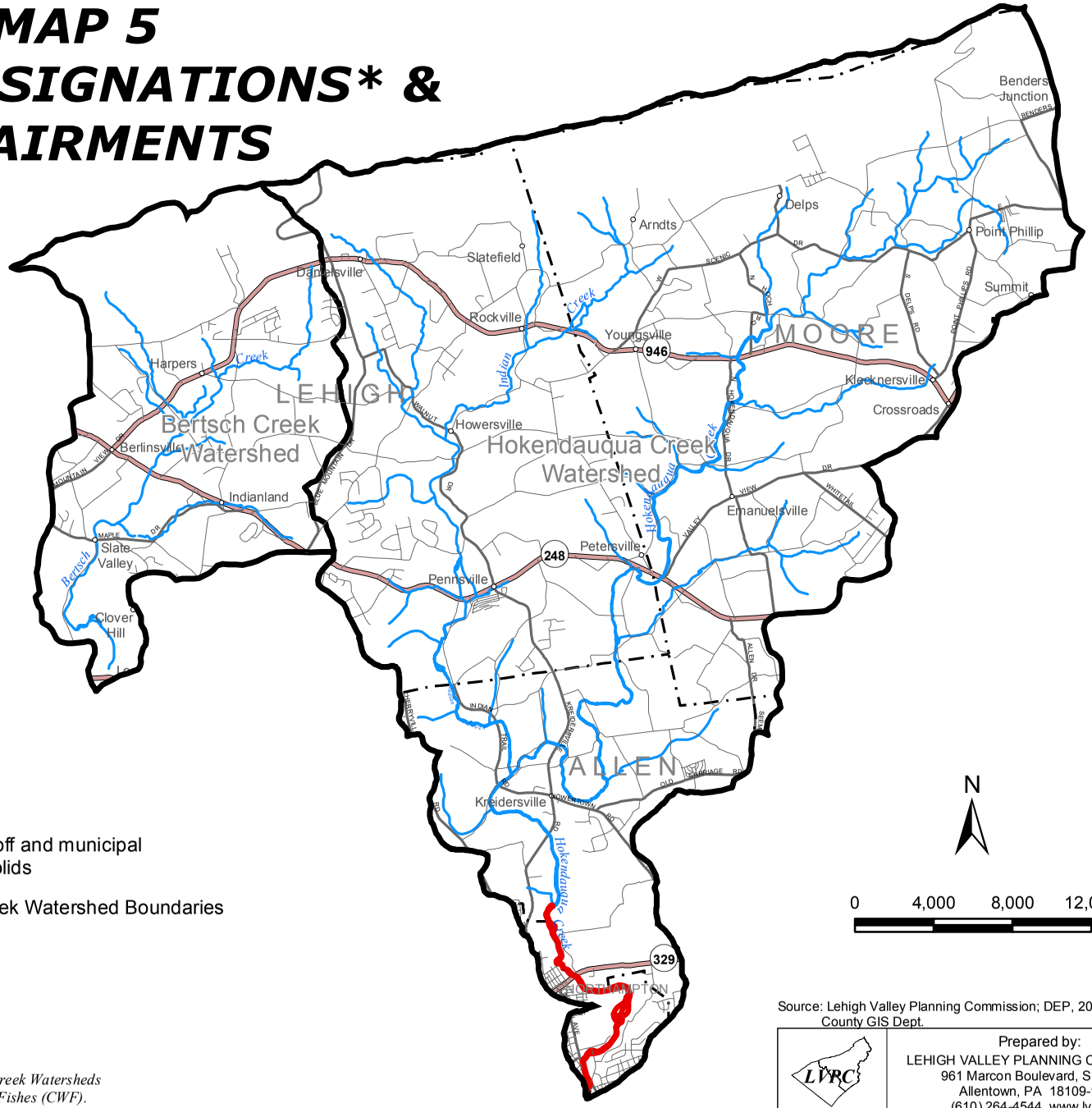
MAP 5
STREAM DESIGNATIONS* & IMPAIRMENTS



- Not Impaired
- Impaired due to urban runoff and municipal point source/suspended solids
- Bertsch/Hokendauqua Creek Watershed Boundaries
- Major Roads
- Minor Roads
- Other Roads
- Municipal Boundaries

**All streams in the Bertsch and Hokendauqua Creek Watersheds have a DEP Stream Designation of Cold Water Fishes (CWF).*

Source: Lehigh Valley Planning Commission; DEP, 2010; Northampton County GIS Dept.

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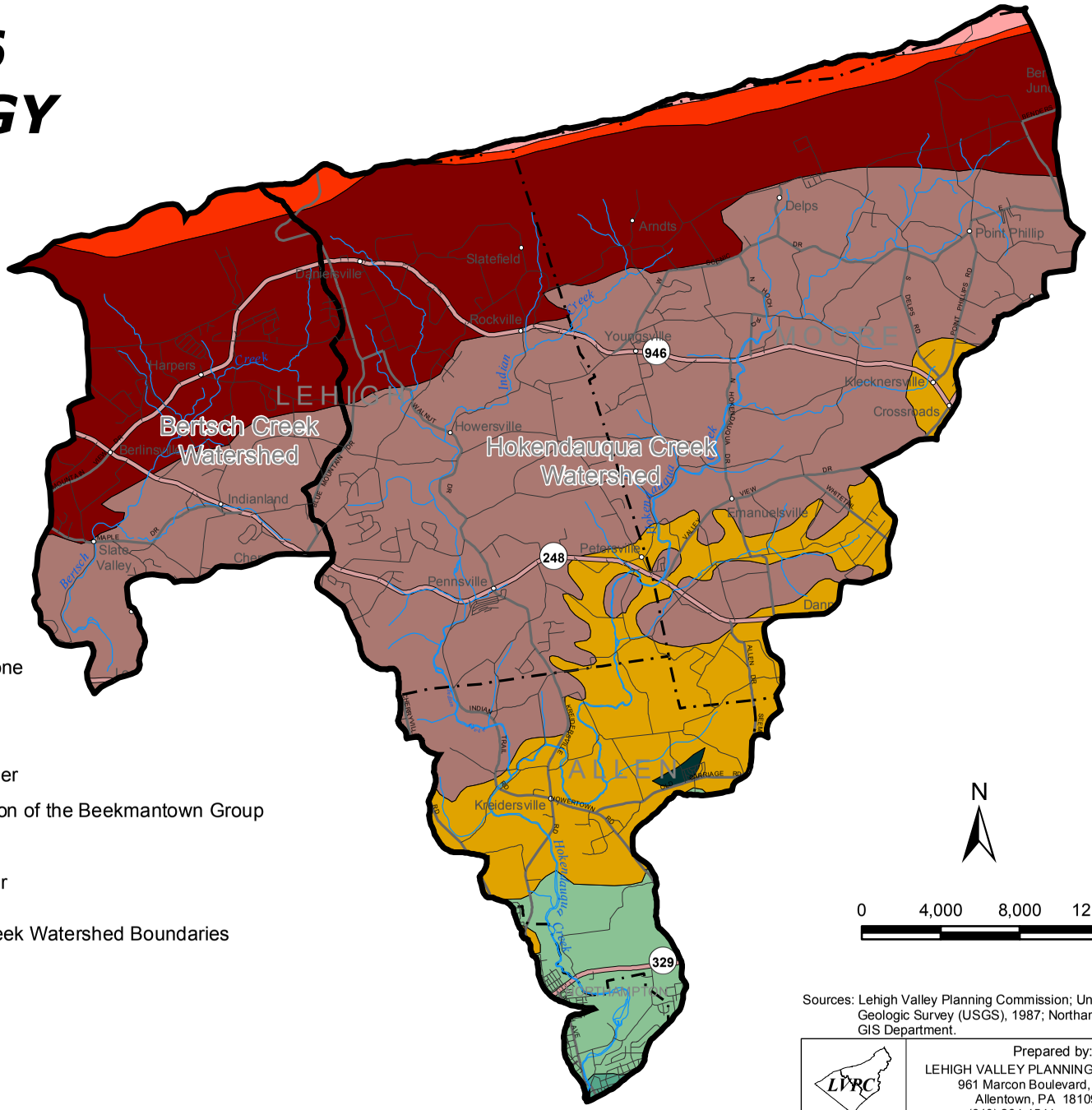
MAP 6
GEOLOGY



- (OCa) Allentown Dolomite
- (Oj) Jacksonburg Limestone
- (Omb) Bushkill Member
- (Omp) Pen Argyl Member
- (Omr) Ramseyburg Member
- (Oo) Ontelaunee Formation of the Beekmantown Group
- (SOswm) Minsi Member
- (Ssl) Lizard Creek Member

- Bertsch/Hokendauqua Creek Watershed Boundaries
- Major Roads
- Minor Roads
- Other Roads
- Municipal Boundaries
- Streams

N

0 4,000 8,000 12,000 Feet

Sources: Lehigh Valley Planning Commission; United States Geologic Survey (USGS), 1987; Northampton County GIS Department.

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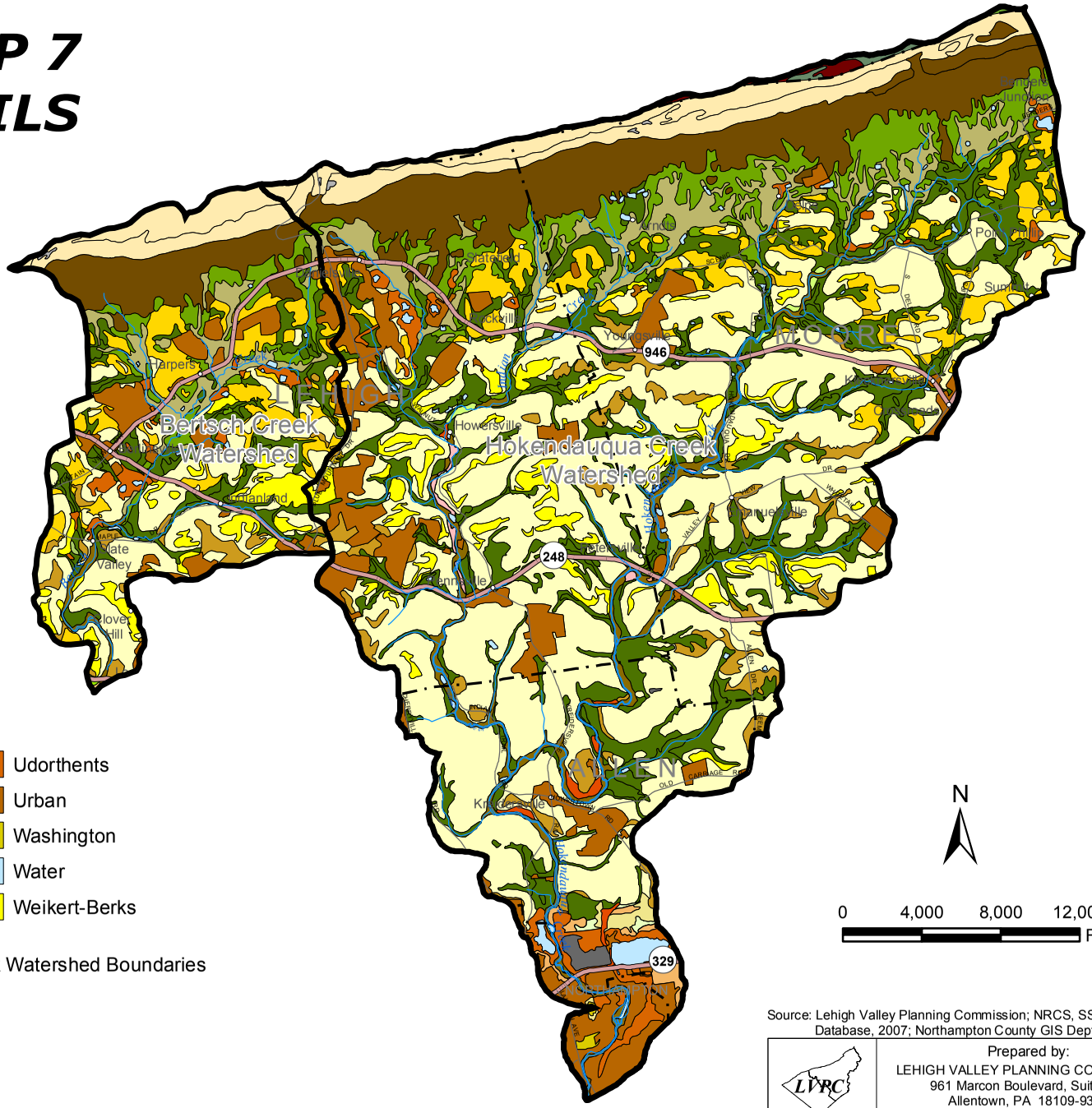
MAP 7
SOILS



- Allenwood
- Andover-Buchanan
- Bedington-Berks
- Berks-Weikert
- Brinkerton-Comly/Comly
- Buchanan
- Chippewa
- Clarksburg
- Conotton
- Delaware
- Duffield/Duffield-Ryder
- Gibraltar
- Hazleton/Hazleton-Rubble
- Holly
- Laidig/Laidig-Rubble
- Middlebury
- Phelps
- Quarries
- Red Hook
- Rubble
- Ryder-Duffield
- Udorthents
- Urban
- Washington
- Water
- Weikert-Berks

- Bertsch/Hokendauqua Creek Watershed Boundaries
- Major Roads
- Minor Roads
- Municipal Boundaries
- Streams

Source: Lehigh Valley Planning Commission; NRCS, SSURGO Database, 2007; Northampton County GIS Dept.

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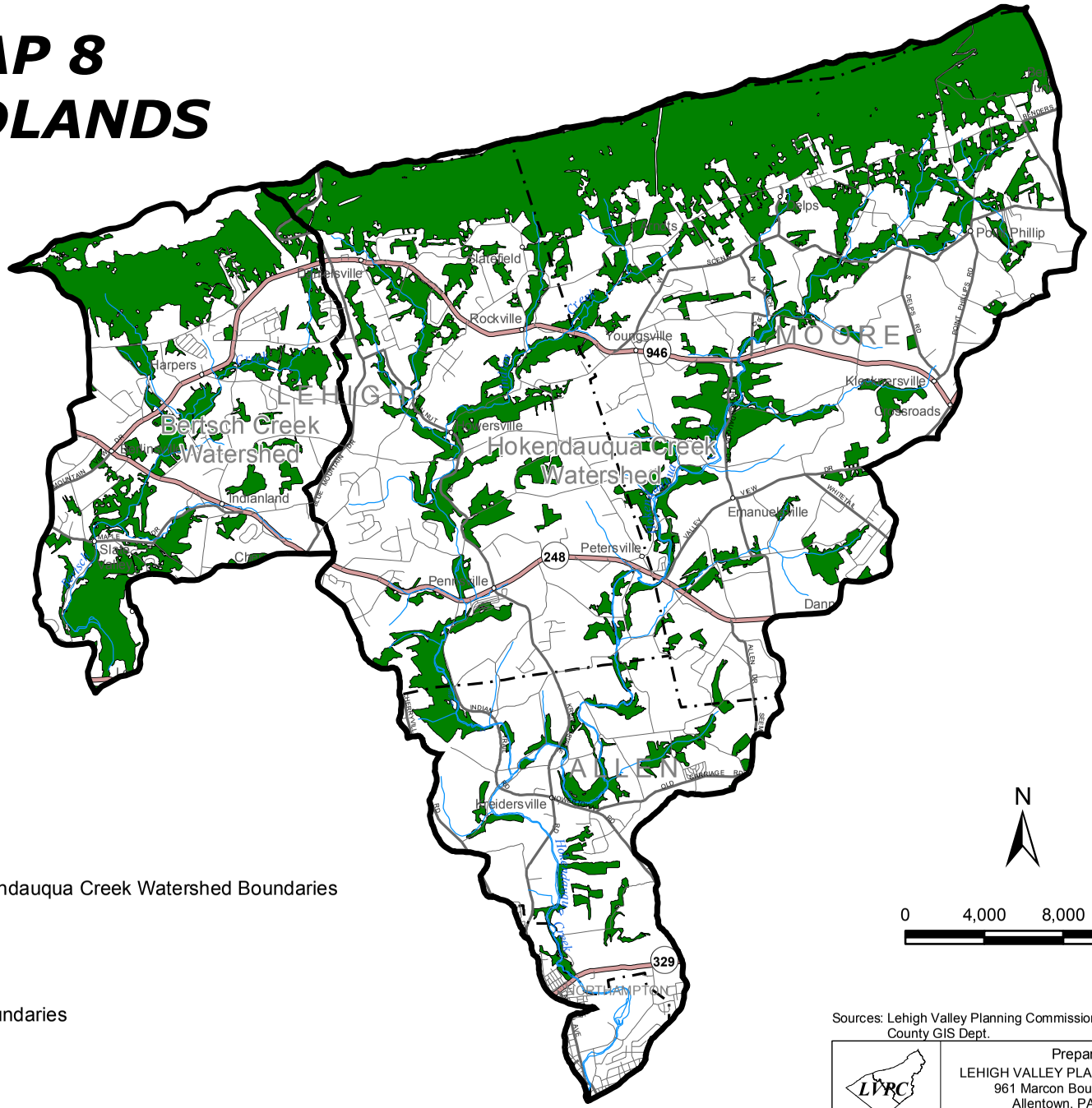
MAP 8
WOODLANDS



Woodlands

Bertsch/Hokendauqua Creek Watershed Boundaries

Major Roads

Minor Roads

Other Roads

Municipal Boundaries

Streams

Sources: Lehigh Valley Planning Commission, 2010; Northampton County GIS Dept.

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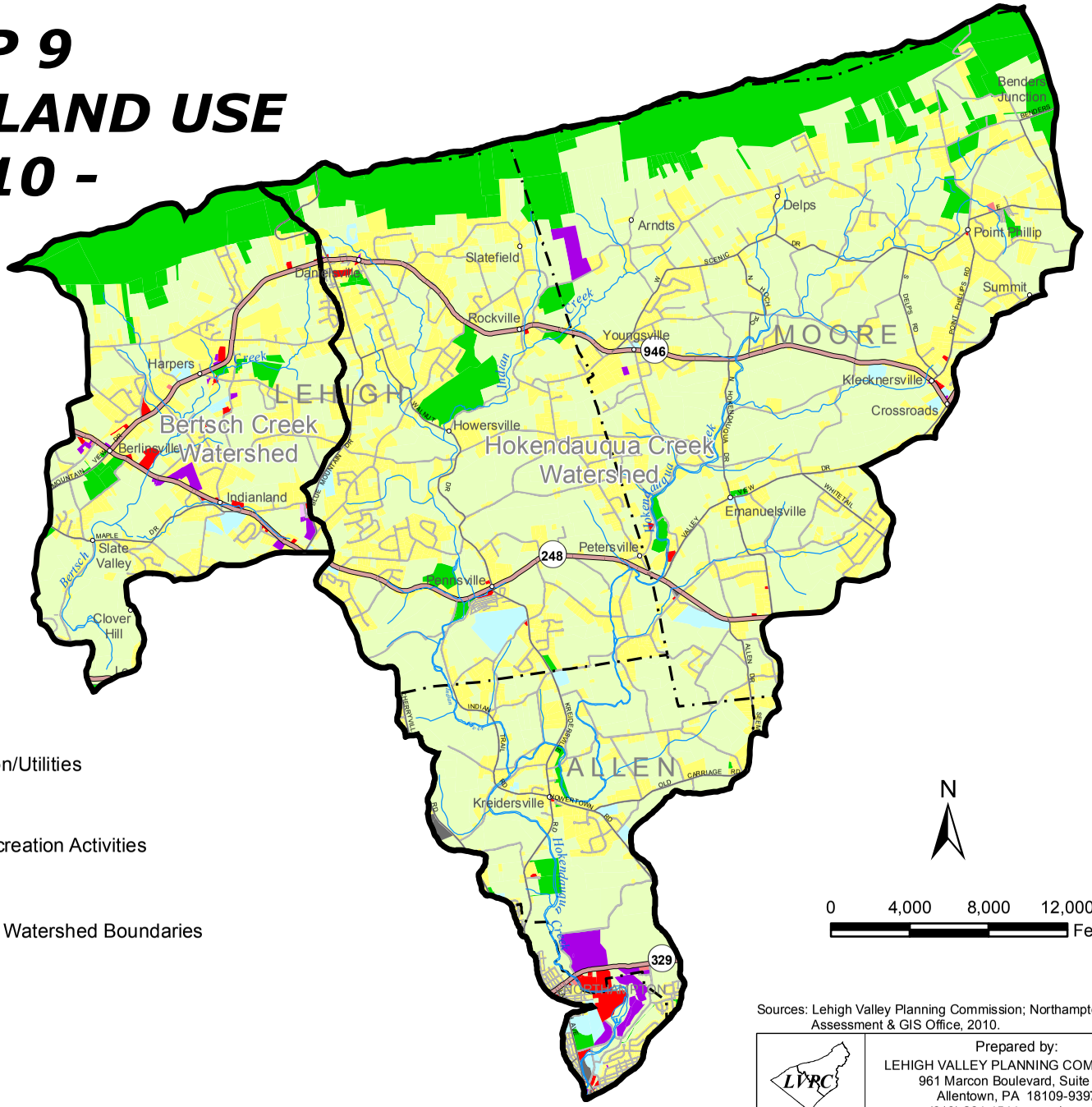
MAP 9
EXISTING LAND USE
- 2010 -



- Residential
- Retail/Commercial
- Manufacturing/Industrial
- Warehousing/Distribution
- Offices
- Transportation/Communication/Utilities
- Public/Quasi-Public
- Parks and Other Outdoor Recreation Activities
- Agricultural & Vacant
- Bertsch/Hokendauqua Creek Watershed Boundaries
- Major Roads
- Minor Roads
- Other Roads
- Municipal Boundaries
- Streams

N

0 4,000 8,000 12,000 Feet

Sources: Lehigh Valley Planning Commission; Northampton County Assessment & GIS Office, 2010.

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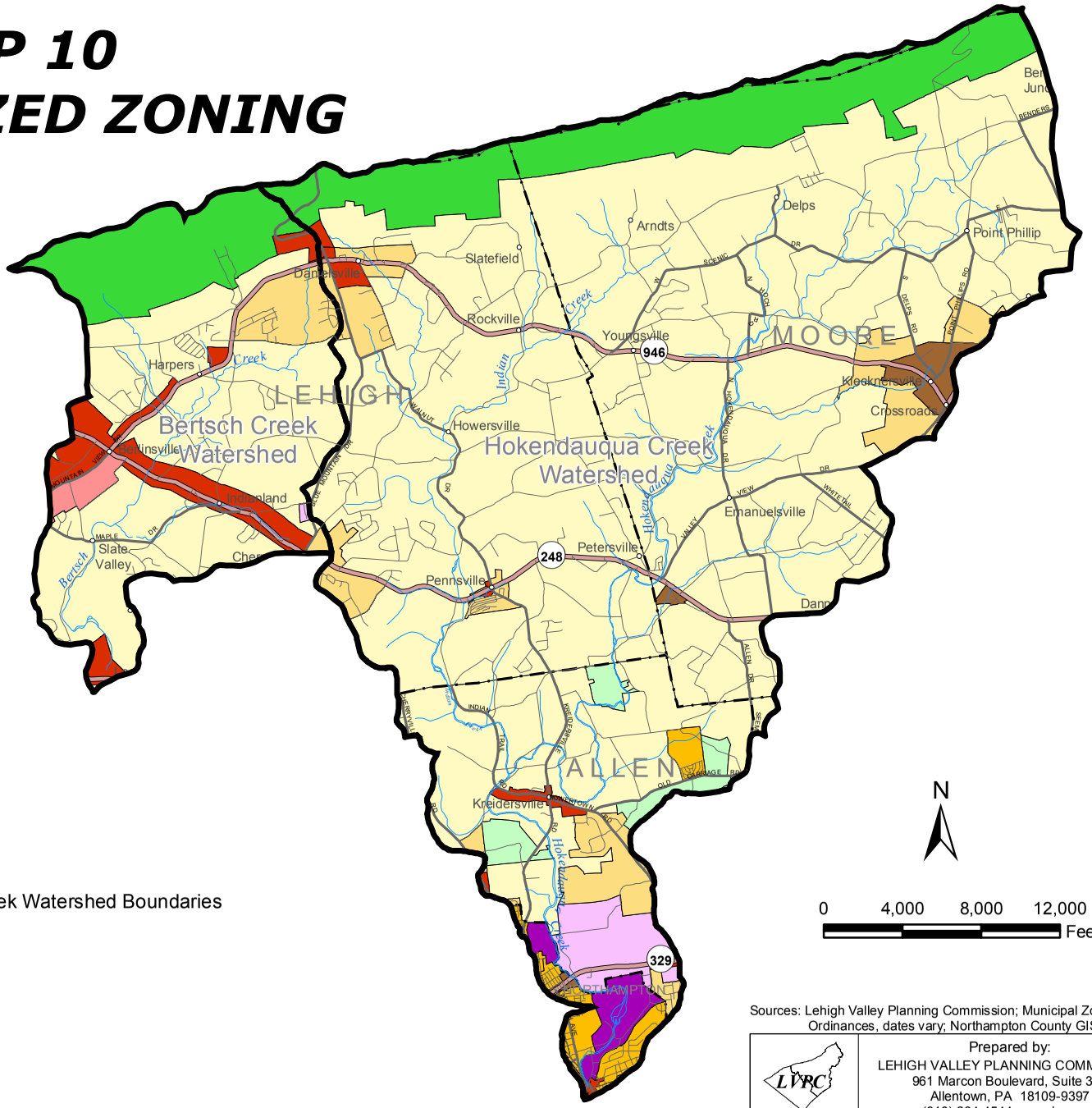
MAP 10
GENERALIZED ZONING



- Agricultural Preservation
- Environmental Protection
- Rural
- Suburban Residential
- Urban Residential
- Office/Business
- Retail Commercial
- Mixed Use
- Light Industrial
- Heavy Industry

- Bertsch/Hokendauqua Creek Watershed Boundaries
- Major Roads
- Minor Roads
- Other Roads
- Municipal Boundaries
- Streams

Sources: Lehigh Valley Planning Commission; Municipal Zoning Ordinances, dates vary; Northampton County GIS Dept.

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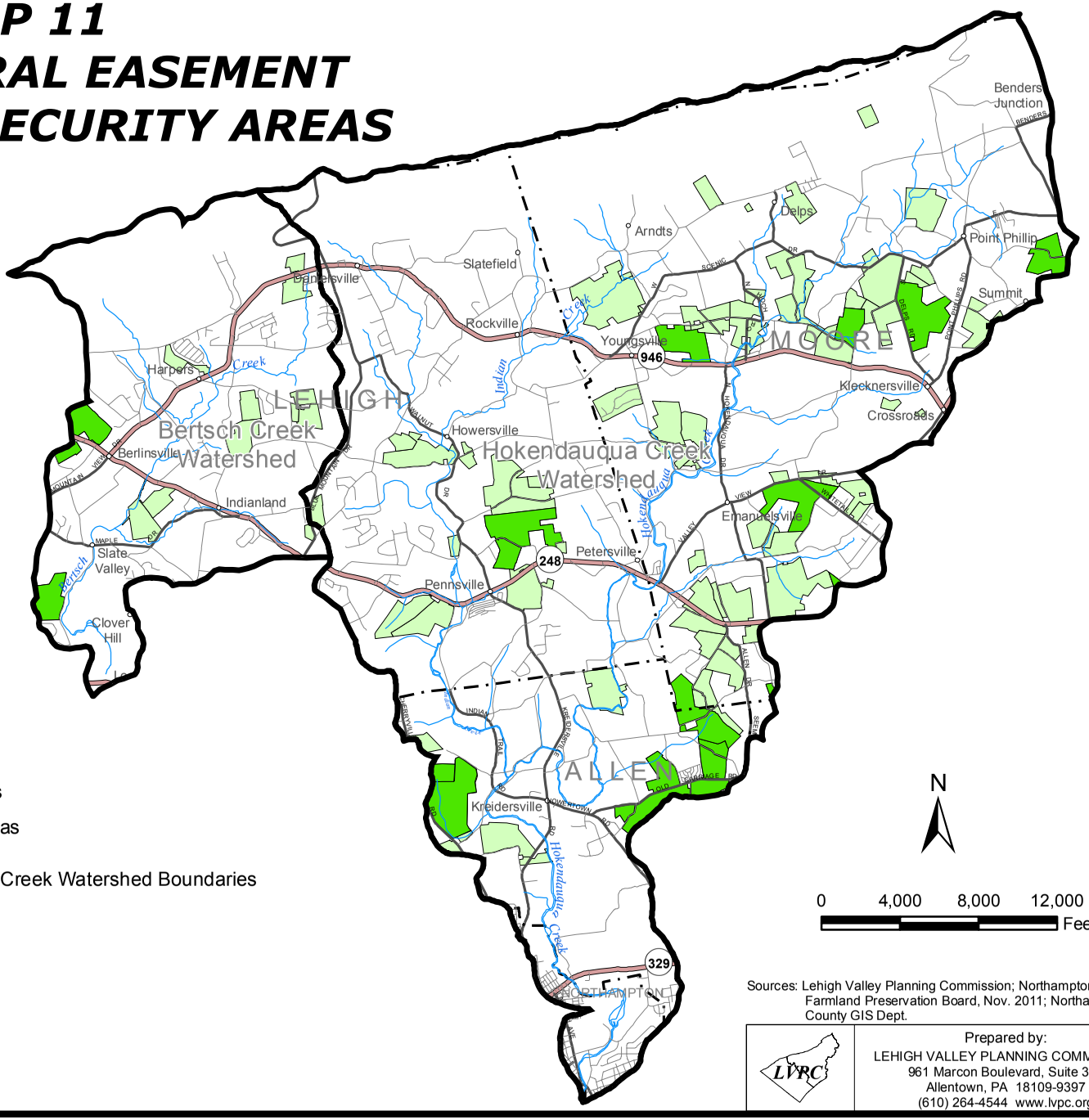
MAP 11
AGRICULTURAL EASEMENT PURCHASES/SECURITY AREAS



Sources: Lehigh Valley Planning Commission; Northampton County Farmland Preservation Board, Nov. 2011; Northampton County GIS Dept.

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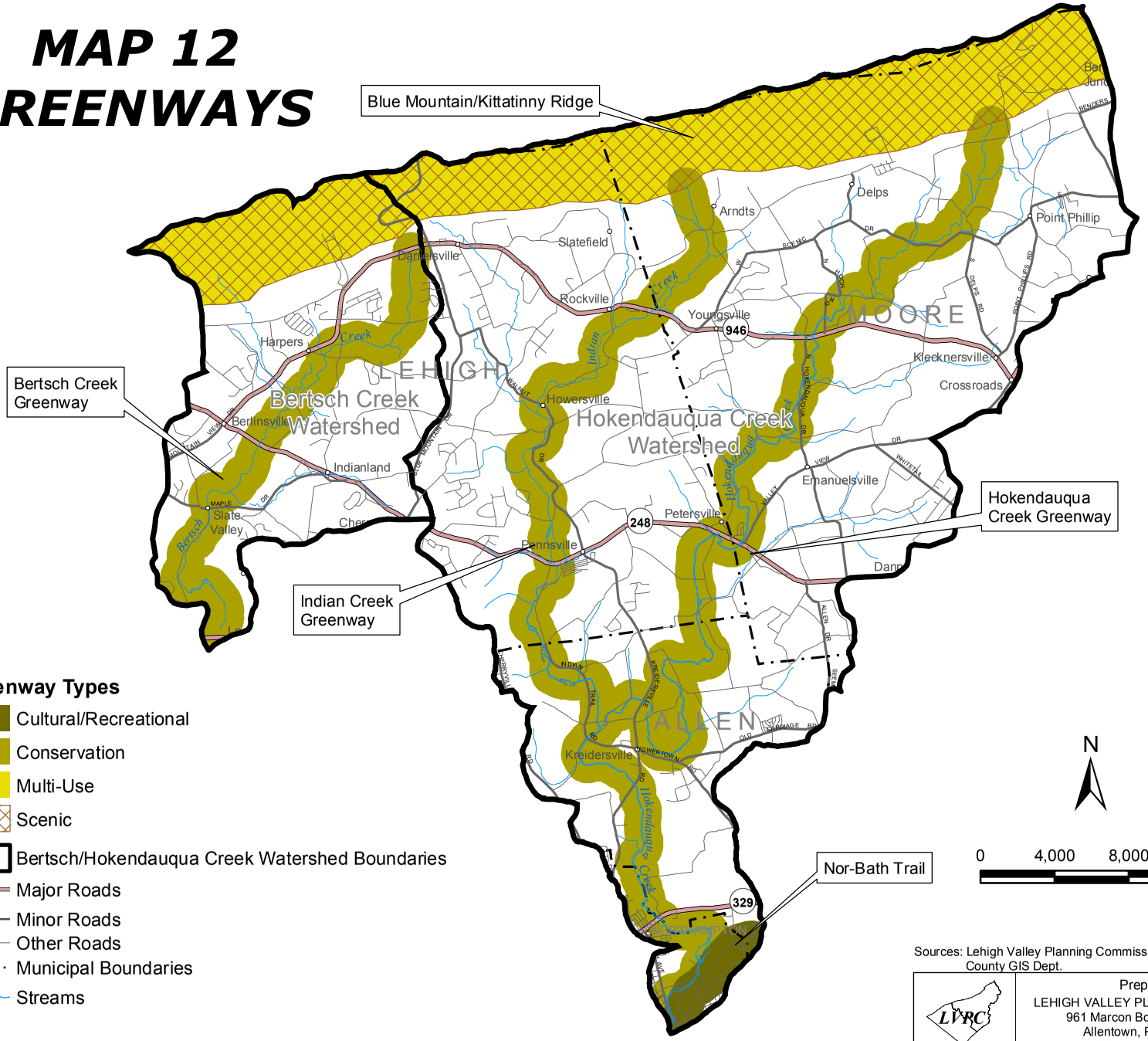
MAP 12
GREENWAYS



Greenway Types

- Cultural/Recreational
- Conservation
- Multi-Use
- Scenic
- Bertsch/Hokendauqua Creek Watershed Boundaries
- Major Roads
- Minor Roads
- Other Roads
- Municipal Boundaries
- Streams

Sources: Lehigh Valley Planning Commission, 2007; Northampton County GIS Dept.

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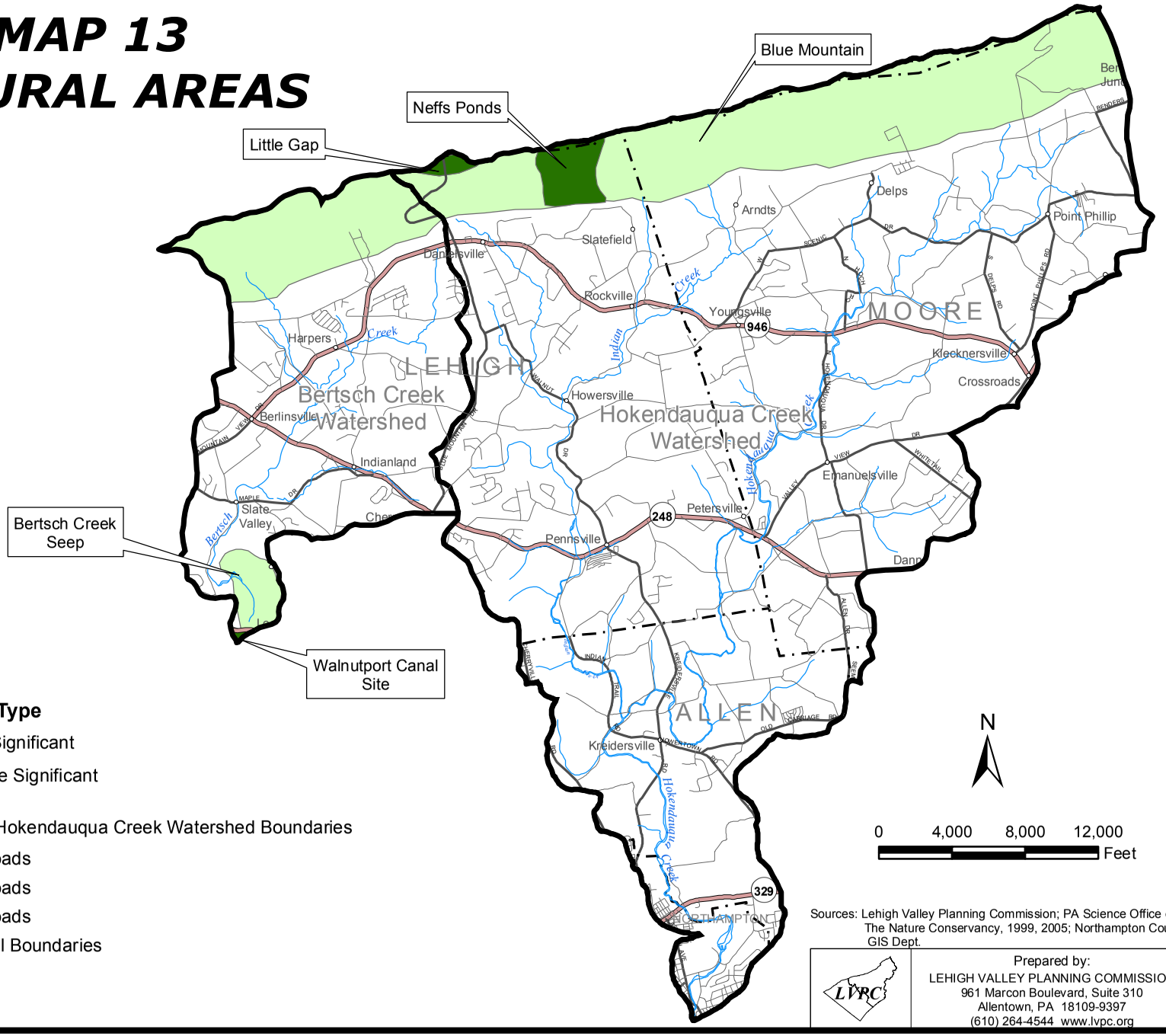
MAP 13
NATURAL AREAS



Natural Area Type

- Locally Significant
- Statewide Significant

- Bertsch/Hokendauqua Creek Watershed Boundaries
- Major Roads
- Minor Roads
- Minor Roads
- Municipal Boundaries
- Streams

Sources: Lehigh Valley Planning Commission; PA Science Office of The Nature Conservancy, 1999, 2005; Northampton County GIS Dept.

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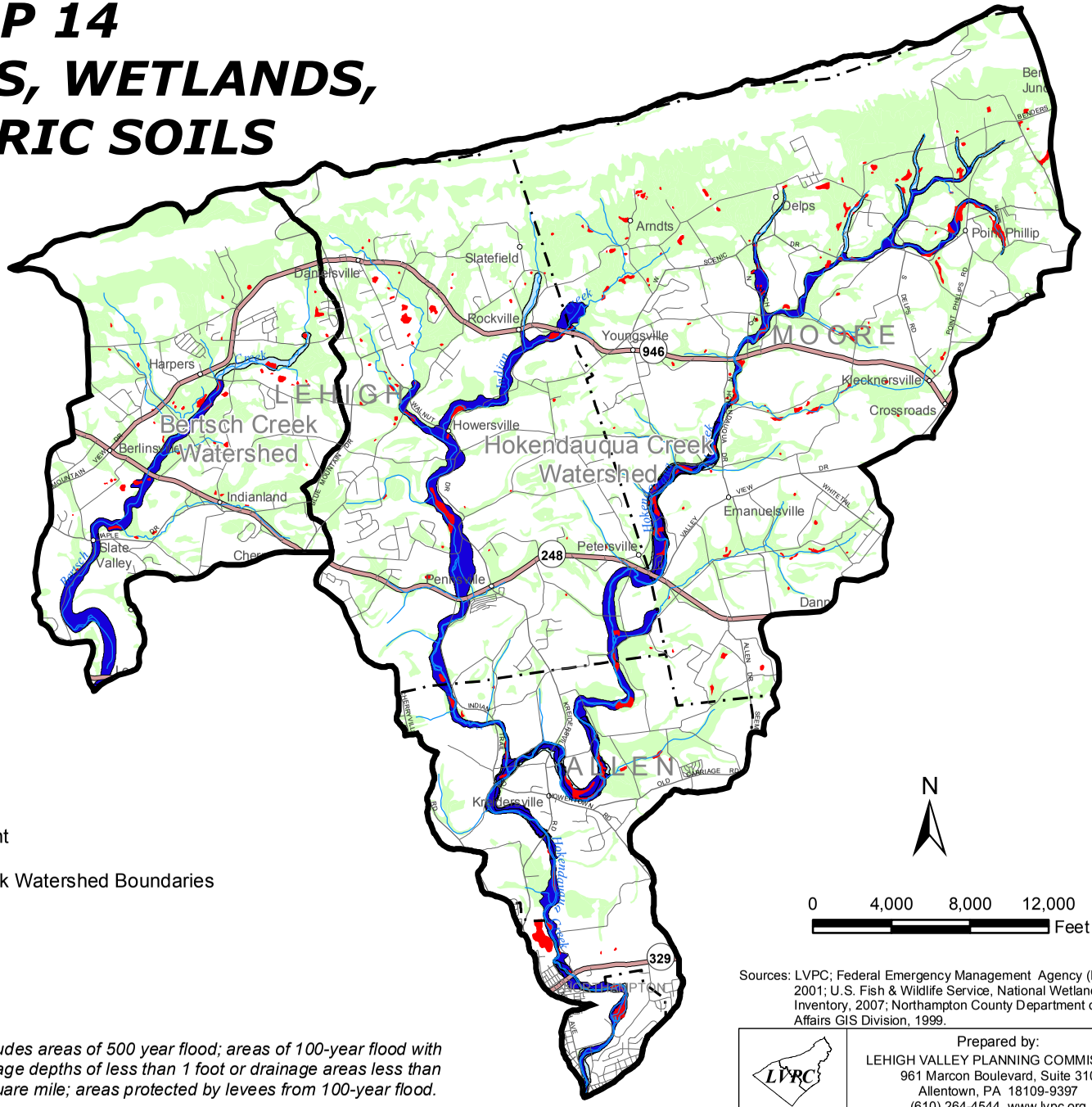
MAP 14
FLOODPLAINS, WETLANDS, and HYDRIC SOILS



100-year Floodplain

500-year Floodplain*

Wetlands

Soils with Hydric Component

Bertsch/Hokendauqua Creek Watershed Boundaries

Major Roads

Minor Roads

Other Roads

Municipal Boundaries

Streams

**Includes areas of 500 year flood; areas of 100-year flood with average depths of less than 1 foot or drainage areas less than 1 square mile; areas protected by levees from 100-year flood.*

Sources: LVPC; Federal Emergency Management Agency (FEMA), 2001; U.S. Fish & Wildlife Service, National Wetlands Inventory, 2007; Northampton County Department of Fiscal Affairs GIS Division, 1999.

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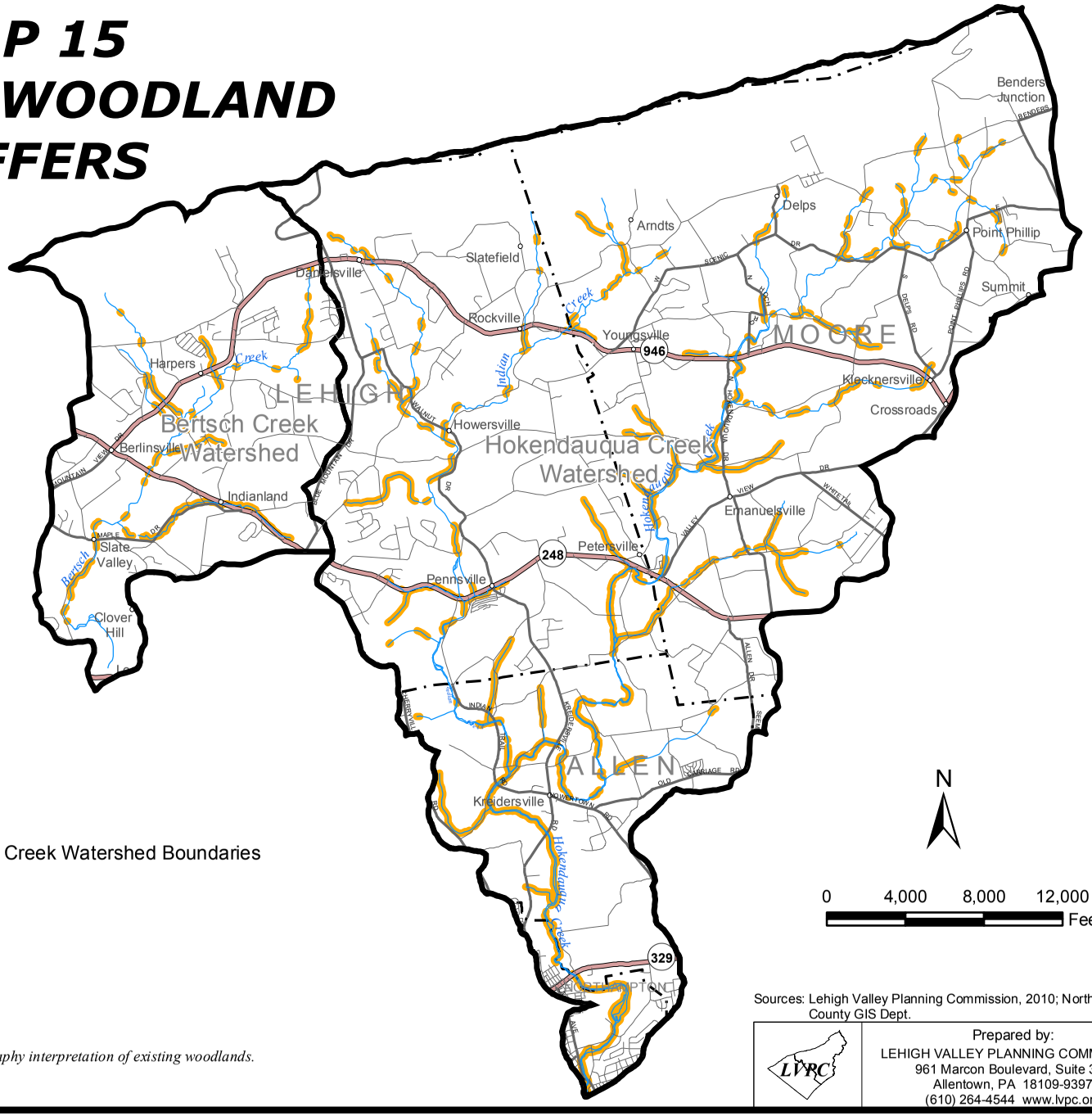
MAP 15
RIPARIAN WOODLAND BUFFERS



*Based on 2010 aerial photography interpretation of existing woodlands.

Sources: Lehigh Valley Planning Commission, 2010; Northampton County GIS Dept.

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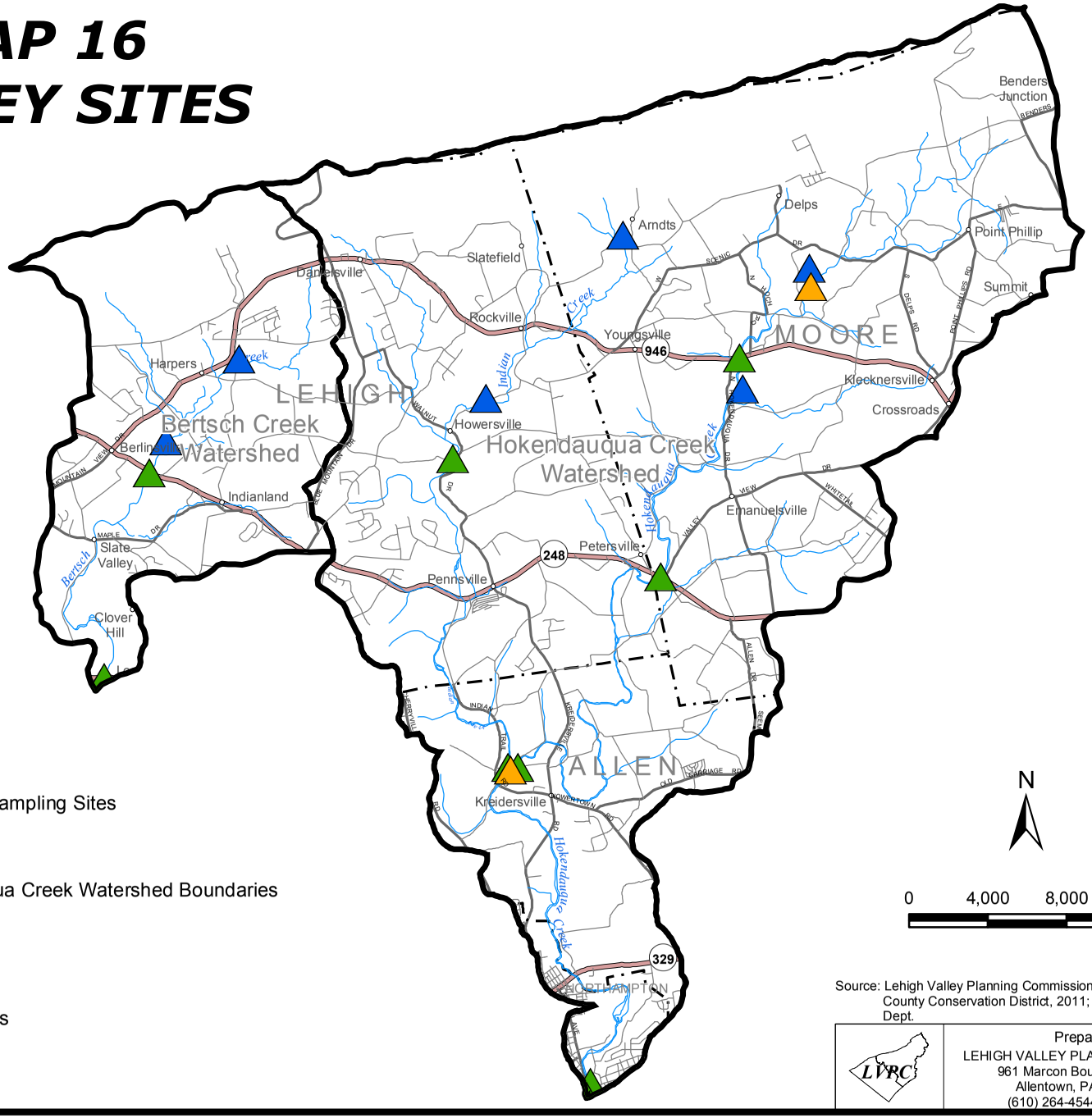
MAP 16
SURVEY SITES



Source: Lehigh Valley Planning Commission, 2010; Northampton County Conservation District, 2011; Northampton County GIS Dept.

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Appendix A
Macroinvertebrate Survey Report

Macroinvertebrate Survey Report

Bertsch Creek, Indian Creek, and Hokendauqua Creek

Northampton County, PA

Submitted by Lance Leonhardt

To Hanover Engineering
Northampton County Conservation District

November 17, 2011

Summary

Macroinvertebrate sampling was conducted on April 3, 2011, at four sites in the upper Hokendauqua Creek Watershed; two on Hokendauqua Creek, and two on Indian Creek, main tributary to Hokendauqua Creek. Macroinvertebrate sampling was also conducted on April 8, 2011 at two sites in the upper Bertsch Creek Watershed.

Both the Hokendauqua and Bertsch watersheds are located in Northampton County, Pennsylvania, and drain from the slope of the Kittatinny Ridge directly into the Lehigh River. These watersheds, particularly toward the headwaters, have forested stream corridors that link the ridge to the river.

Macroinvertebrate sampling and assessment followed Pennsylvania Department of Environmental Protection (PA DEP) protocols[1]. Using PA DEP's "A Benthic Index of Biotic Integrity (IBI) for Wadeable Freestone Streams in Pennsylvania" as an evaluative tool, the collected and sub-sampled macroinvertebrate assemblages had the following IBI scores for each stream set (upstream site listed first):

- Hokendauqua Creek Site #1 (Lilly Hill Rd.) = 78.8
  Hokendauqua Creek Site #2 (SR 4005) = 83.6
  IBI score average = 81.2

- Indian Creek Site #1 (Delps Rd.) = 72.3
  Indian Creek Site #2 (Beech Dr.) = 93.3
  IBI score average = 82.8

- Bertsch Creek Site #1 (Municipal Rd.) = 86.1
  Bertsch Creek Site #2 (Rt. 248) = 72.3.
  IBI score average = 79.2

An IBI score of $\geq$ 63 is required for Aquatic Life Use (ALU) attainment, and a score of $\geq$ 80 is the benchmark to qualify for consideration of special protection High Quality/Exceptional Value (HQ/EV) antidegradation water uses[1]. The Hokendauqua Creek Basin and Bertsch Creek Basin are currently designated as CWF-MF (Cold Water Fishes-Migratory Fishes) (PA Code CH. 93)[2].

Introduction

Both the Hokendauqua and Bertsch watersheds in Northampton County, Pennsylvania, have their beginning on the slope of the Kittatinny Ridge. The narrow, eastern-most ridge in the Appalachian Mountains is covered along its top by mostly continuous, but increasingly fragmented forest, from Pennsylvania into New Jersey. This stretch provides forested breeding and migratory habitat for many bird, mammal, reptile, amphibian, and insect species. The ridge also collects water for the formation of wetlands and streams and the life they support down slope to the Lehigh River.[3]

In the northwest corner of Northampton County, a few remaining forested lobes connect the Kittatinny Ridge to the Lehigh River primarily along the Hokendauqua Creek and its main tributary, Indian Creek, and the separate Bertsch Creek. This stretch of riparian and upland forested streams, represent important conservation corridors linking a variety of habitats on the ridge to habitats along the river[4]. The Hokendauqua and Bertsch Creeks each drain directly into the Lehigh River. (See Appendix A-1 to A-8 for Google Earth images of sampling sites.)

Conservation plans by several groups[3, 4, 5] have identified the ecological value of the Kittatinny Ridge and Lehigh River and the need for maintaining forested stream corridors to enhance that value.

Forested stream corridors allow for the movement of the very diversity (terrestrial and aquatic species) they support. Trees improve the quality of water and life in streams that, in turn, support many forest species. Trees shade, cool, and filter water, adding fallen leaves and wood to feed stream life. Woody debris creates a variety of microhabitats, spurring biodiversity, especially sensitive, cold-cool water macroinvertebrate species that require the conditions provided by forested headwater streams[6].

Sensitive macroinvertebrates are more intolerant to the effects of human-associated disturbances, like warming water, more fine sediment, storm-water runoff, and dissolved, manufactured chemicals. As these factors increase with decreasing forested-area and more human development, populations of sensitive macroinvertebrates decline[7, 8].

Because sensitive macros are associated with the generally healthy, more “natural conditions” of forested streams-- they can be used as indicators of a stream’s biological condition and integrity (the ability to support native species found in the natural habitat of an area) [9]. The natural habitat of Pennsylvania is mature forest.

The presence or absence of sensitive macroinvertebrates in proportion to the abundance of more pollution tolerant species, are data that can be used in a biotic index. A biotic index is made up of several "metrics" or ecological descriptions, each providing a score based on the macroinvertebrate assemblage sampled. The metric scores are summed for a total score determining the biotic integrity of a stream section and the appropriate aquatic life use designation and protection. The PA DEP uses an index of biotic integrity for macroinvertebrates[1] to help determine the aquatic life use designations for streams such as cold-water fishes (CWF), and qualification for special protection antidegradation water uses, High Quality (HQ), and Exceptional Value (EV).

The goal of this study, using macroinvertebrates as an assessment tool, was to determine whether portions of the Hokendauqua, Indian, and Bertsch Creeks might qualify for a change in status from CWF (as all 3 streams are currently designated) to HQ/EV CWF. The High Quality (HQ) and Exceptional Value (EV) status affords increased protection of the stream sections so designated[2].

Methods

Macroinvertebrate sampling was conducted on April 3, 2011 at four sites in the upper Hokendauqua Creek Watershed; two on Hokendauqua Creek, and two on Indian Creek, a main tributary to Hokendauqua Creek. Macroinvertebrate sampling was also conducted on April 8, 2011 at two sites in the upper Bertsch Creek Watershed. The total of six macroinvertebrate sampling sites where selected using Google Earth images and ground-truthing. (See Appendix A.)

Field sampling and lab methods followed the procedure for antidegradation surveys described in "A Benthic Index of Biotic Integrity for Wadeable Freestone Streams in Pennsylvania" Appendix A[1]. All macroinvertebrate samples at the sampling reaches, approximately 100 meters in length, were collected using a D-frame net with 500-micron mesh. Sample collection was spread out over the entire reach, with six of the best riffle habitat areas of different depths (fast and slow) and substrate types chosen for sampling.

At each of the six riffles per sampling reach, the substrate within an approximately one square meter area was disturbed immediately upstream of the net by kicking for about 1

minute to an approximate depth of 10 cm. The resulting six "D-frame efforts" for each sampling reach were composited into one sample container and preserved with 95% ethanol.

Prior to the sub-sampling, each composited sample from the sampling reach was rinsed in a standard USGS No. 35 sieve to remove fine materials and residual preservative. The composited sample was then placed in a 28-square gridded pan (Pan 1) 14" x 8" x 2" in size, and stirred after water was added to the depth of the sample. A 2" x 2" grid was randomly selected using a 28 random number set, and all debris and organisms were entirely removed from the grid with a tubular 4 inch^2 grid cutter and placed in a second gridded pan (Pan 2). All identifiable organisms from the grid were floated, entirely picked, counted, and sub-totaled. This procedure was repeated until 4 randomly selected grids had been sub-sampled and 200 organisms ($\pm$ 20%) were obtained from Pan 2.

Nearly all of the sub-sampled macroinvertebrates were identified to the genus-level. Some macroinvertebrate taxa (e.g. Chironomidae, Oligochaeta) where identified at higher taxonomic levels as per PA-DEP protocol.

To assess the biological condition of the two sampling sites, the identified macroinvertebrate taxa from the sub-samples were applied to the PA DEP's Benthic Index of Biotic Integrity[1] (IBI).

The IBI consists of 6 metrics, each a measurable, ecologically-based attribute of macroinvertebrate populations that predictably change (numerically increasing or decreasing) in response to increased human-associated stressors. Summing the numeric scores of the metrics produces a single score representing the site's level of biological integrity.

The PA DEP has recently established use attainment thresholds or benchmarks based on IBI scores in assessing qualification for the special protection antidegradation water uses, High Quality (HQ) and Exceptional Value (EV) waters. An IBI score of $\geq$ 63 is required for Aquatic Life Use (ALU) attainment (i.e. CWF), and a score of $\geq$ 80 is the antidegradation candidacy benchmark required as a qualifier for special protection status of EV and HQ[1]. This "population-based IBI approach" (outlined in ""A Benthic Index of Biotic Integrity for Wadeable Freestone Streams in Pennsylvania"[1]) "will replace [the] site-specific reference comparison approach"[1] currently outlined in Chapter 93.4b (PA Code[2]) to qualify sites for HQ/EV, the reason for its use in this study.

Other factors such as habitat condition parameters, in addition to IBI scores, are also considered when determining antidegradation candidacy and to distinguish between EV and HQ status[2].

Results and Discussion

One of the two macroinvertebrate sampling sites on each stream scored > 80 on the IBI: Bertsch Creek site #1 = 86.1; Indian Creek site #2 = 93.3; Hokendauqua Creek site #2 = 83.6. The other sampling site in the pair for each stream scored in the 70's on the IBI: Bertsch Creek site #2 = 72.3; Indian Creek site #1 = 72.3; Hokendauqua Creek site #1 = 78.8.

The average IBI score between the two assessed sampling sites for each stream were: Bertsch Creek ave.IBI score = 79.2; HokendauquaCreek ave.IBI score = 81.2; Indian Creek ave.IBI score = 82.8. (See Appendix B for macroinvertebrate data.)

A score of $\geq$ 80 is the benchmark for consideration of High Quality/Exceptional Value (HQ/EV) special protection antidegradation designations[1].

Higher IBI scores are equated to a higher biotic integrity associated with the presence of highly sensitive macroinvertebrate taxa and the forested, smaller stream habitats (with minimal levels of human disturbance) that support them[10].

Highly sensitive macros have characteristics adapted to high quality forested stream conditions. They are often stenothermic or coldwater obligates, long-lived K-strategists, with populations at fairly constant levels and having specialized feeding needs[9]. Given the conditions supporting these special requirements, highly sensitive macros should represent a high portion of the taxa in high quality forested small stream communities, but often with low relative abundances[8]. Their occurrence indicates that where they live is ecologically healthy enough to sustain them, having a natural biological condition with a high biotic integrity.

Because water flows downstream, healthy upstream habitat is critical to maintaining healthy downstream conditions. This often makes forested headwater sections of stream systems conservation priorities[3, 4, 5]. The two sampling sites for each stream were selected to assess the stream's headwaters and were located in the approximate upper one-third of the stream's estimated total length.

The percent of total stream length covered from the source to site #2 (downstream-most sampling site) for each stream were estimated to be: Bertsch Creek sampling site coverage = 36% of the total stream length (1.89 mi/5.22 mi.); Indian Creek sampling site coverage = 38.6% of the total stream length (2.84 mi. / 7.35 mi); Hokendauqua sampling site coverage = 26.5% of the total stream length (4.16 mi/15.68 mi.). (See Appendix A-9 for sampling site descriptions.)

Even though every stream and each stream section is unique[11], stream community type classifications can provide information about species associations and the community type that, by comparison, a stream section may best represent. The Pennyslvania Aquatic Community Classification Project (PACC) identified twelve genus-level stream communities[12], using statistically significant indicator values of macroinvertebrate taxa [13]. Seven of the twelve most applicable PACC genus-level stream communities were used to classify (best professional judgment) each sampling site's community type using the sub-sampled macroinvertebrates taxa. (See Appendix C for PACC community comparisons.)

Although the six sampling sites had representative macroinvertebrate indicators species of several potential PACC genus-level stream community types, the combination of expected community indicator species, and predicted average values for taxa richness, number of EPT (mayfly, stonefly and caddisfly) taxa, and number of intolerant taxa, best describe 5 of the 6 sampling sites as a "High Quality Small Stream Community." Indian Creek Site #1 might be better classified as a "High Quality Headwater Stream Community."

Epeorus, a zero-tolerance, cold-cool water mayfly species[14], was present in the sub-samples for all 6 sites and is the top indicator species for the "High Quality Small Stream Community". Also present in the sub-samples for all 6 sites were indicator species for the "High Quality Headwater Stream Community"; *Amphinemura (*top indicator) and *Prosimulium*. Another zero-tolerance, cold-cool water mayfly species[14], *Ameletus*, was present in the sub-samples for 5 of 6 sampling sites.

The PACC describes the High Quality Stream Community as a "strong indicator of a high quality, naturally functioning small stream system"[12]. It should be noted that the term "high quality" as used by the PACC depicts a stream community type found in reaches having little watershed disturbance, and should not be confused with the HQ special protection antidegradation designation[2].

Examination of the Bertsch and Hokendauqua watersheds using Google Earth images shows patches of forested strips concentrated along the stream channels and surrounded by non-forested habitat. The stream corridors are the last remaining, still tenuously connected, forested-patches linking the Kittatinny Ridge to the Lehigh River. (See Appendix A-1 to A-6)

Although whittled down on the landscape to being primarily along the Bertsch, Indian, and Hokendauqua Creeks in the northwest corner of Northampton County, for each stream, most forested patches (riparian-upland trees) at and upstream of the sampling sites have remained relatively intact (maintained forested-patch area) since at least the early 1990's. (See Appendix A-7, A-8)

Indian Creek Sampling Site #2, which had the highest IBI score, is a good example of the stream habitat quality that can be generated by maintaining adequate forested-patch area in a stream corridor. Just upstream of a golf course and Beech Drive, the site is located along a hemlock-lined north-facing slope and is positioned downstream of nearly three miles of mostly connected forested buffer. The conditions present at the site over time have allowed for the presence of a high quality stream community.

Conclusion

Stream corridors are ecologically-important links to sustaining biodiversity and water quality within and between their watersheds, and so are conservation priorities[3, 4, 5]. As indicated by sampling site IBI scores, PACC Community type, and indicator species present, the stream corridors in the upper one-third of the Berstch, Indian, Hokendauqua Creeks (and possibly other sites downstream) seem capable of supporting high quality stream communities. Consideration for HQ special protection antidegradation designation appears warranted.

References

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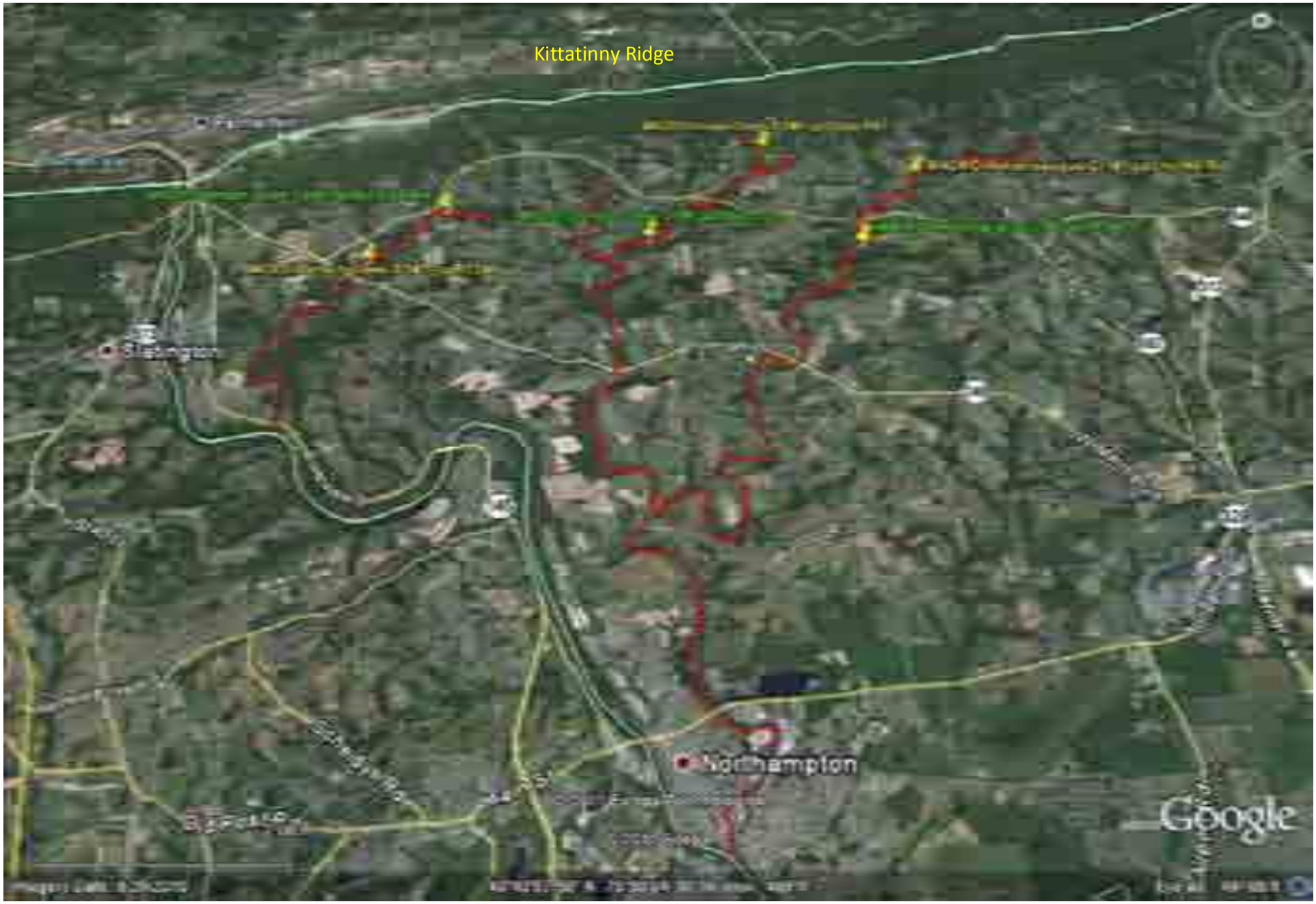
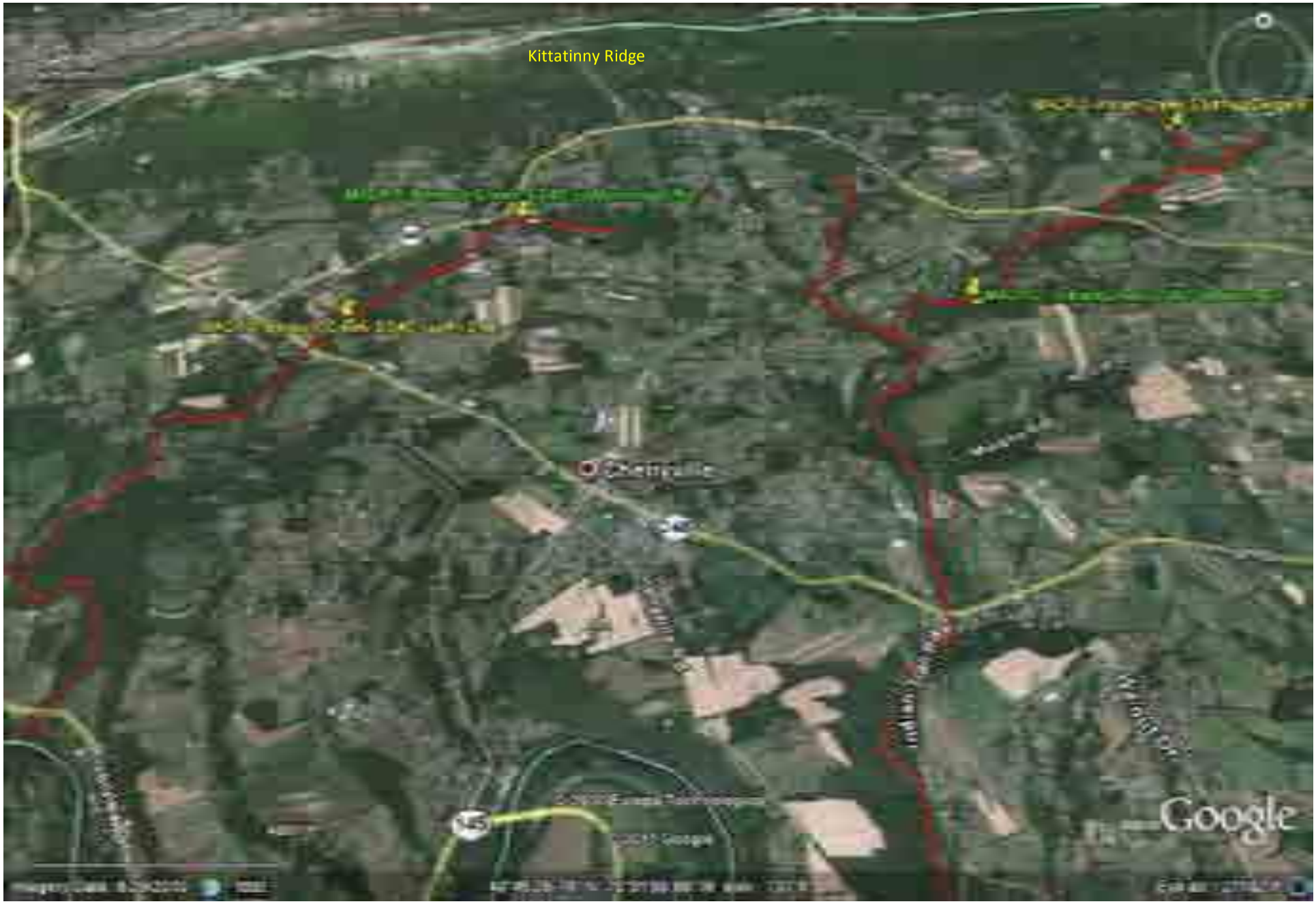
Appendix A: Google Earth Images of Sampling Sites/Site Description Table

Appendix B: Macroinvertebrate Data

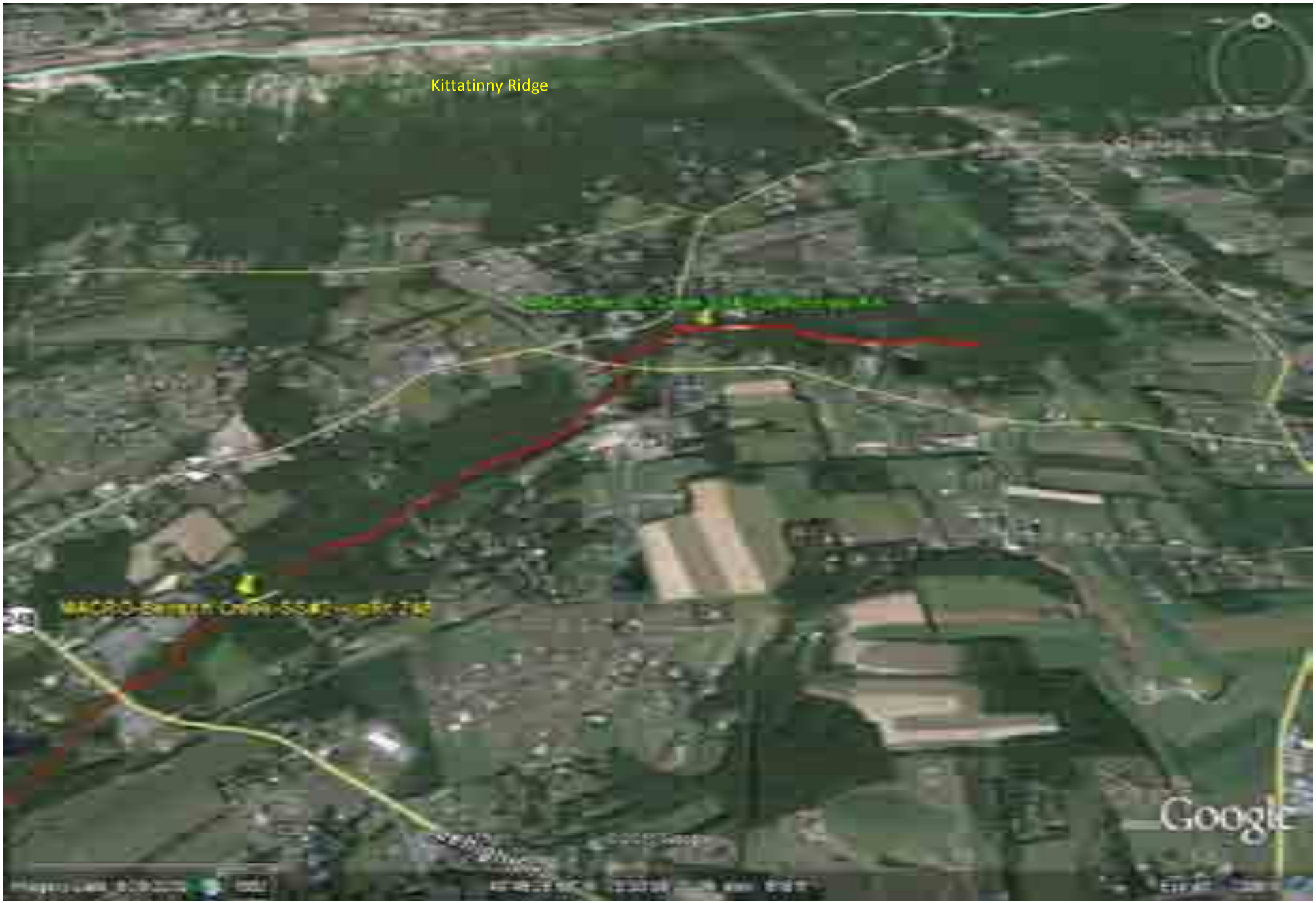
Appendix C: PACC Community Comparisons



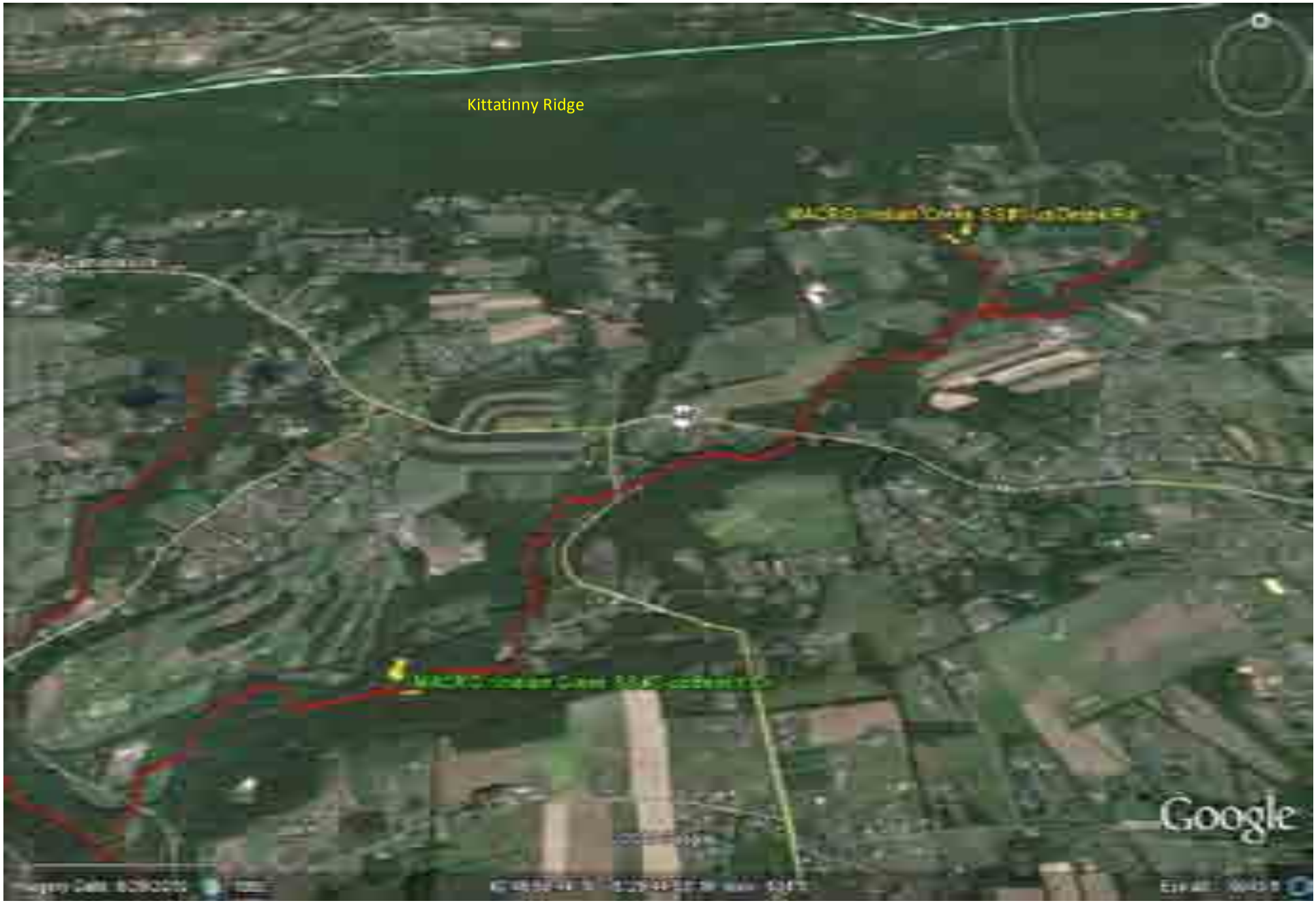
A-1: Macroinvertebrate Sampling Sites on the Bertsch/Indian/Hokendauqua Creeks in relation to the Kittatinny Ridge



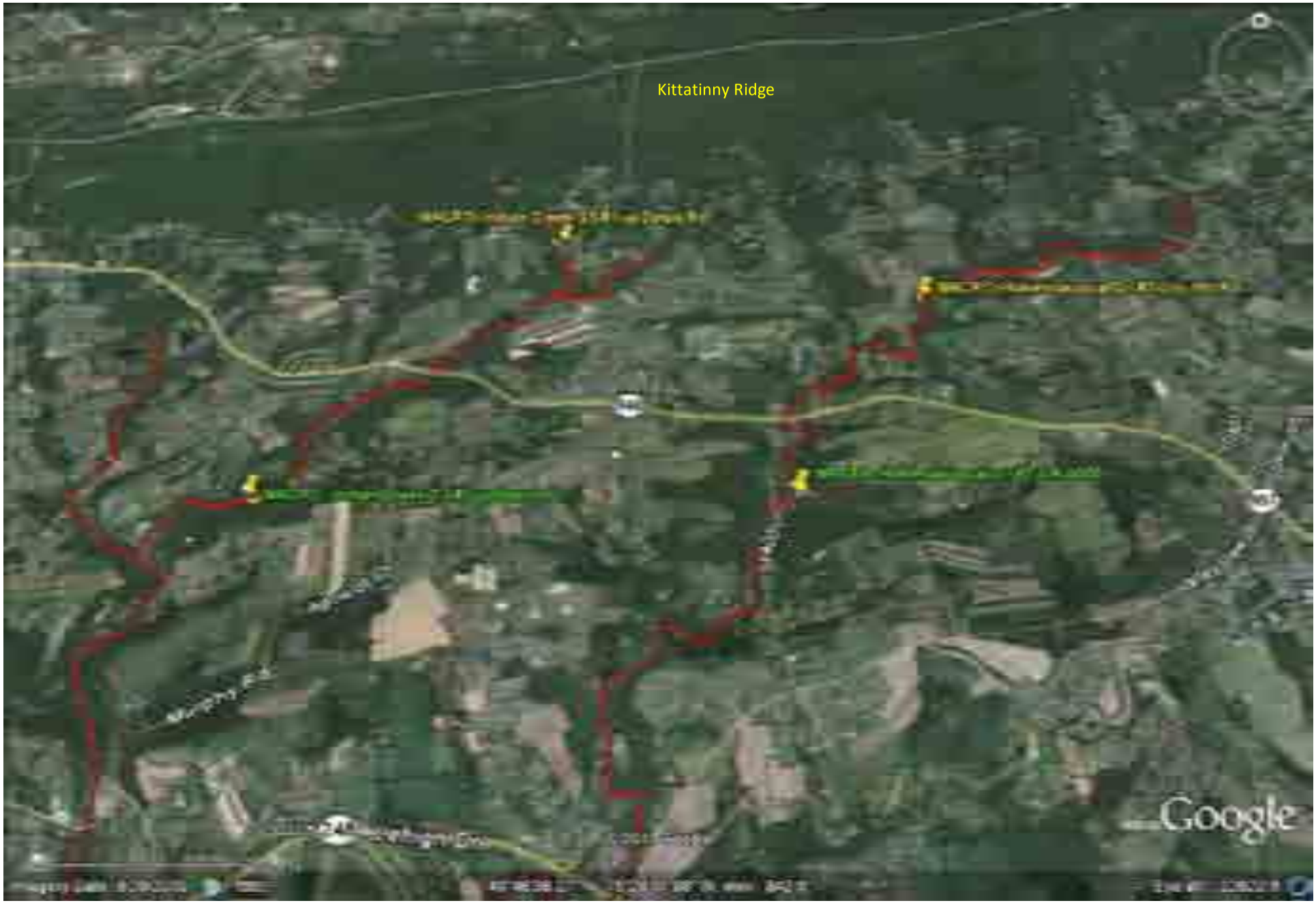
A-2: Macroinvertebrate Sampling Sites on the Bertsch and Indian Creeks



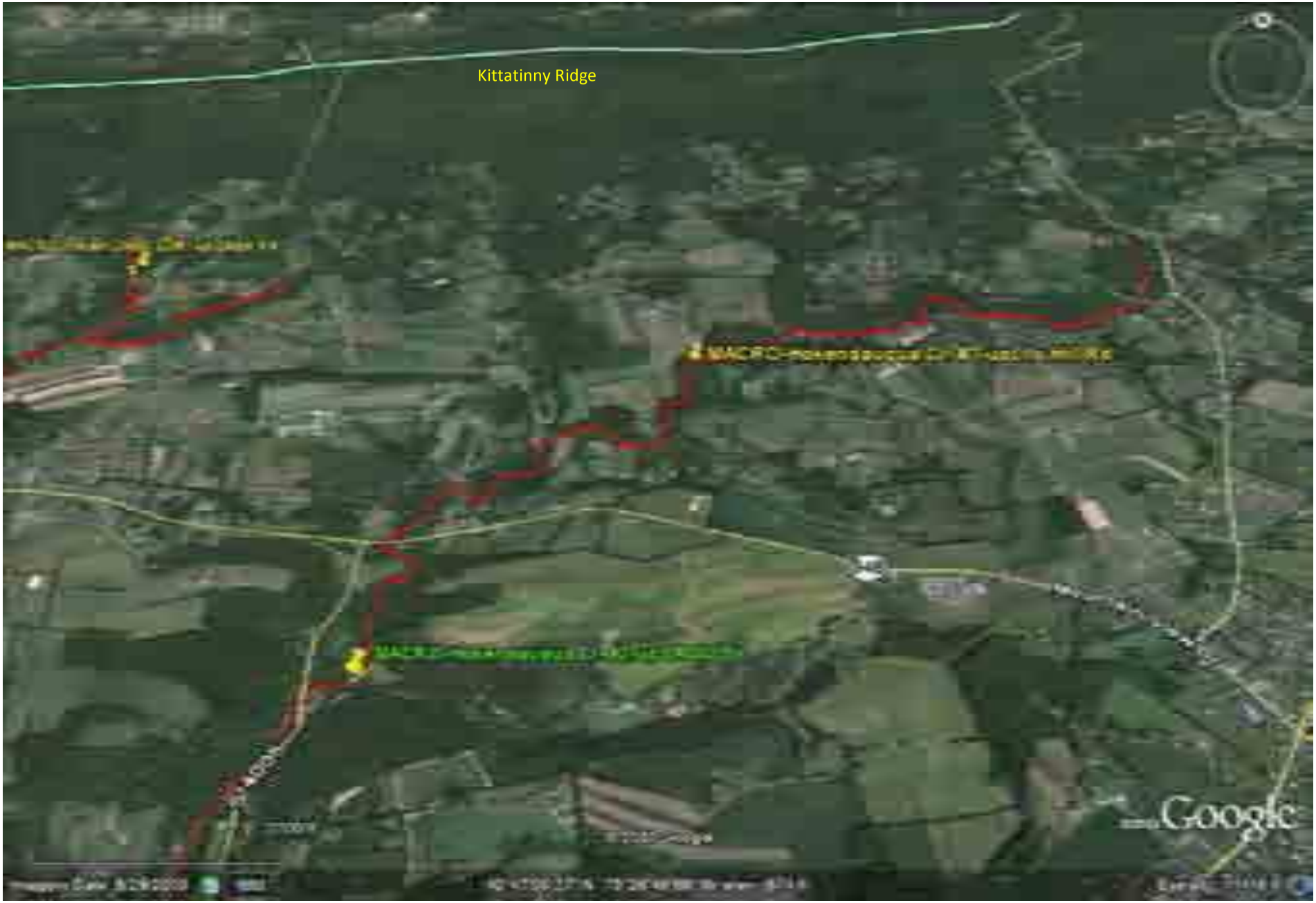
A-3: Macroinvertebrate Sampling Sites on Bertsch Creek



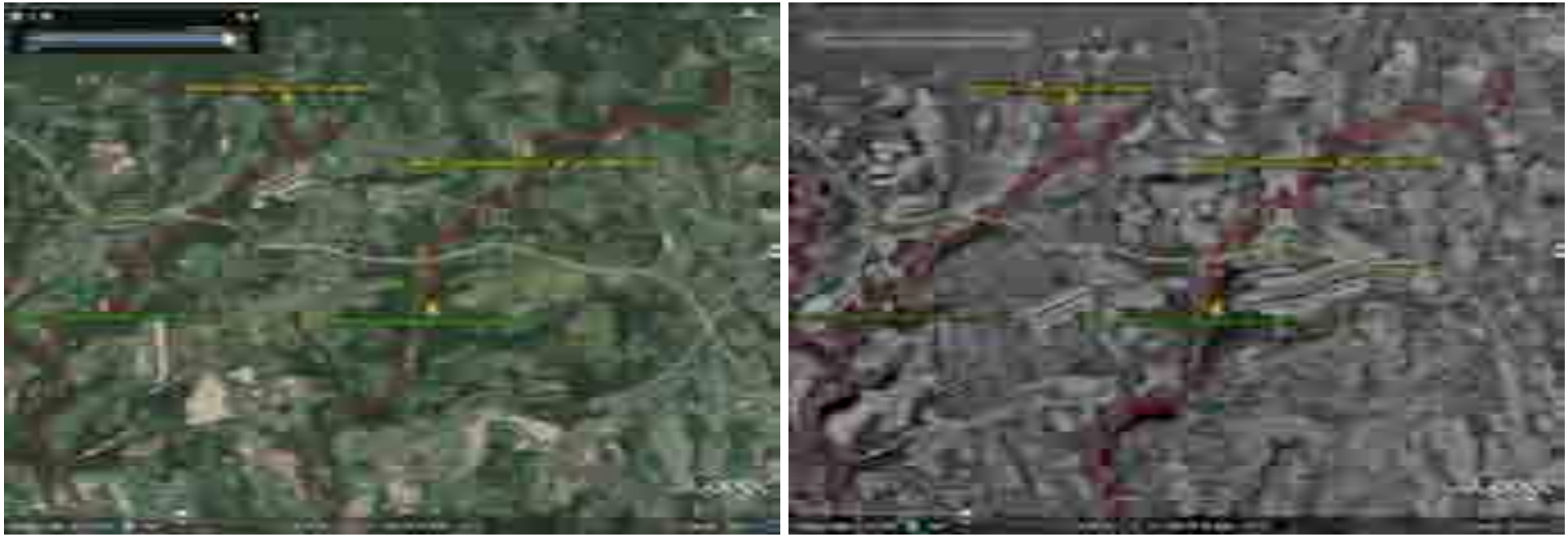
A-4: Macroinvertebrate Sampling Sites on Indian Creek



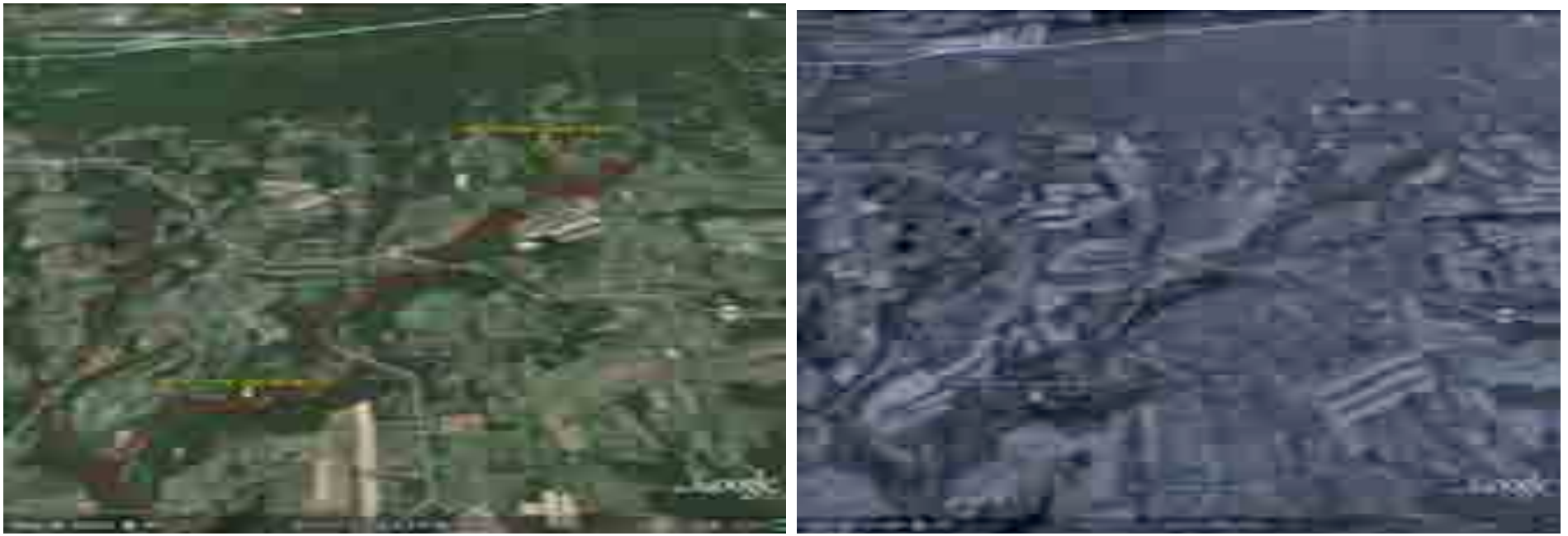
A-5: Macroinvertebrate Sampling Sites on Indian and Hokendauqua Creeks



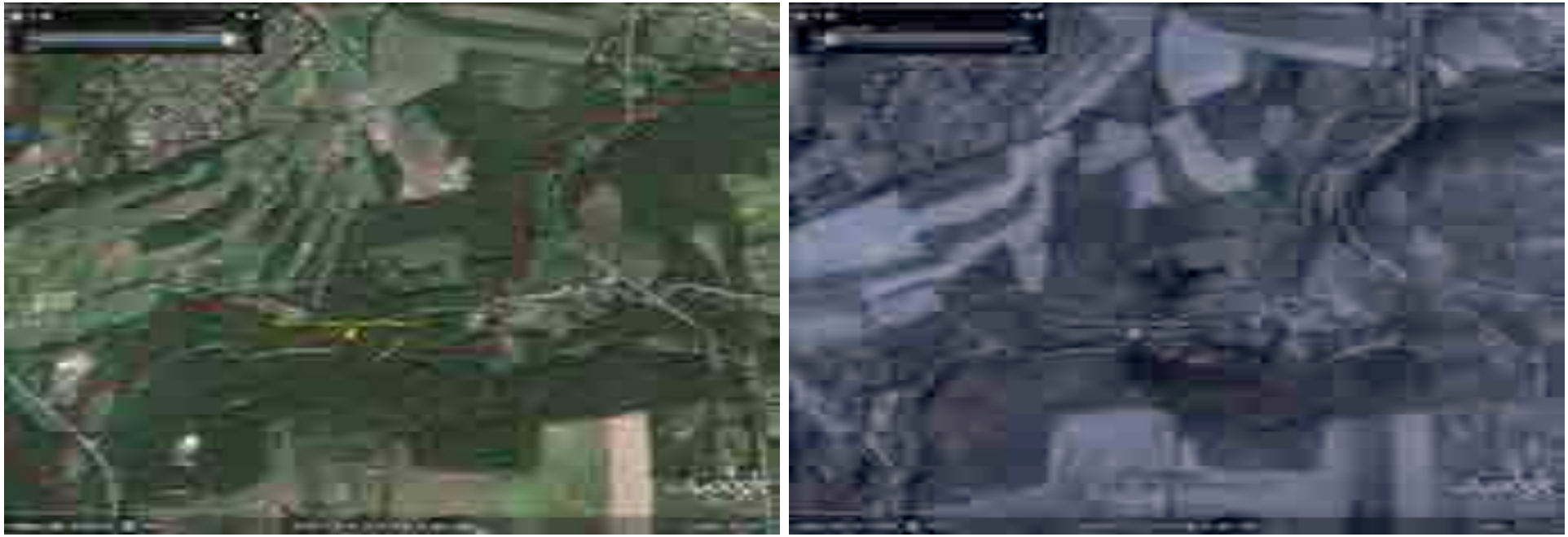
A-6: Macroinvertebrate Sampling Sites on Hokendauqua Creek



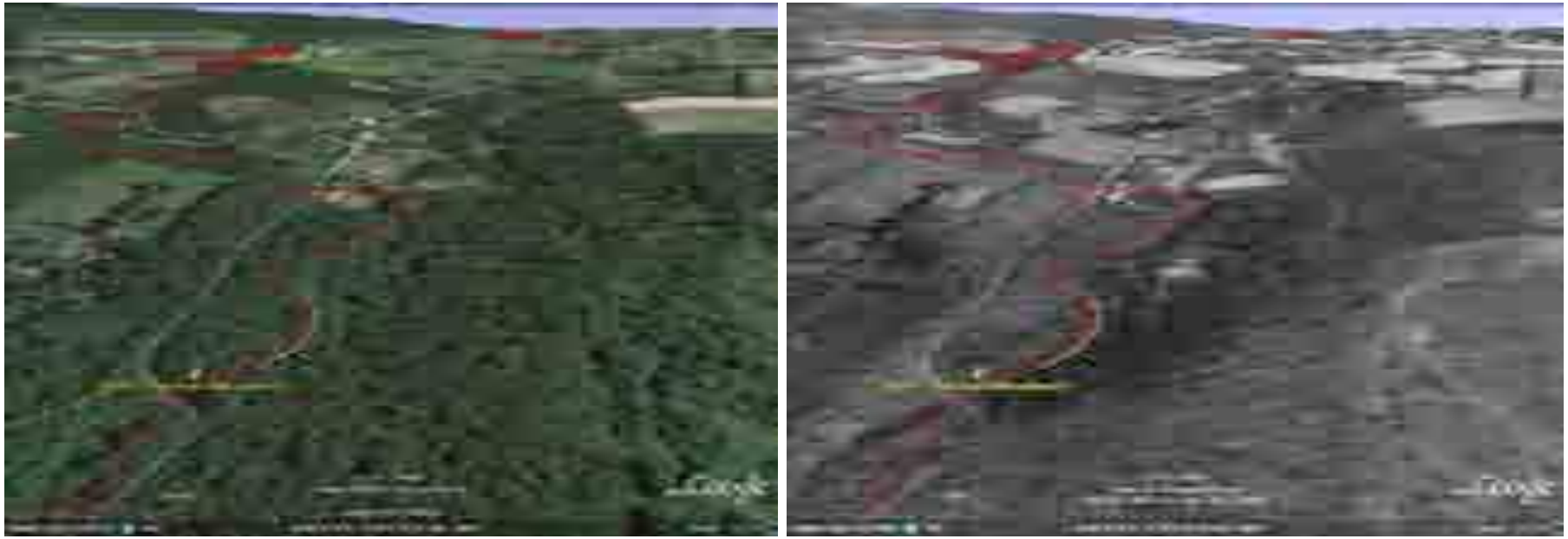
A-7a: Upper Indian Creek and Hokendauqua Watershed: Forested and Non-forested area. August 2010 (left); April 1992 (right)



A-7b: Upper Indian Creek Watershed: Forested and Non-forested area. August 2010 (left); April 1992 (right)



A-8a: Indian Creek Macroinvertebrate Sampling Site#2 upstream of Beech Drive: Forested and Non-forested area. August 2010 (left); April 1992 (right)



A-8b: Indian Creek Macroinvertebrate Sampling Site#2 upstream of Beech Drive: North-facing slope-hemlock component. August 2010 (left); April 1992 (right)

A-9 **Sampling Site Descriptions for Bertsch, Indian, and Hokendauqua Creeks**

	Bertsch Cr. **Site #1**	**Bertsch Cr.** **Site #2**	**Indian Cr.** **Site #1**	**Indian Cr.** **Site #2**	**Hokendauaqua Cr.** **Site #1**	**Hokendauaqua Cr.** **Site #2**
Location	**40^{0}46'50.28''N 75^{0}32'56.86''W elevation 576 ft.**	**40^{0}46'06.62''N 75^{0}33'51.74''W elevation 510 ft.**	**40^{0}47'46.53''N 75^{0}28'46.23''W elevation 697 ft.**	**40^{0}46'25.86''N 75^{0}30'16.32''W elevation 555 ft.**	**40^{0}47'24.68''N 75^{0}26'42.06''W elevation 646 ft.**	**40^{0}46'24.74''N 75^{0}27'32.27''W elevation 590 ft.**
Distance Downstream from source	0.56 mi.	1.89 mi.	.31 mi.	2.84 mi.	2.25 mi.	4.16 mi.
% of Total Stream Length (downstream of source)	10.7%	36.2%	4.2%	38.6%	14.3%	26.5%
Total Length of Stream (source to mouth)	Bertsch Creek 5.22 mi.		Indian Creek 7.35 mi.		Hokendauqua Creek 15.68 mi.	
Average Width Forested Buffer (Riparian-Upland) of Sampling Site Length left/right side upstream sampling length = 100m	L 156.5ft. 51.3m R 355.5ft. 108.0m	L 466.9ft. 142.3m R 500.1ft. 152.4m	L 384ft. 117 m R 350.3ft. 106.8 m	L 217.5ft. 66.4m R 675.2ft. 205.8m	L 150.9ft. 46.0m R 423.4ft. 129.0m	L 137.9ft. 123.1m R 144.9ft. 44.2m
Riparian Type	Broadleafed Deciduous	Broadleafed Deciduous	Broadleafed Deciduous	Broadleafed Deciduous/Coniferous	Broadleafed Deciduous	Broadleafed Deciduous
Main Bedrock Type	shale	shale	shale	shale	shale	shale
Watershed Area (sq. mi.)	Bertsch Creek Watershed = 9.6 sq. mi.[a]				Hokendauqua Creek watershed (including Indian Creek) = 40.95 sq. mi.[a].	

[*] **Distances/Lengths estimated using Google Earth images (August 2010)**

[a] **County of Northampton Pennsylvania Geographic Information Services**

B-1A Bertsch Creek Sampling Site #1 (~ 100m upstream of Municipal Road) Macroinvertebrate Sub-sample April 8, 2011

Site: 40°46'50.28''N 75°32'56.86''W elevation 576 ft. Taxonomic Classification Class	Order	Family	Genus	Number of Individuals in Sample	Functional Feeding Group	Pollution Tolerance Value*	Sensitive Taxa (PTV 0-3)
INSECTS/	Plecoptera	Perlidae	*Acroneuria*	14	PR (predator)	0	S
		Perlodidae	*Isoperla*	9	PR	2	S
		Nemouridae	*Prostoia*	28	SH	2	S
			Amphinemura	9	SH	3	S
	Ephemeroptera	Heptageniidae	*Epeorus*	15	SC (scraper)	0	S
			Macaffertium (*Stenonema)*	3	SC	3	S
		Ameletidae	*Ameletus*	8	CG	0	S
	Ephemerellidae		*Ephemeralla*	48	CG	1	S
			Eurylophella	1	SC	4	
	Trichoptera	Hydropsychidae	*Hydropsyche*	2	FC	5	
			Diplectrona	7	FC	0	S
			Cheumatopsyche	7	FC	6	
		Philopotamidae	*Chimarra*	10	FC	4	
		Rhyacophilidae	*Rhyacophila*	8	PR	1	S
		Brachycentridae	*Micrasema*	2	SH	2	S
		Limnephilidae	*Pycnopsyche*	1	SH	4	
		Uenoidae	*Neophylax*	1	SC	3	S
		Polycentropodidae	*Polycentropus*	1	FC	6	
	Coleoptera	Psephenidae	*Psephenus*	1	SC	4	
			Ectopria	5	SC	5	
		Elmidae	*Promoresia*	4	SC	2	S
		Ptilodactylidae	*Anchytarsus*	1	SH	5	
	Diptera	Chironomidae		7	CG	6	
		Tipulidae	*Dicranota*	1	PR	3	S
			Limnophila	1	PR	3	S
		Empididae	*Clinocera*	6	PR	6	
		Simuliidae	*Prosimulium*	17	FC	2	S
			Simulium	2	FC	6	
	Odonata	Gomphidae	*Lanthus*	6	PR	5	
	Megaloptera	Corydalidae	*Nigronia*	2	PR	2	S
TOTAL NUMBER of INDIVIDUALS IN SAMPLE				227			Total STaxa = 17
TOTAL TAXA = 30							
Sampling Method: 6 D-frame composite 200 ± 40 subsample Sampling length=100m					Collector: Lance Leonhardt		

* An Index of Biotic Integrity for Wadeable Freestone Riffle-Run Streams in Pennsylvania (PADEP April 2009)/Appendix F

B-1B Bertsch Creek Sampling Site #1 (~ 100m upstream of Municipal Road) Macroinvertebrate Sub-sample April 8, 2011

Metric	Standardization Equation	Observed Metric Value	Standardized Metric Score	Adjusted Standardized Metric Score (Maximum = 1.000)
Total Taxa Richness	observed value/33	30	0.909	0.909
EPT Taxa Richness (PTV 0-4 only)	observed value/19	15	0.789	0.789
Modified Beck's Index	observed value/38	22	0.579	0.579
Hilsenhoff Biotic Index	(10-observed value)/(10-1.89)	2.14	0.969	0.969
Shannon Diversity	observed value/2.86	2.845	0.995	0.995
Percent Sensitive Individuals (PTV 0-3)	observed value/84.5	77.97	0.923	0.923
Average of adjusted standardized core metric scores x 100 = **IBI Score =**				**= 86.1**

[1] An Index of Biotic Integrity for Wadeable Freestone Riffle-Run Streams In Pennsylvania (PADEP April 2009)

October-May

IBI Score ≥ 63 = Aquatic Life Use (ALU) attainment
IBI Score < 50 = ALU Impairment
IBI Score 50-63 = ALU Impairment with any of the following:

June-September

IBI Score ≥ 50 = Aquatic Life Use (ALU) attainment
IBI Score < 40 = ALU Impairment
IBI Score 40-50 = ALU Impairment with any of the following:

1) Beck's Index score < 20 and % Sensitive Individuals < 20%
2) Sample dominated by tolerant taxa or individuals
3) Mayflies, stoneflies or caddisflies are absent from sub-sample

Aquatic Life Use (ALU): A use designation relating to the level of water quality a stream is expected to meet in providing habitat suitable for supporting ecologically-desirable aquatic organisms.

B-2A **Bertsch Creek Sampling Site #2 (~375m Upstream of Rt. 248) Macroinvertebrate Sub-sample April 8, 2011**

Site: 40^{0}46'06.62''N 75^{0}33'51.74''W elevation 510 ft. Taxonomic Classification Class	Order	Family	Genus	Number of Individuals in Sample	Functional Feeding Group	Pollution Tolerance Value*	Sensitive Taxa (PTV 0-3)
INSECTS/	Plecoptera	Perlidae	*Acroneuria*	2	PR (predator)	0	S
		Chloroperlidae	*Sweltsa*	1	PR	0	S
		Nemouridae	*Prostoia*	5	SH (shredder)	2	S
			Amphinemura	1	SH	3	S
	Ephemeroptera	Heptageniidae	*Epeorus*	21	SC (scraper)	0	S
			Macaffertium (*Stenonema)*	6	SC	3	S
		Ameletidae	*Ameletus*	1	CG (collector gatherer)	0	S
	Ephemerellidae		*Ephemeralla*	4	CG	1	S
			Eurylophella	4	SC	4	
	Trichoptera	Hydropsychidae	*Hydropsyche*	8	FC (filter collector)	5	
			Diplectrona	6	FC	0	S
			Cheumatopsyche	25	FC	6	
		Philopotamidae	*Chimarra*	5	FC	4	
			Dolophilodes	1	FC	0	S
		Hydroptilidae	*Leucotrichia*	1	SC	6	
		Uenoidae	*Neophylax*	13	SC	3	S
		Polycentropodidae	*Polycentropus*	1	FC	6	
	Coleoptera	Psephenidae	*Psephenus*	3	SC	4	
			Ectopria	1	SC	5	
	Diptera	Chironomidae		47	CG	6	
		Tipulidae	*Tipula*	1	SH	4	
		Simuliidae	*Prosimulium*	35	FC	2	S
			Simulium	1	FC	6	
			Stegopterna	1	FC	6	
	Odonata	Gomphidae	*Lanthus*	1	PR	5	
			Stylogomphus	1	PR	4	
ARACHNIDA	Hydracarina			1	PR	7	
ANNELIDA	Oligochaeta			2	CG	10	
TOTAL NUMBER of INDIVIDUALS IN SAMPLE				199			Total STaxa = 12
TOTAL TAXA = 28							
Sampling Method: 6 D-frame composite 200 $\pm$ 40 subsample Sampling length=100m						Collector: Lance Leonhardt	

* An Index of Biotic Integrity for Wadeable Freestone Riffle-Run Streams in Pennsylvania (PADEP April 2009)/Appendix F

B-2B **Bertsch Creek Sampling Site #2 (~375m Upstream of Rt. 248) Macroinvertebrate Sub-sample April 8, 2011**

Metric	Standardization Equation	Observed Metric Value	Standardized Metric Score	Adjusted Standardized Metric Score (Maximum = 1.000)
Total Taxa Richness	observed value/33	28	0.848	0.848
EPT Taxa Richness (PTV 0-4 only)	observed value/19	13	0.684	0.684
Modified Beck's Index	observed value/38	22	0.579	0.579
Hilsenhoff Biotic Index	(10-observed value)/(10-1.89)	3.68	0.779	0.779
Shannon Diversity	observed value/2.86	2.507	0.877	0.877
Percent Sensitive Individuals (PTV 0-3)	observed value/84.5	48.2	0.57	0.57
Average of adjusted standardized core metric scores x 100 = **IBI Score =**				**= 72.3**

[1] An Index of Biotic Integrity for Wadeable Freestone Riffle-Run Streams In Pennsylvania (PADEP April 2009)

October-May

IBI Score ≥ 63 = Aquatic Life Use (ALU) attainment
IBI Score < 50 = ALU Impairment
IBI Score 50-63 = ALU Impairment with any of the following:

June-September

IBI Score ≥ 50 = Aquatic Life Use (ALU) attainment
IBI Score < 40 = ALU Impairment
IBI Score 40-50 = ALU Impairment with any of the following:

1) Beck's Index score < 20 and % Sensitive Individuals < 20%
2) Sample dominated by tolerant taxa or individuals
3) Mayflies, stoneflies or caddisflies are absent from sub-sample

Aquatic Life Use (ALU): A use designation relating to the level of water quality a stream is expected to meet in providing habitat suitable for supporting ecologically-desirable aquatic organisms.

B-3A **Indian Creek Sampling Site #1 (~70m upstream of Delps Road) Macroinvertebrate Sub-sample April 3, 2011**

Site: 40^{0}47'46.53''N 75^{0}28'46.23''W elevation 697 ft. Taxonomic Classification Class Order Family Genus				Number of Individuals in Sample	Functional Feeding Group	Pollution Tolerance Value*	Sensitive Taxa (PTV 0-3)
INSECTS/	Plecoptera	Perlodidae	*Isoperla*	2	PR	2	S
			Diploperla	1	PR	2	S
		Leuctridae	*Leuctra*	1	SH	0	S
		Nemouridae	*Prostoia*	3	SH (shredder)	2	S
			Amphinemura	3	SH	3	S
	Ephemeroptera	Heptageniidae	*Epeorus*	1	SC (scraper)	0	S
		Ephemerellidae	*Ephemeralla*	7	CG	1	S
		Leptophlebiidae	*Paraleptophlebia*	3	CG	1	S
		Baetidae	*Baetis*	1	CG	6	
		Ameletidae	*Ameletus*	7	CG	0	S
	Trichoptera	Hydropsychidae	*Diplectrona*	2	FC (filter collector)	0	S
		Rhyacophilidae	*Rhyacophila*	18	PR	1	S
	Coleoptera	Elmidae	*Microcylloepus*	2	SC	2	S
		Ptilodactylidae	*Anchytarsus*	13	SH	5	
	Diptera	Chironomidae		4	CG	6	
		Tipulidae	*Tipula*	2	SH	4	
		Simuliidae	*Prosimulium*	137	FC	2	S
			Simulium	1	FC	6	
	Megaloptera	Corydalidae	*Nigronia*	7	PR	2	S
ANNELIDA	Oligochaeta			2	CG	10	
TOTAL NUMBER of INDIVIDUALS IN SAMPLE				217			Total STaxa = 14
TOTAL TAXA = 20							
Sampling Method: 6 D-frame composite 200 ± 40 subsample Sampling length=100m					Collector: Lance Leonhardt		

*An Index of Biotic Integrity for Wadeable Freestone Riffle-Run Streams in Pennsylvania (PADEP April 2009)/Appendix F

B-3B **Indian Creek Sampling Site #1 (~70m upstream of Delps Road) Macroinvertebrate Sub-sample April 3, 2011**

Metric	Standardization Equation	Observed Metric Value	Standardized Metric Score	Adjusted Standardized Metric Score (Maximum = 1.000)
Total Taxa Richness	observed value/33	20	0.606	0.606
EPT Taxa Richness (PTV 0-4 only)	observed value/19	11	0.579	0.579
Modified Beck's Index	observed value/38	24	0.632	0.632
Hilsenhoff Biotic Index	(10-observed value)/(10-1.89)	2.17	0.965	0.965
Shannon Diversity	observed value/2.86	1.59	0.556	0.556
Percent Sensitive Individuals (PTV 0-3)	observed value/84.5	89.4	1.06	1.000
Average of adjusted standardized core metric scores x 100 = **IBI Score =**				**= 72.3**

[1] An Index of Biotic Integrity for Wadeable Freestone Riffle-Run Streams In Pennsylvania (PADEP April 2009)

October-May

IBI Score ≥ 63 = Aquatic Life Use (ALU) attainment
IBI Score < 50 = ALU Impairment
IBI Score 50-63 = ALU Impairment with any of the following:

June-September

IBI Score ≥ 50 = Aquatic Life Use (ALU) attainment
IBI Score < 40 = ALU Impairment
IBI Score 40-50 = ALU Impairment with any of the following:

1) Beck's Index score < 20 and % Sensitive Individuals < 20%
2) Sample dominated by tolerant taxa or individuals
3) Mayflies, stoneflies or caddisflies are absent from sub-sample

Aquatic Life Use (ALU): A use designation relating to the level of water quality a stream is expected to meet in providing habitat suitable for supporting ecologically-desirable aquatic organisms.

B-4A **Indian Creek Sampling Site #2 (~ 50m upstream of Beech Drive) Macroinvertebrate Sub-sample April 3, 2011**

Site: 40^{0}46'25.86''N 75^{0}30'16.32''W elevation 555 ft. Taxonomic Classification Class Order Family Genus	Number of Individuals in Sample	Functional Feeding Group	Pollution Tolerance Value*	Sensitive Taxa (PTV 0-3)
INSECTS/ Plecoptera Perlidae *Acroneuria*	4	PR (predator)	0	S
Chloroperlidae *Sweltsa*	3	PR	0	S
Alloperla	2	CG (collector gatherer)	0	S
Nemouridae *Prostoia*	21	SH (shredder)	2	S
Amphinemura	3	SH	3	S
Taeniopterygidae *Strophopteryx*	11	SH	3	S
Ephemeroptera Heptageniidae *Epeorus*	27	SC (scraper)	0	S
Macaffertium (*Stenonema)*	6	SC	3	S
Stenacron	1	SC	4	
Ephemerellidae *Ephemerella*	22	CG	1	S
Leptophlebiidae *Paraleptophlebia*	1	CG	1	S
Baetidae *Baetis*	2	CG	6	
Ameletidae *Ameletus*	1	CG	0	S
Trichoptera Hydropsychidae *Diplectrona*	4	FC (filter collector)	0	S
Hydropsyche	3	FC	5	
Cheumatopsyche	9	FC	6	
Philopotamidae *Dolophilodes*	2	FC	0	S
Chimarra	2	FC	4	
Rhyacophilidae *Rhyacophila*	10	PR	1	S
Polycentropodidae *Polycentropus*	1	FC	6	
Uenoidae *Neophylax*	5	SC	3	S
Coleoptera Psephenidae *Psephenus*	3	SC	4	
Ectopria	2	SC	5	
Diptera Chironomidae	9	CG	6	
Tipulidae *Tipula*	2	SH	4	
Dicranota	1	PR	3	S
Empididae *Clinocera*	2	PR	6	
Simuliidae *Prosimulium*	39	FC	2	S
Simulium	1	FC	6	
Blephariceridae *Blepharicera*	1	SC	0	S
MOLLUSCA Bivalvia Sphaeriidae *Pisidium*	1	FC	8	
ANNELIDA Oligochaeta	2	CG	10	
TOTAL NUMBER of INDIVIDUALS IN SAMPLE	203			Total STaxa = 18
TOTAL TAXA = 32				
Sampling Method: 6 D-frame composite 200 ± 40 subsample Sampling length=100m			Collector: Lance Leonhardt	

*An Index of Biotic Integrity for Wadeable Freestone Riffle-Run Streams in Pennsylvania (PADEP April 2009)/Appendix F

B-4B **Indian Creek Sampling Site #2 (~ 50m upstream of Beech Drive) Macroinvertebrate Sub-sample April 3, 2011**

Metric	Standardization Equation	Observed Metric Value	Standardized Metric Score	Adjusted Standardized Metric Score (Maximum = 1.000)
Total Taxa Richness	observed value/33	32	0.97	0.97
EPT Taxa Richness (PTV 0-4 only)	observed value/19	17	0.895	0.895
Modified Beck's Index	observed value/38	32	0.842	0.842
Hilsenhoff Biotic Index	(10-observed value)/(10-1.89)	2.27	0.953	0.953
Shannon Diversity	observed value/2.86	2.82	0.986	0.986
Percent Sensitive Individuals (PTV 0-3)	observed value/84.5	80.3	0.95	0.95
Average of adjusted standardized core metric scores x 100 = **IBI Score =**				**= 93.3**

[1] An Index of Biotic Integrity for Wadeable Freestone Riffle-Run Streams In Pennsylvania (PADEP April 2009)

October-May

IBI Score ≥ 63 = Aquatic Life Use (ALU) attainment
IBI Score < 50 = ALU Impairment
IBI Score 50-63 = ALU Impairment with any of the following:

June-September

IBI Score ≥ 50 = Aquatic Life Use (ALU) attainment
IBI Score < 40 = ALU Impairment
IBI Score 40-50 = ALU Impairment with any of the following:

1) Beck's Index score < 20 and % Sensitive Individuals < 20%
2) Sample dominated by tolerant taxa or individuals
3) Mayflies, stoneflies or caddisflies are absent from sub-sample

Aquatic Life Use (ALU): A use designation relating to the level of water quality a stream is expected to meet in providing habitat suitable for supporting ecologically-desirable aquatic organisms.

B-5A Hokendauqua Creek Sampling Site #1 (~ 675m upstream of Lilly Hill Rd.) Macroinvertebrate Sub-sample April 3, 2011

Site: 40°47'24.68''N 75°26'42.06''W elevation 646 ft. Taxonomic Classification Class	Order	Family	Genus	Number of Individuals in Sample	Functional Feeding Group	Pollution Tolerance Value*	Sensitive Taxa (PTV 0-3)
INSECTS/	Plecoptera	Perlidae	*Acroneuria*	1	PR (predator)	0	S
		Perlodidae	*Isoperla*	1	PR	2	S
		Chloroperlidae	*Sweltsa*	1	PR	0	S
			Alloperla	6	CG (collector gatherer)	0	S
		Nemouridae	*Prostoia*	29	SH (shredder)	2	S
			Amphinemura	2	SH	3	S
		Taeniopterygidae	*Strophopteryx*	8	SH	3	S
	Ephemeroptera	Heptageniidae	*Epeorus*	13	SC (scraper)	0	S
			Macaffertium (*Stenonema)*	8	SC	3	S
		Ephemerellidae	*Ephemeralla*	10	CG	1	S
			Drunella	2	SC	1	S
		Baetidae	*Baetis*	1	CG	6	
	Trichoptera	Hydropsychidae	*Hydropsyche*	3	FC	5	
			Cheumatopsyche	14	FC	6	
		Philopotamidae	*Chimarra*	10	FC	4	
		Rhyacophilidae	*Rhyacophila*	1	PR	1	S
		Polycentropodidae	*Polycentropus*	1	FC	6	
		Uenoidae	*Neophylax*	14	SC	3	S
	Coleoptera	Psephenidae	*Psephenus*	8	SC	4	
		Elmidae	*Optioservus*	6	SC	4	
	Diptera	Chironomidae		29	CG	6	
		Tipulidae	*Hexatoma*	1	PR	2	S
		Empididae	*Clinocera*	28	PR	6	
			Hemerodromia	1	PR	6	
		Simuliidae	*Prosimulium*	17	FC	2	S
			Simulium	1	FC	6	
	Megaloptera	Corydalidae	*Nigronia*	2	PR	2	S
	Odonata	Gomphidae	*Ophiogomphus*	1	PR	1	S
			Gomphus	1	PR	5	
CRUSTACEA	Decapoda	Cambaridae		1	CG	6	
ANNELIDA	Oligochaeta			5	CG	10	
TOTAL NUMBER of INDIVIDUALS IN SAMPLE				226			Total STaxa = 17
TOTAL TAXA = 31							
Sampling Method: 6 D-frame composite 200 ± 40 subsample Sampling length=100m					Collector: Lance Leonhardt		

*An Index of Biotic Integrity for Wadeable Freestone Riffle-Run Streams in Pennsylvania (PADEP April 2009)/Appendix F

B-5B Hokendauqua Creek Sampling Site #1 (~ 675m upstream of Lilly Hill Rd.) Macroinvertebrate Sub-sample April 3, 2011

Metric	Standardization Equation	Observed Metric Value	Standardized Metric Score	Adjusted Standardized Metric Score (Maximum = 1.000)
Total Taxa Richness	observed value/33	31	0.939	0.939
EPT Taxa Richness (PTV 0-4 only)	observed value/19	14	0.737	0.737
Modified Beck's Index	observed value/38	25	0.658	0.658
Hilsenhoff Biotic Index	(10-observed value)/(10-1.89)	3.68	0.779	0.779
Shannon Diversity	observed value/2.86	2.87	1.00	1.00
Percent Sensitive Individuals (PTV 0-3)	observed value/84.5	51.8	0.613	0.613
Average of adjusted standardized core metric scores x 100 = **IBI Score =**				**= 78.8**

[1] An Index of Biotic Integrity for Wadeable Freestone Riffle-Run Streams In Pennsylvania (PADEP April 2009)

October-May

IBI Score $\geq$ 63 = Aquatic Life Use (ALU) attainment
IBI Score < 50 = ALU Impairment
IBI Score 50-63 = ALU Impairment with any of the following:

June-September

IBI Score $\geq$ 50 = Aquatic Life Use (ALU) attainment
IBI Score < 40 = ALU Impairment
IBI Score 40-50 = ALU Impairment with any of the following:

1) Beck's Index score < 20 and % Sensitive Individuals < 20%
2) Sample dominated by tolerant taxa or individuals
3) Mayflies, stoneflies or caddisflies are absent from sub-sample

Aquatic Life Use (ALU): A use designation relating to the level of water quality a stream is expected to meet in providing habitat suitable for supporting ecologically-desirable aquatic organisms.

B-6A Hokendauqua Creek Sampling Site #2 (~150m upstream of SR 4005) Macroinvertebrate Sub-sample April 3, 2011

Site: 40°46'24.74''N 75°27'32.27''W elevation 590 ft. Taxonomic Classification Class	Order	Family	Genus	Number of Individuals in Sample	Functional Feeding Group	Pollution Tolerance Value*	Sensitive Taxa (PTV 0-3)
INSECTS/	Plecoptera	Perlidae	*Acroneuria*	5	PR (predator)	0	S
		Perlodidae	*Isoperla*	1	PR	2	S
		Chloroperlidae	*Alloperla*	3	CG (collector gatherer)	0	S
		Leuctridae	*Leuctra*	1	SH (shredder)	0	S
		Nemouridae	*Prostoia*	49	SH	2	S
			Amphinemura	2	SH	3	S
		Taeniopterygidae	*Strophopteryx*	2	SH	3	S
	Ephemeroptera	Heptageniidae	*Epeorus*	23	SC (scraper)	0	S
			Macaffertium (*Stenonema)*	10	SC	3	S
		Ameletidae	*Ameletus*	2	CG	0	S
		Ephemerellidae	*Ephemeralla*	20	CG	1	S
			Drunella	15	SC	1	S
		Baetidae	*Baetis*	2	CG	6	
	Trichoptera	Hydropsychidae	*Hydropsyche*	6	FC	5	
			Cheumatopsyche	9	FC	6	
		Philopotamidae	*Chimarra*	14	FC	4	
		Rhyacophilidae	*Rhyacophila*	7	PR	1	S
		Uenoidae	*Neophylax*	2	SC	3	S
	Coleoptera	Psephenidae	*Psephenus*	6	SC	4	
		Elmidae	*Optioservus*	1	SC	4	
			Stenelmis	1	SC	5	
			Macronychus	1	SC	2	S
	Diptera	Chironomidae		21	CG	6	
		Tipulidae	*Hexatoma*	1	PR	2	S
		Empididae	*Clinocera*	2	PR	6	
		Simuliidae	*Prosimulium*	23	FC	2	S
	Odonata	Gomphidae	*Stylogomphus*	1	PR	4	
TOTAL NUMBER of INDIVIDUALS IN SAMPLE				230			Total STaxa = 17
TOTAL TAXA = 27							
Sampling Method: 6 D-frame composite 200 ± 40 subsample Sampling length=100m						Collector: Lance Leonhardt	

* An Index of Biotic Integrity for Wadeable Freestone Riffle-Run Streams in Pennsylvania (PADEP April 2009)/Appendix F

B-6B Hokendauqua Creek Sampling Site #2 (~150m upstream of SR 4005) Macroinvertebrate Sub-sample April 3, 2011

Metric	Standardization Equation	Observed Metric Value	Standardized Metric Score	Adjusted Standardized Metric Score (Maximum = 1.000)
Total Taxa Richness	observed value/33	27	0.818	0.818
EPT Taxa Richness (PTV 0-4 only)	observed value/19	15	0.789	0.789
Modified Beck's Index	observed value/38	26	0.684	0.684
Hilsenhoff Biotic Index	(10-observed value)/(10-1.89)	2.47	0.928	0.928
Shannon Diversity	observed value/2.86	2.68	0.937	0.937
Percent Sensitive Individuals (PTV 0-3)	observed value/84.5	72.6	0.859	0.859
Average of adjusted standardized core metric scores x 100 = **IBI Score =**				**= 83.6**

[1] An Index of Biotic Integrity for Wadeable Freestone Riffle-Run Streams In Pennsylvania (PADEP April 2009)

October-May

IBI Score ≥ 63 = Aquatic Life Use (ALU) attainment
IBI Score < 50 = ALU Impairment
IBI Score 50-63 = ALU Impairment with any of the following:

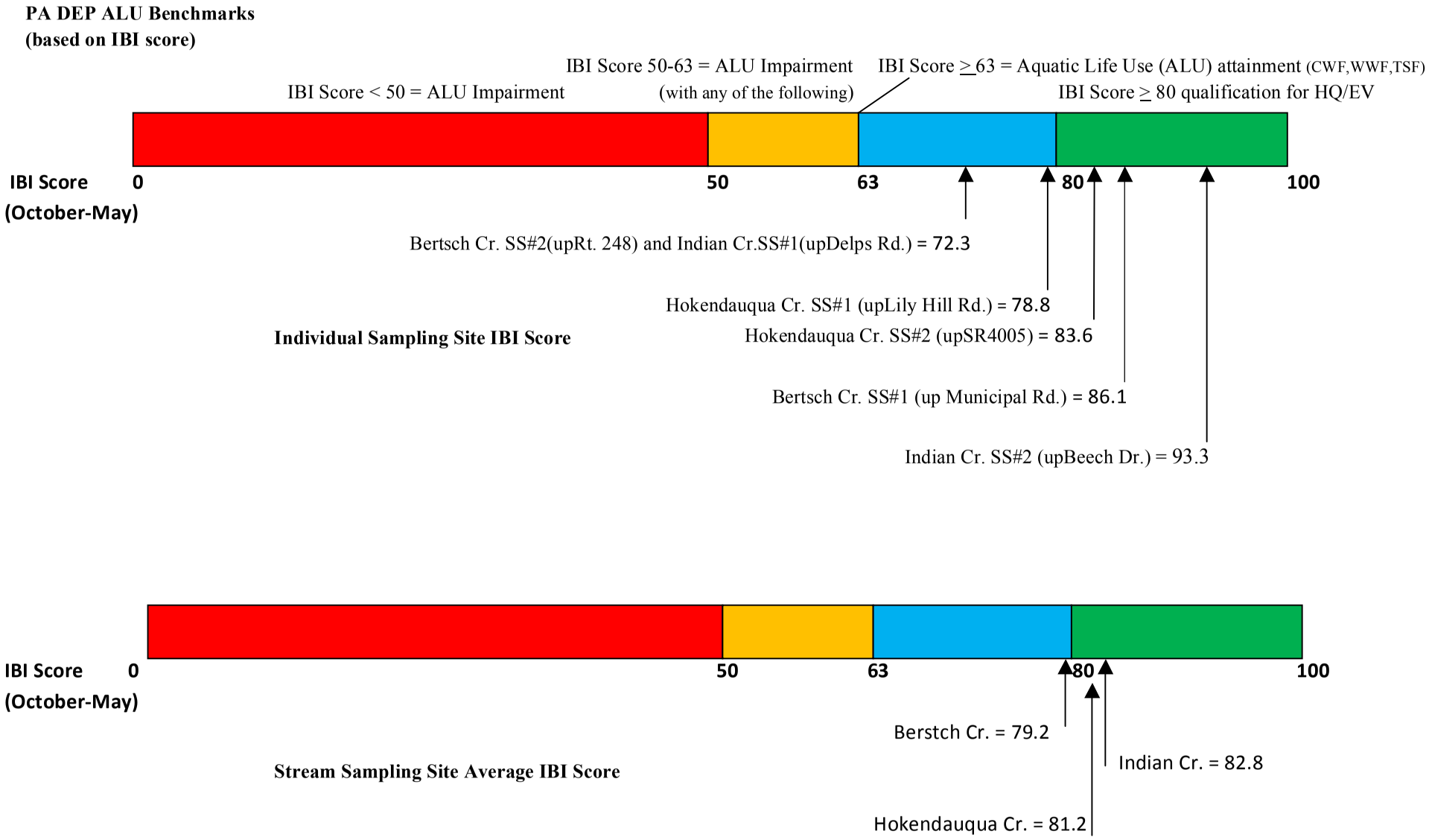
June-September

IBI Score ≥ 50 = Aquatic Life Use (ALU) attainment
IBI Score < 40 = ALU Impairment
IBI Score 40-50 = ALU Impairment with any of the following:

1) Beck's Index score < 20 and % Sensitive Individuals < 20%
2) Sample dominated by tolerant taxa or individuals
3) Mayflies, stoneflies or caddisflies are absent from sub-sample

Aquatic Life Use (ALU): A use designation relating to the level of water quality a stream is expected to meet in providing habitat suitable for supporting ecologically-desirable aquatic organisms.

B-7 **Comparison of IBI Scores to PA DEP Aquatic Life Use (ALU) Benchmarks**



B-8 **Sampling Site Highly Sensitive Macroinvertebrate Taxa**

Zero Tolerance Value* / Highly Sensitive Macroinvertebrate Taxa	Bertsch Cr. Site #1	Bertsch Cr. Site #2	Indian Cr. Site #1	Indian Cr. Site #2	Hokendauaqua Cr. Site #1	Hokendauaqua Cr. Site #2
Insecta Ephemeroptera Heptageniidae *Epeorus*	X	X	X	X	X	X
Insecta Ephemeroptera Ameletidae *Ameletus*	X	X	X	X		X
Insecta Plecoptera Perlidae *Acroneuria*	X	X		X	X	X
Insecta Plecoptera Chloroperlidae *Sweltsa*		X		X	X	
Insecta Plecoptera Chloroperlidae *Alloperla*				X	X	X
Insecta Plecoptera Leuctridae *Leuctra*			X			X
Insecta Trichoptera Hydropsychidae *Diplectrona*	X	X	X	X		
Insecta Trichoptera Philopotamidae *Dolophilodes*		X		X		
Insecta Diptera Blephariceridae *Blepharicera*				X		
Other Highly Sensitive Macroinverterbate Taxa tolerance value* ( )						
Insecta Ephemeroptera Ephemerellidae (1) *Drunella*					X	X
Insecta Ephemeroptera Leptophlebiidae (1) *Paraleptophlebia*			X	X		
Insecta Plecoptera Perlodidae (2) *Isoperla*	X		X		X	X
Insecta Trichoptera Rhyacophilidae (1) *Rhyacophila*	X		X	X	X	X
Taxa Per Site	6	6	7	10	7	8

*Hilsenhoff/PA DEP[1]

Blue = stenothermal cold-eurythermal cool species (Poff 2006)[14]

Appendix C: Comparison of PACC Stream Community Genus-Level Macroinvertebrate Indicator Taxa to Sampling Site Macroinvertebrate Taxa

C-1

High Quality Small Stream Community	Bertsch Cr. Site #1	Bertsch Cr. Site #2	Indian Cr. Site #1	Indian Cr. Site #2	Hokendauaqua Cr. Site #1	Hokendauaqua Cr. Site #2
Insecta Ephemeroptera Heptageniidae *Epeorus**	X	X	X	X	X	X
Insecta Plecoptera Perlodidae *Isoperla*	X		X		X	X
Insecta Coleoptera Elmidae *Oulimnius**						
Insecta Plecoptera Pteronarcyidae *Pteronarcys*						
Insecta Trichoptera Rhyacophilidae *Rhyacophila*	X		X	X	X	X
Insecta Trichoptera Hydropsychidae *Diplectrona*	X	X	X	X		
Insecta Plecoptera Perlidae *Acroneuria*	X	X		X	X	X
Insecta Ephemeroptera Heptageniidae *Cinygmula*						
Insecta Plecoptera Chloroperlidae *Sweltsa*		X		X	X	
Insecta Diptera Tipulidae *Hexatoma*					X	X
Insecta Ephemeroptera Leptophlebiidae *Paraleptophlebia*			X	X		
Insecta Odonata Gomphidae *Lanthus*	X	X				
Insecta Diptera Tipulidae *Dicranota*	X			X		
Insecta Trichoptera Uenoidae *Neophylax*	X	X		X	X	X
Blue = stenothermal cold-eurythermal cool species (Poff et al. 2006)						
**Has Strongest Indicator(s) of Community Type Present (PA ACC)*	X	X	X	X	X	X
Expected for community type: *Taxa Richness ()* *EPT Taxa (15.2)* *Intolerant taxa (11.7)*	EPT Taxa= 18 Int. Taxa = 17 (0-3)	EPT Taxa= 17 Int. Taxa = 12 (0-3)	EPT Taxa= 12 Int. Taxa = 14 (0-3)	EPT Taxa= 21 Int. Taxa = 18 (0-3)	EPT Taxa= 18 Int. Taxa = 17 (0-3)	EPT Taxa= 18 Int. Taxa = 17 (0-3)

(indicator species listed in table for each PACC community type have indicator values of ≥10)

C-2

High Quality Headwater Stream Community	Bertsch Cr. Site #1	Bertsch Cr. Site #2	Indian Cr. Site #1	Indian Cr. Site #2	Hokendauaqua Cr. Site #1	Hokendauaqua Cr. Site #2
Insecta Plecoptera Nemouridae *Amphinemura**	X	X	X	X	X	X
Insecta Trichoptera Lepidostomatidae *Lepidostoma**						
Insecta Plecoptera Leuctridae *Leuctra*			X			X
Insecta Diptera Simuliidae *Prosimulium*	X	X	X	X	X	X
Blue = stenothermal cold-eurythermal cool species (Poff et al. 2006)						
**Has Strongest Indicator(s) of Community Type Present (PA ACC)*	X	X	X	X	X	X
Expected for community type: *Taxa Richness (16.2)* *EPT Taxa (9)* *Intolerant taxa (6.5)*	EPT Taxa= 18 Int. Taxa = 17 (0-3)	EPT Taxa= 17 Int. Taxa = 12 (0-3)	EPT Taxa= 12 Int. Taxa = 14 (0-3)	EPT Taxa= 21 Int. Taxa = 18 (0-3)	EPT Taxa= 18 Int. Taxa = 17 (0-3)	EPT Taxa= 18 Int. Taxa = 17 (0-3)

(indicator species listed in table for each PACC community type have indicator values of ≥10)

C-3

Forested Headwater Stream Community	Bertsch Cr. Site #1	Bertsch Cr. Site #2	Indian Cr. Site #1	Indian Cr. Site #2	Hokendauaqua Cr. Site #1	Hokendauaqua Cr. Site #2
Insecta Plecoptera Chloroperlidae *Alloperla**				X	X	X
Insecta Diptera Tipulidae *Tipula**		X	X	X		
Insecta Ephemeroptera Ameletidae *Ameletus*	X	X	X	X		X
Blue = stenothermal cold-eurythermal cool species (Poff et al. 2006)						
**Has Strongest Indicator(s) of Community Type Present (PA ACC)*		X	X	X	X	X
Expected for community type: *Taxa Richness (9.3)* *EPT Taxa (5.9)* *Intolerant taxa ( )*	EPT Taxa= 18 Int. Taxa = 17 (0-3)	EPT Taxa= 17 Int. Taxa = 12 (0-3)	EPT Taxa= 12 Int. Taxa = 14 (0-3)	EPT Taxa= 21 Int. Taxa = 18 (0-3)	EPT Taxa= 18 Int. Taxa = 17 (0-3)	EPT Taxa= 18 Int. Taxa = 17 (0-3)

(indicator species listed in table for each PACC community type have indicator values of ≥10) (except for *Tipula* (9.9) and *Ameletus (* 8.9)

C-4

High Quality Large Stream Community	Bertsch Cr. Site #1	Bertsch Cr. Site #2	Indian Cr. Site #1	Indian Cr. Site #2	Hokendauaqua Cr. Site #1	Hokendauaqua Cr. Site #2
Insecta Ephemeroptera Ephemerellidae *Drunella**					X	X
Insecta Ephemeroptera Baetidae *Acentrella**						
Insecta Ephemeroptera Ephemerellidae *Serratella*						
Insecta Ephemeroptera Ephemerellidae *Ephemeralla*	X	X	X	X	X	X
Insecta Ephemeroptera Heptageniidae *Leucrocruta*						
Insecta Trichoptera Philopotamidae *Dolophilodes*		X		X		
Insecta Trichoptera Hydropsychidae *Ceratopsyche*						
Insecta Ephemeroptera Baetidae *Baetis*			X	X	X	X
Insecta Trichoptera Glossosomatidae *Agapetus*						
Blue = stenothermal cold-eurythermal cool species (Poff et al. 2006)						
**Has Strongest Indicator(s) of Community Type Present (PA ACC)*					X	X
Expected for community type: *Taxa Richness (16.2)* *EPT Taxa (9)* *Intolerant taxa ()*	EPT Taxa= 18 Int. Taxa = 17 (0-3)	EPT Taxa= 17 Int. Taxa = 12 (0-3)	EPT Taxa= 12 Int. Taxa = 14 (0-3)	EPT Taxa= 21 Int. Taxa = 18 (0-3)	EPT Taxa= 18 Int. Taxa = 17 (0-3)	EPT Taxa= 18 Int. Taxa = 17 (0-3)

(indicator species listed in table for each PACC community type have indicator values of ≥10)

C-5

Common Small Stream Community	Bertsch Cr. Site #1	Bertsch Cr. Site #2	Indian Cr. Site #1	Indian Cr. Site #2	Hokendauaqua Cr. Site #1	Hokendauaqua Cr. Site #2
Insecta Ephemeroptera Heptageniidae *Stenonema*[*]	X	X		X	X	X
Insecta Coleoptera Psephenidae *Psephenus*[*]	X	X		X	X	X
Insecta Trichoptera Philopotamidae *Chimarra*	X	X		X	X	X
Insecta Trichoptera Glossosomatidae *Glossosoma*						
Insecta Ephemeroptera Isonychiidae *Isonychia*						
Blue = stenothermal cold-eurythermal cool species (Poff et al. 2006)						
[*]*Has Strongest Indicator(s) of Community Type Present (PA ACC)*	X	X		X	X	X
Expected for community type: *Taxa Richness (20.2)* *EPT Taxa (11.8)* *Intolerant taxa ()*	EPT Taxa= 18 Int. Taxa = 17 (0-3)	EPT Taxa= 17 Int. Taxa = 12 (0-3)	EPT Taxa= 12 Int. Taxa = 14 (0-3)	EPT Taxa= 21 Int. Taxa = 18 (0-3)	EPT Taxa= 18 Int. Taxa = 17 (0-3)	EPT Taxa= 18 Int. Taxa = 17 (0-3)

(indicator species listed in table for each PACC community type have indicator values of ≥10)

C-6

Small Urban Stream Community	Bertsch Cr. Site #1	Bertsch Cr. Site #2	Indian Cr. Site #1	Indian Cr. Site #2	Hokendauaqua Cr. Site #1	Hokendauaqua Cr. Site #2
*Cheumatopsyche**	X	X		X	X	X
*Stenelmis**						X
Simulium	X	X	X	X	X	
Hemerodromia						
Blue = stenothermal cold-eurythermal cool species (Poff et al. 2006)						
[*]*Has Strongest Indicator(s) of Community Type Present (PA ACC)*	X	X		X	X	X
Expected for community type: *Taxa Richness (12.2)* *EPT Taxa (4.3)* *Intolerant taxa (1.4)*	EPT Taxa= 18 Int. Taxa = 17 (0-3)	EPT Taxa= 17 Int. Taxa = 12 (0-3)	EPT Taxa= 12 Int. Taxa = 14 (0-3)	EPT Taxa= 21 Int. Taxa = 18 (0-3)	EPT Taxa= 18 Int. Taxa = 17 (0-3)	EPT Taxa= 18 Int. Taxa = 17 (0-3)

(indicator species listed in table for each PACC community type have indicator values of ≥10)

C-7

Mixed Land Use Stream Community	Bertsch Cr. Site #1	Bertsch Cr. Site #2	Indian Cr. Site #1	Indian Cr. Site #2	Hokendauaqua Cr. Site #1	Hokendauaqua Cr. Site #2
*Hydropsyche**	X	X		X	X	X
*Nigronia**	X		X		X	
Blue = stenothermal cold-eurythermal cool species (Poff et al. 2006)						
*Has Strongest Indicator(s) of Community Type Present (PA ACC)	X	X	X	X	X	X
Expected for community type: *Taxa Richness (8.8)* *EPT Taxa (6.0)* *Intolerant taxa ()*	EPT Taxa= 18 Int. Taxa = 17 (0-3)	EPT Taxa= 17 Int. Taxa = 12 (0-3)	EPT Taxa= 12 Int. Taxa = 14 (0-3)	EPT Taxa= 21 Int. Taxa = 18 (0-3)	EPT Taxa= 18 Int. Taxa = 17 (0-3)	EPT Taxa= 18 Int. Taxa = 17 (0-3)

(indicator species listed in table for each PACC community type have indicator values of ≥10)

Appendix B
DEP Sampling Locations & Macroinvertebrate Sampling Summaries

Bertsch Creek Sampling Locations

Macroinvertebrate Sample Summary

version: 3.0 1/31/2012 10:28:16 AM

Assessment ID:	58813 Bertsch Ck (BC01)
Station ID:	20081119-1543-sleap (Latitude: 40.7754, Longitude: -75.5549)
Method:	6-Dframe Composite, 200 subsample
Location:	Upstream of Lehigh Twp. Municipal Authority discharge.N 040 46 31.9W-075 33 18.1

Comments:

Land Use: Site located in forested area. Surrounding area is rural, fields and homes, small town upstream.

Impairment: Actual collection date 5-30-2007

Taxa:

Total # Organisms: 214

Code	Standardized ID Level	Number	Tolerance
1020400300	Baetis	19	6
1020401300	Plauditus	17	4
1020800200	Drunella	7	1
1020800300	Ephemerella	11	1
1030300400	Boyeria	1	2
1040400100	Amphinemura	1	3
1040500200	Leuctra	10	0
1040700100	Agnetina	5	2
1040700400	Acroneuria	2	0
1060200400	Nigronia	2	2
1080100200	Dolophilodes	14	0
1080400300	Diplectrona	1	0
1080400600	Cheumatopsyche	10	6
1080400700	Hydropsyche	7	5
1080600100	Glossosoma	11	0
1080600200	Agapetus	1	0
1080910100	Lepidostoma	1	1
1121200500	Hemerodromia	1	6
1121900700	Antocha	3	3
1121901600	Limnophila	1	3
1122100500	Simulium	14	6
1122200000	Chironomidae	70	6
11000000000	Oligochaeta	2	10
13040100100	Cambarus	1	6
15000000000	Hydracarina	2	7

Metrics:

Metric Name	Raw Metric Values	Standarized Metric Values: Freestone Riffle-Run						
		6D200 2009 Small	6D200 2009 Large	6D200 2007	2D100	Multihabitat Pool-Glide	Limestone 2006	Limestone 2009
Total Richness	25	75.8	80.6	71.4		80.6	135.1	138.9
Ephemeroptera Richness	4					66.7		
Trichoptera Richness	7					63.6		
EPT Richness	15			65.2	98.0	88.2	187.5	187.5
Trichoptera Richness (PTV 0-4)	5				138.9			
EPT Richness (PTV 0-4)	12	63.2	75.0					
Becks Index (version 3)	27	71.1	122.7	69.2				
Becks Index (version 4)	25				125.6	113.6		208.3
FC + PR + SH Richness	15				129.3			
Hilsenhoff Biotic Index	4.10	72.7	84.9	71.8	87.5		93.8	95.8
% Intolerant Individuals (PTV 0-3)	33.2	39.3	49.8				126.2	
% Intolerant Individuals (PTV 0-5)	44.4			48.0				
% Tolerant Individuals (PTV 7-10)	1.9						99.1	99.6
Shannon Diversity	2.48	86.6	86.6	85.4		101.9	129.0	116.3
IBI Score		68.1	79.5	68.5	97.1	83.2	98.8	99.2

% Ephemeroptera: 25.23 % Plecoptera: 8.41 % Trichoptera: 21.03
% Ephemeroptera (PTV 0-4): 16.36 % Dominant Taxon: 32.71

Habitat:

1 Instream Cover:	17	2 Epifaunal Substrate:	15	
3 Embeddedness:	15	4 Velocity/Depth Regimes:	14	
5 Channel Alterations:	19	6 Sediment Deposition:	13	
7 Frequency of Riffles:	14	8 Channel Flow Status:	12	
9 Condition of Banks:	15	10 Bank Vegetation:	17	**Total**
11 Grazing or Disruptive:	20	12 Riparian Vegetation:	20	191

Impairment:

Insufficient? Y Impaired? N/A Biology Impaired? N/A
Habitat Impaired? N/A Rock picks influenced? N Impact Localized? N
Designated Use needs reevaluation? N

Macroinvertebrate Sample Summary

version: 3.0 1/31/2012 10:32:31 AM

Assessment ID: 58815 Bertsch Ck (BC02)
Station ID: 20081120-1357-sleap (Latitude: 40.7746, Longitude: -75.5557)
Method: 6-Dframe Composite, 200 subsample
Location: Downstream of STP discharge: N 40 46 31.6, W -075 33 21.6

Comments:

Land Use: Forested at station site.
Impairment: Actual collection date 5-30-2007

Taxa:

Total # Organisms: 478

Code	Standardized ID Level	Number	Tolerance
1020400300	Baetis	14	6
1020800300	Ephemerella	2	1
1040801200	Isoperla	2	2
1080400600	Cheumatopsyche	4	6
1080400700	Hydropsyche	3	5
1080500100	Rhyacophila	1	1
1101300800	Oulimnius	1	5
1101301000	Stenelmis	1	5
1121900400	Tipula	1	4
1121900700	Antocha	1	3
1122100500	Simulium	11	6
1122200000	Chironomidae	385	6
4000000000	Turbellaria	3	9
11000000000	Oligochaeta	41	10
13050100100	Caecidotea	7	6
15000000000	Hydracarina	1	7

Metrics:

Metric Name	Raw Metric Values	Standarized Metric Values: Freestone Riffle-Run						
		6D200 2009 Small	6D200 2009 Large	6D200 2007	2D100	Multihabitat Pool-Glide	Limestone 2006	Limestone 2009
Total Richness	16	48.5	51.6	45.7		51.6	86.5	88.9
Ephemeroptera Richness	2					33.3		
Trichoptera Richness	3					27.3		
EPT Richness	6			26.1	39.2	35.3	75.0	75.0

Trichoptera Richness (PTV 0-4)	1				27.8			
EPT Richness (PTV 0-4)	3	15.8	18.8					
Becks Index (version 3)	5	13.2	22.7	12.8				
Becks Index (version 4)	7				35.2	31.8		58.3
FC + PR + SH Richness	8				69.0			
Hilsenhoff Biotic Index	6.29	45.7	53.4	45.1	55.0		59.0	60.2
% Intolerant Individuals (PTV 0-3)	1.3	1.5	1.9				4.9	
% Intolerant Individuals (PTV 0-5)	2.5			2.7				
% Tolerant Individuals (PTV 7-10)	9.4						91.5	92.0
Shannon Diversity	0.86	30.2	30.2	29.8		35.6	45.0	40.6
IBI Score		25.8	29.8	27.0	45.2	35.8	60.3	69.2

% Ephemeroptera: 3.35 % Plecoptera: 0.42 % Trichoptera: 1.67
% Ephemeroptera (PTV 0-4): 0.42 % Dominant Taxon: 80.54

Habitat:

1 Instream Cover:	10	2 Epifaunal Substrate:	5	
3 Embeddedness:	12	4 Velocity/Depth Regimes:	12	
5 Channel Alterations:	19	6 Sediment Deposition:	10	
7 Frequency of Riffles:	5	8 Channel Flow Status:	12	
9 Condition of Banks:	14	10 Bank Vegetation:	15	**Total**
11 Grazing or Disruptive:	20	12 Riparian Vegetation:	20	154

Impairment:

Insufficient? Y Impaired? N/A Biology Impaired? N/A
Habitat Impaired? N/A Rock picks influenced? N Impact Localized? N
Designated Use needs reevaluation? N

Macroinvertebrate Sample Summary

version: 3.0 1/31/2012 10:42:11 AM

Assessment ID:	58816 Bertsch Ck (BC03)
Station ID:	20081120-1452-sleap (Latitude: 40.7711, Longitude: -75.5604)
Method:	6-Dframe Composite, 200 subsample
Location:	Downstream, first bridge crossing below the Lehigh Twp. STP discharge.

Comments:

Land Use: Farmland, old fields and residential areas with some forested area along portions of stream.
Impairment: Actual collection date 5-30-2007

Taxa:

Total # Organisms: 207

Code	Standardized ID Level	Number	Tolerance
1020400300	Baetis	44	6
1040400100	Amphinemura	1	3
1080400300	Diplectrona	1	0
1080400600	Cheumatopsyche	5	6
1080400700	Hydropsyche	1	5
1101000200	Psephenus	1	4
1101300600	Optioservus	1	4
1101300800	Oulimnius	8	5
1121900400	Tipula	1	4
1122200000	Chironomidae	48	6
4000000000	Turbellaria	2	9
5999999999	Nematoda	1	9
11000000000	Oligochaeta	64	10
13050100100	Caecidotea	28	6
15000000000	Hydracarina	1	7

Metrics:

Metric Name	Raw Metric Values	Standarized Metric Values						
		Freestone Riffle-Run						
		6D200 2009 Small	6D200 2009 Large	6D200 2007	2D100	Multihabitat Pool-Glide	Limestone 2006	Limestone 2009
Total Richness	15	45.5	48.4	42.9		48.4	81.1	83.3
Ephemeroptera Richness	1					16.7		
Trichoptera Richness	3					27.3		

EPT Richness	5			21.7	32.7	29.4	62.5	62.5
Trichoptera Richness (PTV 0-4)	1				27.8			
EPT Richness (PTV 0-4)	2	10.5	12.5					
Becks Index (version 3)	3	7.9	13.6	7.7				
Becks Index (version 4)	6				30.2	27.3		50.0
FC + PR + SH Richness	7				60.3			
Hilsenhoff Biotic Index	7.17	34.9	40.7	34.4	42.0		45.0	45.9
% Intolerant Individuals (PTV 0-3)	1.0	1.2	1.5				3.8	
% Intolerant Individuals (PTV 0-5)	6.8			7.4				
% Tolerant Individuals (PTV 7-10)	32.9						67.8	68.1
Shannon Diversity	1.77	61.8	61.8	61.0		72.8	92.1	83.0
IBI Score		27.0	29.8	29.2	38.6	37.0	58.7	65.5

% Ephemeroptera: 21.26 % Plecoptera: 0.48 % Trichoptera: 3.38
% Ephemeroptera (PTV 0-4): 0 % Dominant Taxon: 30.92

Habitat:

1 Instream Cover:	0	2 Epifaunal Substrate:	0		
3 Embeddedness:	0	4 Velocity/Depth Regimes:	0		
5 Channel Alterations:	0	6 Sediment Deposition:	0		
7 Frequency of Riffles:	0	8 Channel Flow Status:	0		
9 Condition of Banks:	0	10 Bank Vegetation:	0	**Total**	
11 Grazing or Disruptive:	0	12 Riparian Vegetation:	0	0	

Impairment:

Insufficient? Y Impaired? N/A Biology Impaired? N/A
Habitat Impaired? N/A Rock picks influenced? N Impact Localized? N
Designated Use needs reevaluation? N

Macroinvertebrate Sample Summary

version: 3.0 1/30/2012 4:46:30 PM

Assessment ID:	58380 Unt Bertsch Ck (UBC01)
Station ID:	20080709-1331-sleap (Latitude: 40.7608, Longitude: -75.5512)
Method:	6-Dframe Composite, 200 subsample
Location:	SR248 Berlinsville end of Country Springs parking lot. Up TR542 (west), down SR4020 (east of)

Comments:

Land Use: Small strip mall. All trees removed around parking lot. Horses pastured upstream and next door downstream.

Impairment: Sample date actually 3-3-2008

Taxa:

Total # Organisms: 183

Code	Standardized ID Level	Number	Tolerance
1010000000	Collembola	5	9
1020400200	Acerpenna	2	6
1020400300	Baetis	13	6
1020400800	Diphetor	1	6
1020401300	Plauditus	1	4
1020600702	Maccaffertium	1	3
1020800300	Ephemerella	13	1
1020800400	Eurylophella	12	4
1030300400	Boyeria	1	2
1040300400	Strophopteryx	1	3
1040400100	Amphinemura	4	3
1040801200	Isoperla	11	2
1040900600	Sweltsa	3	0
1080100100	Chimarra	3	4
1080100200	Dolophilodes	1	0
1080400600	Cheumatopsyche	3	6
1080400700	Hydropsyche	6	5
1080500100	Rhyacophila	1	1
1101300600	Optioservus	39	4
1101300800	Oulimnius	8	5
1121200100	Chelifera	2	6
1121900400	Tipula	3	4
1121900700	Antocha	1	3
1121901100	Dicranota	1	3
1122100400	Prosimulium	36	2
1122100500	Simulium	1	6
1122200000	Chironomidae	9	6
15000000000	Hydracarina	1	7

Metrics:

Metric Name	Raw Metric Values	Standarized Metric Values						
		Freestone Riffle-Run						
		6D200 2009 Small	6D200 2009 Large	6D200 2007	2D100	Multihabitat Pool-Glide	Limestone 2006	Limestone 2009
Total Richness	28	84.8	90.3	80.0		90.3	151.4	155.6
Ephemeroptera Richness	7					116.7		
Trichoptera Richness	5					45.5		
EPT Richness	16			69.6	104.6	94.1	200.0	200.0
Trichoptera Richness (PTV 0-4)	3				83.3			
EPT Richness (PTV 0-4)	11	57.9	68.8					
Becks Index (version 3)	13	34.2	59.1	33.3				
Becks Index (version 4)	21				105.5	95.5		175.0
FC + PR + SH Richness	16				137.9			
Hilsenhoff Biotic Index	3.68	77.9	90.9	76.9	93.8		100.5	102.6
% Intolerant Individuals (PTV 0-3)	40.4	47.8	60.6				153.6	
% Intolerant Individuals (PTV 0-5)	79.8			86.3				
% Tolerant Individuals (PTV 7-10)	3.3						97.7	98.2
Shannon Diversity	2.63	92.1	92.1	90.8		108.4	137.1	123.6
IBI Score		65.8	77.0	72.8	95.4	87.6	99.6	99.7

% Ephemeroptera: 23.50 % Plecoptera: 10.38 % Trichoptera: 7.65
% Ephemeroptera (PTV 0-4): 14.75 % Dominant Taxon: 21.31

Habitat:

1 Instream Cover:	14	2 Epifaunal Substrate:	14	
3 Embeddedness:	16	4 Velocity/Depth Regimes:	15	
5 Channel Alterations:	15	6 Sediment Deposition:	11	
7 Frequency of Riffles:	16	8 Channel Flow Status:	19	
9 Condition of Banks:	10	10 Bank Vegetation:	16	**Total**
11 Grazing or Disruptive:	7	12 Riparian Vegetation:	1	154

Impairment:

Insufficient? N Impaired? N Biology Impaired? N
Habitat Impaired? N Rock picks influenced? N Impact Localized? N
Designated Use needs reevaluation? N

Macroinvertebrate Sample Summary

version: 3.0 1/31/2012 11:34:24 AM

Assessment ID:	58626 Bertsch Ck (BC04)
Station ID:	20080318-1320-tdaley (Latitude: 40.7399, Longitude: -75.5744)
Method:	6-Dframe Composite, 200 subsample
Location:	Probabilistic SEG 26/SITE 024 used for ICE station. 200 m upstream of SR0145 bridge. Northampton Co. - Lehigh Twp. Cementon Quad

Comments:

Land Use:
Impairment: Freestone IBI = 51.1

Taxa:

Total # Organisms: 209

Code	Standardized ID Level	Number	Tolerance
1020400300	Baetis	5	6
1020600702	Maccaffertium	2	3
1020800400	Eurylophella	3	4
1040400100	Amphinemura	1	3
1040700400	Acroneuria	1	0
1080100100	Chimarra	1	4
1080400600	Cheumatopsyche	1	6
1080400700	Hydropsyche	2	5
1080500100	Rhyacophila	3	1
1081100100	Neophylax	2	3
1122100400	Prosimulium	158	2
1122200000	Chironomidae	29	6
11000000000	Oligochaeta	1	10

Metrics:

Standarized Metric Values

Metric Name	Raw Metric Values	Freestone Riffle-Run						
		6D200 2009 Small	6D200 2009 Large	6D200 2007	2D100	Multihabitat Pool-Glide	Limestone 2006	Limestone 2009
Total Richness	13	39.4	41.9	37.1		41.9	70.3	72.2
Ephemeroptera Richness	3					50.0		
Trichoptera Richness	5					45.5		
EPT Richness	10			43.5	65.4	58.8	125.0	125.0

Trichoptera Richness (PTV 0-4)	3				83.3			
EPT Richness (PTV 0-4)	7	36.8	43.8					
Becks Index (version 3)	6	15.8	27.3	15.4				
Becks Index (version 4)	10				50.3	45.5		83.3
FC + PR + SH Richness	7				60.3			
Hilsenhoff Biotic Index	2.78	89.0	103.9	87.8	107.1		114.8	117.2
% Intolerant Individuals (PTV 0-3)	79.9	94.6	119.8				303.8	
% Intolerant Individuals (PTV 0-5)	82.8			89.5				
% Tolerant Individuals (PTV 7-10)	0.5						100.5	101.0
Shannon Diversity	0.96	33.5	33.5	33.0		39.4	49.9	45.0
IBI Score	51.5	57.7	51.1	71.9	46.8	86.7	83.4	

% Ephemeroptera: 4.78 % Plecoptera: 0.96 % Trichoptera: 4.31
% Ephemeroptera (PTV 0-4): 2.39 % Dominant Taxon: 75.60

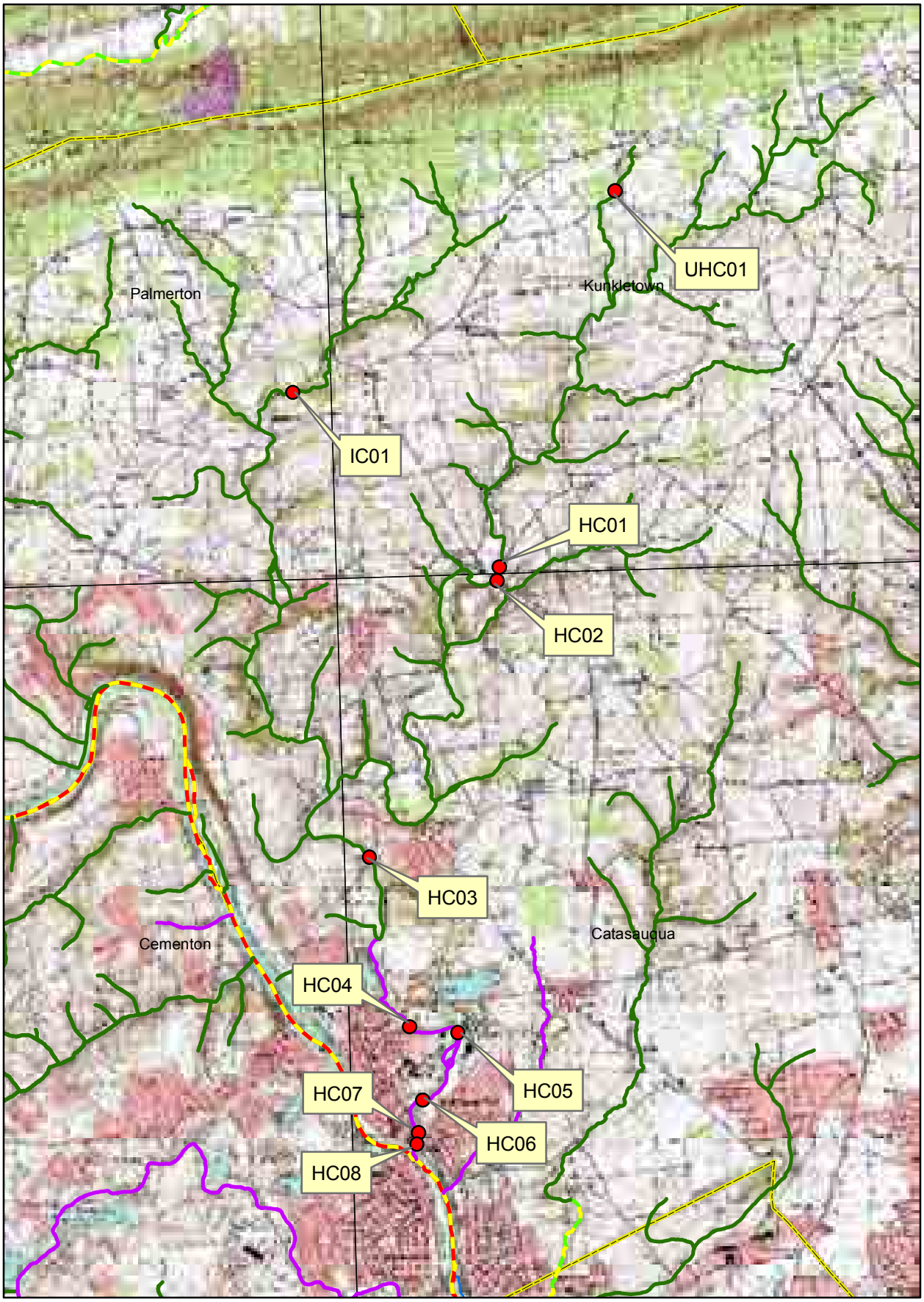
Habitat:

1 Instream Cover:	16	2 Epifaunal Substrate:	15	
3 Embeddedness:	16	4 Velocity/Depth Regimes:	16	
5 Channel Alterations:	16	6 Sediment Deposition:	16	
7 Frequency of Riffles:	16	8 Channel Flow Status:	15	
9 Condition of Banks:	18	10 Bank Vegetation:	18	**Total**
11 Grazing or Disruptive:	15	12 Riparian Vegetation:	15	192

Impairment:

Insufficient? N Impaired? N Biology Impaired? N
Habitat Impaired? N Rock picks influenced? N Impact Localized? N
Designated Use needs reevaluation? N

Hokendauqua Creek Sampling Locations



Macroinvertebrate Sample Summary

version: 3.0 1/30/2012 3:33:49 PM

Assessment ID:	58774 UNT Hokendauqua (UHC01)
Station ID:	20081007-1100-tdaley (Latitude: 40.7985, Longitude: -75.4513)
Method:	6-Dframe Composite, 200 subsample
Location:	1099 Moser Rd (SR4009). Moore Twp. - Northampton Co. Kunkletown Quad

Comments:

Land Use:
Impairment:

Taxa:

Total # Organisms: 210

Code	Standardized ID Level	Number	Tolerance
1020400100	Acentrella	1	4
1020600702	Maccaffertium	40	3
1030200700	Lanthus	1	5
1030201000	Stylogomphus	1	4
1030300400	Boyeria	1	2
1030700100	Calopteryx	2	6
1080100100	Chimarra	13	4
1080100200	Dolophilodes	14	0
1080300500	Polycentropus	3	6
1080400300	Diplectrona	1	0
1080400600	Cheumatopsyche	71	6
1080400700	Hydropsyche	44	5
1101000200	Psephenus	1	4
1101100200	Helichus	1	5
1101300600	Optioservus	8	4
1121200300	Clinocera	1	6
1121900400	Tipula	2	4
1122200000	Chironomidae	5	6

Metrics:

Metric Name	Raw Metric Values	Standarized Metric Values						
		Freestone Riffle-Run						
		6D200 2009 Small	6D200 2009 Large	6D200 2007	2D100	Multihabitat Pool-Glide	Limestone 2006	Limestone 2009
Total Richness	18	54.5	58.1	51.4		58.1	97.3	100.0
Ephemeroptera Richness	2					33.3		

Trichoptera Richness	6					54.5		
EPT Richness	8			34.8	52.3	47.1	100.0	100.0
Trichoptera Richness (PTV 0-4)	3				83.3			
EPT Richness (PTV 0-4)	5	26.3	31.3					
Becks Index (version 3)	7	18.4	31.8	17.9				
Becks Index (version 4)	12				60.3	54.5		100.0
FC + PR + SH Richness	12				103.4			
Hilsenhoff Biotic Index	4.51	67.7	79.0	66.8	81.5		87.3	89.1
% Intolerant Individuals (PTV 0-3)	26.7	31.6	40.0				101.5	
% Intolerant Individuals (PTV 0-5)	61.0			65.9				
% Tolerant Individuals (PTV 7-10)	0.0						101.0	101.5
Shannon Diversity	1.93	67.5	67.5	66.5		79.4	100.5	90.6
IBI Score		44.3	51.3	50.6	75.5	54.5	97.4	96.6

% Ephemeroptera: 19.52 % Plecoptera: 0 % Trichoptera: 69.52
% Ephemeroptera (PTV 0-4): 19.52 % Dominant Taxon: 33.81

Habitat:

1 Instream Cover:	0	2 Epifaunal Substrate:	0		
3 Embeddedness:	0	4 Velocity/Depth Regimes:	0		
5 Channel Alterations:	0	6 Sediment Deposition:	0		
7 Frequency of Riffles:	0	8 Channel Flow Status:	0		
9 Condition of Banks:	0	10 Bank Vegetation:	0	**Total**	
11 Grazing or Disruptive:	0	12 Riparian Vegetation:	0	0	

Impairment:

Insufficient? N Impaired? N Biology Impaired? N
Habitat Impaired? N Rock picks influenced? N Impact Localized? N
Designated Use needs reevaluation? N

Macroinvertebrate Sample Summary

version: 3.0 1/30/2012 3:22:34 PM

Assessment ID:	58632 Indian Ck (IC01)
Station ID:	20080318-1505-tdaley (Latitude: 40.7736, Longitude: -75.5063)
Method:	6-Dframe Composite, 200 subsample
Location:	Probabilistic SEG 03/SITE 008. 100 m downstream of T551 bridge. Northampton Co. - Lehigh Twp. Palmerton Quad

Comments:

Land Use:
Impairment: Freestone IBI = 68.5

Taxa:

Total # Organisms: 219

Code	Standardized ID Level	Number	Tolerance
1020400300	Baetis	4	6
1020400800	Diphetor	2	6
1020600100	Epeorus	3	0
1020600702	Maccaffertium	2	3
1020800200	Drunella	1	1
1020800300	Ephemerella	1	1
1030200700	Lanthus	1	5
1040300400	Strophopteryx	1	3
1040300500	Taenionema	1	3
1040400100	Amphinemura	1	3
1040400500	Prostoia	1	2
1040500200	Leuctra	1	0
1040700400	Acroneuria	2	0
1040801200	Isoperla	1	2
1080300500	Polycentropus	2	6
1080400300	Diplectrona	2	0
1080400600	Cheumatopsyche	3	6
1080400700	Hydropsyche	2	5
1081100100	Neophylax	9	3
1101000200	Psephenus	1	4
1101300600	Optioservus	2	4
1101300800	Oulimnius	2	5
1120201500	Probezzia	1	6
1121200300	Clinocera	5	6
1122100400	Prosimulium	92	2
1122100500	Simulium	1	6
1122200000	Chironomidae	72	6
11000000000	Oligochaeta	2	10
13040100100	Cambarus	1	6

Metrics:

Metric Name	Raw Metric Values	Standarized Metric Values						
		Freestone Riffle-Run						
		6D200 2009 Small	6D200 2009 Large	6D200 2007	2D100	Multihabitat Pool-Glide	Limestone 2006	Limestone 2009
Total Richness	29	87.9	93.5	82.9		93.5	156.8	161.1
Ephemeroptera Richness	6					100.0		
Trichoptera Richness	5					45.5		
EPT Richness	18			78.3	117.6	105.9	225.0	225.0
Trichoptera Richness (PTV 0-4)	2				55.6			
EPT Richness (PTV 0-4)	13	68.4	81.3					
Becks Index (version 3)	19	50.0	86.4	48.7				
Becks Index (version 4)	22				110.6	100.0		183.3
FC + PR + SH Richness	16				137.9			
Hilsenhoff Biotic Index	3.81	76.3	89.1	75.3	91.8		98.4	100.5
% Intolerant Individuals (PTV 0-3)	53.9	63.8	80.8				204.9	
% Intolerant Individuals (PTV 0-5)	57.5			62.2				
% Tolerant Individuals (PTV 7-10)	0.9						100.1	100.6
Shannon Diversity	1.84	64.5	64.5	63.6		75.9	96.0	86.6
IBI Score		68.5	82.6	68.5	89.5	85.8	99.1	97.8

% Ephemeroptera: 5.94 % Plecoptera: 3.65 % Trichoptera: 8.22
% Ephemeroptera (PTV 0-4): 3.20 % Dominant Taxon: 42.01

Habitat:

1 Instream Cover:	14	2 Epifaunal Substrate:	15	
3 Embeddedness:	14	4 Velocity/Depth Regimes:	14	
5 Channel Alterations:	18	6 Sediment Deposition:	13	
7 Frequency of Riffles:	16	8 Channel Flow Status:	18	
9 Condition of Banks:	10	10 Bank Vegetation:	15	**Total**
11 Grazing or Disruptive:	15	12 Riparian Vegetation:	13	175

Impairment:

Insufficient? N Impaired? N Biology Impaired? N
Habitat Impaired? N Rock picks influenced? N Impact Localized? N
Designated Use needs reevaluation? N

Macroinvertebrate Sample Summary

version: 3.0 1/30/2012 4:15:29 PM

Assessment ID:	55060 Hokendauqua Ck (HC01)
Station ID:	20050809-1030-TLD (Latitude: 40.7503, Longitude: -75.4727)
Method:	6-Dframe Composite, 200 subsample
Location:	75 m ups of Whispering Hollow Trailer Park STP discharge. 40 45 01.3 75 28 22.6

Comments:

Land Use: Kunkletown Quad Moore Twp. Northampton Co.
Impairment:

Taxa:

Total # Organisms: 113

Code	Standardized ID Level	Number	Tolerance
1020400100	Acentrella	3	4
1020400300	Baetis	10	6
1020500100	Isonychia	3	3
1020600100	Epeorus	1	0
1020600700	Stenonema(old genus)	5	3
1021000200	Caenis	1	7
1040500200	Leuctra	2	0
1040700300	Paragnetina	2	1
1040700400	Acroneuria	3	0
1040900200	Alloperla	1	0
1060200400	Nigronia	2	2
1080100100	Chimarra	36	4
1080100200	Dolophilodes	1	0
1080400600	Cheumatopsyche	6	6
1080400700	Hydropsyche	11	5
1080700800	Leucotrichia	6	6
1101000200	Psephenus	2	4
1101300800	Oulimnius	2	5
1101301000	Stenelmis	1	5
1120900100	Atherix	1	2
1122200000	Chironomidae	14	6

Metrics:

Metric Name	Raw Metric Values	Standarized Metric Values						
		Freestone Riffle-Run						
		6D200 2009 Small	6D200 2009 Large	6D200 2007	2D100	Multihabitat Pool-Glide	Limestone 2006	Limestone 2009
Total Richness	21	63.6	67.7	60.0		67.7	113.5	116.7
Ephemeroptera Richness	6					100.0		
Trichoptera Richness	5					45.5		
EPT Richness	15			65.2	98.0	88.2	187.5	187.5
Trichoptera Richness (PTV 0-4)	2				55.6			
EPT Richness (PTV 0-4)	10	52.6	62.5					
Becks Index (version 3)	19	50.0	86.4	48.7				
Becks Index (version 4)	19				95.5	86.4		158.3
FC + PR + SH Richness	9				77.6			
Hilsenhoff Biotic Index	4.33	69.9	81.6	69.0	84.1		90.1	92.0
% Intolerant Individuals (PTV 0-3)	18.6	22.0	27.9				70.7	
% Intolerant Individuals (PTV 0-5)	67.3			72.8				
% Tolerant Individuals (PTV 7-10)	0.9						100.1	100.6
Shannon Diversity	2.41	84.3	84.3	83.1		99.2	125.6	113.2
IBI Score		57.1	68.4	66.5	82.2	81.2	93.5	98.7

% Ephemeroptera: 20.35 % Plecoptera: 7.08 % Trichoptera: 53.10
% Ephemeroptera (PTV 0-4): 10.62 % Dominant Taxon: 31.86

Habitat:

1 Instream Cover:	14	2 Epifaunal Substrate:	16	
3 Embeddedness:	15	4 Velocity/Depth Regimes:	15	
5 Channel Alterations:	16	6 Sediment Deposition:	15	
7 Frequency of Riffles:	16	8 Channel Flow Status:	13	
9 Condition of Banks:	15	10 Bank Vegetation:	12	**Total**
11 Grazing or Disruptive:	10	12 Riparian Vegetation:	10	167

Impairment:

Insufficient? N Impaired? N Biology Impaired? N
Habitat Impaired? N Rock picks influenced? N Impact Localized? N
Designated Use needs reevaluation? N

Macroinvertebrate Sample Summary

version: 3.0 1/30/2012 4:18:09 PM

Assessment ID:	55059 Hokendauqua Ck (HC02)
Station ID:	20050809-1000-TLD (Latitude: 40.7495, Longitude: -75.4735)
Method:	6-Dframe Composite, 200 subsample
Location:	30 m dws of Whispering Hollow North Trailer Park STP discharge. 40 44 58.1 75 28 25.3

Comments:

Land Use: Catasauqua Quad Moore Twp. Northampton Co.
Impairment:

Taxa:

Total # Organisms: 114

Code	Standardized ID Level	Number	Tolerance
1020400300	Baetis	3	6
1020500100	Isonychia	2	3
1020600700	Stenonema(old genus)	7	3
1020800500	Serratella	1	2
1030200800	Ophiogomphus	1	1
1040500200	Leuctra	8	0
1040700300	Paragnetina	1	1
1040700400	Acroneuria	7	0
1060200400	Nigronia	1	2
1080100100	Chimarra	26	4
1080100200	Dolophilodes	1	0
1080300500	Polycentropus	1	6
1080400600	Cheumatopsyche	4	6
1080400700	Hydropsyche	5	5
1080700800	Leucotrichia	2	6
1081700500	Oecetis	2	8
1101000200	Psephenus	4	4
1101300600	Optioservus	1	4
1101300800	Oulimnius	1	5
1101301000	Stenelmis	2	5
1121900700	Antocha	2	3
1122200000	Chironomidae	32	6

Metrics:

Metric Name	Raw Metric Values	Standarized Metric Values						
		Freestone Riffle-Run						
		6D200 2009 Small	6D200 2009 Large	6D200 2007	2D100	Multihabitat Pool-Glide	Limestone 2006	Limestone 2009
Total Richness	22	66.7	71.0	62.9		71.0	118.9	122.2
Ephemeroptera Richness	4					66.7		
Trichoptera Richness	7					63.6		
EPT Richness	14			60.9	91.5	82.4	175.0	175.0
Trichoptera Richness (PTV 0-4)	2				55.6			
EPT Richness (PTV 0-4)	8	42.1	50.0					
Becks Index (version 3)	15	39.5	68.2	38.5				
Becks Index (version 4)	18				90.5	81.8		150.0
FC + PR + SH Richness	11				94.8			
Hilsenhoff Biotic Index	4.13	72.4	84.5	71.4	87.1		93.3	95.3
% Intolerant Individuals (PTV 0-3)	27.2	32.2	40.8				103.4	
% Intolerant Individuals (PTV 0-5)	61.4			66.4				
% Tolerant Individuals (PTV 7-10)	1.8						99.2	99.7
Shannon Diversity	2.38	83.1	83.1	82.0		97.9	123.8	111.6
IBI Score		56.0	66.3	63.7	83.9	77.2	98.8	99.2

% Ephemeroptera: 11.40 % Plecoptera: 14.04 % Trichoptera: 35.96
% Ephemeroptera (PTV 0-4): 8.77 % Dominant Taxon: 28.07

Habitat:

1 Instream Cover:	13	2 Epifaunal Substrate:	15	
3 Embeddedness:	15	4 Velocity/Depth Regimes:	15	
5 Channel Alterations:	15	6 Sediment Deposition:	15	
7 Frequency of Riffles:	16	8 Channel Flow Status:	13	
9 Condition of Banks:	16	10 Bank Vegetation:	13	**Total**
11 Grazing or Disruptive:	14	12 Riparian Vegetation:	13	173

Impairment:

Insufficient? N Impaired? N Biology Impaired? N
Habitat Impaired? N Rock picks influenced? N Impact Localized? N
Designated Use needs reevaluation? N

Macroinvertebrate Sample Summary

version: 3.0 1/30/2012 4:23:27 PM

Assessment ID:	57246 Hokendauqua Ck (HC03)
Station ID:	20050809-1405-tdaley (Latitude: 40.7143, Longitude: -75.4958)
Method:	2-Dframe Composite, 100 subsample
Location:	50 m ups of SR4003 bridge. Catasauqua Quad Allen Twp. - Northampton Co.

Comments:

Land Use:
Impairment:

Taxa:

Total # Organisms: 114

Code	Standardized ID Level	Number	Tolerance
1020400100	Acentrella	1	4
1020400300	Baetis	3	6
1020500100	Isonychia	4	3
1020600700	Stenonema(old genus)	1	3
1020800500	Serratella	6	2
1021000200	Caenis	6	7
1040700400	Acroneuria	2	0
1080100100	Chimarra	13	4
1080300300	Neureclipsis	1	7
1080400600	Cheumatopsyche	27	6
1080400700	Hydropsyche	14	5
1080700800	Leucotrichia	2	6
1081100100	Neophylax	1	3
1101000200	Psephenus	4	4
1101300600	Optioservus	3	4
1101300800	Oulimnius	2	5
1101301000	Stenelmis	6	5
1120900100	Atherix	1	2
1121200500	Hemerodromia	1	6
1121900700	Antocha	1	3
1122100500	Simulium	1	6
1122200000	Chironomidae	13	6
11000000000	Oligochaeta	1	10

Metrics:

Metric Name	Raw Metric Values	Standarized Metric Values						
		Freestone Riffle-Run						
		6D200 2009 Small	6D200 2009 Large	6D200 2007	2D100	Multihabitat Pool-Glide	Limestone 2006	Limestone 2009
Total Richness	23	69.7	74.2	65.7		74.2	124.3	127.8
Ephemeroptera Richness	6					100.0		
Trichoptera Richness	6					54.5		
EPT Richness	13			56.5	85.0	76.5	162.5	162.5
Trichoptera Richness (PTV 0-4)	2				55.6			
EPT Richness (PTV 0-4)	7	36.8	43.8					
Becks Index (version 3)	5	13.2	22.7	12.8				
Becks Index (version 4)	12				60.3	54.5		100.0
FC + PR + SH Richness	8				69.0			
Hilsenhoff Biotic Index	5.00	61.7	71.9	60.8	74.2		79.5	81.2
% Intolerant Individuals (PTV 0-3)	14.0	16.6	21.0				53.2	
% Intolerant Individuals (PTV 0-5)	51.8			56.0				
% Tolerant Individuals (PTV 7-10)	7.0						93.9	94.4
Shannon Diversity	2.57	89.9	89.9	88.7		105.8	134.0	120.8
IBI Score		48.0	53.9	56.8	68.8	76.6	87.8	95.9

% Ephemeroptera: 18.42 % Plecoptera: 1.75 % Trichoptera: 50.88
% Ephemeroptera (PTV 0-4): 10.53 % Dominant Taxon: 23.68

Habitat:

1 Instream Cover:	13	2 Epifaunal Substrate:	12		
3 Embeddedness:	12	4 Velocity/Depth Regimes:	14		
5 Channel Alterations:	18	6 Sediment Deposition:	12		
7 Frequency of Riffles:	15	8 Channel Flow Status:	14		
9 Condition of Banks:	15	10 Bank Vegetation:	16	**Total**	
11 Grazing or Disruptive:	13	12 Riparian Vegetation:	13	167	

Impairment:

Insufficient? N Impaired? N Biology Impaired? N
Habitat Impaired? N Rock picks influenced? N Impact Localized? N
Designated Use needs reevaluation? N

Macroinvertebrate Sample Summary

version: 3.0 1/30/2012 4:26:05 PM

Assessment ID: 58831 Hokendauqua Ck (HC04)
Station ID: 20081202-1135-sleap (Latitude: 40.6926, Longitude: -75.49)
Method: 6-Dframe Composite, 200 subsample
Location: Upstream of salt pile, downstream of SR329 bridge.

Comments:

Land Use: Residential/commercial area. Park-like setting along stream.
Impairment:

Taxa:

Total # Organisms: 208

Code	Standardized ID Level	Number	Tolerance
1020500100	Isonychia	5	3
1020600702	Maccaffertium	32	3
1020800300	Ephemerella	7	1
1020800400	Eurylophella	1	4
1020800500	Serratella	5	2
1021000200	Caenis	5	7
1040700400	Acroneuria	1	0
1060100100	Sialis	2	6
1080100100	Chimarra	66	4
1080400600	Cheumatopsyche	10	6
1080400700	Hydropsyche	3	5
1080700800	Leucotrichia	7	6
1101000200	Psephenus	4	4
1101300600	Optioservus	16	4
1101301000	Stenelmis	3	5
1120900100	Atherix	1	2
1121200500	Hemerodromia	2	6
1122200000	Chironomidae	22	6
4000000000	Turbellaria	11	9
8030400000	Planorbidae	1	6
11000000000	Oligochaeta	1	10
13030200100	Gammarus	1	4
13050100100	Caecidotea	1	6
15000000000	Hydracarina	1	7

Metrics:

Metric Name	Raw Metric Values	Standarized Metric Values						
		Freestone Riffle-Run						
		6D200 2009 Small	6D200 2009 Large	6D200 2007	2D100	Multihabitat Pool-Glide	Limestone 2006	Limestone 2009
Total Richness	24	72.7	77.4	68.6		77.4	129.7	133.3
Ephemeroptera Richness	6					100.0		
Trichoptera Richness	4					36.4		
EPT Richness	11			47.8	71.9	64.7	137.5	137.5
Trichoptera Richness (PTV 0-4)	1				27.8			
EPT Richness (PTV 0-4)	7	36.8	43.8					
Becks Index (version 3)	7	18.4	31.8	17.9				
Becks Index (version 4)	13				65.3	59.1		108.3
FC + PR + SH Richness	9				77.6			
Hilsenhoff Biotic Index	4.49	67.9	79.3	67.0	81.8		87.6	89.4
% Intolerant Individuals (PTV 0-3)	24.5	29.0	36.7				93.2	
% Intolerant Individuals (PTV 0-5)	69.7			75.4				
% Tolerant Individuals (PTV 7-10)	8.7						92.2	92.7
Shannon Diversity	2.38	83.2	83.2	82.0		97.9	123.9	111.7
IBI Score		51.3	58.7	59.8	64.9	72.6	95.5	97.0

% Ephemeroptera: 26.44 % Plecoptera: 0.48 % Trichoptera: 41.35
% Ephemeroptera (PTV 0-4): 24.04 % Dominant Taxon: 31.73

Habitat:

1 Instream Cover:	17	2 Epifaunal Substrate:	15		
3 Embeddedness:	15	4 Velocity/Depth Regimes:	16		
5 Channel Alterations:	14	6 Sediment Deposition:	14		
7 Frequency of Riffles:	14	8 Channel Flow Status:	20		
9 Condition of Banks:	15	10 Bank Vegetation:	16	**Total**	
11 Grazing or Disruptive:	13	12 Riparian Vegetation:	12	181	

Impairment:

Insufficient? Y Impaired? N/A Biology Impaired? N/A
Habitat Impaired? N/A Rock picks influenced? N Impact Localized? N
Designated Use needs reevaluation? N

Macroinvertebrate Sample Summary

version: 3.0 1/30/2012 4:28:43 PM

Assessment ID:	58830 Hokendauqua Ck (HC05)
Station ID:	20081202-1114-sleap (Latitude: 40.6916, Longitude: -75.4815)
Method:	6-Dframe Composite, 200 subsample
Location:	Above old dam, unknown effluent pipe (old STP?) discharging along left bank. Station is downstream of salt pile stored on Horwith company land.

Comments:

Land Use: Industrial site and abandoned industrial area and railroad tracks.

Impairment: Stream has few riffles here and a dam, but was the only accessible site downstream and relatively near the salt pile. Lots of sediment and mud.

Taxa:

Total # Organisms: 199

Code	Standardized ID Level	Number	Tolerance
1020400600	Centroptilum	4	2
1020600702	Maccaffertium	1	3
1021000200	Caenis	3	7
1030800500	Enallagma	5	8
1080300500	Polycentropus	1	6
1081001000	Hydatophylax	2	2
1101300000	Elmidae	1	5
1122200000	Chironomidae	49	6
8020100000	Valvatidae	1	2
8030300000	Physidae	2	8
8030400000	Planorbidae	1	6
11000000000	Oligochaeta	8	10
11030200000	Tubificidae	1	10
13030200100	Gammarus	15	4
13030500100	Hyalella	82	8
13050100100	Caecidotea	17	6
13070000000	Cladocera	6	5

Metrics:

Metric Name	Raw Metric Values	Standarized Metric Values						
		Freestone Riffle-Run						
		6D200 2009 Small	6D200 2009 Large	6D200 2007	2D100	Multihabitat Pool-Glide	Limestone 2006	Limestone 2009
Total Richness	17	51.5	54.8	48.6		54.8	91.9	94.4
Ephemeroptera Richness	3					50.0		
Trichoptera Richness	2					18.2		
EPT Richness	5			21.7	32.7	29.4	62.5	62.5
Trichoptera Richness (PTV 0-4)	1				27.8			
EPT Richness (PTV 0-4)	3	15.8	18.8					
Becks Index (version 3)	3	7.9	13.6	7.7				
Becks Index (version 4)	5				25.1	22.7		41.7
FC + PR + SH Richness	4				34.5			
Hilsenhoff Biotic Index	6.75	40.1	46.8	39.5	48.2		51.7	52.8
% Intolerant Individuals (PTV 0-3)	4.0	4.7	6.0				15.2	
% Intolerant Individuals (PTV 0-5)	15.1			16.3				
% Tolerant Individuals (PTV 7-10)	50.8						49.7	49.9
Shannon Diversity	1.84	64.2	64.2	63.3		75.6	95.7	86.2
IBI Score		30.7	34.0	32.9	33.7	41.8	61.1	64.6

% Ephemeroptera: 4.02 % Plecoptera: 0 % Trichoptera: 1.51
% Ephemeroptera (PTV 0-4): 2.51 % Dominant Taxon: 41.21

Habitat:

1 Instream Cover:	15	2 Epifaunal Substrate:	8	
3 Embeddedness:	5	4 Velocity/Depth Regimes:	10	
5 Channel Alterations:	14	6 Sediment Deposition:	5	
7 Frequency of Riffles:	4	8 Channel Flow Status:	20	
9 Condition of Banks:	15	10 Bank Vegetation:	16	**Total**
11 Grazing or Disruptive:	14	12 Riparian Vegetation:	12	138

Impairment:

Insufficient? N Impaired? Y Biology Impaired? N
Habitat Impaired? Y Rock picks influenced? N Impact Localized? Y
Designated Use needs reevaluation? N

Macroinvertebrate Sample Summary

version: 3.0 1/30/2012 4:31:19 PM

Assessment ID: 58829 Hokendauqua Ck (HC06)
Station ID: 20081202-1049-sleap (Latitude: 40.6833, Longitude: -75.4877)
Method: 6-Dframe Composite, 200 subsample
Location: Northampton Municipal Park upstream of Nortampton STP.

Comments:

Land Use: Urban area, mostly residential, some industry.
Impairment:

Taxa:

Total # Organisms: 199

Code	Standardized ID Level	Number	Tolerance
1020500100	Isonychia	3	3
1020600702	Maccaffertium	15	3
1020800300	Ephemerella	1	1
1021000200	Caenis	4	7
1040700400	Acroneuria	1	0
1080100100	Chimarra	6	4
1080300300	Neureclipsis	3	7
1080400500	Ceratopsyche	9	5
1080400600	Cheumatopsyche	85	6
1080400700	Hydropsyche	9	5
1080700400	Hydroptila	1	6
1080700800	Leucotrichia	8	6
1090100900	Petrophila	2	5
1101300600	Optioservus	2	4
1101301000	Stenelmis	1	5
1121200500	Hemerodromia	2	6
1121500200	Limnophora	3	6
1121900700	Antocha	2	3
1122100500	Simulium	1	6
1122200000	Chironomidae	11	6
4000000000	Turbellaria	12	9
8030300000	Physidae	2	8
8030400000	Planorbidae	1	6
8030500000	Ancylidae	3	7
11000000000	Oligochaeta	3	10
13030200100	Gammarus	6	4
13030500100	Hyalella	1	8
15000000000	Hydracarina	2	7

Metrics:

Metric Name	Raw Metric Values	Standarized Metric Values						
		Freestone Riffle-Run						
		6D200 2009 Small	6D200 2009 Large	6D200 2007	2D100	Multihabitat Pool-Glide	Limestone 2006	Limestone 2009
Total Richness	28	84.8	90.3	80.0		90.3	151.4	155.6
Ephemeroptera Richness	4					66.7		
Trichoptera Richness	7					63.6		
EPT Richness	12			52.2	78.4	70.6	150.0	150.0
Trichoptera Richness (PTV 0-4)	1				27.8			
EPT Richness (PTV 0-4)	5	26.3	31.3					
Becks Index (version 3)	5	13.2	22.7	12.8				
Becks Index (version 4)	10				50.3	45.5		83.3
FC + PR + SH Richness	11				94.8			
Hilsenhoff Biotic Index	5.73	52.7	61.4	51.9	63.4		67.9	69.3
% Intolerant Individuals (PTV 0-3)	11.1	13.1	16.6				42.2	
% Intolerant Individuals (PTV 0-5)	28.6			30.9				
% Tolerant Individuals (PTV 7-10)	15.1						85.8	86.2
Shannon Diversity	2.37	82.7	82.7	81.6		97.4	123.2	111.1
IBI Score		45.5	50.9	51.6	62.9	72.3	82.6	89.8

% Ephemeroptera: 11.56 % Plecoptera: 0.50 % Trichoptera: 60.80
% Ephemeroptera (PTV 0-4): 9.55 % Dominant Taxon: 42.71

Habitat:

1 Instream Cover:	16	2 Epifaunal Substrate:	16		
3 Embeddedness:	15	4 Velocity/Depth Regimes:	16		
5 Channel Alterations:	14	6 Sediment Deposition:	14		
7 Frequency of Riffles:	15	8 Channel Flow Status:	20		
9 Condition of Banks:	14	10 Bank Vegetation:	13	**Total**	
11 Grazing or Disruptive:	12	12 Riparian Vegetation:	8	173	

Impairment:

Insufficient? Y Impaired? N/A Biology Impaired? N/A
Habitat Impaired? N/A Rock picks influenced? N Impact Localized? N
Designated Use needs reevaluation? N

Macroinvertebrate Sample Summary

version: 3.0 1/30/2012 4:34:33 PM

Assessment ID:	57247 Hokendauqua Ck (HC07)
Station ID:	20050809-1250-tdaley (Latitude: 40.6787, Longitude: -75.4893)
Method:	2-Dframe Composite, 100 subsample
Location:	50 m dws of Main St. bridge. Catasauqua Quad Northampton Bor. - Northampton Co.

Comments:

Land Use:
Impairment:

Taxa:

Total # Organisms: 115

Code	Standardized ID Level	Number	Tolerance
1020400100	Acentrella	1	4
1020400300	Baetis	9	6
1020500100	Isonychia	1	3
1021000200	Caenis	1	7
1080100100	Chimarra	24	4
1080300500	Polycentropus	2	6
1080400600	Cheumatopsyche	33	6
1080400700	Hydropsyche	17	5
1080700800	Leucotrichia	7	6
1101301000	Stenelmis	4	5
1122200000	Chironomidae	14	6
4000000000	Turbellaria	1	9
13030100100	Crangonyx	1	4

Metrics:

Metric Name	Raw Metric Values	Standarized Metric Values						
		Freestone Riffle-Run						
		6D200 2009 Small	6D200 2009 Large	6D200 2007	2D100	Multihabitat Pool-Glide	Limestone 2006	Limestone 2009
Total Richness	13	39.4	41.9	37.1		41.9	70.3	72.2
Ephemeroptera Richness	4					66.7		
Trichoptera Richness	5					45.5		
EPT Richness	9			39.1	58.8	52.9	112.5	112.5

Trichoptera Richness (PTV 0-4)	1				27.8			
EPT Richness (PTV 0-4)	3	15.8	18.8					
Becks Index (version 3)	0	0.0	0.0	0.0				
Becks Index (version 4)	4				20.1	18.2		33.3
FC + PR + SH Richness	5				43.1			
Hilsenhoff Biotic Index	5.37	57.1	66.6	56.3	68.7		73.6	75.2
% Intolerant Individuals (PTV 0-3)	0.9	1.1	1.3				3.4	
% Intolerant Individuals (PTV 0-5)	41.7			45.1				
% Tolerant Individuals (PTV 7-10)	1.7						99.3	99.8
Shannon Diversity	1.99	69.5	69.5	68.5		81.8	103.5	93.3
IBI Score		30.5	33.0	41.0	43.7	51.2	74.4	79.0

% Ephemeroptera:	10.43	% Plecoptera:	0	% Trichoptera:	72.17
% Ephemeroptera (PTV 0-4):	1.74	% Dominant Taxon:	28.70		

Habitat:

1 Instream Cover:	16	2 Epifaunal Substrate:	14	
3 Embeddedness:	14	4 Velocity/Depth Regimes:	17	
5 Channel Alterations:	9	6 Sediment Deposition:	13	
7 Frequency of Riffles:	16	8 Channel Flow Status:	13	
9 Condition of Banks:	15	10 Bank Vegetation:	7	**Total**
11 Grazing or Disruptive:	8	12 Riparian Vegetation:	8	150

Impairment:

Insufficient?	N	Impaired?	Y	Biology Impaired?	Y
Habitat Impaired?	N	Rock picks influenced?	N	Impact Localized?	N

Designated Use needs reevaluation? N

Macroinvertebrate Sample Summary

version: 3.0 1/30/2012 4:38:51 PM

Assessment ID:	58563 Hokendauqua Ck (HC08)
Station ID:	20080916-1432-tdaley (Latitude: 40.6782, Longitude: -75.4895)
Method:	6-Dframe Composite, 200 subsample
Location:	Downstream of Main St. bridge and upsteam of R.R. bridge. Northampton Co. - Northampton Bor. Catasauqua Quad

Comments:

Land Use: Collection date actually 4-30-2008
Impairment: Freestone IBI = 27.8

Taxa:

Total # Organisms: 229

Code	Standardized ID Level	Number	Tolerance
1020500100	Isonychia	3	3
1020600702	Maccaffertium	2	3
1020800300	Ephemerella	3	1
1021000200	Caenis	1	7
1040400100	Amphinemura	3	3
1040700400	Acroneuria	1	0
1080100100	Chimarra	2	4
1080400600	Cheumatopsyche	2	6
1101301000	Stenelmis	2	5
1122100500	Simulium	1	6
1122200000	Chironomidae	205	6
4000000000	Turbellaria	1	9
11000000000	Oligochaeta	2	10
13030100100	Crangonyx	1	4

Metrics:

Metric Name	Raw Metric Values	Standarized Metric Values: Freestone Riffle-Run						
		6D200 2009 Small	6D200 2009 Large	6D200 2007	2D100	Multihabitat Pool-Glide	Limestone 2006	Limestone 2009
Total Richness	14	42.4	45.2	40.0		45.2	75.7	77.8
Ephemeroptera Richness	4					66.7		
Trichoptera Richness	2					18.2		
EPT Richness	8			34.8	52.3	47.1	100.0	100.0

Trichoptera Richness (PTV 0-4)	1				27.8			
EPT Richness (PTV 0-4)	6	31.6	37.5					
Becks Index (version 3)	5	13.2	22.7	12.8				
Becks Index (version 4)	9				45.2	40.9		75.0
FC + PR + SH Richness	6				51.7			
Hilsenhoff Biotic Index	5.82	51.5	60.1	50.9	62.0		66.5	67.9
% Intolerant Individuals (PTV 0-3)	5.2	6.2	7.8				19.8	
% Intolerant Individuals (PTV 0-5)	7.4			8.0				
% Tolerant Individuals (PTV 7-10)	1.7						99.3	99.8
Shannon Diversity	0.60	20.8	20.8	20.5		24.5	31.0	27.9
IBI Score		27.6	32.4	27.8	47.8	40.4	65.4	74.7

% Ephemeroptera: 3.93 % Plecoptera: 1.75 % Trichoptera: 1.75
% Ephemeroptera (PTV 0-4): 3.49 % Dominant Taxon: 89.52

Habitat:

1 Instream Cover:	16	2 Epifaunal Substrate:	16	
3 Embeddedness:	15	4 Velocity/Depth Regimes:	16	
5 Channel Alterations:	5	6 Sediment Deposition:	12	
7 Frequency of Riffles:	16	8 Channel Flow Status:	14	
9 Condition of Banks:	11	10 Bank Vegetation:	8	**Total**
11 Grazing or Disruptive:	6	12 Riparian Vegetation:	6	141

Impairment:

Insufficient?	N	Impaired?	Y	Biology Impaired?	Y
Habitat Impaired?	N	Rock picks influenced?	N	Impact Localized?	N

Designated Use needs reevaluation? N

Appendix C
Fish Species Collection Table & Sampling Site Maps

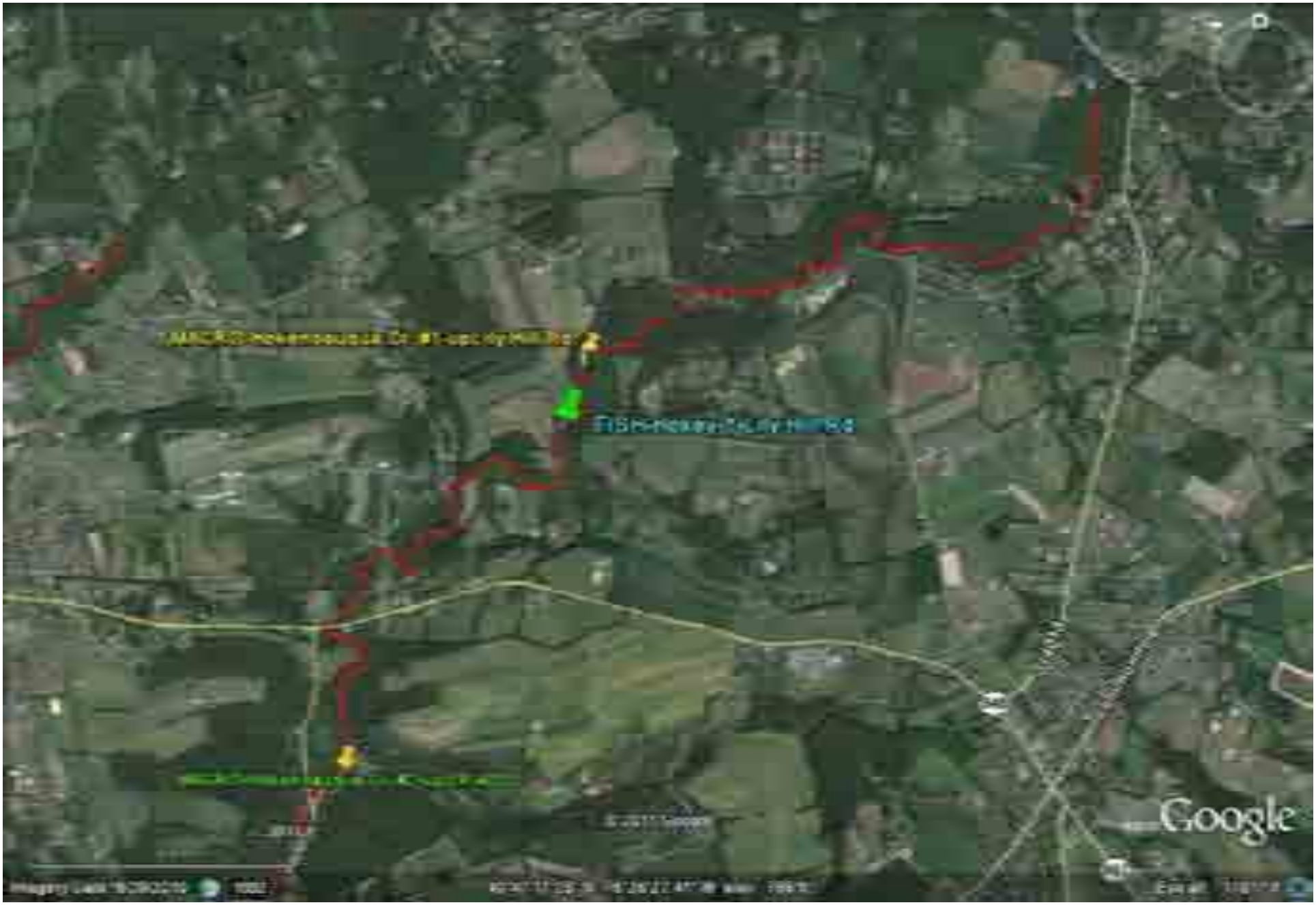
Fish Species Collected at Hokendauqua Creek and Indian Creek Sampling Sites (July 2011)

Common Name	Scientific Name	Site #1-Lily Hill Rd. July 22, 2011 (sample section started @ end of path off Lily Hill Rd. going 100m upstream on Hokendauaqua Creek) (% = relative abundance in sample)	Site #2A-Millrace Rd. July 24, 2011 (sample section started @ confluence of Indian Creek and Hockendauqua Creek, going 100m upstream on Indian Creek) (% = relative abundance in sample)	Site #2B-Millrace Rd. July 24, 2011 (sample section started below confluence of Indian Creek and Hockendauqua Creek, going 100m upstream on Hockendauqua Creek) (% = relative abundance in sample)
Brown Trout	*Salmo trutta*	**X** (4.9%)	**X** (4.8%)	**X** (2.9%)
White Sucker	*Catostomus commersoni*	**X** (46.9%)	**X** (4.8%)	**X** (14.7%)
American Eel	*Anguilla rostratus*	**X** (1.4%)	----	**X** (2.9%)
Blacknose Dace	*Rhinichthys attratulus*	**X** (10.5%)	**X** (21.0%)	**X** (14.7%)
Longnose Dace	*Rhinichthys cataractae*	**X** (0.7%)	**X** (37.1%)	**X** (26.5%)
Creek Chub	*Semotilus atromaculatus*	**X** (10.5%)	**X** (3.2%)	**X** (2.9%)
Cutlips Minnow	*Exoglossum maxillingua*	**X** (2.1%)	**X** (19.4%)	**X** (14.7%)
Common Shiner	*Luxilus cornatus*	**X** (7.7%)	**X** (1.6%)	**X** (2.9%)
Tessellated Darter	*Etheostoma olmstedi*	**X** (9.1%)	**X** (3.2%)	**X** (2.9%)
Bluegill Sunfish	*Lepomis macochirus*	**X** (2.8%)	----	----
Pumpkinseed Sunfish	*Lepomis gibbosus*	**X** (2.8%)	----	----
Red-breasted Sunfish		----	**X** (1.6%)	----
Rock Bass	*Ambloplites rupestris*	----	----	**X** (11.8%)
Margined Madtom	*Notorus insignis*	**X (0.7%)**	**X** (3.2%)	**X** (2.9%)
Total Species =14	**Number of Species per Site**	**12**	**(10)** **12** (total both sites)	**(11)**

Collector: Lance Leonhardt

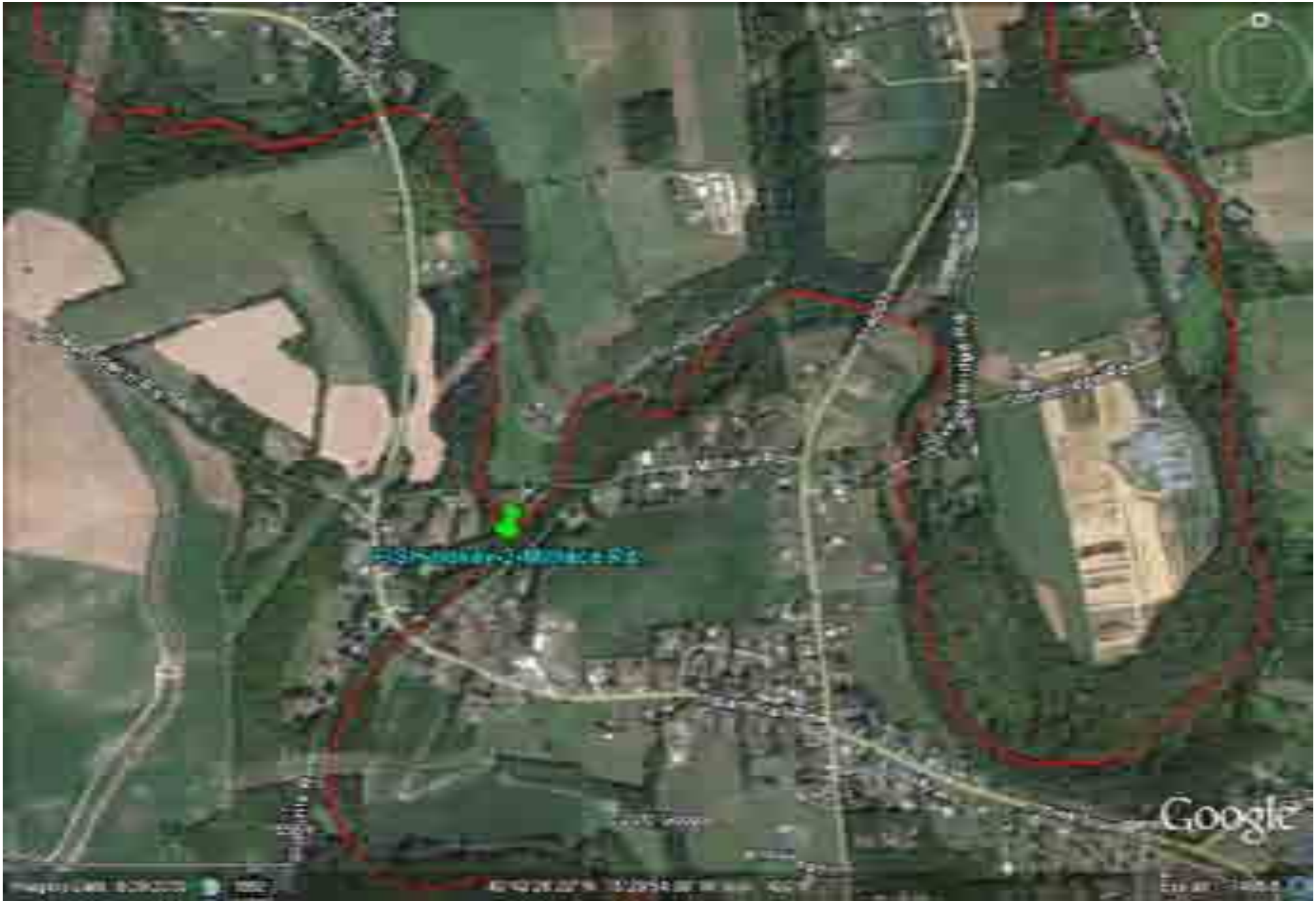
Sampling Gear: Electrofishing backpack 100-1100 V DC/Dip net

Concentrated Single Pass (pools/riffles)



Hokendauqua Creek Fish Sampling Site-1 (Lily Hill Road)

Site location: $40^0$47’13.00’’N $75^0$26’46.56’’W elevation 642 ft.



Hokendauqua Creek and Indian Creek Fish Sampling Sites (Millrace Rd.) 2A (Indian Creek 100m upstream of confluence) and **2B** (Hokendauqua Creek 100m below confluence)
Site location: $40^0$43'19.19''N $75^0$30'08.69'W elevation 361 ft.

Appendix D
PFBC Species Collection
Metrix Table

Site species collection matrix from Bertsch Creek Sub-SubBasin 02C. Data collected within 1976 survey year. Column Headings Legend:
1- Section 2 Rivermile 1.7 Site Date 10/12/1976 SiteLatLon 404506753450

Common Name	Scientific Name	1	Code
American Eel	Anguilla rostrata	X	501
Blacknose Dace	Rhinichthys atratulus	X	341
Brown Trout	Salmo trutta	X	122
Fallfish	Semotilus corporalis	X	352
Johnny Darter	Etheostoma nigrum	X	729
White Sucker	Catostomus commersonii	X	401

Site species collection matrix from Hokendauqua Creek Sub-SubBasin 02C. Data collected within 1978 survey year. Column Headings Legend:
1- Section 5 Rivermile 0 Site Date 8/17/1978 SiteLatLon 404031752925
2- Section 4 Rivermile 2 Site Date 8/17/1978 SiteLatLon 404139752930
3- Section 4 Rivermile 3.3 Site Date 8/18/1978 SiteLatLon 404338752910
4- Section 4 Rivermile 3.4 Site Date 8/18/1978 SiteLatLon 404250752945
5- Section 4 Rivermile 5 Site Date 8/18/1978 SiteLatLon 404440752858
6- Section 2 Rivermile 10 Site Date 8/21/1978 SiteLatLon 404526752828
7- Section 2 Rivermile 11.6 Site Date 8/21/1978 SiteLatLon 404619752741
8- Section 2 Rivermile 12.2 Site Date 8/21/1978 SiteLatLon 404707752651
9- Section 2 Rivermile 15 Site Date 8/21/1978 SiteLatLon 404745752515

Common Name	Scientific Name	1	2	3	4	5	6	7	8	9	Code
American Eel	Anguilla rostrata	X				X	X	X			501
Blacknose Dace	Rhinichthys atratulus		X	X	X	X	X	X	X	X	341
Bluegill	Lepomis macrochirus			X	X						674
Brown Trout	Salmo trutta				X	X	X	X	X	X	122
Common Shiner	Luxilus cornutus	X	X	X	X	X	X	X	X	X	306
Creek Chub	Semotilus atromaculatus				X		X	X	X	X	351
Cutlips Minnow	Exoglossum maxillingua	X	X	X	X						261
Fallfish	Semotilus corporalis	X	X	X	X	X	X	X	X	X	352
Hornyhead Chub	Nocomis biguttatus						X				361
Largemouth Bass	Micropterus salmoides	X					X		X		692
Longnose Dace	Rhinichthys cataractae		X	X	X	X	X	X	X	X	342

Common Name	Scientific Name	1	2	3	4	5	6	7	8	9	Code
Margined Madtom	Noturus insignis		X	X	X	X	X	X			483
Pumpkinseed	Lepomis gibbosus		X	X	X		X	X			673
Rainbow Trout	Oncorhynchus mykiss					X					121
Redbreast Sunfish	Lepomis auritus	X	X		X		X				671
Redfin Pickerel	Esox americanus					X				X	191
Rock Bass	Ambloplites rupestris	X			X						651
Satinfin Shiner	Cyprinella analostana	X			X						302
Smallmouth Bass	Micropterus dolomieu		X	X	X	X	X				691
Spottail Shiner	Notropis hudsonius	X		X			X	X	X		311
Tessellated Darter	Etheostoma olmstedi	X	X	X	X		X	X	X	X	721
White Sucker	Catostomus commersonii	X		X	X	X	X	X	X	X	401

Site species collection matrix from Indian Creek Sub-SubBasin 02C. Data collected within 1978 survey year. Column Headings Legend:
1- Section 3 Rivermile 0.4 Site Date 8/17/1978 SiteLatLon 404339753009
2- Section 2 Rivermile 2.2 Site Date 8/16/1978 SiteLatLon 404439753037
3- Section 2 Rivermile 4 Site Date 8/16/1978 SiteLatLon 404559753040

Common Name	Scientific Name	1	2	3	Code
American Eel	Anguilla rostrata	X		X	501
Blacknose Dace	Rhinichthys atratulus	X	X	X	341
Brown Trout	Salmo trutta	X	X	X	122
Common Shiner	Luxilus cornutus	X	X	X	306
Creek Chub	Semotilus atromaculatus	X	X	X	351
Cutlips Minnow	Exoglossum maxillingua	X	X		261
Fallfish	Semotilus corporalis	X			352
Largemouth Bass	Micropterus salmoides			X	692
Longnose Dace	Rhinichthys cataractae	X	X	X	342
Margined Madtom	Noturus insignis	X			483
Rainbow Trout	Oncorhynchus mykiss			X	121
Tessellated Darter	Etheostoma olmstedi	X	X	X	721
White Sucker	Catostomus commersonii	X	X	X	401

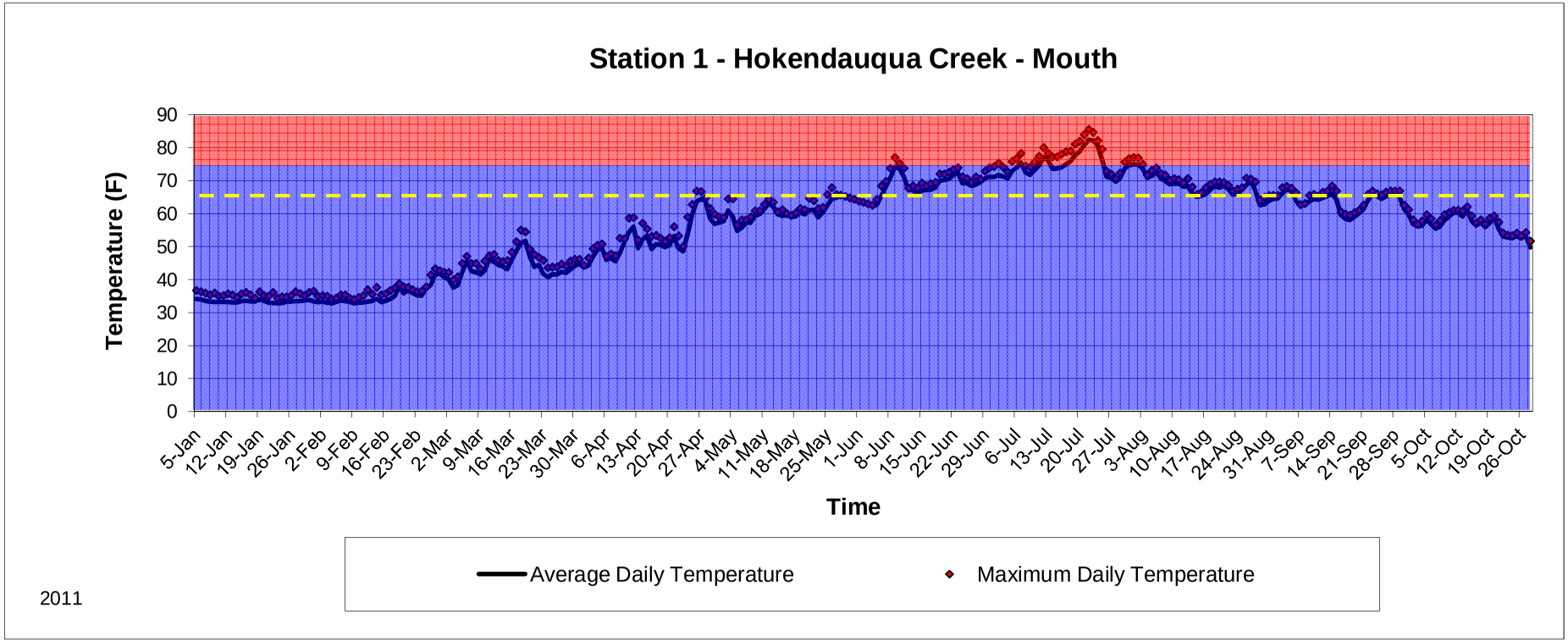
Site species collection matrix from Hokendauqua Creek Sub-SubBasin 02C. Data collected within 1999 survey year. Column Headings Legend:
1- Section 5 Rivermile 0 Site Date 7/7/1999 SiteLatLon 404037752925
2- Section 4 Rivermile 2.04 Site Date 7/7/1999 SiteLatLon 404140752933
3- Section 4 Rivermile 3.09 Site Date 7/7/1999 SiteLatLon 404330752953
4- Section 2 Rivermile 9.24 Site Date 7/9/1999 SiteLatLon 404550750800
5- Section 2 Rivermile 12.2 Site Date 7/9/1999 SiteLatLon 404707752651
6- Section 2 Rivermile 15 Site Date 7/8/1999 SiteLatLon 404745752515

Common Name	Scientific Name	1	2	3	4	5	6	Code
American Eel	Anguilla rostrata	X	X		X	X		501
Blacknose Dace	Rhinichthys atratulus		X	X	X	X	X	341
Bluegill	Lepomis macrochirus	X	X		X	X	X	674
Brown Trout	Salmo trutta				X	X	X	122
Brown Trout - Hatchery	Salmo trutta	X			X	X		135
Chain Pickerel	Esox niger						X	195
Common Shiner	Luxilus cornutus	X	X		X		X	306
Creek Chub	Semotilus atromaculatus	X					X	351
Cutlip Minnow	Exoglossum maxillingua	X	X			X		261
Fallfish	Semotilus corporalis	X	X	X	X	X	X	352
Largemouth Bass	Micropterus salmoides				X			692
Longnose Dace	Rhinichthys cataractae	X	X	X		X	X	342
Margined Madtom	Noturus insignis		X	X	X	X		483
Rainbow Trout - Hatchery	Oncorhynchus mykiss				X	X		134
Redbreast Sunfish	Lepomis auritus		X					671
Redfin Pickerel	Esox americanus					X		191
Rock Bass	Ambloplites rupestris						X	651
Satinfin Shiner	Cyprinella analostana	X						302
Smallmouth Bass	Micropterus dolomieu	X	X	X				691
Tessellated Darter	Etheostoma olmstedi			X	X	X	X	721
White Sucker	Catostomus commersonii	X	X	X	X	X	X	401

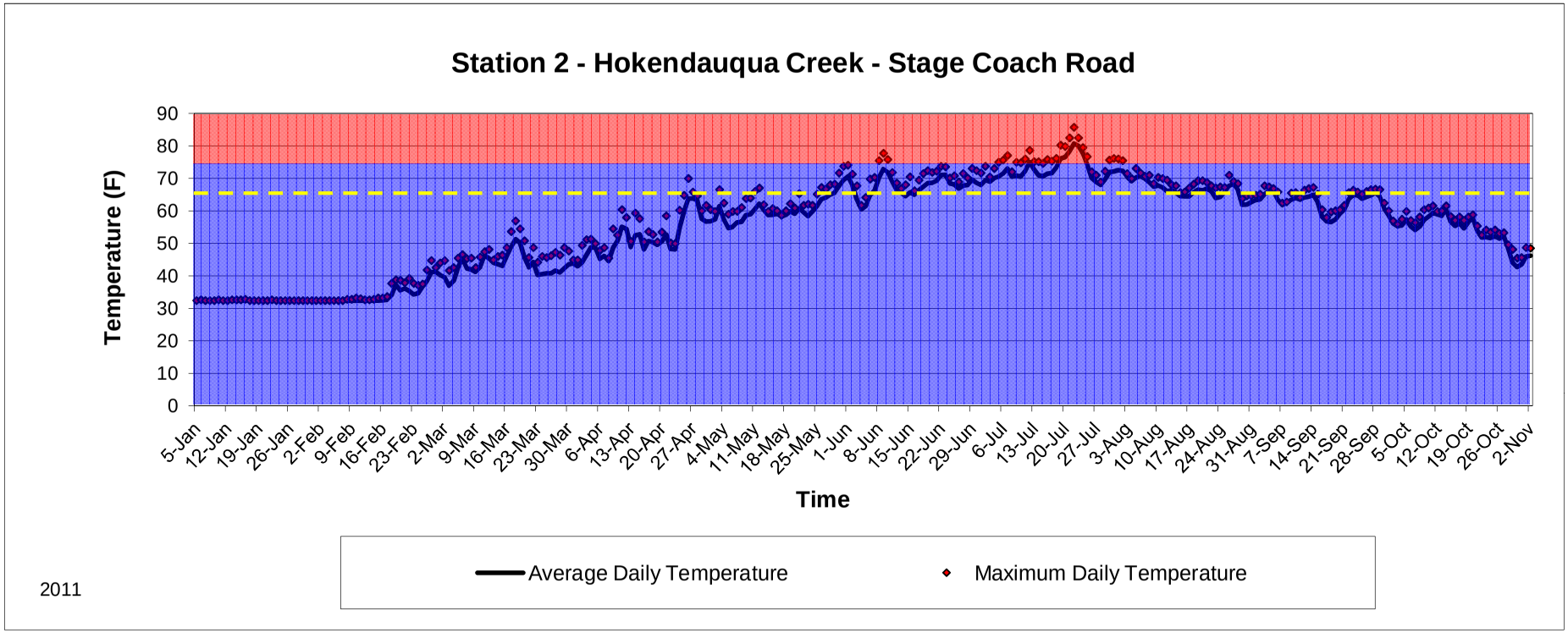
Site species collection matrix from Hokendauqua Creek Sub-SubBasin 02C. Data collected within 2006 survey year. Column Headings Legend:
1- Section 2 Rivermile 8.35 Site Date 3/23/2006 SiteLatLon 404433752858
2- Section 2 Rivermile 14.02 Site Date 3/23/2006 SiteLatLon 404730752628

Common Name	Scientific Name	1	2	Code
Blacknose Dace	Rhinichthys atratulus	X	X	341
Brook Trout - Hatchery	Salvelinus fontinalis	X	X	136
Brown Trout	Salmo trutta	X	X	122
Brown Trout - Hatchery	Salmo trutta	X	X	135
Channel Catfish	Ictalurus punctatus	X	X	475
Largemouth Bass	Micropterus salmoides		X	692
Pumpkinseed	Lepomis gibbosus		X	673
Rainbow Trout - Golden	Oncorhynchus mykiss	X	X	128
Rainbow Trout - Hatchery	Oncorhynchus mykiss	X	X	134
Tessellated Darter	Etheostoma olmstedi	X	X	721
White Sucker	Catostomus commersonii	X	X	401

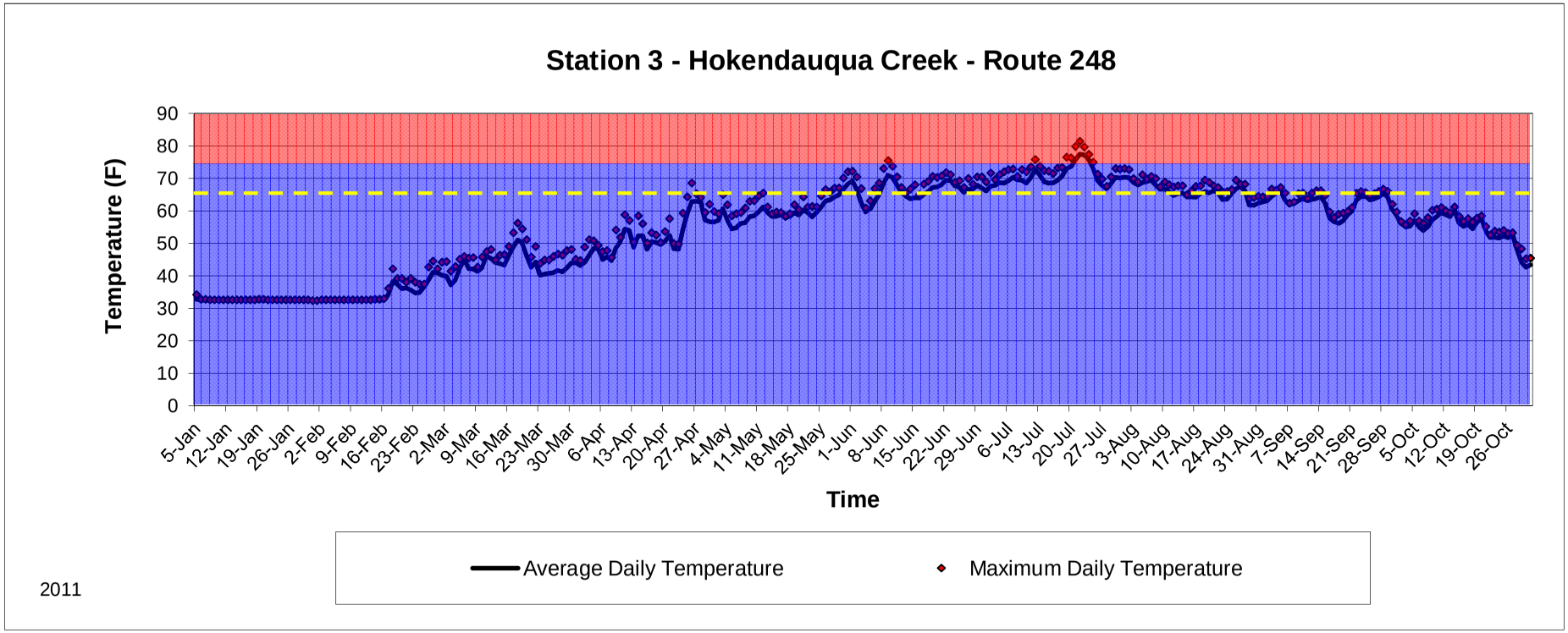
Appendix E
Temperature Data Graphs


Station 1 - Hokendauqua Creek - Mouth
Temperature (F)
90
80
70
60
50
40
30
20
10
0
5-Jan
12-Jan
19-Jan
26-Jan
2-Feb
9-Feb
16-Feb
23-Feb
2-Mar
9-Mar
16-Mar
23-Mar
30-Mar
6-Apr
13-Apr
20-Apr
27-Apr
4-May
11-May
18-May
25-May
1-Jun
8-Jun
15-Jun
22-Jun
29-Jun
6-Jul
13-Jul
20-Jul
27-Jul
3-Aug
10-Aug
17-Aug
24-Aug
31-Aug
7-Sep
14-Sep
21-Sep
28-Sep
5-Oct
12-Oct
19-Oct
26-Oct
Time
Average Daily Temperature
Maximum Daily Temperature

2011

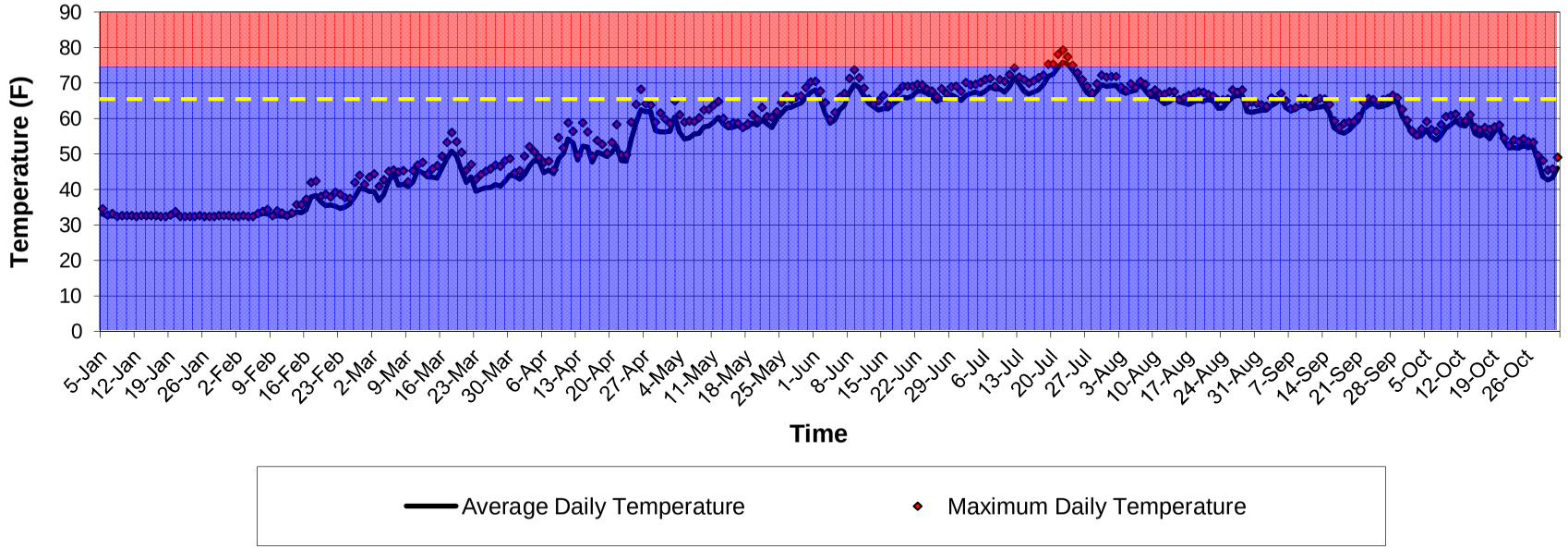

Station 2 - Hokendauqua Creek - Stage Coach Road
Temperature (F)
90
80
70
60
50
40
30
20
10
0
5-Jan
12-Jan
19-Jan
26-Jan
2-Feb
9-Feb
16-Feb
23-Feb
2-Mar
9-Mar
16-Mar
23-Mar
30-Mar
6-Apr
13-Apr
20-Apr
27-Apr
4-May
11-May
18-May
25-May
1-Jun
8-Jun
15-Jun
22-Jun
29-Jun
6-Jul
13-Jul
20-Jul
27-Jul
3-Aug
10-Aug
17-Aug
24-Aug
31-Aug
7-Sep
14-Sep
21-Sep
28-Sep
5-Oct
12-Oct
19-Oct
26-Oct
2-Nov
Time
Average Daily Temperature
Maximum Daily Temperature

2011

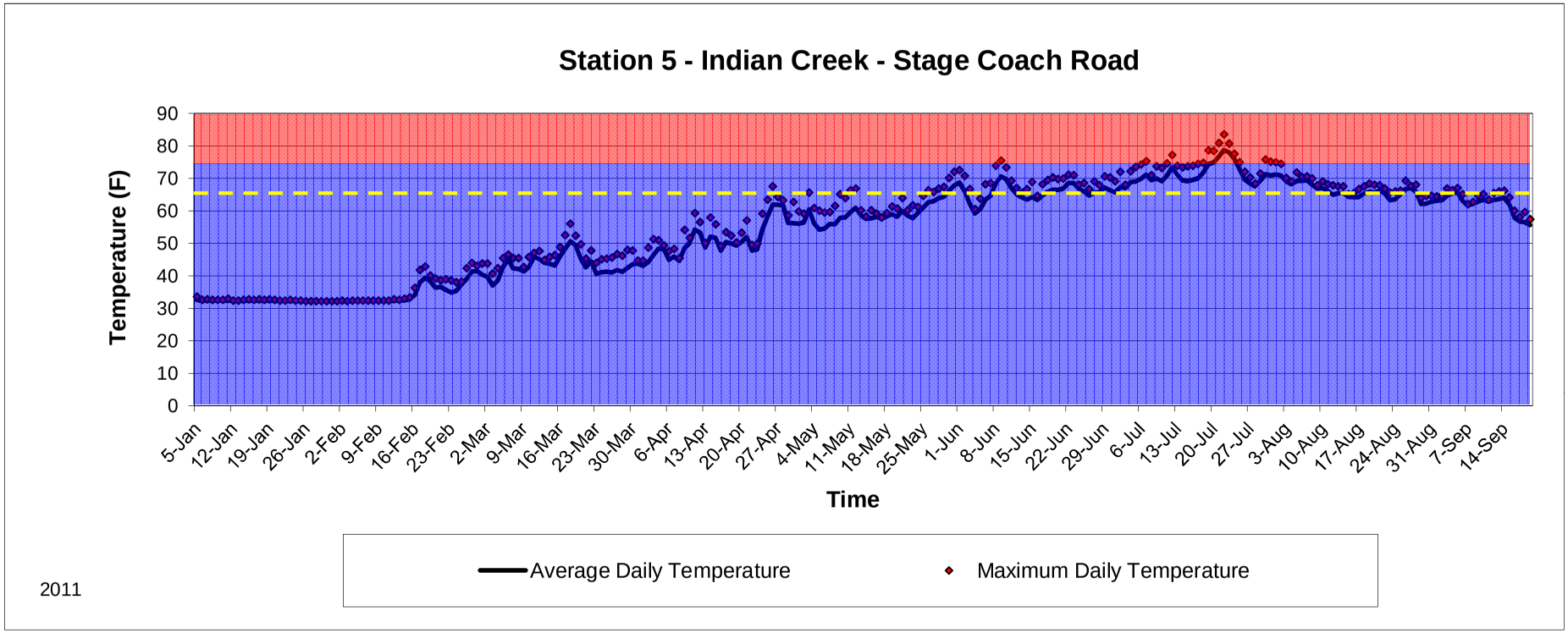

Station 3 - Hokendauqua Creek - Route 248
Temperature (F)
90
80
70
60
50
40
30
20
10
0
5-Jan
12-Jan
19-Jan
26-Jan
2-Feb
9-Feb
16-Feb
23-Feb
2-Mar
9-Mar
16-Mar
23-Mar
30-Mar
6-Apr
13-Apr
20-Apr
27-Apr
4-May
11-May
18-May
25-May
1-Jun
8-Jun
15-Jun
22-Jun
29-Jun
6-Jul
13-Jul
20-Jul
27-Jul
3-Aug
10-Aug
17-Aug
24-Aug
31-Aug
7-Sep
14-Sep
21-Sep
28-Sep
5-Oct
12-Oct
19-Oct
26-Oct
Time
Average Daily Temperature
Maximum Daily Temperature

2011

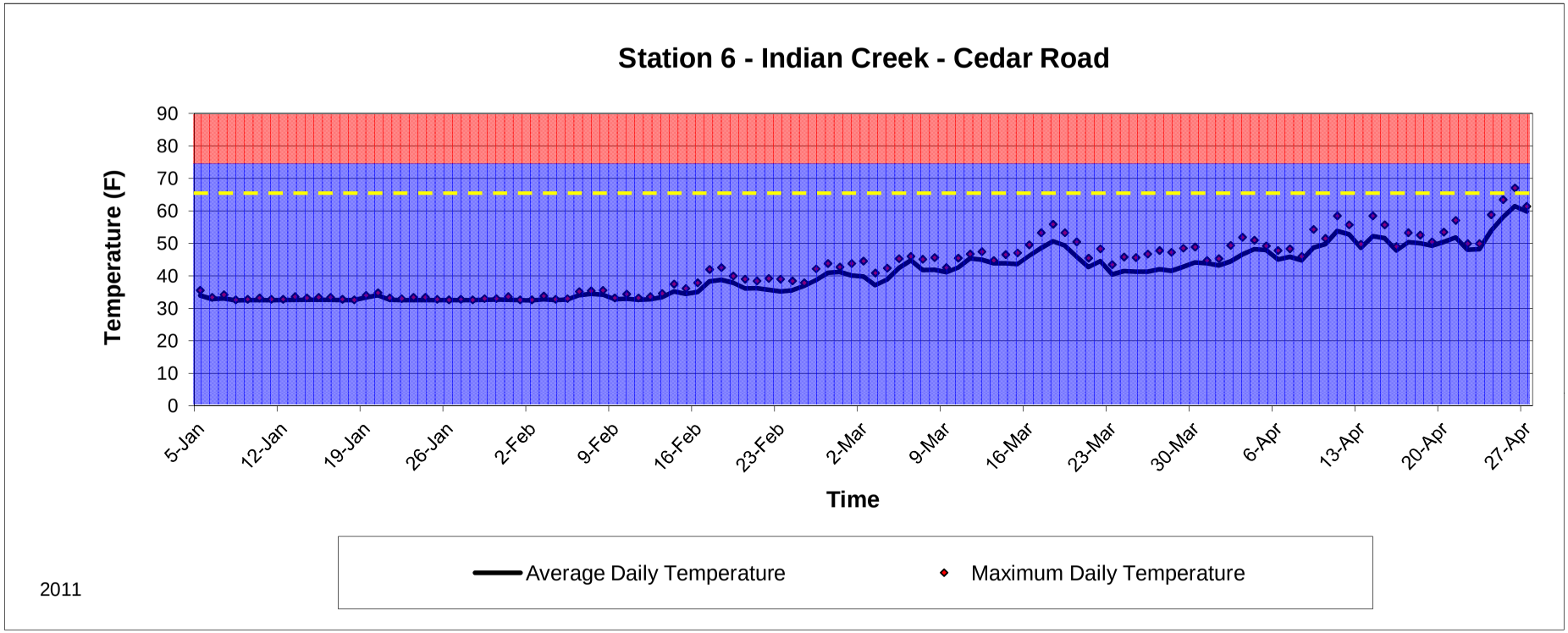
Station 4 - Hokendauqua Creek - Hoch Road



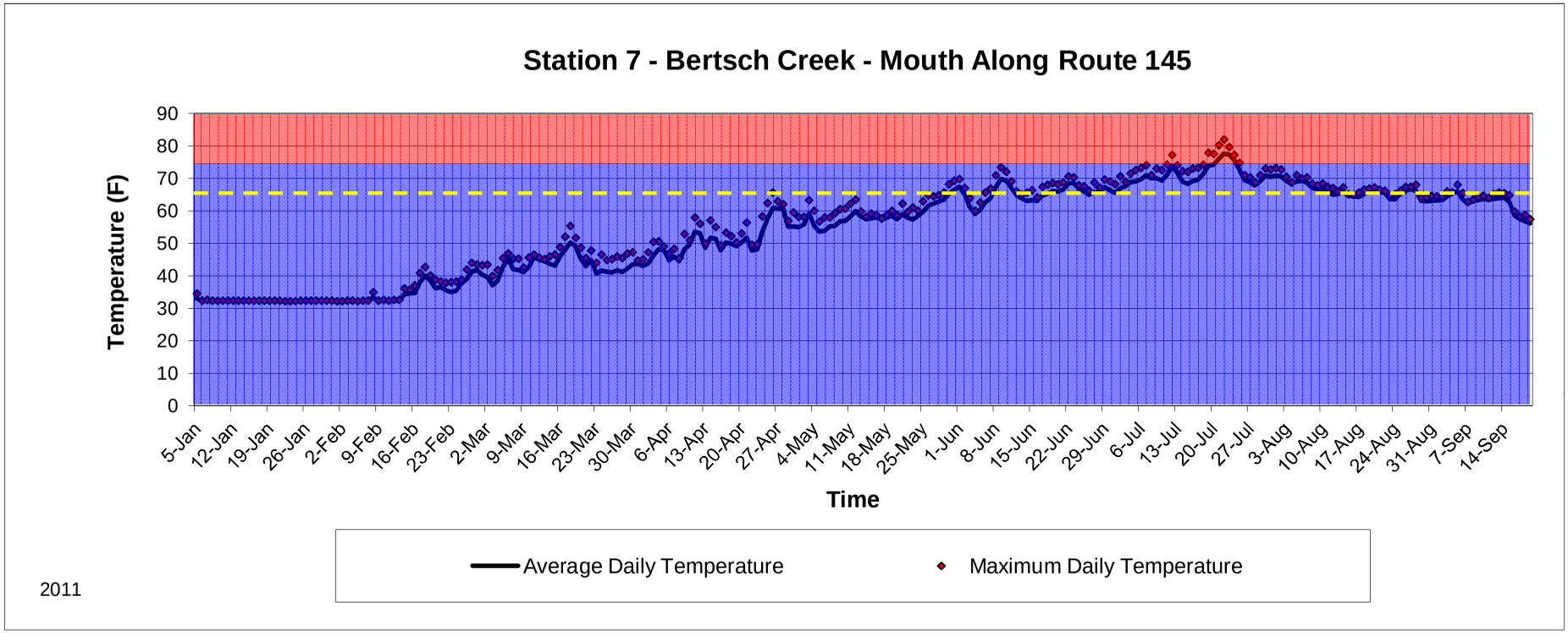
2011


Station 5 - Indian Creek - Stage Coach Road
Temperature (F)
90
80
70
60
50
40
30
20
10
0
5-Jan
12-Jan
19-Jan
26-Jan
2-Feb
9-Feb
16-Feb
23-Feb
2-Mar
9-Mar
16-Mar
23-Mar
30-Mar
6-Apr
13-Apr
20-Apr
27-Apr
4-May
11-May
18-May
25-May
1-Jun
8-Jun
15-Jun
22-Jun
29-Jun
6-Jul
13-Jul
20-Jul
27-Jul
3-Aug
10-Aug
17-Aug
24-Aug
31-Aug
7-Sep
14-Sep
Time
Average Daily Temperature
Maximum Daily Temperature

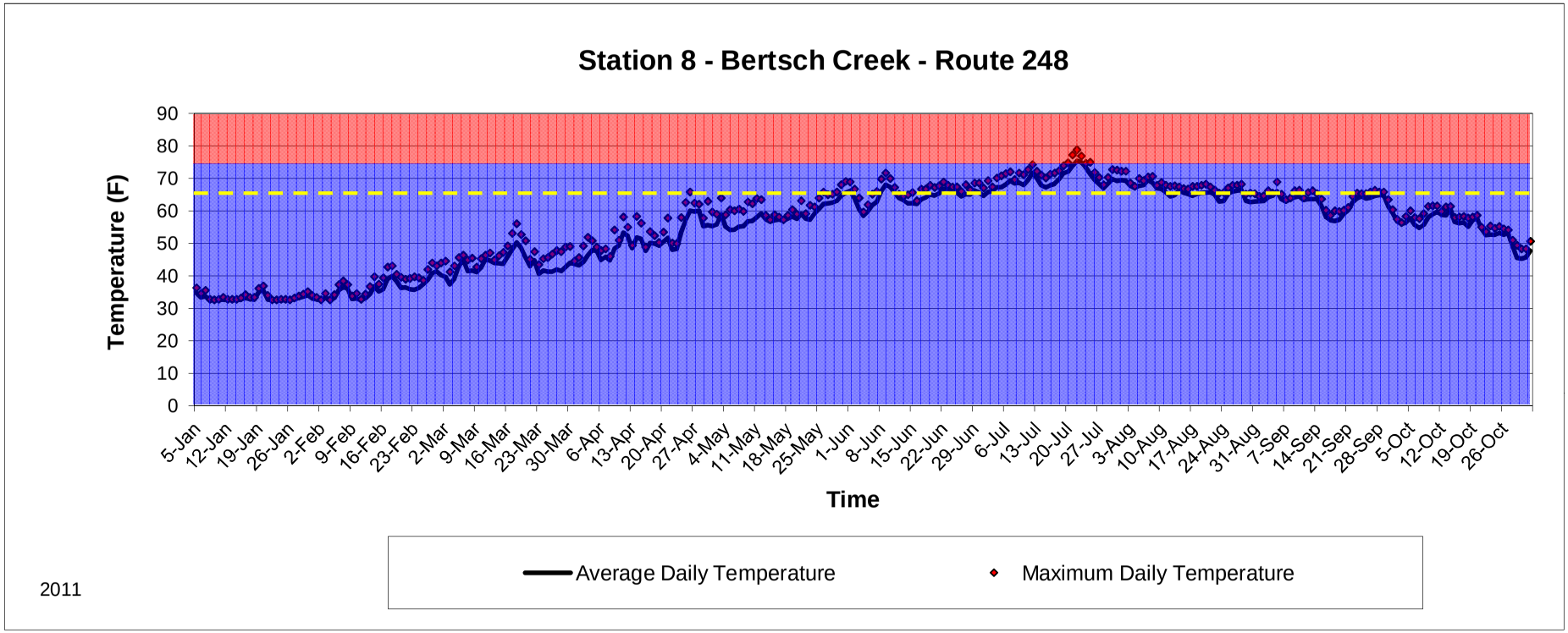
2011


Station 6 - Indian Creek - Cedar Road
Temperature (F)
90
80
70
60
50
40
30
20
10
0
5-Jan
12-Jan
19-Jan
26-Jan
2-Feb
9-Feb
16-Feb
23-Feb
2-Mar
9-Mar
16-Mar
23-Mar
30-Mar
6-Apr
13-Apr
20-Apr
27-Apr
Time
Average Daily Temperature
Maximum Daily Temperature

2011


Station 7 - Bertsch Creek - Mouth Along Route 145
Temperature (F)
90
80
70
60
50
40
30
20
10
0
5-Jan
12-Jan
19-Jan
26-Jan
2-Feb
9-Feb
16-Feb
23-Feb
2-Mar
9-Mar
16-Mar
23-Mar
30-Mar
6-Apr
13-Apr
20-Apr
27-Apr
4-May
11-May
18-May
25-May
1-Jun
8-Jun
15-Jun
22-Jun
29-Jun
6-Jul
13-Jul
20-Jul
27-Jul
3-Aug
10-Aug
17-Aug
24-Aug
31-Aug
7-Sep
14-Sep
Time
Average Daily Temperature
Maximum Daily Temperature

2011


Station 8 - Bertsch Creek - Route 248
Temperature (F)
90
80
70
60
50
40
30
20
10
0
5-Jan
12-Jan
19-Jan
26-Jan
2-Feb
9-Feb
16-Feb
23-Feb
2-Mar
9-Mar
16-Mar
23-Mar
30-Mar
6-Apr
13-Apr
20-Apr
27-Apr
4-May
11-May
18-May
25-May
1-Jun
8-Jun
15-Jun
22-Jun
29-Jun
6-Jul
13-Jul
20-Jul
27-Jul
3-Aug
10-Aug
17-Aug
24-Aug
31-Aug
7-Sep
14-Sep
21-Sep
28-Sep
5-Oct
12-Oct
19-Oct
26-Oct
Time
Average Daily Temperature
Maximum Daily Temperature

2011