Former Haverford State Hospital

ECOLOGICAL ASSESSMENT

Natural Lands Trust

Princeton Hydro

December 2008

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for this Ecological Assessment Project was a collaborative effort including:

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The Quadrangle
Ad Hoc Haverford State Citizens Advisory Board

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Executive Summary

This *Ecological Assessment* was prepared by Natural Lands Trust and Princeton Hydro for the 124 acres of natural areas that are dedicated for passive open space on the former Haverford State Hospital site in Haverford Township, northeastern Delaware County. The *Assessment* describes upland and wetland vegetation on the site and the results of surveys of selected terrestrial wildlife, fish, and macroinvertebrate species. Based on these biological inventories, the *Assessment* identifies threats to the natural features on the property and describes the ecological condition of the site and its value to the surrounding Darby Creek Watershed. Recommendations for the sustainable stewardship of the natural areas that complement plans for public access and passive use are also provided.

The natural areas on the project site occur in three sections separated by Route 476 and the residential development of Haverford Reserve. Two first order tributaries—North and South Brooks—form deep valleys in their own subwatersheds on the site, feeding into Darby Creek west and east of Route 476, respectively. The 124-acre property is largely forested (~110 acres) with mature mixed hardwood forests straddling the two first order tributaries and younger forests occurring in areas released from agriculture following the construction of the Haverford State Hospital in the 1960's. The presence of mature forest buffering the North and South Brooks has largely protected the perennial water quality of the streams which generally support a diverse aquatic fauna. Small occurrences of shrubland, old field/upland meadow, and marsh/wet meadow were also documented within the forest matrix. A meadow located in the North Brook section of the project site supports an unusual diversity of native herbaceous species. Several site characteristics—the size of the natural areas on the property relative to the surrounding landscape, the diversity of the plant communities, and the abundant water resources—combine to offer habitat for numerous resident and migratory birds.

The condition of the plant communities on the project site reflects the common influences affecting natural areas today, particularly invasive plant species and an overabundant deer population. Invasive species have the greatest impact in the younger forests on the site because of their more fertile soils and more recent release from agriculture. Signs of heavy deer use include a lack of adequate tree regeneration, heavily browsed shrubs, a barren understory in parts of the mature forest, and scat and tracks throughout the site. Additional stewardship issues on the property relate to hazards, aesthetics, trail layout relative to the steep slopes and sensitive habitats, as well as water quality of the perennial streams that has been compromised in some areas by culverts or invasive plants. Our major recommendations for the stewardship of the natural areas on the property address these issues with consideration for the public use plans for the site and include the following:

- Conduct an assessment of hazard trees particularly near recently disturbed areas of potential public use and address issues with trees that pose a danger to visitors.
- Remove attractive nuisances, trash, and debris from the property prior to opening it to public use.
- Restrict or minimize trail use in sensitive areas that include wetlands, water resources, steep slopes, and

special plant resource areas. Existing trails that fall within these sensitive areas can remain except for the trails within "The Meadow" which should be moved to the outer edge of the proposed meadow restoration area.

- In general, limit trail use to foot traffic, to minimize noise, disturbance to sensitive habitats, and conflicts with pedestrians.
- Control invasive plant species beginning in areas of low invasive species impact (e.g., the mature forests) and consider using volunteers to annually monitor invasive plants and participate in appropriate control activities. Avoid creating additional forest gaps that perpetuate invasive plant populations and fragment intact forest parcels.
- Establish a deer management program for the property. Monitor the effects of deer overabundance and reduce the population, as needed, through periodic use of sharpshooters.
- Monitor areas of stormwater erosion on the property as additional impervious cover is developed in the Haverford Reserve subdivision and work with the neighboring Quadrangle community and the Delaware County Conservation District to explore options for decreasing channel flow into South Brook.
- Stabilize, regrade, and replant eroded drainage areas to eliminate gullies and reduce further erosion. Re-grade the old access road along Darby Creek west of Route 476 to drain water away from the creek.
- Conduct a more comprehensive botanical inventory of the meadow in the North Brook section.
- Expand and restore the meadow to approximately 3.5 acres by removing scattered woody vegetation within the meadow back to the forest edge and consider the use of prescribed fire to enhance the meadow community.
- Limit frequent mowing within the meadow to the area near the fire ring and restrict camping to the western and northern border of the meadow after woody species have been removed.

Introduction and Purpose

In 2002, Haverford Township purchased the 209-acre former Haverford State Hospital site from the state. The terms of the deed stated a minimum of 120 acres must be preserved as passive open space and a minimum of 15 acres for active community recreation. In 2006, Haverford Township signed an agreement to sell approximately 40 acres to a private developer to be used for residential purposes. Of the remaining acreage, approximately 124 acres are dedicated to passive open space and approximately 45 acres are intended for active community recreation. In 2007, the Haverford State Citizens Advisory Board and the Darby Creek Valley Association were awarded a forty-five thousand dollar ($45,000.00) grant from the National Fish and Wildlife Foundation to develop an Environmental Action Plan to assess the 124 acres of forest, wetlands, and riparian corridors on the site for passive public use. Natural Lands Trust (NLT) and Princeton Hydro were hired to conduct an ecological assessment of the natural resources in the pubic use area and to provide recommendations for the sustainable and environmentally-sensitive public use of the site. Specific goals of this project include the following:

1. To conduct and analyze baseline inventories of upland and wetland vegetation, fish and macroinvertebrate species, and selected wildlife terrestrial species;

2. To identify threats to the natural features of the site and assess the ecological condition of the property and its ecological value to the Darby Creek Watershed;

3. To provide recommendations for the sustainable stewardship of the natural areas that is compatible with the plans for passive public use of the site.

The *Ecological Assessment* will help to meet goals and objectives of local and state conservation plans. The *Darby Creek Watershed Conservation Plan* (2005) identifies the re-use and stewardship of the former Haverford State Hospital property as a key opportunity to achieve watershed goals related to maintaining and restoring riparian corridors, enhancing ecological resources, and increasing recreation and environmental education opportunities in the watershed. The watershed plan states, "in Haverford Township, the re-use of the keystone Haverford State Hospital site, certainly the largest development site in the Watershed, epitomizes virtually every issue discussed in this Plan. This Plan argues strongly for conservation-oriented planning concept at this remaining ecological 'island' in the Watershed." The plan continues by explaining "its open space functions and values, from water resources quantity and quality to biodiversity and habitat to air quality and aesthetics, are of tremendous importance and must be maximized." This ecological assessment includes natural resource inventories that provide documentation of current ecological values and provides recommendations that support many of the goals in the *Darby Creek Watershed Conservation Plan*.

The *Pennsylvania Wildlife Action Plan* (WAP), completed in 2005 also identifies a number of strategic wildlife management objectives for maintaining and enhancing wildlife habitat that are relevant to the former Haverford State Hospital site. The purpose of the WAP is to conserve Pennsylvania's diverse wildlife, to maintain their role in ecological processes, and to protect and enhance species of conservation concern. Objectives in the plan address the need for increasing the public's understanding of the habitat needs of wildlife, promoting habitat management on non-game public lands to ensure diverse levels of game and wildlife, and developing a heightened awareness of user responsibility and respect for private and public lands and landowners. These objectives are also addressed in this ecological assessment.

Ecological Inventory and Analysis

The subject property for this ecological assessment, part of the former Haverford State Hospital site, includes 124 acres that is bordered by residential properties along Darby Road to the north and Marple Road to the south in Haverford Township, Delaware County (see ***Map 1: Location*** and ***Map 2: 2005 Aerial Photography***). The natural areas on the site include an extensive northern section straddling North Brook, a forested area along the southeastern boundary of the property and draining into South Brook, and a parcel west of Route 476 that includes the floodplain and associated wetlands along Darby Creek and adjacent upland areas.

PHOTO 1: North Brook surrounded by red oak–mixed hardwood forest. August 2008.

BASELINE MAPPING

We created and analyzed a series of baseline maps from existing and available data for the site, including current aerial photography, hydrology, topography, and soils. Descriptions and analyses of these data are included in the following sections and serve as the initial phase of the ecological assessment of the site.

Hydrology

The subject property is located in the higher elevations of the Darby Creek Watershed within the Delaware River Basin. Two spring-fed first order tributaries, North Brook *(Photo 1)* and South Brook, form their own subwatersheds on the site, feeding into Darby Creek *(Photo 2)* west and east of Route 476, respectively (see ***Map 3: Hydrologic Features***). Base flows of these perennial streams are maintained by springs, seeps, and depressional wetlands along their course through the property *(Photo 3, page 4)*. North

PHOTO 2: Darby Creek and surrounding floodplain forest. August 2008.

PHOTO 3: Seep and spring on slope near North Brook. August 2008.

PHOTO 4: Vernal pool in Darby Creek section. March 2008.

PHOTO 5: Vernal pool in Darby Creek section. August 2008.

Brook is obstructed by an undersized steel culvert that retards storm flows; a marsh has developed upstream of the culvert and moved the confluence of two feeder streams downstream to just above the culvert. Further downstream, North Brook travels under Route 476 through a five-foot diameter concrete culvert. Vernal (seasonal) pools occur in and near the floodplain forest west of Route 476 *(Photos 4 and 5)*.

Topography

The elevation changes approximately 150 feet within the site, ranging from about 340 feet at the highest point to 190 feet along Darby Creek in the southwest corner of the site (see ***Map 4: Topographic Features***). In general the site is characterized by rolling hills with less than 15% slopes and flatter areas in the higher elevations and along the streams. Most of the steep slopes (>25%) on the property follow the North and South Brook corridors that form relatively deep valleys running northeast to southwest across the site. The Darby Creek section includes a broad floodplain corridor surrounding the creek with 15–25% slopes leading up to a former railroad bed.

Soils

The types of rock formations that form the foundation of southeastern Pennsylvania are quite diverse. A long history of folding, compression and intrusion of volcanic material has left us a legacy of rock types ranging from soft limestones and shales to very durable gneisses, diabase and quartzite. Typically, hard rocks form the high lands and soft rocks the lower-lying areas. Different rock formations vary in porosity; each formation will allow groundwater to pass through rapidly or slowly (or not at all) to feed streams and rivers through springs and seeps. Generally, softer rocks are more porous.

Differences in chemical composition of rocks also have a strong influence on soil quality. Taken together, soil wetness and soil chemical composition tend to be the strongest influences on soil fertility.

Much can be predicted about the types of plants that will grow on a site by understanding the type of soil occurring there. Extreme wetness or dryness in soils creates stress for plants and so specialized floras typically grow in these locations. In between the harsh conditions imposed by wetness or dryness, plant growth is more strongly determined by soil fertility. Descriptions of soils in County Soil Surveys can be very useful in determining whether a soil is extremely wet or dry and fertile or infertile. Fertility can be related back to geology, with quartzite and many sandstones and shales producing lower fertility soils and gneiss, limestone, diabase, schist, and some shales and sandstones producing richer soils. Most native plant communities are highly tolerant of low soil fertility and are often outcompeted on high-fertility soils by exotic invasive species.

Soils

SYMBOL	SOIL NAME	TEXTURE	DEPTH TO SHWT*	DRAINAGE	LOCATION ON PROPERTY**
GnB	Glenville, 3–8% slopes	silt loam	1′–3′	somewhat poorly drained	South
GnB2	Glenville, 3–8% slopes, moderately eroded	silt loam	1′–3′	somewhat poorly drained	North
MgB2	Manor, 3–8% slopes, moderately eroded	loam	6′+	well-drained	Darby, North
MgC	Manor, 8–15% slopes	loam	6′+	well-drained	North
MgC2	Manor, 8–15% slopes, moderately eroded	loam	6′+	well-drained	Darby
MgC3	Manor, 8–15% slopes, severely eroded	loam	6′+	well-drained	Darby, North, South
MgD	Manor, 15–25% slopes	loam	6′+	well-drained	Darby, North
MgD2	Manor, 15–25% slopes, moderately eroded	loam	6′+	well-drained	Darby
MgD3	Manor, 15–25% slopes, severely eroded	loam	6′+	well-drained	North, South
MhE	Manor and Channery, 25–35% slopes	loam	6′+	well-drained	South
MhE3	Manor and Channery, 25–35% slopes, severely eroded	loam	6′+	well-drained	North, South
MkF	Manor, 35–60% slopes	loam	6′+	well-drained	North, South
We	Wehadkee	silt loam	0′–1′	poorly drained (hydric)	Darby
WoA	Worsham, 0–3% slopes	silt loam	0′–1′	poorly drained (hydric)	Darby, North

* *Depth to seasonal high water table*
** *Sections of property surrounding North Brook, South Brook, and Darby Creek*

Soils on the property include loams and silt loams with hydric (poorly drained) soils underlying Darby Creek and its floodplain and somewhat poorly drained soils underlying North and South Brooks (see ***Map 5: Soils***). Soils along the deep valleys of the North and South Brooks underlie steep slopes and tend to be highly erodible and more sensitive to disturbance related to trail construction and use. Public access in areas of poorly drained and somewhat poorly drained soils such as those along the immediate corridors of North and South Brooks and the floodplain of Darby Creek should be limited to protect the stability of the soils and the sensitive habitats they support. A summary of the soils on the property and selected soil properties that pertain to trail construction and use is found on the previous page.

VEGETATION SURVEY

Since January of this year (2008), David Steckel and Andrea Stevens of Natural Lands Trust have conducted 12 site visits to the 124 acres of natural areas surrounding the former Haverford State Hospital footprint. We referenced 2005 aerial photography and baseline mapping of hydrology, topography, and soils during our site visits, and we used a Global Positioning System (GPS) unit to record locations of plant community boundaries, stewardship issues, special features, and existing trails.

The natural areas on the property include two terrestrial (upland) forest communities, two palustrine (wetland) forest communities, a small shrubland area, old field/(upland) meadows, and marsh/wet meadows (see ***Map 6: Vegetation Communities***). Communities were identified based on Fike's *Terrestrial and Palustrine Plant Communities of Pennsylvania* (1999) and are described below. A complete list of species in each community is included in Appendix A.

PHOTO 6: Red oak mixed hardwood / tuliptree-beech-maple forest. August 2008.

1. ***Red oak–mixed hardwood/tuliptree–beech–maple forest (29.9 acres).*** This forest is a mix of the two communities that are the most common forest types in our region. Dominant canopy species include red and black oak (*Quercus rubra, Q. velutina*), with tuliptree (*Liriodendron tulipifera*), beech (*Fagus grandifolia*), sugar maple (*Acer saccharum*), and hickories (*Carya* spp.). Sugar maple is frequent in the understory and spicebush (*Lindera benzoin*) dominates the shrub layer *(Photo 6)*. This forest is the oldest on the property, as indicated by patches of mature forest in the same locations on ***Map 7: Historical Aerial Photography 1937*** and, as a result, is least impacted by exotic invasive plant species. This community buffers North Brook and South Brook and is critical to the protection of water quantity (forests maximize water infiltration that helps ensure perennial flow from seeps and springs) and quality (through shading and the contribution of organic matter to support aquatic biota).

2. ***Red maple terrestrial forest (63.3 acres).*** This forest is the most extensive plant community on the site and covers large swaths of the North Brook and South Brook watersheds on the property. Dominant canopy species include red maple (*Acer rubrum*), red ash (*Fraxinus pennsylvanica*), black cherry (*Prunus serotina*) and tuliptree, with red ash, tuliptree, red maple, and hickories in the understory *(Photo 7)*. In and around the old field/terrestrial meadow in the middle of the northern block of this forest, we found a variation of the red maple terrestrial forest containing Scots pine (*Pinus sylvestris*), white pine (*Pinus strobus*), bigtooth aspen (*Populus grandidentata*), crabapple (*Malus* sp.), and black locust (*Robinia pseudoacacia*). This red maple terrestrial forest ranges in age from approximately 20 to 60 years and, overall, is moderately impacted by invasive plants including multiflora rose (*Rosa multiflora*), oriental bittersweet (*Celastrus orbiculatus*), and Japanese corktree (*Phellodendron amurense*).

PHOTO 7: Red maple terrestrial forest. January 2008.

PHOTO 8: Red maple palustrine forest. August 2008.

PHOTO 9: Sycamore-box-elder floodplain forest. October 2008.

PHOTO 10: Shrubland invaded by multiflora rose. March 2008.

3. ***Red maple palustrine forest (5.4 acres).*** This wetland forest covers the northern extent of the parcel west of Route 476 and is dominated by red maple and red ash in the overstory, with less frequent pin oak (*Quercus palustris*), shagbark hickory (*Carya ovata*), and black cherry *(Photo 8)*. Understory trees include box-elder (*Acer negundo*) and black walnut (*Juglans nigra*). Several species of invasive plants are moderately impacting the shrub layer of this forest, including multiflora rose, Japanese honeysuckle (*Lonicera japonica*), and privet (*Ligustrum vulgare*). The red maple palustrine forest is similar in age (20–60 years) to its terrestrial version.

4. ***Sycamore–box-elder floodplain forest (11.5 acres).*** This community occurs in the floodplain of the Darby Creek west of Route 476 and surrounds pockets of marsh/wet meadow along the riparian corridor *(Photo 9)*. This community is highly variable, containing palustrine and terrestrial areas and significant patches of red maple (palustrine) and sweetgum (*Liquidambar styraciflua*). Dominant canopy species include red maple, red ash, and willow (*Salix* sp.), with less common occurrences of sycamore (*Platanus occidentalis*), box-elder, pin oak, and sweetgum. Understory and shrub associates include hornbeam (*Carpinus caroliniana*), sassafras (*Sassafras albidum*), spicebush, and an invasive species component of Japanese honeysuckle and oriental bittersweet, with mile-a-minute (*Persicaria perfoliata*) in open areas of the forest floor.

5. ***Terrestrial shrubland (1.1 acres).*** A shrubland heavily invaded by multiflora rose is located along the southern border of the property and includes few native plant species aside from a very occasional canopy tree that is structurally compromised by aggressive climbing vines, including porcelain-berry (*Ampelopsis brevipedunculata*), oriental bittersweet and grape (*Vitis* sp.) *(Photo 10)*.

6. ***Old field/terrestrial meadow (9.6 acres).*** This open community occurs in three areas on the property: (1) in the middle of the large forest block between North Brook and Darby Road *(Photo 11)*,

PHOTO 11 *(right)*: **Old field / meadow with aspen in background. September 2008.**

PHOTO 12 *(below)*: **Old field/meadow under power line west of Route 476. August 2008.**

(2) within the power line and sewer rights-of-way near the northern boundary, and (3) west of Route 476 along a power line right-of-way *(Photo 12)*. This early successional community is dominated by various species of grasses and forbs (see Appendix A for complete listing). The first area (between North Brook and Darby Road), known locally as "The Meadow," was stripped of topsoil in the development of the Haverford State Hospital several decades ago (see ***Map 8: Historical Aerial Photography 1971***), leaving only mineral soil as a substrate for the predominantly native meadow flora that has inhabited the site since that time.

7. ***Marsh/wet meadow (1.5 acres).*** Several areas of marsh/wet meadow occur on the property, and include cat-tail marsh *(Photo 13)* and skunk cabbage (*Symplocarpus foetidus*) forest wetlands along the North and South Brooks *(Photo 14)*. Marsh/wet meadow areas resting within the Sycamore box-elder floodplain forest west of Route 476 along Darby Creek Red contain red maple and scattered willow, with buttonbush (*Cephalanthus occidentalis*), silky dogwood (*Cornus amomum*), swamp rose (*Rosa palustris*), and highbush blueberry (*Vaccinium corymbosum*) occurring as occasional shrub components. A diverse forb and graminoid flora characterizes these areas (see plant species list in Appendix A) and includes cat-tail (*Typha latifolia*), tussock sedge (*Carex stricta*), touch-me-not (*Impatiens* sp.), cinnamon fern (*Osmunda cinnamomea*), arrowhead (*Sagittaria* sp.), with occasional common reed (*Phragmites australis*).

Invasive Plant Species

We classified the impact of invasive plant species across the property using three ranking categories: low, medium, or high (see ***Map 9: Impact of Invasive Plant Species***). These are subjective categories and are based solely on observational rather than quantitative data. High impact areas are those where most layers of the forest support invasive plants that, in some cases, have become the dominant species. In these areas, canopy species are typically compromised by extensive growth of vines *(Photo 15)* and invasive species form a dense and often impenetrable shrub layer, leaving marginal habitat for native flora *(Photo 10, page 9)*. Medium impact areas are less densely invaded and include a significant native species component in the lower forest layers and heavier infestations in gaps and along edges *(Photo 16)*. Low impact areas have relatively intact native plant communities.

PHOTO 13 *(left)*: **Marsh/wet meadow west of Route 476. August 2008.**

PHOTO 14 *(below)*: **Skunk cabbage seep. April 2008.**

PHOTO 15: Vines (oriental bittersweet) growing up understory trees in high impact invasive area. March 2008.

PHOTO 16: The invasive mile-a-minute vine along the edge of red maple terrestrial forest in medium impact invasives area. August 2008.

PHOTO 17: High impact invasive area under power line in North Brook section (mile-a-minute, porcelain-berry, and grape vines). August 2008.

PHOTO 18: Invasive-dominated gap in red oak–mixed hardwood forest. These forests have low invasive impact because invasions are limited to these gap areas. August 2008.

In general, medium and high impact areas occur in those sections of the property (the younger red maple terrestrial and palustrine forests) released from agriculture over the past 60 years (see ***Maps 7 and 8: Historical Aerial Photography 1937*** and ***1971***), or where natural windthrow gaps in the mature forest or manmade openings (utility rights-of-way) provide extensive edge habitat that facilitates rapid growth of vines such as mile-a-minute or porcelain-berry *(Photo 17)*. Low impact areas are predominantly covered by mature forests. Due to the shading and limited disturbance of the soil over the past century, these areas have not provided favorable conditions for the establishment of invasive species. However, recent disturbance from windthrows of canopy trees, construction, and overabundant deer is allowing invasives to gain a foothold in isolated gaps *(Photo 18)* and along forest edges.

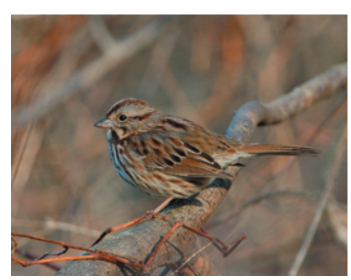
WILDLIFE SURVEY

This section includes a description of the wildlife communities and habitats on the property based on surveys conducted by Princeton Hydro. In particular, the utilization of the site by migratory and resident birds was examined as a means of determining the overall health of the various habitats on site. Scientists often utilize birds to qualify the ecosystems of a site, serving as umbrella taxa in developing conservation strategies for the lesser-observed species. For example, by initiating actions to protect bird habitat, other species would also be served. The focus of the wildlife inventory for the former Haverford State Hospital site is based on an assessment of suitable habitat for bird species and species observed at the site (both by Princeton Hydro staff and historical accounts). In

Indigo bunting

Chestnut-sided warbler

American goldfinch



Song sparrow

addition, the site was assessed relevant to opportunities for passive recreational uses such as hiking and bird watching, and to provide recommendations for minimizing potential impacts to wildlife.

Methods

Bird surveys were conducted during peak migration times in fall 2007 and spring 2008 in order to better gauge the usefulness of the site as a stopover area during these migration times, as well as provide a better indicator of species richness. Specifically, the fall surveys were conducted on September 26 and 27 and October 3, 2007. The spring surveys were conducted on May 1, 2, and 19, 2008. Each survey began no later than 7:00 A.M. since birds are most active during the pre-dawn to 9:00 A.M. timeframe.

Birds were identified in the field both visually and audibly, although most avian identifications were made solely on the basis of bird song. This is a common technique among ornithologists and is particularly useful when surveying during the growing season when vegetation often obscures birds from view. This was a qualitative survey, meaning that species populations were not quantified and only a total species count was recorded. Other wildlife was observed visually, audibly, or by tracks/scat. Both the avian and other wildlife species lists can be found in Appendix B.

For this survey, the former Haverford State Hospital site was split into three general areas or plant community types. The results from both the North and South Brooks and their associated riparian areas and forests were summarized together based on their similarity with respect to habitat and documented/field-verified birding accounts (see Appendix C for the 1999 Valley Forge Audubon Society *Nesting Bird Inventory*). The old field/terrestrial meadow area located north of North Brook was treated as a separate survey area due to the marked difference in habitat as compared with the surrounding red maple terrestrial forest. The third survey area consisted of the floodplain and riparian corridor west of Route 476 along the Darby Creek.

Results

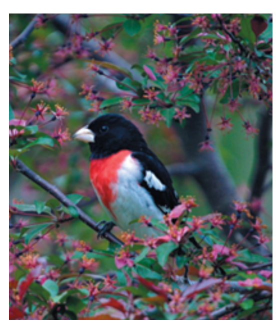
A cumulative species list was compiled during each survey event and a grand total of 62 avian species was observed at the former Haverford State Hospital site between fall 2007 and spring 2008 (Appendix B). Combined with the Valley Forge Audubon Society's *Nesting Bird Inventory* of the site conducted on March 10, 1999 (Appendix C), the total number of avian species documented at the site since 1999 is 72, with approximately 130 species utilizing the site during migration (Valley Forge Audubon Society, 1999). Various lists of species identified in the *Pennsylvania Wildlife Action Plan* as "Priority Species Associated with Forests" are included as Appendix D.

1. ***Meadow.*** The old field/terrestrial meadow located in the northern section of the project site represents a unique habitat and plant community. The majority of the preserved site, not including developed areas, includes red maple and red oak–mixed hardwood forest habitat so the meadow offers a varied nesting site for certain bird species that favor edge habitats (Blue-winged warbler, Indigo bunting, Chestnut-sided warbler, etc.). The meadow is too small to serve as habitat for grassland bird species that prefer large expansive


Yellow warbler


Black-throated green warbler


Yellow-rumped warbler


Rose-breasted grosbeak


American redstart

grasslands. Common species that were observed in the meadow include American goldfinch, Eastern towhee, Song sparrow, American crow, and Yellow warbler. The Scots pine and white pine dispersed throughout the meadow provide suitable stopover habitat for migrants that prefer mixed deciduous-coniferous forests and forest edges such as Black-throated blue warbler, Black-throated green warbler, Yellow-rumped warbler, and Prairie warbler. The Blue-winged warbler, a species that has declined since the 1960's, was also observed during our surveys. The Blue-winged warbler is known to occupy similar forested habitats as the Golden-winged warbler, a species of concern in the state but not documented on the former Haverford State Hospital property. It is interesting to note that the fragmentation of forest habitats and competition from the Blue-winged warbler are often cited as reasons for the declining populations of the Golden-winged warbler. The early successional forest within the meadow comprised of big-tooth aspen, crabapple, and black cherry, also offers suitable habitat for Black-and-white warbler, Rose-breasted grosbeak, and American redstart.

Other wildlife directly observed in the meadow area include red fox, Eastern cottontail, white-footed mouse, garter snake, and American toad. Evidence of white-tailed deer (scat) was observed as would be expected in an edge habitat. Deer utilize edges for foraging and bedding.

2. North and South Brook Forests. The red oak–mixed hardwood forests and red maple terrestrial forests surrounding the North and South Brooks represent two typical forest community types in the region. The immediate proximity of the mature oak forest and younger maple forest on this site allows various bird species to utilize both forest types for foraging and nesting. This is especially true of generalist species such as Gray catbird, Northern cardinal, and Carolina wren.

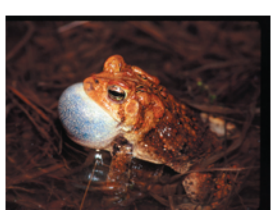
The mature red oak–mixed hardwood forest, though impacted by white-tailed deer and, to a lesser extent, invasive plant species in the understory, was healthy enough at the time of the survey to attract vulnerable species such as Wood thrush. This is notable because this species has seen a dramatic population decline due to understory

Red fox

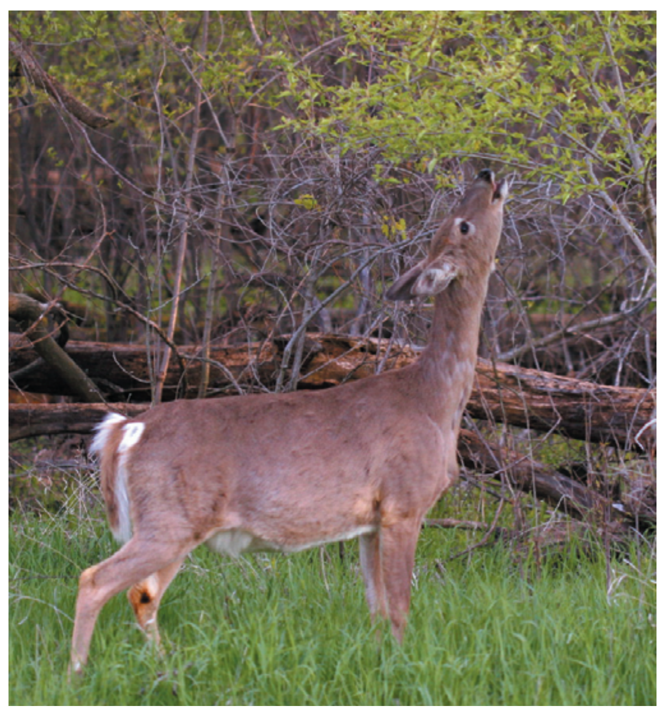
White-footed mouse

Eastern garter

Eastern cottontail



American toad



White-tailed deer

overbrowsing by deer and nest parasitism by Brown-headed cowbirds. Brown-headed cowbirds were observed in all three survey habitats, and they prefer edge habitats. The utility line expansion in the North Brook mature forest has increased this edge habitat type which will lead to potential impacts on vulnerable species.

The avian species observed in these two forest types represent a typical forest avian community for this region. Birds such as Red-eyed vireo, Ovenbird, Wood thrush, Veery, Cooper's hawk, Great horned owl, White-breasted nuthatch, Hairy woodpecker, and Red-bellied woodpecker were observed. Overall, these areas provide excellent opportunities for bird and wildlife watching. Furthermore, these forests could serve as a refuge for forest interior birds such as the Scarlet tanager (observed), Cerulean warbler, Great-crested flycatcher, given the extent of development in Haverford Township.

3. *Darby Creek Riparian Corridor Area.* The Darby Creek survey area west of Route 476 includes a mosaic of habitat types (riparian floodplains, forested wetland, marsh, and terrestrial forest) suited to a wide variety of bird species.

The reliable, deep, swift base flow of Darby Creek offers an attractive habitat for aquatic birds *(Photo 2, page 3)*. In contrast, the North and South Brooks provide more shallow stream flows *(Photo 19, page 16)*. Specifically, the Spotted sandpiper, Great blue heron, Mallard duck, and Belted kingfisher were all observed on Darby Creek. Northern rough-winged swallows were observed nesting in the far bank of Darby Creek, and Cedar waxwings and Blue-gray gnatcatchers were observed in the sycamores along the riparian corridor.

Wood ducks were observed in the sycamore–box-elder floodplain forest, which was inundated during the spring 2008 surveys. This forested wetland also could provide suitable habitat for the Prothonotary warbler, Red-shouldered hawk, Northern water thrush (historically observed), and Pileated woodpecker. The marsh/wet meadows located in the south half of this area could offer good habitat for Swamp sparrow (historically

Wood thrush

Brown-headed cowbird

Red-eyed vireo

Oven bird

White-breasted nuthatch

Great horned owl

Scarlet tanager

Red-bellied woodpecker

PHOTO 19: North Brook. April 2008.

observed), Marsh wren (PA State Rank S2S3B), Red-winged blackbird, and Great blue heron.

In general, avian species observed in the main area of the property were also found in this western parcel. A Scarlet tanager was observed in this area which demonstrates how important these swaths of woodland are for providing wildlife corridors in order to maintain the biological and ecological integrity of Haverford Township's natural areas.

Conclusions

As reported in the *Pennsylvania Wildlife Action Plan*, more than one in four Pennsylvanians actively participates in watchable wildlife recreation. The natural areas of the former Haverford State Hospital site could offer great opportunities for recreation such as bird and wildlife watching.

Spotted sandpiper

Mallard duck

Belted kingfisher

Wood duck

Great blue heron

Marsh wren

Red-winged blackbird

Throughout Pennsylvania the biggest declines in bird populations have occurred in grassland, wetland and early successional habitats. All these habitats are found on the former Haverford State Hospital site. The preservation of this property is a significant benefit for wildlife in southeastern Pennsylvania and the implementation of appropriate long-term conservation measures is necessary to preserve the observed species on the site, as well as the species of special concern that could potentially utilize the site.

MACROINVERTEBRATE SURVEY

Macroinvertebrates are primarily benthic (bottom-dwelling) fauna, such as insects, insect larvae, worms, mollusks (snails, clams), and crustaceans (scuds, shrimp, crayfish), which are common in freshwater and marine environments, and play an integral role in the aquatic food web of all stream systems. Characterization of benthic macroinvertebrate communities is important for compiling an inventory of these keystone organisms and to assess and document biological impairment in their communities and stream health in general.

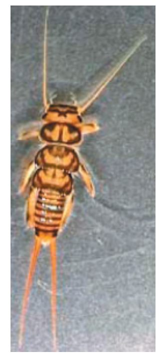
Macroinvertebrate communities include a broad range of species with varying sensitivity to environmental conditions and pollutants. Since benthic macroinvertebrates have limited migration patterns, or a sessile mode of life, they are particularly well-suited for assessing site-specific ecosystem health. Therefore, assessing the various macroinvertebrate communities can provide an ecological measure of fluctuating environmental conditions. In general, when pollution sensitive macroinvertebrate species are most dominant, the stream is determined to be non-impaired. When pollution tolerant macroinvertebrate species are most dominant, the stream is determined to be impaired.

Streams are determined to be impaired when species of pollution-tolerant groups (such as worms and midges) tend to dominate over pollution sensitive forms (e.g., mayflies, stoneflies, etc.), with an overall depression in species diversity. Environmental factors that may adversely affect stream biology can include

Benthic Macroinvertebrates Usually Indicative of Good Water Quality

Aquatic beetle

Mayfly nymph



Stonefly nymph

Caddisfly larvae

Benthic Macroinvertebrates Usually Indicative of Poor Water Quality

Midge

Aquatic sowbug

Leech

Segmented worm

Black fly larvae

All photographs taken by D. Bryson, NJDEP human induced conditions or natural conditions that affect chemical and/or physical parameters, as listed below:

- Lack of dissolved oxygen
- Higher than normal temperature
- Excessive sediment loading or turbidity
- Presence of toxicants (in various chemical forms)
- Eutrophication, which is excessive nutrients promoting undesirable vegetation or algal blooms, and increased turbidity
- Degraded habitat
    a. lack of bank vegetation/canopy (= poor bank stability, lack of shade)
    b. excessive sedimentation (= poor substrate and water clarity)
    c. lack of streamflow (= low dissolved oxygen, possible sedimentation, undesirable vegetation)

Human activities or practices, land uses, and natural features or events that can contribute to degraded stream quality include:

- Deforestation/development/construction (largely via runoff from non-point sources)
- Urbanization/industrialization (largely via runoff from non-point sources)
- Agricultural operations (largely via runoff from non-point sources)
- Municipal or industrial wastewater discharge (point source)
- Artificial channelization or habitat alteration
- Upstream impoundment, lake or pond
- Drought conditions

The ecological assessment of the former Haverford State Hospital site includes a description of the macroinvertebrate communities found by surveys conducted by Princeton Hydro within North Brook and South Brook and their respective confluences with the receiving waterway Darby Creek. This section focuses on describing the macroinvertebrate communities found within discrete locations on the two streams. The end goal was to document the infaunal community, i.e., aquatic organisms that inhabit the substrate or bottom of a water body, at the site and to analyze the community with respect to stream quality and watershed processes.

Macroinvertebrate sampling has garnered much attention recently as a cost effective sampling regime capable of describing the ecological status of lotic systems. The power of invertebrate sampling lies in the ability to integrate abiotic components such as aqueous chemistry, hydrology, substrate suitability, and thermal regime with biologic components to make inferences about higher trophic levels and pollutant loading in the context of general stream health and watershed processes that affect stream function.

Methods

In total, six infaunal samples were collected from the site. Sampling methodology was consistent with that outlined in the scope of work that specified that each sample would be a composite of several sub-samples. Specifically, sub-samples were collected using a D-net with a 500 µm mesh net. Direct sampling of the substrate was accomplished through kick methodology or manual disturbance. Other likely habitat, such as adventitious roots, submerged macrophytes, or coarse woody debris (CWD) was sampled by sweeping the D-net over its surface. At least five sub-sample composites were collected to form each sample. All samples were preserved in 70% isopropanol. Sample methodology is primarily consistent with EPA Rapid Bioassessment Protocols (Barbour et al. 1999), but also utilizes some methods identified in the New Jersey Ambient Biomonitoring Network sampling protocols (Honachefsky 2007).

The most important component of this sampling was identifying and bracketing distinct areas of North Brook and South Brook with particular focus on communities upstream and downstream of structures that impede water flow. While the effects of impeded flow of water are less structurally important to the benthic infauna than the fish community, they are still worth investigating.

Identification of invertebrates was performed with a stereoscope under 30x magnification in Princeton Hydro's laboratory. Identification was conducted to the family level with the aid of Rawlyk (1998), Cushing and Allan (2001), and Pennak (1989).

Statistical analyses and description of the communities utilize a variety of commonly accepted metrics and indices including those described in EPA Rapid Bioassessment Protocols. Each collected sample was analyzed to determine the number of individuals by family, genus, and species. Five biometric indicators were used to calculate an Impairment Score. Each biometric measures a different component of community structure and has a different range of sensitivity to pollution stress. The current Rapid Bioassessment Protocol uses the following metrics:

1. **Total Taxa or Taxa Richness** (number of families) – an index of community diversity; the number usually increases with increasing water or habitat quality.
2. **Percent Contribution of the Dominant Family** (to total abundance) – dominance by relatively few species/families may indicate environmental stress.
3. **Number of Ephemeroptera-Plecoptera-Trichoptera (EPT) Families** – the number of families represented within the orders Ephemeroptera (mayflies), Plecoptera (stoneflies) and Trichoptera (caddisflies), which are generally pollution-sensitive.
4. **Percent EPT** (of the total number of individuals) – would increase with increasing water quality.
5. **Family Biotic Index (FBI) or Hilsenhoff Biotic Index** – tolerance values of 0–10 are assigned to individual families (zero = most intolerant); these values are used in the formula for calculating the Biotic Index which summarizes the overall pollution tolerance of the entire benthic macroinvertebrate community with a single value.

Each biometric is scored a 6, 3, or 0. The scores for each biometric are then added together to calculate the Impairment Score. A sample result with a score of 24 to 30 is classified as non-impaired. Results indicating a score of 6 or less are classified as severely impaired, while results with a score between 9 and 21 indicate moderate impairment. The Impairment Scoring Criteria are listed at right.

Results

In total, six sites were investigated: three (3) sites were located on North Brook, while the remaining three (3) were located on South Brook (see ***Map 10: Macroinvertebrate Sampling Sites***). Each of these streams had corresponding locations including an upstream, downstream, and confluence site. All field sampling was conducted on a single date, May 1, 2008. The following section outlines the results of the sampling including statistical and biometric analysis. Appendix E includes the raw data for this survey.

1. ***North Brook Upstream.*** The upstream station on North Brook bracketed the upper culvert on the stream at the trail crossing *(Photo 20)* extending upstream into the wetland with several sub-samples collected both upstream and downstream of this culvert over a total distance of approximately 250

PHOTO 20: North Brook at trail crossing. May 2008.

Impairment Scoring Criteria

Biometric	Score 6	Score 3	Score 0
Taxa Richness	>10	10 to 5	4 to 0
EPT Index	>5	5 to 3	2 to 0
Percent Dominance	<40	40 to 60	>60
Percent EPT	>35	35 to 10	<10
FBI	0 to 4	4 to 6	6 to 10

Biological Assessment	Total Score
Non-Impaired	24 to 30
Moderately Impaired	9 to 21
Severely Impaired	0 to 6

PHOTO 21: Marsh upstream from North Brook Trail culvert. October 2008.

North Brook Upstream	
Abundance	194
Taxa Richness	19
EPT Index	6
Percent Dominance	41.24
Percent EPT	18.56
FBI	6.04
Dominant Taxon	Chironomidae

North Brook Downstream	
Abundance	97
Taxa Richness	11
EPT Index	5
Percent Dominance	29.90
Percent EPT	53.61
FBI	5.03
Dominant Taxon	Chironomidae

North Brook Confluence	
Abundance	95
Taxa Richness	12
EPT Index	4
Percent Dominance	38.95
Percent EPT	14.74
FBI	5.33
Dominant Taxon	Chironomidae

meters. The substrate in the reach upstream of the culvert was poor and consisted almost entirely of fine sands as all coarser rocks were completely embedded. Immediately downstream of the culvert the substrate improved greatly, consisting primarily of gravels and angular cobble with some degree of fines deposition in slower reaches.

This stream segment exhibited both the highest taxa richness and the highest FBI scores of all sample locations, but relatively low percent EPT. The incongruence noted in this sample is due to the disparate stream quality conditions between the upstream and downstream segments. In particular the high richness for Dipterans at this site increased the total richness in this reach, and at the same time elevated FBI scores. FBI scores were also raised by the relative abundance of Tubificidae worms, Sphaeriidae clams, and Physidae snails both of which are highly tolerant. However, the high quality of the section downstream of the culvert also ensured that the EPT index was also scored well, and in fact was equal to the high quality South Brook Upstream site.

Overall, this site is characterized as moderately impaired because of its high FBI score, indicating the prevalence of pollution tolerant organisms, relatively high percent dominance, and low percent EPT. However, taxa richness and EPT index scored well for this site. Again, these disparities arise because this is a composite sample incorporating widely varying conditions. It must be noted that while the culvert marked a clear delineation in terms of the infaunal community, based on preliminary field observation and variable metric scores, the culvert may in fact benefit downstream community structure as fine sediments seem to be largely trapped upstream of the culvert. Additionally, this area seemed to be more accurately classified as a wetland type of system (marsh) than a riparian one due to flatter topology and more typical wetland vegetation *(Photo 21)*.

2. ***North Brook Downstream.*** The downstream station was located in the reach immediately upstream of the culvert under Route 476, and was sampled over a reach of approximately 200 meters. The substrate, and subsequently the invertebrate

community, was similar to the lower portions of the upstream station with gravels and cobble. A rocked swale from a newly constructed basin discharges to this reach of North Brook.

This station had a lower abundance and taxa richness than the upstream station but fared better in the other metrics. In particular, low percent dominance and high percent EPT are good indicators of a balanced community in this stream stretch. Dipertan richness was much reduced in this stretch, as was the abundance of some of the more tolerant taxa such as Physidae and Sphaeriidae. This led to a better FBI score, despite the dominance of Chironomids.

Overall, this stream segment scores better in most critical areas than the upstream station. In particular, the relatively high EPT index and high percent EPT show the high quality of this segment because of its ability to support an abundance of these sensitive organisms.

3. *North Brook Confluence.* The third station on North Brook was located downstream of the Route 476 culvert down to the confluence with Darby Creek. Two sub-samples were taken in Darby Creek itself, one upstream and one downstream of the confluence with North Brook. Substrate in this area of North Brook was poor with much fine material, although there were some adventitious roots, however Darby Creek had relatively high quality gravel.

This station exhibited a shift in community structure from the North Brook Downstream reach. The shift was most evident in the loss of an EPT taxa (Trichoptera: Philopotamidae) as well as a large decline in EPT abundance and a subsequent much lower percent EPT. FBI increased slightly with the increased abundance of several tolerant taxa. Scuds (Gammaridae), the second most abundant group behind the Chironomids, were sampled in high density in this area. Diversity decreased, despite increased richness, as over 65% of the sample was contained in two (2) taxa.

This sample is significantly different from the other two samples in several important metrics; it has a lower EPT index and percent EPT scores than the other samples on North Brook. This shows a fairly important shift away from the EPT taxa in this stretch. While FBI did not show a major increase relative to the downstream station, there was a shift in overall composition.

PHOTO 22: Upstream portion of South Brook. April 2008.

South Brook Upstream	
Abundance	226
Taxa Richness	17
EPT Index	6
Percent Dominance	41.15
Percent EPT	51.33
FBI	4.66
Dominant Taxon	Chironomidae

4. *South Brook Upstream.* The upstream station was located upstream of a newly constructed basin with the upper terminus about 250 meters downstream of Darby Road *(Photo 22)*. Sub-samples were collected over a distance of approximately 200 meters. Substrate was very good in this area, characterized by angular cobbles. There was evidence of bank erosion in this reach, which indicates increased hydraulic loading from upstream sources. With the observed erosion in the stream deposition of materials was limited to larger grain sizes such as fine gravels.

This station exhibited both high abundance and high taxa richness. The key metrics indicating quality in this segment include EPT index and percent EPT, both of which are high. EPT index was tied for the highest counted (with North Brook Upstream) and had the lowest FBI score of any sampled station indicating the increased abundance of pollution sensitive species. Percent dominance was somewhat high despite the richness and abundance of EPT taxa and Chironomid larvae were the dominant organism. The infaunal composition for this station was also the best encountered of all the stations and was the only station with multiple Odonata (Dragonflies and Damselflies) and Plecoptera (Stoneflies) taxa.

Overall, this station was probably the best observed for the former Haverford State Hospital site. This qualification is related to the high EPT Index and percent EPT, overall infaunal composition, richness, and low FBI scores relative to the other stations. However, the continued dominance of Chironomids, moderately high percent dominance, and moderate FBI is still indicative of a small degree of impairment in this community.

PHOTO 23: Downstream portion of South Brook. March 2008.

South Brook Downstream	
Abundance	137
Taxa Richness	15
EPT Index	5
Percent Dominance	62.04
Percent EPT	22.63
FBI	5.58
Dominant Taxon	Chironomidae

South Brook Confluence	
Abundance	254
Taxa Richness	11
EPT Index	4
Percent Dominance	77.95
Percent EPT	7.09
FBI	5.70
Dominant Taxon	Chironomidae

5. *South Brook Downstream.* The downstream station was limited to the areas between the construction entrance off Darby Creek Road and the semi-breached impoundment upstream *(Photo 23)*. This reach was marked by some loss in the quality of habitat with greater density of invasive species, headcuts within the stream, and sediment deposition; however the substrate was generally good. This reach had increased gradient and numerous natural steps and riffles.

The downstream station of South Brook saw a decline in quality of the macroinvertebrate assemblage. Besides a loss in abundance, taxa richness and EPT index saw declines relative to the upstream station. Both percent dominance and FBI increased substantially. While the taxa represented were relatively close, with the obvious exception of the loss of two Odonata families and one Plecoptera, EPT species played a decreased role in the overall composition. Chironomids, once again the dominant taxa, were much more prevalent in the sample.

This site exhibited perhaps the biggest loss in quality between adjacent segments at the site. While the assemblage of families changed only slightly, their relative abundances shifted dramatically such that pollutant tolerant families became more prevalent which is reflected in higher FBI scores and lower percent EPT. This suggests a source of impairment between the upstream and downstream stations that could be related to both instream processes and watershed disturbances.

6. *South Brook Confluence.* The confluence station stretched from the culvert under the construction entrance off of Darby Creek Road down to the confluence with Darby Creek. This area is characterized by a high gradient with numerous stepped pools and riffles down to Darby Creek. While large substrate was prevalent in this reach much of it was embedded and served as poor invertebrate habitat. Several sub-samples were collected in Darby Creek both above and below the confluence with South Brook.

As with the North Brook Confluence station, this station exhibited a fairly wide shift in assemblage relative to the other South Brook stations and resembled that of the North Brook Confluence station. Abundance was significantly higher in this station relative to the downstream station, which was driven primarily by the increased abundance of Chironomids, which were again the dominant taxa, at 78% composition of the sample. All other metrics exhibited decreased quality represented by decreases in taxa richness, EPT index, and percent EPT with increases in percent dominance and FBI. The increased FBI however was only slightly higher than that calculated for the downstream station.

This station was depauparate of both Odonata and Plecoptera taxa, but contained Gammarid amphipods as did North Brook Confluence. The driving taxon in this assemblage was Chironomidae, which exhibited very high percent dominance. Overall, this was the worst scoring station.

Impairment Scoring Criteria

Impairment Scoring Criteria assign scores based on the various metrics above in a semi-quantitative assessment that integrates various components to yield a score and qualitative classification of impairment. While this metric is generally limited to 100 organism subsamples there is no major shifts expected in this dataset due to the relatively small size. This approach is valuable in describing the various metrics as a cohesive set with a single statement of quality.

The stations sampled on the former Haverford State Hospital site exhibit two classifications under the impairment scoring criteria listed below. North Brook Downstream and South Brook Upstream have both been classified as Non-Impaired, while the remaining four sites (North Brook Upstream, North Brook Confluence, South Brook Downstream, and South Brook Confluence) are rated as Moderately Impaired (see ***Map 10: Macroinvertebrate Sampling Sites***). It is important to note that on the continuum of the classification scheme the non-impaired stations qualified at the lowest allowable score for that rank. Similarly, for the South Brook Confluence station, the lower score indicates a higher level of impairment than the other stations ranked as moderately impaired.

Stream Station	North Brook Upstream	North Brook Downstream	North Brook Confluence	South Brook Upstream	South Brook Downstream	South Brook Confluence
Metric	Metric Score					
Taxa Richness	19	11	12	17	15	11
EPT Index	6	5	4	6	5	4
Percent Dominance	41.24	29.90	38.95	41.15	62.04	77.95
Percent EPT	18.56	53.61	14.74	51.33	22.63	7.09
FBI	6.04	5.03	5.33	4.66	5.58	5.70
	Scoring Criteria					
Taxa Richness	6	6	6	6	6	6
EPT Index	6	3	3	6	3	3
Percent Dominance	3	6	6	3	0	0
Percent EPT	3	6	3	6	3	0
FBI	0	3	3	3	3	3
SUM	**18**	**24**	**21**	**24**	**15**	**12**
	Moderately Impaired	**Non-Impaired**	**Moderately Impaired**	**Non-Impaired**	**Moderately Impaired**	**Moderately Impaired**

Conclusions

In general, both North Brook and South Brook exhibit some moderate impairment in the benthic macroinvertebrate communities and by extension, stream function, although by the ranking system described above the North Brook Downstream and South Brook Upstream stations were classified as Non-Impaired. The dominant taxon at all stations was Chironomidae, but percent dominance varied between 30 and 78%. Richness varied somewhat widely, but EPT index was fairly consistent despite a wide range of percent EPT. When viewed in light of the scoring criteria some interesting patterns were observed. All stations scored full marks for taxa richness, indicating a fairly wide variety of benthic macroinvertebrates colonized these two streams. However, FBI indicates moderate impairments at five of six stations and severe impairments at the North Brook Upstream station, which indicates that the infaunal assemblage across all stations is at least moderately pollution tolerant. However, EPT taxa tended to be moderately well represented per EPT index score and relatively abundant, with the exception of South Brook Confluence.

A more specific, spatial analysis is also appropriate for this site. North Brook scored better on average than South Brook. However, North Brook exhibited an abnormal pattern in which the downstream station, which is the middle station between the upstream and confluence stations, actually scored better and had a better macroinvertebrate assemblage than the upstream station. This again is likely due to the presence of the culvert in this area. The portions of the upstream station above the culvert consisted of a poor assemblage of invertebrates with increased Dipteran richness and more tolerant organisms than the downstream segment of the upstream station. While this resulted in a lower score than would be expected for an upstream segment relative to those stations below the scoring is not necessarily reflective of a true impairment or a source of pollution, but is more reflective of low hydrology. Since the upper portion of this stream more closely functions like a wetland, with low flow velocities, increased water temperature, and different carbon cycling than a true stream system it may be inappropriate to score the invertebrate community as a standard stream system.

There was no surprise that the confluence station on North Brook scored below the downstream station. This is undoubtedly related to the impacts associated with stormwater runoff, discharges from Route 476 and the new basin, and channelization of North Brook as well as the highly urbanized watershed of Darby Creek and its related impairments.

South Brook exhibited a more typical pattern of impairment with decreased stream function as identified in the benthic infauna with distance moved downstream, such that the upstream station exhibited better water quality than the downstream station, which in turn exhibited better water quality than the confluence station. It should be noted that the South Brook Upstream station exhibited the best macroinvertebrate biometrics. As discussed above, the South Brook Downstream station, exhibited the greatest reduction in summed ranking of any adjacent stations when compared to the upstream station. Specifically identifying the source of impairment is beyond the scope of the baseline ecological inventory, which solely documents conditions at the time of sampling, but it is important to note several potential stimuli that could cause impairments in the infauna. As noted above, these include increased hydraulic loading, as evidenced by bank erosion, decreased sediment quality and deposition related to altered hydraulics, discharge of the newly constructed basin, or streambank encroachment from infrastructure and residential development. As with North Brook, the confluence station exhibited the lowest biometrics in South Brook, which is again related to impairments in Darby Creek and stormwater discharges and sediment deposition in the South Brook proper.

Submerged and floating aquatic vegetation was observed in the North and South Brook, and Darby Creek, and its presence can indicate nutrient loading to the streams. However, the aquatic vegetation observed was not considered excessive or widespread. Invasive plant species were also observed within the riparian corridors, including knotweed, phragmites, Japanese stiltgrass, and multiflora rose and measures to replace these invasive species with woody native vegetation would be beneficial for the wildlife habitat.

The results from the macroinvertebrate investigation conducted on the streams at the former Haverford State Hospital site are consistent with the data previously reported by the Darby Creek Valley Association (DCVA) and data reported by the Pennsylvania Department of Environmental Protection (PADEP). The DCVA has monitored the macroinvertebrate communities in Darby Creek from 2004 until 2008, following the PADEP Volunteer Monitoring Program and the PA Snapshot guidance. The DCVA macroinvertebrate results for the Haverford Township site, just downstream of the property were reported as improving from a rating of "poor" in 2005 to "very good" in 2007 (see article in Appendix F). However, the reporting guidance utilized by DCVA is different from the reporting protocol utilized by Princeton Hydro, and hydraulic conditions could affect the macroinvertebrate results, such as drought or flooding conditions.

Under the Clean Water Act, the PADEP is required to publish the *Pennsylvania Integrated Water Quality Monitoring and Assessment Report*, which documents impaired waterways and their probable causes. The *2008 Integrated Water Quality Report* cited data from 2002 and designated Darby Creek as impaired for aquatic life (macroinvertebrates) for each monitoring station from its headwaters to the confluence with the Delaware River. This report identifies non-point source pollutants in stormwater runoff and metal pollutants as the possible cause of the aquatic life impairments. Copies of the relevant PADEP summary tables from the Integrated Report are included in Appendix G and the full report can be viewed at the following website: **http://www.depweb.state.pa.us/watersupply/cwp/view.asp?a=1261&q=535678**.

FISHERY SURVEY

Fish are the most familiar component of stream ecosystems to many people because they are larger than most aquatic life forms and a source of recreation for many people, and thus are more easily understood. Fish, like benthic macroinvertebrates, are useful indicators of stream ecological function and biological impairment because they form the top level of most food webs in stream ecosystems. Fish and fishery communities are reliable indicators of water quality conditions, but they tend to be more sensitive to physical conditions than to toxins per se. Factors like dissolved oxygen levels, pH, food availability, substrate quality and structure, and adequate hydrology tend to be the most important factors affecting site utilization and because of their mobility they will avoid areas that do not meet biological requirements. Fish colonization of a particular site can also be used to gauge the presence of barriers to movement and other factors in streams.

The ecological assessment includes a thorough description of the fish communities found by Princeton Hydro within the North Brook and South Brook and their respective confluences with the receiving waterway Darby Creek. The level of analysis at the Haverford site was meant to accomplish several goals. The primary goal is to document and inventory the fishery community found onsite. The fishery community composition is then used to make inferences about water quality and hydrology, biological integrity of the stream systems, watershed processes that could affect utilization, to potentially identify protected species, and to differentiate the fishery composition of North Brook, South Brook, and Darby Creek.

Methods

All fish were captured in the survey utilizing stream electrofishing equipment; a non-lethal technique that temporarily stuns fish. Electrofishing is a particularly effective method of capturing fish because it allows targeting on key pieces of structure likely to hold fish and is very effective in shallow stream environments. Fish are immediately captured without the lag of using nets resulting in a much higher catch per unit effort (CPUE). Capture mortality is effectively nil making this a preferred sampling technique from a conservation perspective. Electrofishing involves the use of electrical currents in the water that serve to

Electrofishing

temporarily stun fish. When fish enter the electrical fields generated around the electrofishing gear in the water column, the nervous system is shocked and the fish float to the surface for capture. Larger fish often involuntarily orient themselves in the electric field and actually move towards the source of the stimulus. The size of the electrical field generated in the water is dependent on a variety of parameters, most importantly water temperature and conductivity, but for the most part is confined to immediately between the electrode probes.

Electrofishing was conducted in-stream utilizing a SmithRoot Model 12 backpack electroshocker unit rated at an operational output of 300 to 600 volts. The electrofishing unit was powered by external 12-volt batteries. This system utilizes electrode probes that are swept over the stream bed. Safety protocols are outlined in Princeton Hydro's *Electrofishing Safety Plan*; specific requirements include the use of proper ground connections, the use of insulated gloves, positive engagement switches, and operable circuit breakers.

Electrofishing was performed using 5-minute timed transects that covered on average of approximately 50 linear meters. In total, 14 of these timed transects were performed, with seven (7) each on North Brook and South Brook. Of the seven transects associated with each stream, one transect was conducted within Darby Creek at the respective confluence.

During the operation of the electrofishing unit stunned fish were captured using long-handled dip nets. Captured fish were then transferred to a temporary holding tank for processing. Processing includes the identification of all fish to a species level and enumeration. Identifications are made utilizing Page and Burr (1991), Murdy, Birdsong, and Musick (1997), Werner (1980), and Steiner (2000). Following their identification, measurement, enumeration, and scale harvesting all fish were returned alive to the creeks. Several voucher specimens were retained for further identification with microscopy and archival purposes.

A variety of population analyses were performed using standard statistical methods and population biology indices as well as simple descriptive statistics. Princeton Hydro has developed a standard freshwater fisheries reporting format that incorporates all collected data to allow a thorough analysis of the fishery. As such, the fishery can be analyzed on a species level, by size class, by biomass, by abundance, by functional or trophic state, and by a variety of other metrics including size and mass distributions.

Mass distribution is calculated using species specific mass-length models derived from published coefficients. Specific coefficients used will be selected as median reported values or for regional fitness. These models are regressions that relate the length of a species to a mass and allow for calculation of biomass metrics without directly measuring mass in the field.

The fishery survey of the former Haverford State Hospital site was conducted on June 5, 2008.

Results

In total, nine (9) species were collected during the course of the survey, with a total abundance of 460 fish. *Tables 1 and 2*, list species, size classes, and abundance. Most abundant were Blacknose Dace, the most abundant fish in small-order streams in the mid-Atlantic region, followed by Creek Chub and White Sucker. The composite fishery of the site is easily categorized into four distinct communities based on species composition, size structure, and abundance. These communities included the South Brook, North Brook upstream of I-476 culvert, North Brook downstream of I-476 culvert, and Darby Creek. The North Brook upstream community consisted solely

Table 1

Fish Species Collected - 2008 Spring Fishery Survey
North Brook, South Brook, and Darby Creek

Common	Scientific	Family
American Eel	*Anguilla rostrata*	Anguillidae
Blacknose Dace	*Rhinichthys atratulus*	Cyprinidae
Creek Chub	*Semotilus atromaculatus*	Cyprinidae
Longnose Dace	*Rhinichthys cataractae*	Cyprinidae
Pumpkinseed	*Lepomis gibbosus*	Centrarchidae
Rock Bass	*Ambloplites rupestris*	Centrarchidae
Spottail Shiner	*Notropis hudsonius*	Cyprinidae
Tessellated Darter	*Etheostoma olmstedi*	Percidae
White Sucker	*Catostomus commersoni*	Catostomidae

Table 2

Fish Collected by Species and Size 2008

	Size Range (inches)								
Species	0-3"	3-6"	6-9"	9-12"	12-15"	15-20"	20-25"	25"+	Totals
American Eel	0	0	0	6	2	8	3	0	19
Blacknose Dace	288	0	0	0	0	0	0	0	288
Creek Chub	8	51	0	0	0	0	0	0	59
Longnose Dace	0	1	0	0	0	0	0	0	1
Pumpkinseed	2	6	0	0	0	0	0	0	8
Rock Bass	0	0	4	0	0	0	0	0	4
Spottail Shiner	12	12	0	0	0	0	0	0	24
Tessellated Darter	1	5	0	0	0	0	0	0	6
White Sucker	2	26	23	0	0	0	0	0	51
Totals	313	101	27	6	2	8	3	0	460

Blacknose Dace

Creek Chub

White Sucker

American Eel

of Blacknose Dace which had a limited distribution in this stretch due to lack of water in the brook. The North Brook downstream community included three additional species, including larger fish that were unable to pass through the I-476 culvert and that had inadequate stream depth in the upper section above the culvert to successfully colonize this reach. The South Brook community was also dominated by Blacknose Dace, but also included American Eel. No barriers to fish passage were identified in the South Brook stream as there was complete colonization by the identified species throughout the entire reach. This stream also had sufficient flow and depth to support larger fish throughout its length. The Darby Creek community consisted of the same species observed in North Brook and South Brook with the addition of several others. The composition of this community consisted of larger fishes, particularly White Sucker, Rock Bass, and Pumpkinseed that are found in higher numbers in higher-order streams such as Darby Creek.

Ultimately, hydrology was the driving factor in the distinction of these fishery communities. The species that were identified in each community were typical of the size of the stream investigated. There were no conspicuous absences of any species

Figure 1

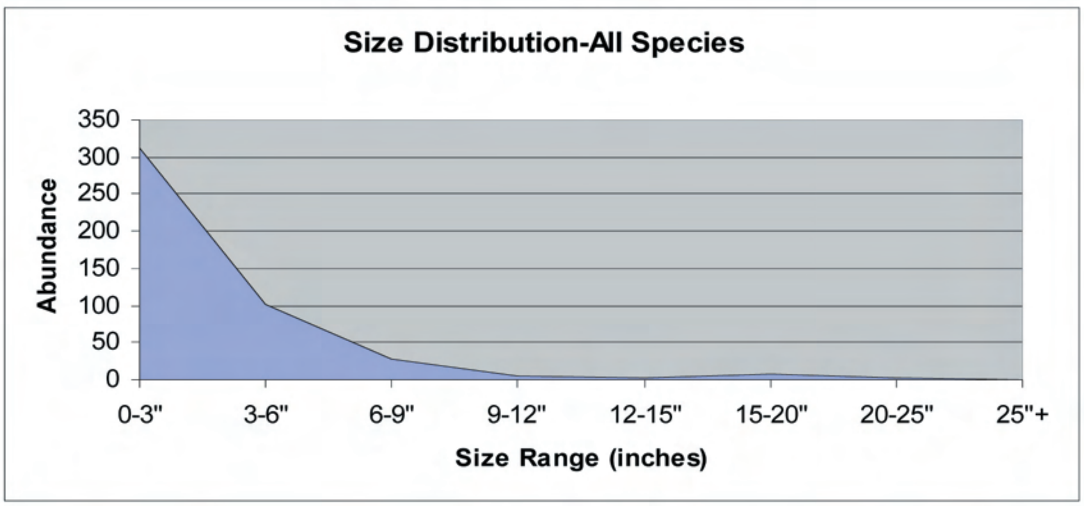
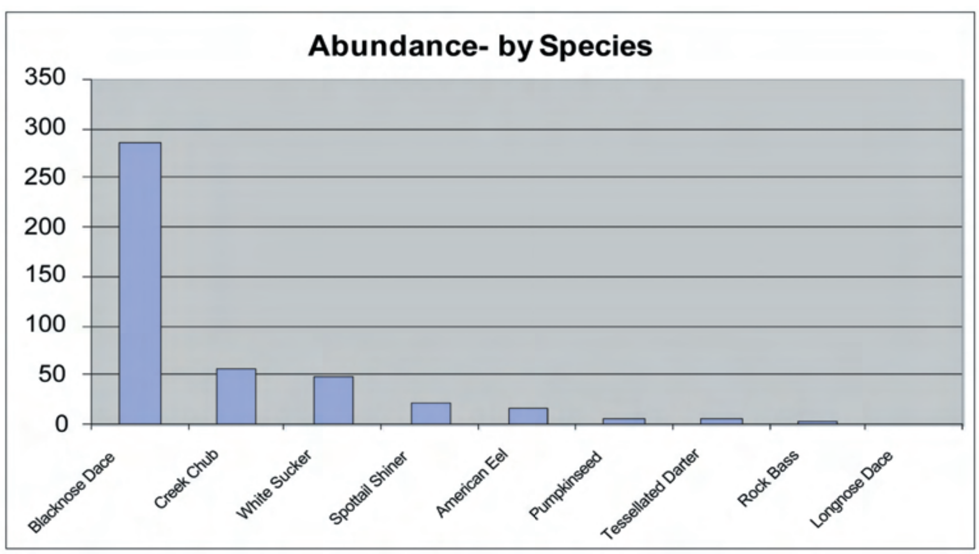


Figure 2



or no surprises in the species captured. No species of special concern were identified in the survey. The one impairment noted in the fishery was that the I-476 culvert was a barrier to fish passage in North Brook. However, hydrology in this stream above the culvert is inadequate to support fish much larger than Blacknose Dace and the effect of the barrier is minimal in terms of colonization potential.

The results of the fishery survey, when viewed as a composite, show a balanced community. The size distribution of the fishery is heavily weighted towards the smaller size classes, and is driven primarily by the Blacknose Dace (*Rhinichthys atratulus*), although both Creek Chubs (*Semotilus atromaculatus*) and White Suckers (*Catostomus commersoni*) were also important components (*Figures 1 and 2*). For the most part the fishery consisted of small species, with all species averaging less than 6 inches in total length with the exception of American Eel (*Anguilla rostrata*) and Rock Bass (*Ambloplites rupestris*) (*Figure 3*).

The biomass of the fishery was also well balanced and showed bimodal distribution with peaks in percent biomass at the 6–9 inch size class and the 15–20 inch class (*Figure 4*).

Detailed results of this survey are parsed into three separate fisheries: North Brook (North Brook transects

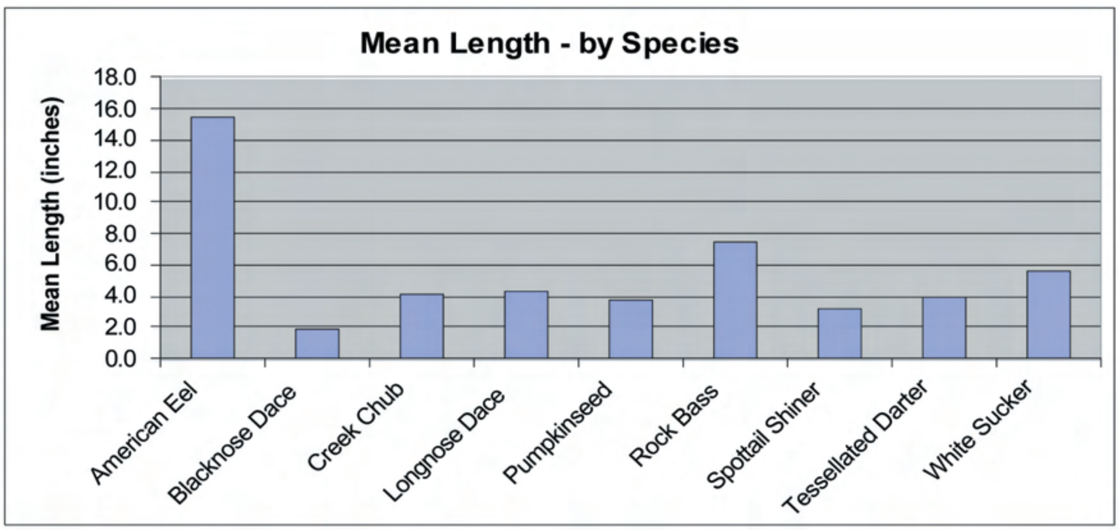


Figure 3

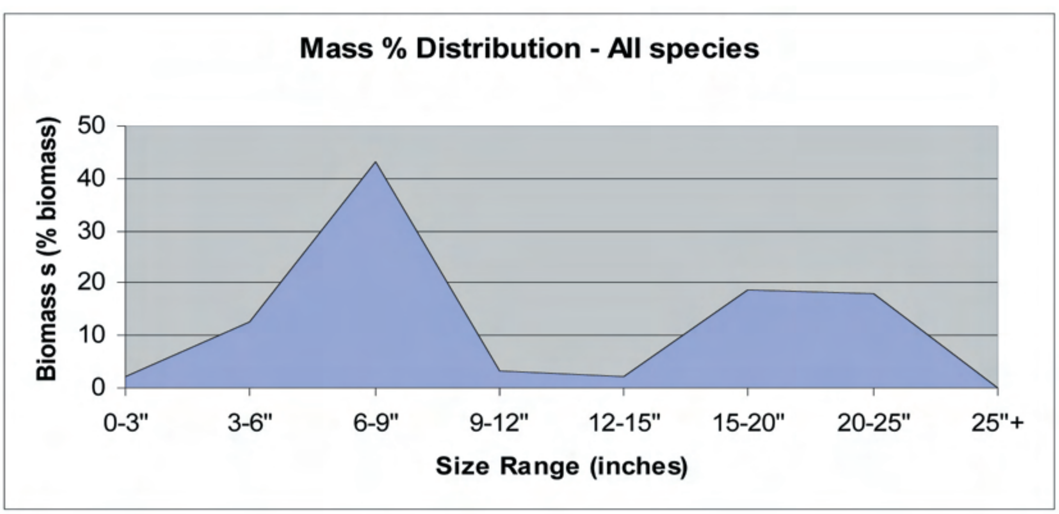


Figure 4

Table 3

North Brook	Abundance	Mass (kg)	Mean Length
Blacknose Dace	95	0.04	2.00
Creek Chub	5	0.02	4.50
Longnose Dace	1	0.01	4.50
White Sucker	5	0.25	5.20
	106	0.32	2.29

South Brook	Abundance	Mass (kg)	Mean Length
American Eel	7	1.48	16.86
Blacknose Dace	162	0.07	2.00
Creek Chub	40	0.12	4.00
Pumpkinseed	1	0.02	4.50
	210	1.70	2.89

Darby Creek	Abundance	Mass (kg)	Mean Length
American Eel	12	1.64	14.75
Blacknose Dace	31	0.01	2.00
Creek Chub	14	0.05	4.50
Pumpkinseed	7	0.09	3.79
Rock Bass	4	0.87	7.50
Spottail Shiner	24	0.08	3.25
Tessellated Darter	6	0.02	4.08
White Sucker	46	2.62	5.82
	144	5.39	5.06

1 to 6), South Brook (South Brook transects 1 to 6), and Darby Creek (North Brook transect 7 and South Brook transect 7). A table showing the individual results of these groupings is included in *Table 3*.

1. **North Brook.** The fishery of North Brook was comprised of only four species. The most important species in this brook, in terms of both abundance and distribution, was the Blacknose Dace, a common member of the minnow family distributed throughout the northeastern United States in headwater streams. In terms of biomass, however, this stream was dominated by White Sucker.

   It is interesting to note that North Brook was originally identified as an area of concern due to the presence of two possible barriers to fish passage. The data partially confirm these concerns, as there was a distinct zonation of the fish community along the sampled reach. Starting upstream, a culvert under a trail (*Photo 20, page 19*) was identified as a possible barrier to fish. While no fish were captured upstream of this culvert, no fish were captured within 250 meters downstream of the culvert either. The first capture, all Blacknose Dace, was made approximately 100 meters upstream of the clearing around the treatment facility; importantly, this transect also marked the first area in the stream with consistent depths greater than 3 cm. Blacknose Dace were then found consistently downstream of the first site of capture until the head of the culvert passing under Route 476. The final transect included within the North Brook grouping, transect 6, was located downstream of the long Route 476 culvert, and upstream of the confluence with Darby Creek. This transect had a different composition than those found upstream and included not only Blacknose Dace, but also Creek Chubs, White Suckers, and a single Longnose Dace (*Rhinichthys cataractae*). Not only were more species found in this stretch, but two of the species identified (White Sucker and Creek Chub) are significantly larger than the dace. Additionally, the abundance in this reach was higher than in any other transect on North Brook and most of the fish were congregated in a deep scour pool at the toe of the Route 476 culvert. Other vertebrates identified in the stream included Northern Two-lined Salamander (*Eurycea bislineata*) and Northern Dusky Salamander (*Desmognathus fuscus*).

   The fishery of North Brook is controlled largely by two influences: hydrology and the Route 476 culvert. The extent of fish colonization in North Brook is largely influenced by the hydrology of the system and the simple need for adequate water depths. This extent of colonization is likely to change significantly over the course of the year and likely reaches further upstream in wet periods, but it seems unlikely that any stable colonization is achieved near the trail culvert simply because depths are insufficient. From this perspective this culvert does not actively act as a barrier to fish passage and flow is insufficient upstream of this culvert to support even small dace. The large culvert under Route 476 certainly does act as a barrier to fish passage as the fishery composition of the transects immediately upstream and immediately downstream of the culvert were very different. It is apparent that both White Suckers and Creek Chubs are unable to pass through and inhabit or at least utilize the portion North Brook upstream of the culvert. In a tangible way the culvert has minimized fishery richness in the upper portions of North Brook, although the hydrology of the stream would certainly limit the colonization of potential White Suckers, however Creek Chubs should have been found in conjunction with the dace if this had been a free flowing system.

2. ***South Brook.*** South Brook, like North Brook, contained only four species of fish, although the composition was different. Besides the abundant Blacknose Dace, the fishery of South Brook was comprised of American Eel, Creek Chub, and Pumpkinseed (*Lepomis macrochirus)*. As with South Brook, Blacknose Dace dominated the fishery in terms of abundance, but both American Eel and Creek Chub accounted for greater percentages of the fishery biomass.

   A possible barrier to fish passage in this brook was a semi-breached dam, however this appeared to have no affect on colonization potential upstream as the same assemblage of fish was recorded above. Indeed, colonization of the stream seemed complete to the upper reaches. Interestingly, both total abundance and percent composition of Creek Chubs generally increased with distance upstream. This finding closely mirrors the findings of the macroinvertebrate survey that showed decreased quality downstream and may be related to somewhat decreased water quality further down in the stream. Hydrology is sufficient throughout South Brook to support a fishery throughout the entirety of the surveyed reach to points above the new basin and 250 meters downstream of Darby Road. In fact, stream depths are sufficient to support large Creek Chubs and American Eels up to nearly 25 inches. The presence of these fish indicate not only good water quality but a more robust community including not only cyprinids (Minnow family), but a predator (eel). Abundance in South Brook was nearly twice that of North Brook.

   Stream channel morphology of South Brook may act as a natural barrier to the passage of some fishes. The downstream portion of South Brook from the construction entrance culvert to the confluence with Darby Creek drops nearly 40 feet in little over 150 meters, and forms a series of small step pools that may inhibit fish passage, however some larger species such as American Eel and Pumpkinseed (Sunfish) have traversed these areas without problem, although no White Suckers were encountered in South Brook. Despite this, there was a marked difference with the community in Darby Creek proper.

3. ***Darby Creek.*** The fish community of Darby Creek was markedly different than either North Brook or South Brook, and the two pooled transects of Darby Creek at the confluences of North Brook and South Brook varied from each other. Three species were identified in Darby Creek that were not observed in either North Brook or South Brook: Rock Bass, Spottail Shiner (*Notropis hudsonius*), and Tessellated Darter (*Etheostoma olmstedi*). Rock Bass are fairly large and would certainly be excluded from North Brook and probably from South Brook, but there is no strong reason why either Spottail Shiner or Tessellated Darter are absent from the tributaries, although both seem to exhibit a preference for sandier substrates than those found in either brook. The greatest difference was the structure of the Darby Creek community relative to the small brooks which was dominated by much larger fish and by higher abundance per transect. The dominant fish in terms of both abundance and biomass in Darby Creek was the White Sucker. Other important species included American Eel and Rock Bass. Spottail Shiner and Blacknose Dace were also important components of this fishery. An additional difference was the much higher biomass and higher capture per unit effort in Darby Creek, which is consistent with its larger size.

   As mentioned above, the two transects in this grouping varied, but both are marked by the biomass dominance of larger fish, White Suckers adjacent to North Brook and American Eel adjacent to South Brook. In fact, the confluence of South Brook with Darby Creek yielded a community more similar to the South Brook fishery than the comparable North Brook transect, but even this varied with the addition of White Sucker and Tessellated Darter in Darby Creek but not South Brook.

Conclusions

Overall, this survey yielded moderate fishery richness, but abundance tended to be fairly high. The most notable characteristic of the fishery as a whole was the formation of four distinct communities within the sampled sites which were: the portion of North Brook upstream of the Route 476 culvert, the community downstream of the Route 476 culvert, Darby Creek, and South Brook. These communities were the result of distinct parameters including channel morphology, hydrology, and water quality. Darby Creek is separated from North Brook and South Brook by virtue chiefly of its size, substrate and hydrology which promotes higher colonization rates, larger fish, and greater biomass which leads to a different community of fish more suited for larger stream systems. South Brook has a more balanced community structure than North Brook with increased fish density, the addition of a large fish (American Eel), and more complete colonization throughout the surveyed reach. Again, hydrology is likely an important factor in differentiating this stream from North Brook, but increased macrophyte abundance, the forage base for Cyprinids, obviously plays a factor in overall fishery quality. Lastly, the fishery of North Brook is limited by several key factors including size and hydrology and a major barrier to fish passage, the Route 476 culvert. Because North Brook is a small system with limited flows, colonization potential of the stream is naturally limited, but the Route 476 culvert is a barrier to fish passage that at a minimum limited upstream colonization by both White Sucker and Creek Chub. North Brook is a headwater stream where there is sustained baseflow, but maximum depth within 150 meters upstream of the Route 476 culvert is one inch, except in storm runoff conditions. The low flow nature of the stream reduces the viability of larger fish species and a diverse fishery. Upstream of the Route 476 culvert along North Brook, there is a concrete structure with a 3-foot grade and 45-degree slope. Any work to install fish ladders or other replacement structures here would not increase fish utilization or diversity to any significant measure due to the insufficient hydrology upstream. Further upstream along North Brook, there is a culvert under the trail immediately below a wetland. Replacement of this culvert would not increase fish utilization or diversity due to insufficient hydrology, but would enhance the aesthetics of the trail.

Overall, the fishery identified at the site on both North Brook and South Brook is appropriate for the general dimensions of the respective streams. The only issue of concern is the barrier to fish passage presented by the Route 476 culvert on North Brook. However, as noted above, colonization potential of North Brook upstream of the culvert is largely limited anyhow due to depth and hydrology constraints that are capable of supporting only the smallest fishes. No State or Federally listed threatened or endangered species or State-listed species of special concern were identified in this survey.

Summary of Assessment of Site Conditions

The resources and natural conditions found on the former Haverford Hospital site are highly characteristic of the Piedmont of southeastern Pennsylvania. Like most properties within this region it has a land use history dominated (at least over the past few centuries) by agriculture and, more recently, (institutional) development. With rolling hills transected by small streams, the distribution of vegetation communities is driven by hydrology, topography, and disturbance history. Those areas with marginal soils (wet, steep) were released from agriculture in the 19^{th} century and now support the mature forests that straddle the first order streams on the east side of Route 476. Younger forests exist in areas released from agriculture following the construction of the Haverford State Hospital in the 1960s. Only those areas that were very wet or continued to receive disturbance through periodic mowing (utility rights-of-way) or construction activities are dominated by herbaceous plants.

The plant communities on the site are typical of the region and their condition reflects the common influences affecting natural areas today, particularly invasive plant species and an overabundant deer population. The oldest forests on the site are least impacted by invasive plant species which are largely isolated to windthrow gaps or along forest edges. In contrast, the younger forests are moderately (and sometimes heavily) impacted by invasive plants because of their more fertile soils and more recent release from agriculture. Signs of heavy deer use include a lack of adequate tree regeneration, heavily browsed shrubs, a barren understory in the mature forest at the eastern tip of the property, and scat and tracks throughout the site.

The presence of mature forest vegetation along North Brook and South Brook has largely protected the perennial water flows and water quality of the streams which generally support a diverse aquatic fauna. Water quality and habitat for fish and macroinvertebrates have been compromised in some sections of the streams by obstructions (culverts) or invasive plants.

The size of the natural area (relative to the surrounding landscape), diversity of plant communities, and abundant water resources offers habitat for numerous wildlife species, particularly resident and migratory birds. Overall, the avian community in the natural areas of the former Haverford State Hospital site is significant, despite continued threats from the surrounding development, invasive species and deer.

The old field/terrestrial meadow located in the northern section of the project site represents an uncommon native plant community and it should receive further study and careful restoration to protect and enhance its special resources.

As referenced in the *Darby Creek Watershed Conservation Plan*, the former Haverford State Hospital site is one of the few remaining large tracts of undeveloped land in the watershed. As such, there are many opportunities to sustain the ecosystem functions of this area that would be beneficial not only to the watershed but also to the surrounding Delaware River Basin and the downstream estuary.

Stewardship Issues and Opportunities

Based on field surveys over the past year, we identified the following stewardship issues and threats to the resources on the former Haverford State Hospital site. The description of each issue is followed by recommendations for addressing the issue. We also highlight opportunities to enhance the natural features on the property to benefit wildlife and human users.

INVASIVE PLANT SPECIES

A ubiquitous problem encountered in the stewardship of natural lands in southeastern Pennsylvania—and increasingly recognized as a threat worldwide—is the presence of invasive plant species. Even though the occasional immigration of new species into plant communities is a normal process, the current high rate of introduction—fueled by the planting of exotic (non-native) species for horticulture, wildlife management, and erosion control—is threatening the integrity of native plant communities and the survival of native species.

Invasive plants—almost all of which are exotic (non-native) plants introduced for horticultural or agricultural purposes—can spread rapidly and aggressively into natural areas and effectively displace native plants and lower biodiversity. Not only do they alter the makeup of the plant communities on a site, but they also may affect soil chemistry and hydrology. Exotic invasive plants are usually less beneficial to wildlife than the native plants they replace, contributing further to loss of biodiversity.

An invasive species is one that rapidly spreads and outcompetes multiple native species, chiefly because of the absence of the predators, pathogens, and herbivores that keep it in check in its native range. An invasive species displays one or more of the following characteristics:

- few predators, herbivores, and diseases
- adaptation to disturbance
- fast germination
- high population growth
- early reproductive maturity
- vegetative as well as sexual reproduction
- pollination by wind or multiple insect species
- wide tolerance to many habitat types
- fast growth rate
- long-range seed dispersal capability
- fruit used by wildlife or humans

Most invasive plants are particularly well adapted to colonize disturbed areas. In southeastern Pennsylvania, disturbance from human activities, particularly sprawl, coupled with the rich horticultural history of the Philadelphia area, has afforded numerous invasive species the opportunity to become well established throughout the region.

The presence of invasive plant species complicates the goal of maintaining healthy native plant communities because invasive plants compete vigorously with preferred native species for “growing space,” the major resources and conditions—light, water, nutrients, temperature, humidity, soil structure, and other factors—that support plant growth in any area. As a result, invasive species have the ability to displace native vegetation, halt or subvert the natural process of succession from field to forest, and homogenize the structural and wildlife food resources of a site. They can also alter nutrient cycling, local hydrology, and fire regimes.

These modifications to native plant communities reduce their habitat value for native fauna, particularly migratory songbirds. Insects are vital links in many of the food chains that make up the food web in ecosystems. Most native insect species are specialist feeders on just one native plant species or a narrow range of species. Exotic invasive plants rarely serve as a food resource for native insect species, which is one of the reasons why they are invasive. The higher the cover and species richness of native plants, the higher the total insect biomass is in a given area of land; conversely, the higher the cover of non-native plants, the scarcer insects are as a food resource for other wildlife. Insects are the richest source of fats and protein for birds and for many small animals that, in turn, are food for larger animals. Where non-native plants are abundant, far less of the total plant biomass is converted, via the food chains that make up the food web, into animal biomass. Invasive plants have adverse impacts on virtually all native wildlife populations, both by degrading habitat directly and by reducing the total food supply.

Map 9: Impact of Invasive Plant Species provides a visual summary of the condition of the former Haverford Hospital site relative to invasive plants. The most prevalent invasive plant species we observed on the site are multiflora rose, privet, porcelainberry, Japanese honeysuckle, grape, oriental bittersweet, mile-a-minute, and corktree *(Photo 24)*. All are abundant within the red maple terrestrial forest and in open areas or gaps in the red oak-mixed hardwood forests. Invasive species in the groundcover layer were less common on the site but dominated in many areas. They include garlic mustard (*Alliaria petiolata*) and Japanese stiltgrass (*Microstegium vimineum*) *(Photo 25)* in the red maple terrestrial forest, stiltgrass in the red maple palustrine forest, lesser celandine (*Ranunculus ficaria*) within the floodplain of South Brook, and Japanese knotweed (*Fallopia japonica*) along Darby Creek *(Photo 26)*.

Recommendations:

The control of invasive plants will be a perpetual concern of land managers at the former Haverford State Hospital site. The extensive edge area and seed sources in the region and the prolific nature of these plants guarantee that even with complete eradication on the property, invasive species can

PHOTO 24: Corktree resprouting with second-year flowering garlic mustard. May 2008.

PHOTO 25: Garlic mustard (first-year leaves) and Japanese stiltgrass on forest floor. April 2008.

PHOTO 26: Japanese knotweed along Darby Creek. October 2008.

quickly reestablish themselves as a serious stewardship problem if not monitored and addressed on a regular basis. A strategy for coexisting with these plants is needed—one that will minimize their effects on the aesthetics and ecological stability of the property, with a minimum of management effort. High priority recommendations include:

- Control invasive species beginning in areas with low invasive species impact (see ***Map 9: Impact of Invasive Plant Species***), such as the mature red oak–mixed hardwood/tuliptree–beech–maple forest. It is important to maintain the integrity of these relatively intact forests to prevent further encroachment from more heavily impacted communities. Follow control strategies highlighted in Appendix H, an excerpt from Natural Lands Trust's *Stewardship Handbook for Natural Lands in Southeastern Pennsylvania.* The highest priority should be given to cutting vines (e.g., oriental bittersweet, porcelain-berry) impacting canopy and understory trees. Preserving the existing canopy cover will slow the spread of other invasive plants in the shrub and groundcover layers. Secondary priorities include the removal of invasive trees within the terrestrial forests and Japanese knotweed along Darby Creek. Only licensed applicators should apply herbicides and only herbicides approved for aquatic use should be applied near wetland areas.
- Consider using volunteers to establish a program to monitor invasive plants annually and to participate in control activities when possible. Volunteer activities could include cutting vines with pruners or handsaws and pulling garlic mustard.
- Avoid creating additional forest gaps (including new trails) that perpetuate invasive plant populations and fragment intact forest parcels. The fragmentation of forested areas increases "edge habitat" and results in low reproductive success for interior forests birds because of greater competition for foraging and nesting sites, high nest depredation (e.g., by the Brown-headed cowbird), brood parasitism, fewer nest sites, poor prey availability, or a combination of these factors. Priority songbird species tend to breed in higher density and with greater success in large (at least 20 acres) contiguous forest tracts greater than 100 meters from the forest edge and with high structural diversity and multiple vegetation layers (e.g., canopy, sub-canopy, and understory). The Blue-gray gnatcatchers, Eastern towhees, Ovenbirds, Scarlet tanagers, and Wood thrushes, found at the former Haverford State Hospital site have a low tolerance for forest disturbances. "Generalist species" such as white-tailed deer, raccoons, and opossums are also attracted to fragmented forest habitat and are occurring at some of the highest levels in history as large unfragmented blocks are lost to development.
- It is important to note that effective control of invasive plants will only be possible if implemented in conjunction with a deer management program (see below).

DEER OVERABUNDANCE

Forest fragmentation, the extirpation of large predators, and cultural norms about hunting have resulted in the proliferation of white-tailed deer to unprecedented population densities. Researchers believe that native forests evolved with deer densities of 5–10 per square mile (1 square mile = 640 acres). Deer populations are no longer regulated as they were for more than 99% of their existence, first by large predators and more recently by Native Americans, for whom venison was a major source of food. A diverse array of predators regulated deer populations for millions of years before humans arrived in our region, including the timber wolf, dire wolf, grizzly bear, giant short-faced bear, mountain lion, American cheetah, and jaguar. Human hunters arrived in what is now southeastern Pennsylvania at least 13,000 years ago, forcing out most of the other major predators, but American Indians, timber wolves, and mountain lions continued to regulate deer populations until Europeans arrived and expelled all three. For the first two centuries after William Penn's arrival, the human population grew exponentially and unlimited hunting began eroding the delicate balance between predators and deer that had prevailed for eons. By 1900, white-tailed deer were nearly extinct in Pennsylvania and other eastern states because of over-harvesting. By instituting game laws, state agencies successfully rebuilt the deer population. Unfortunately, these hunting rules, which largely persisted through the 20th century, focused on providing a "maximum sustained yield" of game for recreational hunters and the deer population consequently soared to unprecedented levels in just a few decades. There is general agreement among scientists, resource managers (foresters, wildlife biologists, farmers, hunters) and landowners (rural and suburban) that this strategy has led to the degradation of forests, agricultural lands, and suburban landscaping throughout the state. (A detailed summary of this issue can be found in the 2005 report by the Deer Management Forum, titled *Managing White-tailed Deer in Forest Habitat From an Ecosystem Perspective*, available at **http://pa.audubon.org**.) The simple reason for this is that abnormally high deer populations affect all vegetation layers of the forest, including shrubs, herbs, and the seeds and seedlings that would have become the next generation of canopy trees, if not consumed by deer.

Statewide, the deer density now averages almost 40 deer per forested square mile, four to eight times the desired density of 5–10 per square mile. In some Pennsylvania suburban areas, populations have risen above 100 per square mile. Deer densities at this level threaten the perpetuation of forest communities, which depend on the ongoing establishment of tree seedlings and saplings in sufficient numbers to occupy the gaps that are created by periodic natural or human disturbance. A density of 15–20 deer per forested square mile has been found in some areas to be a maximum level allowing minimal advance tree and shrub regeneration (a sufficient number of established seedlings and saplings available to replace existing trees and shrubs following mortality or disturbance of existing vegetation), with a density of 5–10 per square mile needed to sustain a high diversity of native species, including native herbaceous plants. In forests that have been subjected to overbrowsing for many years, the deer density will probably need to be lowered even further than the eventual optimal level for a period of time to allow the forest to regenerate.

Deer are browsers, which means their diet consists mainly of newly grown twigs of woody plants, primarily trees and shrubs. When populations are high, deer can consume all of the established seedlings, as well as many tree seeds (particularly acorns) and herbaceous plants. Over 100 species of native wildflowers and other plant species have been extirpated from Pennsylvania; at least some of these losses have been partly a result of overbrowsing by deer, and many more species are known to be in trouble in the state from the same cause. Browsing by overabundant deer dramatically reduces the survival of native flora and has led to the collapse of plant species diversity in the forest understory and the near cessation of tree reproduction in vast areas of Pennsylvania forests. The resulting lack of cover, food, and structural diversity within forests has undoubtedly reduced wildlife populations, particularly of small mammal and bird species. Native oaks, which are highly preferred food for deer, are not regenerating, which means that wildlife-rich oak forests will cease to exist as adult trees age and die. Furthermore, exotic (non-native) invasive plant species are generally avoided by deer and other plant-eating wildlife (which is one of the reasons they are invasive), so deer have contributed to their proliferation by stripping the forests of their native competitors. The elimination of tree regeneration not only removes the defining component of the future forest (canopy trees), it greatly amplifies the effects of other stressors by freeing up growing space to invasive plant species and

physically creating the disturbed soil conditions to promote their spread.

Part of the problem in understanding the forest health problem is that it is too easy to "see the forest for the trees." Most forests in our region still look healthy, with a canopy of large trees that have grown since the last extensive clearing in the late nineteenth and early twentieth centuries. The spread of invasive introduced shrub and understory tree species into natural areas over the last few decades has filled in the vegetation layers vacated by native species as the result of high deer densities. Most forests still look superficially healthy because they are green. Forests with an understory stripped of vegetation have a park-like structure, with tall canopy trees and a uniform low understory or no understory at all. Forests in some parts of our region have looked like this for so long that many people have the impression it is normal and natural.

PHOTO 27 *(right)*: **Evidence of deer browsing in shrub layer of forest. January 2008.**

PHOTO 28 *(below)*: **Prominent browse line in red oak mixed hardwood forest. August 2008.**

The forested areas on the former Haverford State Hospital site are clearly impacted by an overabundant deer population. Within the natural areas we noted evidence of overbrowsing not only on native species of understory plants that are typically preferred by deer *(Photo 27)*, but also species typically avoided by deer such as spicebush, beech, and even multiflora rose. The loss of understory vegetation negatively affects suitable nesting habitats for birds and mammals that rely upon ground and lower canopy nesting, foraging and hiding areas. Other signs of heavy browsing include a lack of adequate tree regeneration, colonization by invasive plant species in disturbed areas, and a barren understory in the mature red oak–mixed hardwood forest at the eastern extent of the property *(Photo 28)*. Based on the deer density recommendation stated above, the 110 acres of wetland and upland forests in the natural areas on the former Haverford State Hospital site can sustainably support approximately two deer.

Recommendations:

- Consider establishing a deer management program for the property. While there are non-lethal options available (fencing, tree shelters) to protect forest vegetation, they would be problematic on this property, restricting access and requiring significant expense and maintenance. Most practical at this time would be lethal removal of deer. While construction is still in progress and the public is not yet accessing the site, a first management option to consider is the use of sharpshooters to reduce the herd to manageable levels. (Haverford Township initiated a deer management program this Fall in an effort to decrease the deer population and its effects on the site's plant communities, as well as to reduce deer-vehicle collisions and the spread of Lyme disease. Members of the Township's police force will participate as sharpshooters in this initial phase of the program.) The initial reduction of the deer herd through sharp shoots should be continued over the next few years (deer are likely to migrate into the property from surrounding areas) and then followed by periodic use of sharpshooters or an annual controlled bow hunt to maintain the deer population at the desired level. The deer management program should be implemented in a manner that does not jeopardize public safety or significantly restrict current or future public use. This can be achieved through the use of sharpshooters (nighttime sharp shoots over bait stations would be best) or bow hunters in more remote portions of the property during defined days and times. Under both methods the hunter(s) would shoot with a downward trajectory from tree stands or from a position with a backdrop (steep hill) at animals within close range (<30 yards). Natural Lands Trust has used deer hunting, without a safety related incident, on 17 preserves over the past 20 years without closing the preserves to passive recreational use. This was accomplished by posting signs informing the public of hunting times and using responsible and skilled (having to pass a proficiency test) hunters. The complete guidelines to Natural Lands Trust's deer management program can be found in Appendix I, an excerpt from Natural Lands Trust's *Stewardship Handbook for Natural Lands in Southeastern Pennsylvania*.

- Ongoing education of the public, particularly residents of the adjacent development, to the effects of overabundant deer will be critical to the success of the deer management program. One option to visually demonstrate the effects is the installation of small (10 meters square) exclosures. The growth of vegetation within the exclosure is often dramatically different than in surrounding areas with unrestricted access by deer. Ideally, exclosures (with accompanying interpretive signage) should be erected in different plant communities (on relatively flat ground) and near public trails (see ***Map 11: Stewardship Issues and Opportunities*** for a few potential locations.) The setup and monitoring of deer exclosures is a valuable educational exercise that could be utilized by local schools and colleges.
- Refer to Appendix I for further details about managing deer in natural areas of southeastern Pennsylvania.

WATER QUALITY

Natural lands directly influence the quality and quantity of water that constitutes the system of streams, wetlands, and groundwater in the region. In general, streams in southeastern Pennsylvania developed (and their aquatic biota evolved) within forested landscapes. Forest cover moderates stream flow throughout the year by maximizing infiltration and groundwater recharge, shades the water surface (helping to maintain cool water temperatures for native fish and aquatic insects) and provides food (leaves) and structural debris (branches, trunks) for aquatic organisms. Streams in forested areas tend to be shallow and wide with rocky beds that serve as breeding and nesting sites for aquatic organisms. Removing forest cover along streams exposes the water surface to sunlight and eliminates preferred food resources. If the dominant cover type along the stream becomes sod-forming grasses (typical in agricultural landscapes) or impervious material, the stream loses the flexibility to wander; with increased surface water inputs during storm events, the stream begins to deepen and narrow its channel. As a result, the rocky streambed, so vital to aquatic organisms, is drastically reduced in surface area and often covered with silt.

The agricultural, suburban, and urban land-use pattern of the region has altered the natural balance of ground and surface water that defined the forested landscape prior to William Penn's arrival in 1682. Almost the entire region has been cleared of forest, plowed and grazed for agriculture, bulldozed for urban and suburban development, planted in lawns, or paved. Each of these actions generates unnatural rates and amounts of stormwater runoff, particularly in the wettest periods of the year. Water that once infiltrated soil and recharged aquifers to gradually feed wetlands and streams during periods of drought is now lost downstream to the Chesapeake and Delaware Bays and Atlantic Ocean. As a result, the frequency and extent of flooding is artificially high, and the water table that allows groundwater to feed wetlands and supply the base flow of streams is artificially reduced to unnaturally low levels during the driest periods of late summer.

Ongoing threats to the quality and quantity of water represent potential threats to the natural lands in the region. With the advance of technology, humans have the ability to alter the landscape more rapidly and at a broader scale than ever before. The more we clear native vegetation, excavate and compact soil, and construct impervious surfaces such as rooftops and parking lots, the more we "short-circuit" the natural hydrologic cycle that recharges aquifers, regulates flooding, maintains diverse aquatic plant and animal communities, and feeds wetlands and streams with clean, plentiful water to support plant, animal, and human needs (including vital drinking water supplies).

The primary threats to water quality and quantity in our region are modifications to hydrology caused by changes in land use. In natural conditions, of the approximately 45 inches of rain that falls in southeastern Pennsylvania each year, 12 inches infiltrate into the groundwater, 25 inches are evapotranspired into the air, and 8 inches run off as surface water. However, once the landscape is urbanized, these proportions change with four main effects:

- Non-point-source pollution results when excessive stormwater runoff volume carries pollutants from residential, commercial, and agricultural areas and sediment from erosion caused by an excessive runoff rate. (Note: point-source pollution is discharged from pipes at industrial facilities or sewage treatment plants.)
- Flooding results from excessive runoff volume.
- Groundwater is depleted by reduced infiltration.
- Streambanks are destabilized by increased stormwater flows.

Under natural conditions, the areas adjoining rivers, streams, lakes, and ponds are protected by forested "riparian buffers." A riparian buffer made up of a mixture of native plant types—herbs, shrubs, and trees—filters out sediment and pollutants, stabilizes banks, mitigates stormwater flows, reduces water temperatures, and provides food for aquatic organisms. It also provides a protected habitat for wildlife to obtain water and other vital resources without being exposed to predators. Because these riparian areas are crucial to the protection and enhancement of water resources, a lack of riparian buffer has an adverse effect on the quality of water and aquatic habitats, and limits the overall wildlife benefits of a site.

Decades of deforestation, agricultural expansion, and increasing suburban development have drastically reduced the extent of water edge protected by forest in southeastern Pennsylvania. (However, in some watersheds, the combination of less acres in agriculture and better management practices promoted by the Natural Resources Conservation Service have increased riparian buffers.) Without the protective canopy and filtering and stabilizing root systems of riparian vegetation, streams can be degraded by thermal pollution and higher levels of total suspended solids, nutrients, and bacteria from stormwater runoff and nearby farms (livestock, fertilizer application) and homes (failing septic systems, lawn fertilizers).

The minimum riparian buffer recommended by the US Forest Service for water quality protection is typically a 95-foot strip along each side of a stream or water body that consists of three zones. The first zone should be a minimum 15-foot (preferably 25–35-foot) strip of undisturbed forest next to the stream or water body, which provides detritus and helps maintain lower water temperatures vital to fish. If steep slopes exist near the stream, this first zone may extend to 50 feet or beyond. The second zone is a 60-foot strip of managed forest where filtration, deposition, plant uptake, anaerobic denitrification, and other natural processes remove sediment and nutrients from runoff and subsurface flows. The third zone is typically a 20-foot strip of grass, or grass and shrubs, reducing the effects of accelerated runoff where concentrated flows from urbanized areas are converted to dispersed flows by water bars or spreaders, facilitating ground contact and infiltration. Vegetation management is important in all three zones to maintain a functioning buffer.

Stream water quality is degraded by erosion, sedimentation, and serious flooding associated with ineffective management of stormwater from impervious surfaces. Uncontrolled roadside runoff (which often contains oils, metals, and salt) from ditches and culverts is a region-wide problem. Severe erosion impacts are evident along stretches of headwater streams in the region, particularly in certain agricultural settings where functioning vegetated buffers have been lacking for many years. Sediment is generated by storm runoff and associated soil erosion from streambanks, farm fields, and construction sites. Excessive sediment in streams can inhibit fish reproduction by smothering eggs, and can harm other aquatic life, particularly bottom-dwelling species that live between pebbles and cobbles, an important link in the aquatic food chain.

Unfortunately, forests are often seen as a good place to direct concentrated runoff from farm fields and roads. While forest cover and forest soils are able to capture and absorb precipitation better than any other land cover, forest vegetation is not good at protecting soils from high amounts of surface water inputs. Frequently, gullies are created within forests by stormwater runoff from adjacent agricultural or residential areas.

As detailed in the ***Wildlife Survey*** section above, the small streams within the former Haverford State Hospital site are relatively healthy due to the forested riparian buffer along most of their course through the property. Our field surveys, however, did reveal several current and potential threats to these streams. Most importantly is the threat of loss of the surrounding native forest due to overabundant deer and invasive plants highlighted above. In addition, there are threats from stormwater runoff originating within and outside the property.

Map 11: Stewardship Issues and Opportunities shows locations (GPS points) where we noted major stormwater runoff concerns. These drainage and erosion issues are primarily limited to five areas on the property:

1. Stormwater runoff from the Quadrangle community beyond the northeast boundary of the site drains onto the property and has cut a channel down the slope to South Brook *(Photo 29)*.
2. Two eroded drainage ditches, likely originating during the Haverford Hospital era, deliver water from the developed area into the surrounding natural areas. One of these channels drains to the south toward South Brook *(Photo 30)* and the second drains to the north into the red

PHOTO 29: End of stormwater channel from Quadrangle parking area, as it enters South Brook. April 2008.

PHOTO 30: Drainage channel coming from construction site bringing water to the south. March 2008.

maple terrestrial forest along North Brook. The stormwater control measures for the Haverford Reserve development appear to address these areas.

3. At the time of our spring site visit, the drainage from the detention basin near the northeastern construction entrance (Darby Road) was bypassing the silt fencing that has been damaged by excess flow *(Photo 31)*. This presents a concern in terms of the effect of the outflow on the pH and siltation levels of North Brook. Water quality in this first order stream will affect downstream conditions in the watershed.
4. On the west side of Route 476 in the Darby Creek section of the project area, a culvert channels stormwater from Route 476 through the red maple palustrine forest *(Photo 32)*.
5. Stormwater flows along the access road west of Route 476 are cutting channels to Darby Creek *(Photo 33)*.

Other potential concerns associated with the planned increase in residential and public use of the watersheds feeding North Brook, South Brook, and Darby Creek are increased stormwater inputs, the use of detention basins by Canada geese, and the effects of unleashed

PHOTO 31: Drainage bypassing silt fencing near northeastern construction entrance, Darby Road. March 2008.

PHOTO 32: Gully erosion from drainage from damaged culvert under Route 476. June 2008.

PHOTO 33: Gully erosion from road running through floodplain forest. June 2008.

PHOTO 34: Partially blocked culvert along North Brook and road erosion likely due to excessive stormwater flows. May 2008.

dogs on stream health. Increased stormwater flows could lead to bank erosion and siltation of the streambeds of North Brook and South Brook. The culvert supporting the internal road over North Brook is already partially blocked and the road is beginning to erode *(Photo 34)* as high stormwater flows overtop the berm. The effectiveness of the stormwater control measures associated with the residential development will have an impact (for better or worse) on the water quality of North Brook and South Brook. Initially, it appears that they have addressed two areas of gully erosion caused by surface flows from the former Haverford Hospital site as noted above. They will need to be similarly effective in preventing increased stormwater inputs to the vulnerable first order streams.

Unnaturally high levels of fecal coliform bacteria and nutrients are evident in some locations downstream from ponds that attract large Canada goose populations. Dogs in streams and wetlands can degrade stream quality through trampling and erosion of streambanks and inputs of sediment and waste material containing nutrients and fecal coliform bacteria.

Recommendations:

- Monitor eroded areas described above and located on ***Map 11: Stewardship Issues and Opportunities***, particularly as the Haverford Reserve is developed and additional impervious cover causes increased stormwater flow.
- Work with the Quadrangle community and the Delaware County Conservation District to explore options for decreasing channel flow to South Brook.
- Stabilize, regrade, and replant eroded drainage areas to eliminate gullies and reduce further erosion. A County Soil Erosion Control Permit would be needed if the area needing stabilization is greater than 1,000 sq.ft. (aggregate of all eroded gullies). All township requirements, reviews, and permits should be addressed as well.
- Re-grade the old access road along Darby Creek west of Route 476 to drain water away from the creek. See above re: regulatory requirements, permits, etc.
- Restrict or minimize trail use and other disturbances in riparian buffer zones (at least 100 feet on each side of North and South Brooks and Darby Creek) in order to protect water quality and aquatic habitats.
- Consider replacing the culvert under the trail along North Brook. Although replacing this culvert would not increase fish utilization or diversity due to insufficient hydrology, it would enhance the aesthetics of the trail for visitors.

HAZARDS

Several hazards were noted in our surveys and these are labeled on ***Map 11: Stewardship Issues and Opportunities***. Of greatest concern is the old railroad bridge in the Darby Creek parcel west of Route 476 *(Photo 35)*. This is an attractive nuisance that should be addressed as soon as possible. Other potential hazards include the remains of the old dam along South Brook *(Photo 36, page 44)*, a remnant brick chimney south of the construction site *(Photo 37, page 44)*, old barbed wire fencing near the northeastern detention basin, and the remains of a ropes course in the area of the meadow *(Photo 38, page 44)* and North Brook. We also noted potential hazard trees near construction areas. With the upheaval and disturbance of soils, root systems of nearby trees are

PHOTO 35: Old railroad bridge as a hazard. March 2008.

PHOTO 36: Remains of an old dam along South Brook. March 2008.

PHOTO 37 *(left)*: Remains of a brick chimney in South Brook section of project area. March 2008.

PHOTO 38: Remains of ropes course posing a potential hazard. January 2008.

weakened and these trees may present a hazard as the public begins to access the property *(Photo 39)*.

Recommendations:

- Remove attractive nuisances from the property before it is open to public use, including the old railroad bridge west of Route 476, the old dam on South Brook, the brick wall south of construction site, barbed wire fencing, and the remains of the ropes course.
- Conduct an assessment of hazard trees near areas of potential public use and address trees that pose a danger to visitors. Monitor hazard trees by foot once each year and following severe storms. Ideally, a certified arborist should be hired to complete this task and address any identified hazards through pruning or removal.

PHOTO 39: Potential hazard tree that may have been weakened by nearby construction activity. March 2008.

AESTHETICS

Trash (plastic, cans, bottles) is lightly scattered throughout the property. In addition, we found older debris (metal, glass, masonry) in several piles in the old field/meadow area in the North Brook section *(Photo 40)* and close to property boundaries (see ***Map 11: Stewardship Issues and Opportunities***).

Recommendations:

- All trash and debris should be removed before the property is opened to the public. Volunteer neighborhood workdays are often a very effective and cost efficient approach to removing debris from areas.

PHOTO 40: Old air conditioners in old field/ meadow of North Brook section. January 2008.

MEADOW OF SPECIAL CONCERN

The area known locally as "The Meadow" in the North Brook section of the property is an early successional community that supports a diverse native flora in habitat conditions that were created with the removal of topsoil when the Haverford State Hospital was developed. Early successional communities usually require periodic disturbance to limit encroachment by woody species and to maintain their open character. Based on a comparison of today's aerial photography of the site with the historical aerial photography from 1971, some encroachment by woody species into this community has occurred and we suggest these changes be monitored and managed to maintain the integrity of this uncommon community.

Recommendations:

- Conduct a more comprehensive botanical inventory of the meadow that includes frequent visits through the growing season (April through September). Because this area has become a popular gathering spot for groups over the years, it needs to be more thoroughly studied to determine whether changes in types or intensity of use would be detrimental to the uncommon flora.
- Limit frequent mowing (more than once annually) within the meadow to the area near the fire ring and the trails.
- Expand and restore the meadow to approximately 3.5 acres (see ***Map 11: Stewardship Issues and Opportunities***) by extending the edge (i.e., removing woody vegetation from the center outward to the boundary of the red maple terrestrial forest). Qualified personnel with pesticide application and equipment (chainsaw, field mower) training will need to be used for this work. Each woody species should be treated properly to prevent root sprouting.
- Reroute existing trails and restrict future trails to the edge areas after woody species have been removed. Restrict camping to the western and northern border of the meadow (this may need to be modified based upon future botanical surveys).
- Consider the use of prescribed fire to enhance this community.

TRAIL LAYOUT

The Township anticipates extensive public use of the former Haverford State Hospital property due to its proximity to residential neighborhoods. This ecological assessment considers the potential impacts of trail use and construction on the natural resources on the subject property, as well as areas that are best suited for public use and perhaps showcase some of the aesthetic natural features of the site. Overall, the site provides excellent opportunities for bird and wildlife watching and given the extent of development in Haverford Township, the forests on the property could serve as a refuge for forest interior birds such as the Scarlet tanager (observed), Cerulean warbler, Great-crested flycatcher.

Several issues should be considered in the layout of trails on the site including forest fragmentation, the integrity of riparian forest buffers and other sensitive habitats, as well as topographical and other physical constraints related to a particular site. In addition, opportunities for locating trails in areas that would provide educational or scenic opportunities for the public should also be explored. We mapped existing trails on the subject property using a GPS unit and these are shown on ***Map 11: Stewardship Issues and Opportunities***. We also identified areas on the property where trails would not be suitable due to sensitive resources (wetlands, water resources, steep slopes, special plant resource areas) and these are displayed on ***Map 12: Trail Layout***. Expanding the trails into these areas should only be done to enhance the educational use of the property. It will require careful planning and, in many areas, structural improvements (e.g., boardwalks) to avoid degradation of sensitive soil and water resources.

Recommendations:

- In general, minimize the creation of new trails to avoid further disturbance and fragmentation that encourages the spread of invasive plants. Use utility rights-of-way (areas that will receive periodic disturbance in their management regime) to expand the trail system.
- Avoid development of new trails in areas identified as unsuitable (see "Sensitive Resource Area" on ***Map 12: Trail Layout***), including wetlands, water resources, steep slopes, and special plant resource areas. We would, however, support the continued use of the existing trails in all areas (including the "Sensitive Resource Area") except "The Meadow." There we recommend that the trail be moved to the outer edge of the proposed meadow restoration area (see ***Map 11: Stewardship Issues and Opportunities***) to minimize the fragmentation of this uncommon community.
- Limit trail use to foot traffic only and restrict future use by bicycles and all terrain vehicles (ATVs) in order to limit noise, disturbance, and destruction of sensitive habitat areas.
- Use the existing access road/sewer line along Darby Creek as part of the proposed trail system. This road begins along the mowed Darby Creek floodplain and continues until the creek flows under Route 476 and goes through a variety of habitats that provide opportunities for interpretive signage about ecosystem functions, habitats, and wildlife that can be observed in such areas. The diverse array of birds observed here makes this site ideal for bird watching.
- Consider highlighting stewardship issues (invasives, deer, water quality) and interesting natural features along trail routes, including (1) "The Meadow," (2) the aspen grove in the meadow (*Photo 9, page 8*), and (3) a basswood grove in the South Brook section.

POTENTIAL FUNDERS FOR HIGH PRIORITY PROJECTS

POTENTIAL FUNDER	PROGRAM	APPROPRIATE PROJECTS
PA Department of Conservation and Natural Resources (DCNR) *Contact:* Fran Rubert 215-560-1183 frubert@state.pa.us	*Community Conservation Partnership Program*	master site plan trail development
	PA Recreational Trails Program	trail development/restoration trailside & trailhead facilities
PA Department of Environmental Protection (DEP) *Contact:* Donna Suevo 484-250-5823 dsuevo@state.pa.us	*Environmental Education Grants Program*	education programs
	Growing Greener Watershed Grants	stormwater control
	Nonpoint Source Implementation Program (Section 319)	stormwater control
PA Department of Community and Economic Development (DCED) *Contact:* Hon. Greg Vitali 1001 East Darby Road Havertown, PA 19083 610-789-3900 Sen. Daylin Leach 717-787-5544	*Single Application for Assistance*	trail development meadow restoration removal of hazardous structures

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Appendix A

Site Vegetation Inventory

Appendix B

Observed Wildlife Species

Appendix C

Valley Forge Audubon Society

Nesting Bird Survey (1999)

Appendix D

PA Wildlife Action Plan – Lists of Priority Species

Appendix E

Macroinvertebrate Sampling Station Data

Appendix F

Darby Creek Valley Association (DCVA)
Winter 2008 Newsletter Article

Appendix G

PADEP 2008 Integrated Water Quality
Monitoring Report

Appendix H

Invasive Vegetation Management

excerpts from Natural Lands Trust's
Stewardship Handbook for Natural Lands in Southeastern Pennsylvania

Appendix I

Deer Management Options

excerpts from Natural Lands Trust's
Stewardship Handbook for Natural Lands in Southeastern Pennsylvania