

# KEY ISSUES

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## GROUNDWATER

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The more sensitive and valuable groundwater protection areas have been delineated for New Castle County. Critical areas are found in both the Piedmont and Coastal Plain province portions of the Piedmont Basin. The following are key groundwater-quality issues for the Piedmont Basin:

- ◆ The important Cockeysville aquifer is currently producing at quantities that have lowered the water table to below stream levels. Consequently, water flows from surface streams into the underlying aquifer. Thus, in addition to the Cockeysville Formation itself, the Mill Creek sub-watershed should be identified as an important drainage area because of the potential vulnerability of the Cockeysville Aquifer to water from Mill Creek, which recharges the aquifer. This watershed is primarily in Delaware although the northwestern extreme extends into Pennsylvania.
- ◆ Natural and anthropogenic problems continue to plague the Newark southern wellfields. The City of Newark could rely more heavily on this source of groundwater once recommendations concerning wellfield management and treatment are implemented. Currently, high iron and manganese levels limit production from some of the wells.
- ◆ Specific groundwater-quality impacts into surface water bodies currently are neither well understood nor evaluated. This is important within those watersheds that have major drinking-water withdrawals.
- ◆ An adequate ambient groundwater monitoring network sufficient to assess groundwater resources does not exist. However, improved coordination between state agencies on data integration will be a first step in developing such a network. However, some amount of resources is needed.
- ◆ Not all waste programs have adequately addressed sites described for this report that are causing groundwater contamination.
- ◆ The Office of Drinking Water data base currently is being placed in an electronic format. However, certain field procedures, such as including well-permit identification numbers with well samples, will greatly improve use of that data in groundwater-quality assessments.
- ◆ The Potomac aquifers found in the Coastal Plain extend well beyond the boundaries of the Piedmont Basin watersheds. Monitoring designs will, thus, be designed with these larger flow systems in mind.

- ◆ The GIS advances developed for this project, which give locational data for groundwater resources and for contaminant sources, should allow specific programs to set priorities with respect to the more critical groundwater resource areas.
- ◆ A characterization of areas with concentrations of domestic septic systems and domestic water wells is needed.
- ◆ An analysis to combine resource protection measures, such as greenways and parkland, is needed to maximize state and local resource protection measures.
- ◆ Locations of non-transient non-community, transient non-community, and miscellaneous public water-supply wells should be verified similar to what has been done for community wells.

## SURFACE WATER

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### Exceeded Criteria

The preliminary assessment of water quality for the Piedmont Basin analyzed data over 34 sampling locations distributed along the Christina River, Brandywine Creek, Red Clay Creek, White Clay Creek, Naamans Creek, and Shellpot Creek in Delaware. For each sampling location, up to 22 water-quality parameters were analyzed, including general chemical and physical parameters, bacteria, nutrients, and metals. Data assessed in the study were retrieved from the U.S. Environmental Protection Agency's Water Quality Information System and were manipulated prior to statistical evaluation due to missing values, censored values, outliers, multiple observations within a month, and small sample sizes.

The preliminary study characterized the water and identified existing and potential water-quality problems in streams through trend and status analysis. It applied all three types of statistical analysis — the graphical method, the estimation method, and a test of hypotheses — on each parameter for each sampling location. The study also identified data gaps that affected the statistical analysis.

As a result of the study, major concerns surfaced with regard to the following parameters in which concentrations frequently violated water-quality criteria:

- ◆ Enterococcus bacteria concentrations frequently exceeded criteria throughout the Piedmont Basin.
- ◆ Zinc exceedances of criteria occurred frequently along Red Clay Creek.
- ◆ Iron violations of criteria occurred along the lower reach of the Christina River.

- ◆ Total phosphorus excessive concentrations (average above 0.1 mg/l) support the concern for nutrient over-enrichment in the Christina River, Brandywine Creek, Red Clay Creek, and White Clay Creek watersheds; however, concentrations are on the decline.

## Trends

Trends in surface-water quality also have been documented in the preliminary assessment of water-quality data for the Piedmont Basin. As a result of the study, major concerns surfaced regarding the following parameters, which show an undesirable trend in direction:

- ◆ Dissolved oxygen concentrations decreased steadily within the last 26 years throughout the entire Piedmont Basin, although criteria were not violated frequently. Therefore, trends indicate that future violations will occur frequently.
- ◆ Nitrate-nitrogen increasing trends in the Christina River, Brandywine Creek, Red Clay Creek, and White Clay Creek from 1970 to 1990 suggest that water quality has declined and will continue to decline in these regions.

## Fish Consumption Advisories

DNREC and the Delaware Department of Health and Social Services issued a public health advisory on the consumption of fish taken from the Christina River basin in April 1996. The advisory is the result of intensive study of contaminants in fish tissues and is being issued due to the detection of elevated levels of polychlorinated biphenyls (PCBs) in the fish. The immediate goal of the advisory is to reduce the population's exposure to PCBs.

The advisory does not apply to drinking water in the Christina basin. Drinking water samples collected from the City of Wilmington, the City of Newark, and United Water Delaware did not reveal elevated levels of PCBs. All sample results were hundreds of times below the federal standard for drinking water and therefore are considered safe.

Specifically, the advisory recommends *no consumption* of any finfish caught in the tidal portion of the Christina River (from the mouth of the river up to Smalley's Dam), the tidal portion of the Brandywine (from the mouth of the river up to Baynard Boulevard), the tidal portion of White Clay Creek (from the mouth up to Route 4), and Little Mill Creek (from its mouth up to Kirkwood Highway). The advisory recommends *limited consumption* of fish caught in the nontidal areas of the Christina River (from Smalley's Dam to Interstate 95), White Clay Creek (from Route 4 to Paper Mill Road) and the nontidal portion of the Brandywine (from Baynard Boulevard to the Pennsylvania state line). Fishermen and their friends and families eating fish caught in the areas where a limited consumption advisory

has been issued are advised to limit their meals of fish from these waters to no more than one 8-ounce meal per month. The advisory also reaffirms the existing advisory on Red Clay Creek, which recommends *no consumption* of fish caught in that waterway. (Please see Map 33.)

Fish taken from the White Clay Creek between the Pennsylvania state line and Paper Mill Road, as well as Becks Pond, did not show elevated levels of PCBs, and no advisory is being issued for these areas.

The findings of the study are consistent with a study completed in 1994 which discovered elevated levels of PCBs in several species of fish taken from the Delaware River and Bay. A consumption advisory remains in effect for the Delaware River and Bay for several fish species.

The advisory is a precautionary measure and is based on a projected health risk to fishermen, their friends, and family who may consume fish from these waterways over a long period of time. For instance, scientists project the lifetime cancer risk to people who consume fish from the tidal Christina River from Newport to Christina Park — the area where the highest levels of PCBs were found — ranges from 1 in 100,000 for those consuming as little as one meal per year, to greater than 1 in 1,000 for those consuming one meal per week. Environmental and public health agencies often seek to reduce exposures when risks exceed a 1-in-100,000 level.

In addition to cancer risks, PCBs also pose special non-cancer health risks to pregnant women and their unborn offspring as well as to nursing mothers and young children. These groups should pay particular attention to the advice given in such announcements. Ultimately, each individual must weigh the risks and benefits of consuming fish from the Christina River in deciding whether to eat or not eat the fish. Those who decide to consume their catch should follow proper trimming and cooking methods.

Along with the study of contaminants in fish and drinking water, DNREC has also conducted sediment sampling throughout the lower Christina basin to determine the magnitude and extent of contamination. Initial results indicate higher levels of PCBs in the sediments in the areas of the river where fish with the highest levels of PCBs were found.

DNREC has been working actively to investigate land-based activities in these areas to determine potential sources and to clean up sites that may be contributing to the contamination. In addition to the Whole Basin Management Program described in this preliminary assessment report, another tool DNREC is using to clean up contaminated sites is the Brownfields initiative, which is designed to promote voluntary cleanup and reuse of abandoned industrial sites. The longer-term goal of DNREC is to be able to lift the advisory once contaminant levels in the fish are reduced to a safe level.

PCBs are a heat retardant formerly used in many applications, especially electrical transformers, capacitors, and other heavy-duty electrical equipment. The manufacture of PCBs was banned in the United States in 1977, although they are still used in closed systems. Prior to 1977, the manufacture, use, and disposal of PCBs were not closely controlled. Consequently, significant quantities of PCBs entered our nation's air, water, and soil. Today, PCBs are released into the environment from unidentified or poorly maintained hazardous waste sites, illegal or improper dumping of PCB wastes, and leaks or releases from equipment containing PCBs.

The International Agency for Research on Cancer and the EPA consider PCBs to be probable cancer-causing agents. When administered in moderate to high doses to experimental animals, PCBs have been shown to increase the incidence of liver cancer and cause other adverse health effects including neuro-development problems in offspring as well as disorders of the immune system. Similar effects in humans though suggested, are not proven.

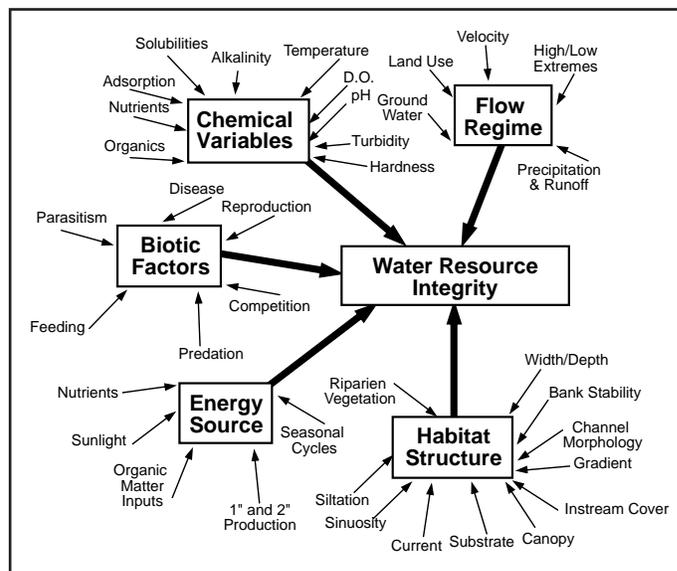
PCBs tend to adsorb to soil particles and are typically transported to waterways as part of stormwater runoff. Once in the water, these particles settle to the bottom where they accumulate in sediments and become available for transfer to the food chain. PCBs are long-lived in the environment and may take decades to break down into forms that are harmless to living organisms.

### Biological Quality of Nontidal Streams

Nontidal streams are by far the most widespread and extensive aquatic resources in the northern Piedmont region: they amount to 272 miles of ephemeral and perennial streams. Approximately 60% of the resource has flow year-round (perennial), while 40% is made up of small headwater channels that go dry for part of the year (ephemeral). The nontidal stream resource extends from the headwaters of the major watersheds in Pennsylvania and Maryland down to the head of tide at (1) Smalley's Pond near Christiana, (2) just below the confluence of the White Clay, Red Clay, and Mill creeks near Stanton, (3) the Brandywine Creek at the Route 13 bridge in downtown Wilmington, and (4) Naamans and Shellpot creeks at the Delaware River.

The ecological quality of surface waters, including nontidal streams, is made up of a complex web of attributes that interact together to support the system as a whole (see Figure 23). Each attribute can be assessed using a variety of discrete measurements. Assessments have traditionally focused on chemical and flow measurements because these best describe point sources of pollution that fall under regulatory control. Measures of biological quality using resident organisms reflect a wide range of attributes of the system and thus can detect impacts from both point and nonpoint sources.

**Figure 23**  
**AQUATIC RESOURCE INTEGRITY**  
(From Yoder, 1991)



Resident organisms provide a direct measure of aquatic life use attainment as required by the Clean Water Act.

A wide variety of aquatic organisms are found in nontidal streams including algae and aquatic mosses, aquatic and semi-aquatic vascular plants (e.g., wild celery *Vallisneria spp.* and duckweed *Lemna spp.*), invertebrate animals (e.g., insect larvae and snails) and vertebrate animals (e.g., fish and amphibians). Various studies have been completed over the years to assess the condition of resident aquatic organisms found in nontidal streams in the region encompassing the Piedmont Basin.

Nontidal streams in the region support a variety of human uses including fishing, swimming, boating, and public water supply. Aquatic organisms are an effective measure of the quality of water supporting these uses. Fishing is a popular activity in all the major creeks and streams in the region. Canoeing and tubing are popular activities in White Clay Creek and Brandywine Creek. Approximately 69% of the potable water in New Castle County comes from surface waters taken directly from nontidal streams or from reservoirs fed by nontidal streams (DNREC, 1996). (The adverse effects of eating contaminated fish in the region were presented earlier.) Therefore, the quality of aquatic organisms in the region affects both recreation and human health interests.

In fall 1993, DNREC collected macroinvertebrate samples and conducted habitat assessments in 39 nontidal streams within the northern Piedmont Basin (DNREC, 1994). Sites

were randomly selected to provide un-biased estimates of the proportion (percent) of stream miles in the region with three classes of quality: “good” (comparable to a reference), “fair” (moderately degraded), and “poor” (severely degraded). This framework provided the basis for an overall assessment of the biological condition of nontidal streams to complement the more detailed assessments that have been completed on specific streams or stream reaches. See Map 34.

The biological monitoring program within DNREC’s Division of Water Resources uses aquatic macroinvertebrates as the indicator of biological quality in nontidal streams. Aquatic macroinvertebrates, principally the larval stages of insects, are good indicators of stream quality because they (1) have a short range and thus represent local conditions; (2) are long-lived (many have life spans of one to five years), and thus reflect long-term conditions; (3) are known to be sensitive to pollution; and (4) are the primary food source for recreationally and economically important fish. These aquatic organisms, in turn, support terrestrial organisms such as birds and humans. As part of the biological assessment, physical habitat measures are also taken to further broaden the ecological assessment and to assist in the interpretation of the biological data.

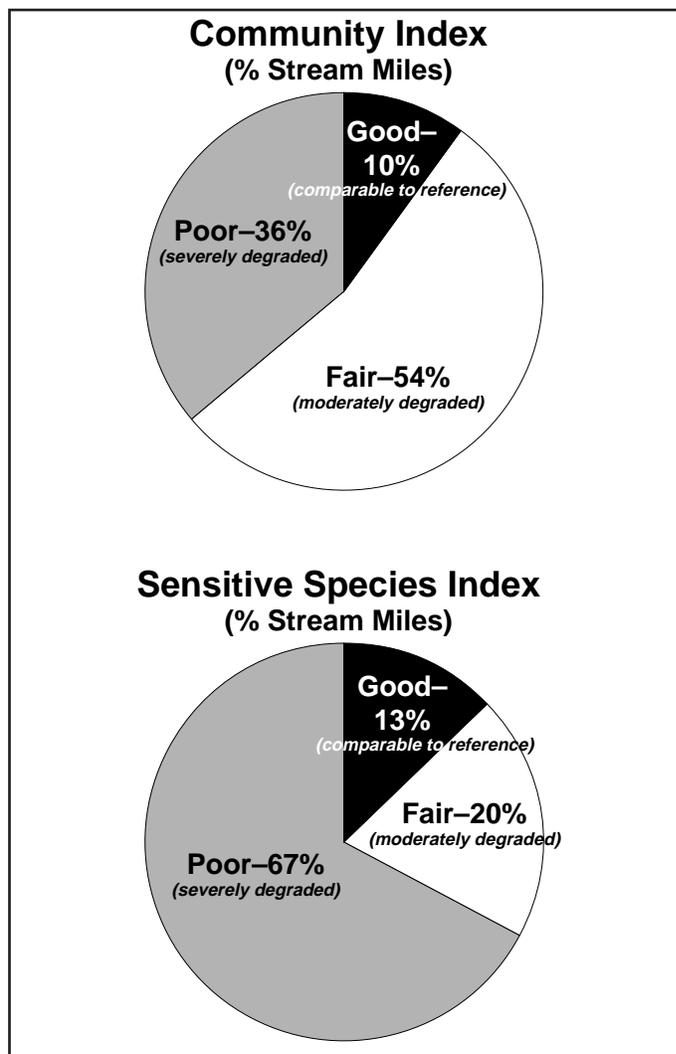
Percent area estimates were reported using two biological indices and one habitat index. “Percent of reference” estimates were first determined for each site by comparing quantitative measures (i.e., metrics) from each site to those from least impacted reference sites (i.e., forested watersheds). Each site was then classified into one of the three quality classes using the following criteria:

Class	Biological Quality	Habitat Quality
good	> 67%	> 89%
fair	34 to 67%	< 34%
poor	60 to 89%	< 60%

The percent area (percent stream miles) was determined as the percent of the 39 sites in each class. Technical procedures follow those developed by the EPA (Plafkin et al., 1989). Confidence intervals were determined using procedures contained in Walpole and Myers (1976).

Biological data were summarized using a Community Index and a Sensitive Species Index. See Figure 24. The Community Index was used to characterize overall condition and was derived from several measures of the macroinvertebrate community. A “poor” Community Index classification indicated severe degradation, including reduction of taxonomic diversity, loss of sensitive species, and loss of community structure and balance. A “fair” Community Index classification indicated an intermediate degree of impairment. The Sensitive Species Index was derived using only

**Figure 24**  
**BIOLOGICAL QUALITY OF NONTIDAL STREAMS IN THE PIEDMONT BASIN**

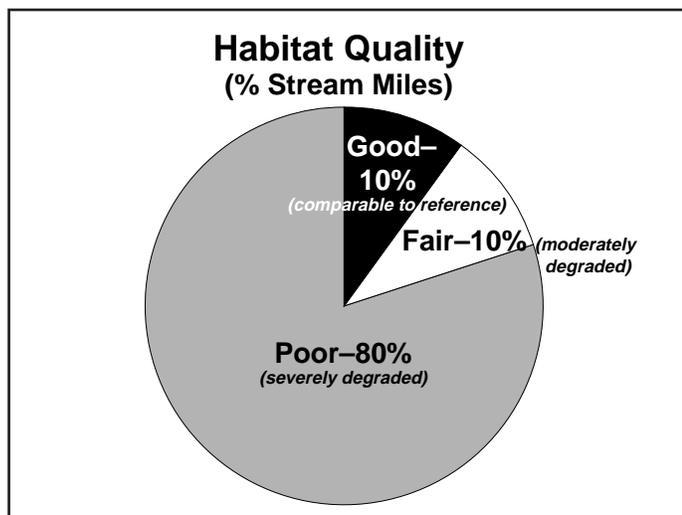


*Proportion (%) of nontidal streams in the Piedmont Basin with three classes of biological quality using two indices (90% confidence interval of +/- 9% to 13%).*

those organisms that are known to be sensitive to pollution. A “poor” classification using the Sensitive Species Index indicated almost complete loss of sensitive species while a “fair” classification indicated partial loss of sensitive species.

Three-fourths (74%) of nontidal stream resources in the region were found to have degraded biological conditions; an equal number of sites were moderately and severely degraded (see Figure 24). Degraded (“poor”) sites were dominated by fly larvae, snails, and worms, while “good” sites were dominated by mayfly, stone fly, and caddis fly larvae. Degraded sites were dominated by pollution-tolerant species

**Figure 25**  
**BIOLOGICAL QUALITY OF NONTIDAL STREAMS**  
**IN THE PIEDMONT BASIN**



*Proportion (%) of nontidal streams in the Piedmont Basin with three classes of habitat quality (90% confidence interval of +/- 8% to 3%).*

while “good” sites were dominated by pollution-sensitive species. Almost all (87%) of the sites in the region showed some loss of sensitive species, with two-thirds (67%) having almost complete loss of sensitive species and consequently being listed as “poor” sites biologically.

Almost all (90%) of the nontidal streams had undergone some degree of habitat degradation (Figure 25) as exhibited by eroded banks, newly deposited sediment in the channel, lack of a shade canopy, and human activity in the riparian zone. Two factors contributed to the degraded habitat conditions of streams in the region. First, stream channels appeared to be unstable, with active erosion along bends and runs, and had newly deposited sediment in the channel. This condition is indicative of urban streams, where the impervious surfaces in the watershed (roads, parking lots, rooftops, etc.) have increased the frequency and magnitude of peak flows. Second, native vegetation (for example, trees) was often replaced by grass (lawns) in the riparian zone. Natural wooded riparian zones promote channel stability, moderate stream temperatures, and provide a buffer between streams and contaminant sources.

## Identification of Problems and Sources

### *Nonpoint Sources — Urbanization*

The 39 sites sampled by DNREC in 1993 were used to provide an initial analysis of the relationships between biological quality, physical habitat quality, and land use.

Physical habitat appeared to be an important stressor affecting nontidal streams in the region. The association between biological quality and physical habitat quality ( $r^2 = 0.35$ ,  $n = 38$ ) provided objective evidence that the impacts to physical habitat may be contributing to the biological condition of these streams (Figure 25). This association was further supported by the classification information. The majority of sites classified as “good” or “poor” for one measure received the same classification using the other measure. None of the sites with “good” biology had “poor” habitat.

Urbanization is a major land use in the region. The habitat conditions at impacted sites were consistent with those associated with urbanization. These included human alteration of the riparian zone, erosion of banks, and deposition of new sediment in channels. Soil is eroded from stream banks when it rains and is deposited as sediment in the channel, where it smothers productive habitats such as pools and riffles. Productive riffles are partially buried in fine sediment in urban streams. Woody material, also important habitat for aquatic organisms, is picked up by storm flows and transported downstream, often accumulating in large piles at bridges.

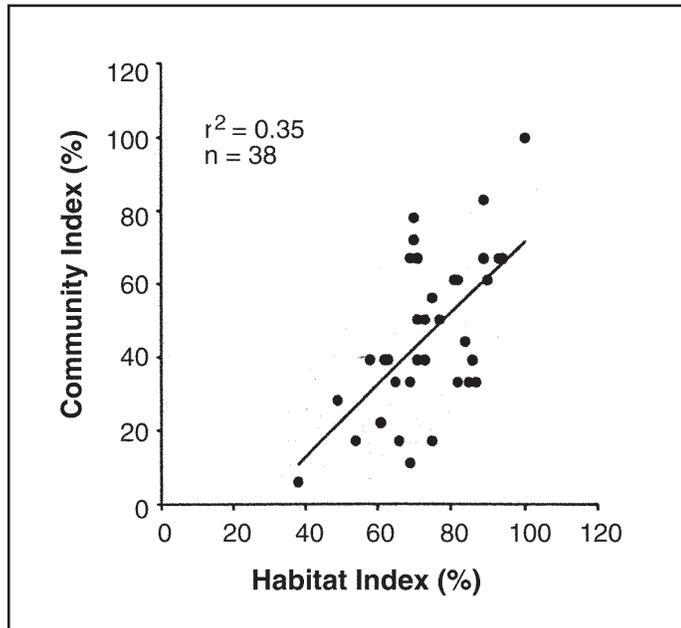
The scatter in the association between biological and physical habitat quality (Figure 26) may be due to the variability in the two measurements or due to stressors other than physical habitat. Other stressors likely in the region include temperature (due to lack of shade), chloride (due to road salts), dissolved oxygen (due to nutrient enrichment and lack of shade), and a variety of metal and organic contaminants (due to stormwater runoff). There are insufficient data to determine the relative contributions of these possible stressors.

To further evaluate the relationship between biological condition and urbanization, we compiled land-use data for the watersheds upstream of each of the 39 sampling stations. Percent impervious cover estimates for each site were calculated to provide the basis for evaluating relationships between biological condition and urban land use. The relationships between percent impervious cover and the Community Index (Figure 27) indicated that the degree of urbanization was associated with the macroinvertebrate community. The association between impervious cover and the Community Index was particularly strong ( $r^2 = 0.71$ ,  $n = 19$ ) for low-density urbanization (< 30% impervious cover).

An even stronger relationship was found between impervious cover and the Sensitive Species Index (Figure 28). There was an almost complete loss of sensitive species once the watershed reached 15% impervious cover. Low-density residential development with acre lots has a 25% impervious cover using these procedures. The association between impervious cover and the Sensitive Species Index was particularly strong ( $r^2 = 0.78$ ,  $n = 19$ ) for low-density urbanization (< 30% impervious cover).

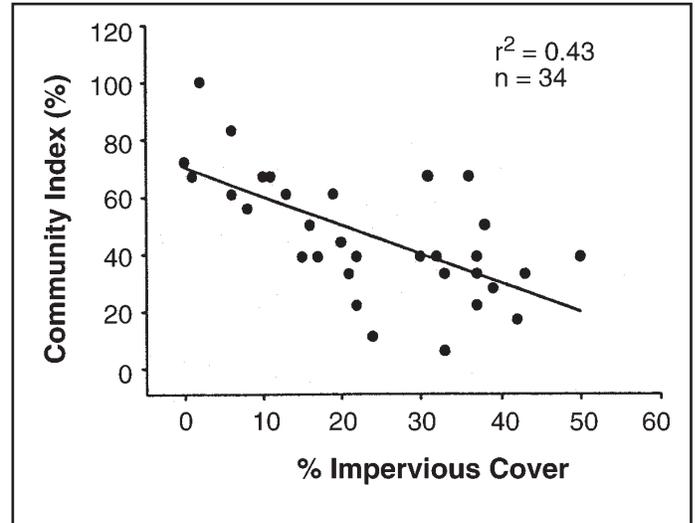
**Figure 26**

**EFFECT OF PHYSICAL HABITAT ON BIOLOGICAL QUALITY OF NONTIDAL STREAMS — PIEDMONT BASIN**



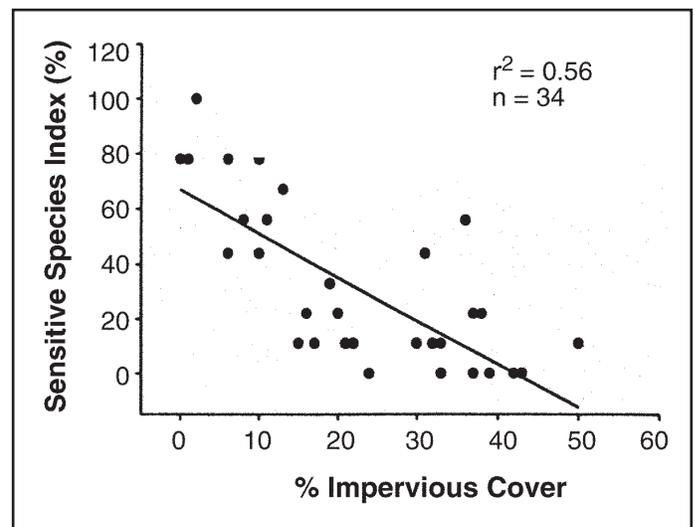
**Figure 27**

**RELATIONSHIP BETWEEN IMPERVIOUS COVER AND COMMUNITY INDEX — PIEDMONT BASIN**



**Figure 28**

**RELATIONSHIP BETWEEN IMPERVIOUS COVER AND SENSITIVE SPECIES INDEX — PIEDMONT BASIN**



**Conclusions**

Aquatic organisms are severely impacted throughout the region. Urbanization appears to be a major nonpoint source of pollution affecting almost all (90%) of the stream miles in the region. Likely stressors include changes in hydrology, water quality, sediment quality, and physical habitat related to urbanization. Further study is needed to define the relative contributions of the various stressors impacting the biota. Point sources and hazardous waste sites also impact a small proportion of the nontidal streams in the region. Most major point sources in the region discharge to tidal waters — with the exception of Red Clay Creek, which receives several discharges in both Pennsylvania and Delaware. Agriculture is no longer a dominant land use in the region, but may also have adverse effects in selected areas.

A small proportion of stream miles (10%) in the region were found to be comparable to reference conditions for either biological or physical habitat quality. Therefore, approximately 30 miles of nontidal streams in the region still remain in “good” condition after 200 years of European settlement and development. The vast majority of stream miles are impacted by a variety of human activities, with urbanization the most widespread. The protection of rare high-quality stream segments and the restoration of numerous impacted segments are management priorities in the region.

*Recommendations*

- ◆ Continue to implement stormwater controls for new developments; aggressively implement controls, including land-use controls, in the few remaining undeveloped, forested watersheds in the region.
- ◆ Coordinate the monitoring of reference areas in Pennsylvania and Maryland to augment the reference site data base for Delaware.

- ◆ Conduct additional studies to identify specific stressors.
- ◆ Evaluate the effectiveness of National Pollutant Discharge Elimination System and stormwater controls.
- ◆ Quantify the economic value of recreational fishing in the region.

## WATER QUANTITY

This Key Issues section should be read in consideration of the climate of the Piedmont Basin — humid-temperate and with generally plentiful rainfall, averaging about 42 inches of fairly evenly distributed annual rainfall. This rainfall replenishes aquifers and maintains perennial stream flow. Rainfall amounts can be erratic, however, being relatively high in some years and low in others. Geology, and its resultant topography, cause both surface and groundwater availability to be unevenly distributed, and the locations of water availability and demand are not coincident.

The largest freshwater supply in the Piedmont Basin is Brandywine Creek, with most of the Brandywine drainage area in Chester County, Pennsylvania. Although the largest water supply for the Piedmont Basin is actually the Delaware River, use is limited to industrial cooling due to the brackish-to-saline nature of the water. Other sources of surface-water supply include the smaller Red and White Clay creeks and the Christina River. These streams have a combined drainage area smaller than that of the Brandywine.

Brandywine Creek has been developed as a source of water supply for several centuries, paralleling the industrialization of the area. The creek was both the source of water supply and water power for a series of early mills that played a crucial role in the development and preservation of the United States as a young nation. By the mid-20th century, the City of Wilmington had bought up the old mill rights and had established a claim to the entire flow of Brandywine Creek as its source of water supply. Wilmington also built Hoopes Reservoir during the 1930s which, along with Brandywine Creek, created excess water-supply capacity for the city.

The flight of population to the suburbs began in the 1950s, where the only surface-water supplies were smaller streams (Red Clay, White Clay, and Christina) that had lower dependable flow; this created a growing imbalance of water-supply capacity relative to demand. Water was one of the City of Wilmington's few bargaining assets which the growing suburbs coveted. The early 1960s drought demonstrated that the combined flows of the smaller streams were insufficient to meet water demands; accordingly, the city was considered the principal source of future water supply for the entire county. However, influential developers had different ideas, and instead of negotiating with the City of

Wilmington for water, the utilities serving the suburbs accelerated the development of groundwater.

At the same time, anticipation of ever-increasing county-wide growth led to the proposal of a large dam on the White Clay Creek above Newark. Flaws with the proposed project — including housing developments in the proposed flood pool, the fact that about half of the flood pool would cover land in Pennsylvania, and the huge cost — proved this project infeasible. Subsequent review of those previous demand projections indicate that population growth was indeed grossly overestimated, as were the water demands that the reservoir would have been designed to meet. Forecasts for heavy growth in water demands, particularly in Wilmington during the last half of the 20th century, have not materialized since the Wilmington population decreased by 125,000 inhabitants in 1950 to a decrease of 75,000 in 1990, and water-using heavy industries either closed or became more efficient. The DuPont Company had acquired and set aside large tracts of land for the project, but most of this land was sold or donated for public parks by the early 1980s. The so-called "Newark Project" was formally stricken from the state's Water Supply Plan in 1984.

At about this time, agencies concerned with water issues became established and/or grew. Planning agencies — including WILMAPCO, the Chester County Water Resources Authority, and the Water Resources Agency for New Castle County — and regulatory agencies — including the Delaware River Basin Commission, Pennsylvania Department of Environmental Regulation (now the Department of Environmental Protection), and DNREC — gradually contributed to the widespread accumulation of reliable data on water usage, improved forecasts of water demands, estimates of sustainable yields of water sources, and criteria for additional water resource development.

Studies of groundwater supply availability conducted during the mid-1950s to the early 1970s estimated progressively higher yield estimates. Such optimism was the result of extensive water exploration and experience with increasing water development projects — particularly in the productive Coastal Plain aquifers relative to the less productive Piedmont aquifers. Any increased water demands in northern New Castle County were met during the 1970s and 1980s by improved management of the existing surface and groundwater supplies through construction of a series of water system interconnections and agreements brokered by the Water Resources Agency for New Castle County. During the 1980s, Artesian Water Company entered an agreement with the City of Chester, Pennsylvania, to tap excess capacity that Chester had developed in the Susquehanna River basin. This arrangement, with progressive annual increases in permitted withdrawals, significantly augmented the dependable public water supply available for New Castle County.

Thus, the fortunate and near-optimal development of water supply in northern New Castle County can be attributed to the geology and history of the area, as well as to technological development: surface-water sources were developed first, incremental groundwater capacity was added, management of capacity was improved through interconnections, and the acquisition of out-of-state surplus waters was eventually accomplished.

One key water quantity issue is that today all of the “easy” water is gone, and increased competition for limited supplies will continue. Groundwater withdrawals can be sustained, but not appreciably increased without the use of artificial recharge technology. All groundwater developed from this point forward will contain naturally objectionable quality due to high iron levels and high corrosivity, which causes problems with metals leaching in plumbing systems. Under the new “Lead and Copper” rule of the Safe Drinking Water Act, the increased levels of water treatment required to minimize such problems will translate into considerable costs.

Local water sources and developed supplies are susceptible to human contamination. Sediment runoff, which causes high turbidity, has dramatically increased with urbanization; this indirectly represents an actual health threat rather than the normally identified villains of organics and metals. Highly turbid water requires higher levels of disinfectants and oxidizers which, along with their by-products (trihalomethanes, aldehydes, ozone, and chlorine), are more of a health threat (cancer risk) than organics and metals. Moreover, the organics and metals are effectively removed by the treatment processes, even though the processes are primarily designed to clarify turbid water. This removal is, however, incidental. Under new treatment rules for surface water and stricter standards for disinfectants and disinfectant by-products, risk from these substances should be reduced. Treating for turbidity also represents a large cost for the consumer.

As described earlier in this report, the Piedmont Basin’s quest for future water supplies continues today with the ongoing Water Supply Plan for New Castle County. Additional, substantial supplies *will be required* early in the next century. Addition of any significant new water source — especially a reservoir project — would be expensive and could involve a necessary degree of environmental loss; this environmental loss would need to be better determined before an informed decision could be made.

As with the abandoned “Newark Project,” the added capacity of Thompsons Station — or any other large project for that matter — would have to be paid for in total, although actual demand for the water will only rise incrementally. To minimize the large up-front costs, the new source of supply should be compatible with existing water treatment and distribution capacity to the extent possible.

Storage would also help offset some of these added costs, such as Hoopes Reservoir does for the City of Wilmington, which uses that stored water supply as a source when Brandywine Creek is turbid.

Improving stream flow would be beneficial — by releases from storage, by reduction of diversions by use of an alternate source(s), or both. Consideration also has to be given to the impact occurring both in-state and particularly in Pennsylvania — which diverts considerable water and has caused quality problems. Thompson’s Station reservoir would help offset these problems.

Another key issue is that, despite a wealth of information available to the planning processes, optimal solutions *do not appear to be forthcoming*. Complicating this, future water supply for the county is envisioned as a joint venture among both public and private interests; therefore, numerous regulatory and institutional issues unprecedented in Delaware remain to be resolved involving project financing, ownership, and operation. The current idea is that an “authority” or similar entity would be created to run the project although this concept is in its infancy and has not yet received scrutiny. Until these issues are resolved, an actual construction date for the project is indeterminable. Fortunately, other interim projects are being developed, providing an additional measure of security for the county’s overall water supply.

To date, water supply, water quantity, environmental restoration, and public health protection programs have not been well-coordinated due to bureaucracy and compartmentalization resulting from separate complex statutes and regulations and separate funding mechanisms. One year, for example, more money was spent monitoring soil and shallow groundwater beneath a field in the Delaware City industrial complex — which posed no threat to water supplies or the aquatic environment — than on the statewide public water monitoring program. Current regulations are extremely weak in these critical areas of economics. Little resources are devoted to innovative areas of study and planning.

The cost of water should be expected to rise dramatically in the next decade in response to necessary and unnecessary cost increases. Combined cost for water and water for average residential customers (at today’s consumption rates) will likely double to more than \$10 per thousand gallons in the very near future.

## SOILS

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The state required all counties to develop or revise their comprehensive plans. The New Castle County Comprehensive Plan has sections entitled Natural Resources, Community Facilities and Services, and Growth Management Program. Most of the discussion presented in this plan was

very similar to the discussion that took place in the Piedmont Whole Basin Workshop held August 27–29, 1996, at Grassdale, New Castle County, Delaware. The plan relays the good understanding expressed at that workshop regarding New Castle County’s existing conditions and problems; the plan even discusses *sustainability* in the Update section and promotes “new alternative forms of development that reduce the rate of land absorption, maximize open space, preserve resources, and are conducive to increasing use of public transit.”

The plan recognizes the need to promote compact development patterns to minimize infrastructure costs, reduce fragmentation of open space, and protect critical areas. Further, the plan states that:

Septic systems should be discouraged since their failure rates and maintenance costs are high, and they can potentially degrade groundwater. Sewer infrastructure operation and maintenance costs will be higher in southern New Castle County due to lack of slope, which will necessitate the use of high energy pumping stations to convey wastewater. In addition, community wastewater treatment systems will be significantly more expensive to operate and maintain as compared to larger regional systems serving more customers.

Substantive proof that septic systems are failing at an alarming rate or that septic systems are leading to significant groundwater pollution is lacking, especially on the larger parcels in New Castle County. A recent professional paper in the *Journal of Environmental Quality* by Nizeyimana et al. (1996) documents that septic systems located in land areas in Pennsylvania adjacent to New Castle County load groundwater at a rate of 0.7 to 1 pound of nitrogen per acre per year. Is that an alarming rate when compared to nitrogen loading rates from lawn fertilization or agricultural production? Dr. William Ritter of the University of Delaware stated in *Report Nutrient Budgets for Appoquinimink Watershed* that cropland contributes 75% of the nitrogen and phosphorus loads from nonpoint sources. By comparison, nitrogen discharged by the Middletown-Odessa-Townsend wastewater treatment plant is less than that contributed from nonpoint sources; and nitrogen from septic systems — though greater than the Middletown-Odessa-Townsend treatment plant discharges — is still less than that contributed from cropland. Any time development takes place, pollution will result, regardless of the type of wastewater treatment employed. Anthropogenic activities damage the environment. Septic systems are not solely responsible and can be as environmentally safe as other wastewater treatment options.

As landscape changes occur, our water resources are directly affected. These changes include alterations to drainage patterns and to land perviousness, hence affecting

the amount and quality of runoff to surface waters; alterations to the amount and quality of water available for groundwater recharge; and alterations in the amount of pollution generated on a particular parcel of land through human activities. It is technically difficult to predict changes in the amount of pollution that will occur as a result of changes on the land surface; it is important, however, to recognize that such changes will occur. For example, if forestland is converted to agricultural, residential, commercial, or industrial use, a significant increase in the amount of pollution will result. In addition to habitat loss and impacts on living resources caused by the conversions, increased pollution will negatively effect both groundwater and surface water quality. Over time, the cumulative impact of these conversions may threaten the sustainability of our water resources.

New Castle County has consolidated amenities into riparian areas with dire results. The loss of riparian buffers increases downstream flooding, and the placement of those amenities within these buffers contributes to the loss of valuable wetlands. Unfortunately, the New Castle County Comprehensive Plan made no recommendations regarding riparian buffers, although research has shown that 100 feet could provide adequate protection for most situations and a 300-foot buffer could be applied for especially critical areas. In any case, a buffer should be larger than the floodplain it is to protect, and its size should be based on available research. DNREC would certainly offer to work with New Castle County toward determining appropriate buffer widths.

## SEDIMENT

### Deposition

Sediment deposition due to accelerated erosion has significant adverse environmental impacts and exacerbates flooding problems. Because of their topography, the watersheds of the Piedmont Basin are particularly susceptible to sediment deposition problems. The costs of removing sediment from blocked drainage structures, ponds, and tidal areas can be calculated. However, the environmental costs associated with lost habitat and other associated impacts are more difficult to assess. In considering the sources of sediment and the cumulative impacts of adding impervious surfaces in a watershed, it is important to recognize the link with land use.

### Suspended Solids

Suspended sediment particles cause turbidity problems in the water treatment process and act as an environmental stressor on aquatic life. The soils in the Piedmont geologic province have a relatively higher percentage of clays than those of the Coastal Plain. Public water supplies are also more dependent on surface waters in the Piedmont than in

the Coastal Plain. Therefore, suspended solids are of particular concern in the watersheds of the Piedmont Basin. The exposure of soils as a result of construction activities and, to a lesser degree, agricultural activities, is considered the major nonpoint source of suspended sediments in the Piedmont Basin.

### **Contaminated and Enriched Sediments**

As soil particles wash off the land through the erosion process, their chemically active nature makes them particularly conducive to transporting adsorbed nutrients, metals, toxics, and other contaminants into the receiving waters. Since most of the heavy industry in Delaware historically has been located in the watersheds of the Piedmont Basin, the potential for contaminated and/or enriched sediments is of special concern in this area.

## **WETLANDS**

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### **Identification and Delineation**

The interrelatedness of wetland ecological characteristics is significant for wetland identification in areas where one or more hydrologic indicators is missing due to seasonal variations in surface- or groundwater, or due to problematic soils or vegetation. For example, some Piedmont riparian areas are distinguished by hydrophytic plant communities and wet but non-hydric or marginally hydric soils. Other floodplain soils may be hydric but lack hydric soil indicators, making wetland identification and delineation problematic.

A difficulty in nontidal wetland assessments in the Piedmont Basin is determining whether wetland hydrology is present. Areas with sufficient groundwater discharge (seeps) may lack surface-water indicators. For surface-water driven wetlands, historical stream gauge data collected by the U. S. Geological Survey for calculating flood frequency and duration may be irrelevant in light of the rate of recent upstream watershed development (pers. comm. between P. Emslie and R. Simmons). The difficulty of identifying and delineating problematic wetlands is significant given the lack of state nontidal wetlands legislation, existing deficiencies in the federal regulatory program, and gaps in the protection of all riparian areas through county floodplain ordinances (DNREC, Delaware Field Evaluation, 1992).

### **Recommendations**

- ◆ Refine understanding and interrelatedness of wetland ecological characteristics through monitoring in reference wetlands.
- ◆ Identify and use non-regulatory mechanisms to protect riparian areas and drier-end “difficult to delineate” wetlands.

### **Legislative and Regulatory Initiatives**

Despite public outreach and a participatory effort with stakeholders and special interest groups, DNREC, to date, has been unsuccessful in passing the Freshwater Wetlands Act. There is presently no state regulatory oversight for freshwater, nontidal wetlands.

At the federal level, the U. S. Army Corps of Engineers’ general permits or nationwide permits are issued for similar classes of activities that result in impacts considered to be either individually or cumulatively minimal on wetland functions, water quality, or the aquatic environment. Nationwide Permit 26, for example, allows discharges of up to 10 acres of fill to *headwater* and *isolated* wetlands. (A pre-discharge notification is required for fills of between 1 and 10 acres.)

Site-specific wetland functional assessment studies have been conducted to apply and compare scientific wetlands assessment techniques, including Best Professional Judgment, to wetlands within various landscape positions. These studies indicate that *above-headwater* wetlands may demonstrate high functionality across the suite of wetland functions. Additionally, although considered to be of minimal impact, case studies on the effects of Nationwide Permit 26 in other states have found off-site impacts to fish and wildlife habitat in most cases (Gladwin and Roelle, 1992). In Delaware, lack of state legislation and deficiencies in the federal regulatory program pose a particular threat to unique wetland ecosystems of less than one acre and to headwater wetlands of high functionality.

Section 401 of the Clean Water Act allows for states to strengthen the U.S. Army Corps of Engineers’ “dredge and fill” program through certification that permit actions will not adversely impact wetlands, surface-water quality, or aquatic ecosystems. Delaware issues water-quality certification for individual U. S. Army Corps of Engineers permits on a case-by-case basis. However, to date, the state has chosen to waive water-quality certification for nationwide permits.

Delaware’s Subaqueous Lands Act does not adequately protect all nontidal rivers, streams, and ponds/lakes. State jurisdiction is defined based on a legal interpretation of “navigability,” which is determined by the depiction of the waterway as a blue line on a U.S. Geological Survey topographic map. This excludes many headwater Piedmont streams and associated riparian and slope wetlands that are intermittent but which provide important water-quality and habitat functions. Additionally, the recent passage of Senate Bill 320 exempts any public agency in New Castle County from the subaqueous permit review process for activities in waterways where the purpose is the “repair, retrofit, or maintenance” of waterways or structures within state jurisdictional waters. The lack of scientific and regulatory oversight for the dredging and/or channelization of Piedmont

streams for flood control may directly or indirectly adversely impact associated riparian wetlands. The Subaqueous Lands Act lacks a buffer provision, allowing indirect and cumulative impacts to aquatic systems, including wetlands from construction projects.

### *Recommendations*

- ◆ Use information generated through EPA state wetland program development grants as one basis for setting conditions for state water-quality certification for individual U. S. Army Corps of Engineers permits.
- ◆ Consider any future or potential certification of nationwide permits for nontidal wetlands as part of the overall Comprehensive Conservation and Management Plan for nontidal wetlands.
- ◆ Strengthen the Subaqueous Lands Act through revised means of determining jurisdictional waters so that headwater and intermittent streams are regulated.
- ◆ Consider amending the Subaqueous Lands Act to include a buffer provision.

## LIVING RESOURCES

### **White Clay Creek Watershed**

White Clay Creek has been the focus of numerous fish and macroinvertebrate studies, some of which are still under way. Stangl (1994) studied the northern portion of the Delaware stretch of this creek looking at the feasibility of establishing a permanent trout fishery. Although not native to White Clay Creek, stocked trout have supported a popular sport fishery in the creek for many years. Stangl found a deficiency of suitable trout habitat. This was apparently due to a number of factors including excessive bank erosion and siltation, inadequate pool habitat and vegetative overhang, extreme high summer water temperatures, and high nutrient runoff. As part of the study, inventories of macroinvertebrates and fish species were conducted. Stangl is now preparing a report that will recommend the minimum allowable flow rates required to maintain fish populations in the creek.

In addition to the above study, Stream Watch volunteers have been collecting macroinvertebrate data in White Clay Creek for the past five years. In general, they have found a pattern of declining water quality in the lower (Delaware) portion of the creek relative to the upper (Pennsylvania) portion (Bernard Sweeney, pers. comm.). At the conclusion of this year, the fifth year of study, the Stroud Water Research Center will summarize and report on the findings.

The creek and the area immediately surrounding it provide habitat for a number of rare species — most notably the bog turtle and a long list of Delaware's rare plants, including

four which are found nowhere else in the state. This type of habitat has been surveyed and is summarized (Delaware Natural Heritage Program, 1994). White Clay Creek State Park contains appropriate habitat for the Delmarva Fox Squirrel, which could be considered for future releases if the federal moratorium is lifted (Ken Reynolds, pers. comm.). A federally listed mussel species has been recorded in the Pennsylvania portion of the tributary; the Delaware portion has never been surveyed for mussels, but potential habitat exists. A variety of botanical and zoological inventories have been conducted in selected sites in the watershed and can be referenced for species lists (e.g., National Park Service, 1994; White Clay Creek Study Task Force and Advisory Committee, 1994; and White, 1990b and 1991).

Many parts of the watershed are protected from development, but one of two high-quality tributaries within the watershed may potentially be dammed to form a backup reservoir for New Castle County. This move would result in direct and dramatic habitat loss in these areas.

### **Red Clay Creek Watershed**

In the earlier part of this century, Red Clay Creek suffered extremely severe impacts from toxic pollutants. In the 1950s and 1960s, there were no fish living in the creek (Shirey, 1991). By the late 1980s, things had recovered to the point where fish were once again inhabiting the creek, but 1995 surveys found no mussel species in the creek (Delaware Natural Heritage Program, 1996b). Odonates (dragonflies and damselflies), another group which is sensitive to water quality, are apparently in a degraded but improving state (Delaware Natural Heritage Program, 1996b). A 1995 study of the macroinvertebrates and algae in the portion of the creek near Ashland found that the creek was "severely impaired" (Mercatante, 1995).

The Delaware Nature Society has played an active role in land protection in the watershed and has supported studies of living resources in some of these areas. These reports include Delaware Nature Society, 1995; Durell, 1992; Gallagher, 1994; and Mercatante, 1995.

Studies of terrestrial fauna indicate that there is some bog turtle habitat in the watershed although good estimates of population size or stability do not exist. The Delaware Natural Heritage Program inventoried declining bird species that were nesting in selected areas of the watershed. A number of parcels provided habitat for forest-interior species that are declining in the Piedmont Basin and throughout their range. Surprisingly, no forest-dependent birds of prey were observed during the study, although the researcher had expected to find barred owls, Cooper's hawks, broad-winged hawks, and/or red-shouldered hawks (Delaware Natural Heritage Program, 1996b). This is cause for concern.

In addition to the species mentioned above, the Delaware Natural Heritage Program data base indicates that there are numerous occurrences of state-rare vertebrates and state-rare plants in the watershed, including six plant species that occur nowhere else in the state.

The watershed is also the site of Delaware's portion of the "state line serpentine barrens." Serpentine barrens are unique grassland habitats that occur on soils formed atop outcrops of serpentinite rock. The rock and soils are high in chromium, magnesium, and other minerals, and hence are toxic to all but the few plant species that have evolved tolerances. This community type, one of the rarest in the United States, has a clustering of occurrences in the vicinity of the Maryland-Delaware-Pennsylvania confluence. This community is of conservation concern not only because of the rarity of the community type, but also because it provides habitat for state and globally rare plant species.

In 1932, Delaware had approximately 500 acres of this unique habitat. By 1975, this habitat had been reduced to 27 acres; and by 1992, it had degraded even further. A portion of the habitat loss is due to the creation of Hoopes Reservoir, which flooded some serpentine barrens; the remaining loss is due to conversion of former barrens to planted lawns. Much of the remaining barrens are threatened with overgrowth by red cedar (*Juniperus virginiana*) trees and exotics. These areas, including those managed as lawns, are restorable (McAvoy, 1992; Nature Conservancy, 1992).

### **Brandywine Creek Watershed**

The Delaware Natural Heritage Program data base indicates that numerous state-rare animal and plant species are found in and around the creek, including seven plant species found nowhere else in Delaware. Bog turtles have been found in this watershed; and the regal fritillary, a federally listed butterfly that is now extirpated from Delaware, was last found here. Brandywine Creek State Park has appropriate habitat for Delmarva fox squirrels, but a reintroduction has never been attempted in the park. Some years ago, a reintroduction in an adjacent area in Pennsylvania was attempted but was not successful (Ken Reynolds, pers. comm.).

Brandywine Creek State Park is a favorite spot for amateur naturalists, especially bird-watchers. The park maintains lists of birds observed as well as other natural history data collected within the park. See also White (1985, 1990a) for inventories of terrestrial vertebrate species in the watershed.

The presence of stone flies (*Plecoptera*) in the northernmost Delaware sections of the creek and the creek's northern Delaware tributaries indicate good water quality (Shirey, 1991). At one time, shad spawned in the creek, but excessive damming resulted in the loss of this fish species.

They temporarily returned when the upper Delaware River was overly polluted, and fish ladders were installed on Brandywine Creek. As the Delaware River pollution was cleaned up, the fish abandoned the Brandywine. The fish ladders fell into disrepair and have since been removed.

### **Shellpot Creek Watershed**

No studies of the living resources in this watershed were uncovered, other than Shirey (1991), which lists fish species found in the creek. The Delaware Natural Heritage Program data base shows virtually no occurrences of rare species within this highly degraded watershed.

### **Naamans Creek Watershed**

As with Shellpot Creek, the South Branch of Naamans Creek has not, to our knowledge, been the subject of any specific studies of its living resources other than Shirey (1991). In the summer of 1996, it was the subject of media attention because of a fish kill, apparently caused by careless draining of chlorinated water from a community pool directly into the creek.

Recently, the forested habitat adjacent to the creek was severely damaged by the replacement and expansion of a gravity-fed sewer line parallel to the creek. The vegetation and topsoil from a forested swath approximately 50 feet wide, adjacent to the creek, were completely removed. As a result of repetitive construction activity, virtually no native plants remained in the corridor, and the soil was sufficiently altered and compacted so as to prevent rapid recolonization by native species. The long-term effect of this activity, if not remedied, will be to fragment and degrade the forest community and to introduce non-native species into the forest.

### **Upper Christina River Watershed**

A botanical inventory of the riparian zone of the Christina River was conducted in 1995 (Delaware Natural Heritage Program, 1996b). Floodplains of the watershed have suffered great degradation. Environmental stress has led to the establishment of alien plant species and garden escapes, which are displacing native vegetation. Activities such as the installation of sewer lines within the floodplain and clearing of native vegetation by neighboring homeowners contributed to establishment of exotics and the overall floodplain degradation. There were a handful of state rare-plant species, with one glaring exception. In the 1930s, the Christina River floodplain harbored populations of swamp pink (*Helonias bullata*), a federally listed species. These populations gradually declined in the 1970s and are now apparently extirpated from the basin. The primary cause of the decline is thought to be increased rates of sedimentation and direct habitat manipulation.

Upland forests adjacent to the riparian areas were also inventoried and described within the report. As with the entire Piedmont Basin, the general lack of large, mature, undisturbed forests was noted. Complete species lists for each of these areas is given within the report.

### Mid- and Lower Christina River Watershed

A botanical inventory of the riparian zone of the Christina River was conducted in 1995 (Delaware Natural Heritage Program, 1996b). The freshwater tidal marshes west of Churchmans Marsh were found to be in very good shape. Although there was low floristic diversity and no rare plant species, this is normal for this type of habitat. These marshes provide important wetlands functions and wildlife habitat.

Bald eagles use the marshes and waters of the lower Christina River and can often be seen soaring above Interstate 95. Their protection is a critical concern in this watershed.

Habitat in this watershed continues to be lost to development. In addition, large portions of marsh (Churchmans Marsh or Artesian Marsh) will be lost if the new reservoir for New Castle County is placed here. The Delaware Division of Fish and Wildlife has incorporated the tidal marshes and impoundments along the lower Christina as part of the Northern Delaware Wetlands Rehabilitation Project.

## AIR

### Ozone

Ozone is the only air pollutant currently monitored by the state that is known to be present in concentrations high enough to cause harm to human health and welfare (including effects on vegetation and damage to some materials). Episodes of high ozone occur during the summer months and impact the entire Piedmont Basin.

### Deposition

Deposition of pollutants from the atmosphere to land and water surfaces can affect the Piedmont Basin.

#### *Nitrogen*

Atmospheric deposition of nitrogen (both wet and dry) is known to be an important contributor to excess nutrient problems in ecosystems like the Piedmont Basin; estimates of nitrogen entering a system from the atmosphere range from 10% – 40% of the total nitrogen.

#### *Acid Rain*

Precipitation in the Piedmont Basin is known to be acidic, with an annual average pH of 4.2.

### Air Toxics

Chemicals commonly known as air toxics can be a concern due to ambient air concentrations and/or

deposition. Limited ambient air monitoring has been done; some is continuing. Monitoring for toxics in deposition has not been done. There have been no direct studies in the Piedmont Basin on ecosystem impacts of air toxics.

## CONTAMINANT SOURCES

### Solid Waste

Piedmont residents and businesses together throw away more than 800 million pounds of trash each year. Nearly all of this waste is disposed of in landfills. Improperly designed or operated landfills can cause pollution of groundwater, surface water, and air and serve as a potential breeding ground for disease-carrying insects and rodents. Since the mid-1960s, landfills have been regulated by the state to reduce these risks. Modern landfills regularly cover the waste to control insects and rodents and are designed to include both a bottom liner to prevent leachate (“garbage juice”) from contaminating ground- or surface water and a gas collection system to control odors and collect methane. Where once nearly every community had its own town dump, today there are only two landfills operating in the Piedmont Basin (see Map 4).

The most pressing solid waste environmental concern today is what to do with our trash when the existing landfills run out of space. Locating a new landfill in a densely populated area like the Piedmont Basin would be difficult if not impossible because no one wants to live next door to even a “modern” landfill. To make our existing landfills last as long as possible, we must reduce the amount of waste to be landfilled. This can be achieved through the following:

- ◆ *Reducing Waste Generated* — The state through its Pollution Prevention Program is working with businesses to reduce waste by using raw materials more efficiently and to eliminate unnecessary packing materials from consumer goods.
- ◆ *Recycling Waste* — Currently there are 47 drop-off recycling centers in the Piedmont Basin that annually collect some 14 million pounds of recyclables.
- ◆ *Burning Waste* — Several communities in Pennsylvania burn their waste to both reduce the volume of material that must be landfilled and to generate electricity.

### Septics

Septic systems may contribute significantly to groundwater nitrate levels. New Castle County has already eliminated the use of many septic systems in areas of high failures, unsuitable soils, and sewer-system availability.

Many older subdivisions are now proposed for septic elimination. To minimize nutrient-loading problems from septic systems, we need to encourage development that works with the existing landscape rather than a cut-and-fill philosophy and promote the establishing of buffers along streams to improve water quality and habitat.

### Hazardous Materials

In 1995, Delaware businesses generated approximately 27,158 tons of hazardous waste. Of that amount, 19,212 tons were generated by Resource Conservation and Recovery Act (RCRA) large-quantity generators. Eighty-eight percent of the hazardous waste generated by RCRA large-quantity generators came from facilities in New Castle County. One of the greatest challenges facing DNREC today is helping industry find ways to reduce or eliminate the amount of hazardous materials managed. The impacts from even a small reduction in the amount of hazardous materials managed improves environmental quality in a number of ways. Important reduction measures include the following:

- ◆ Decreasing the levels of hazardous constituents managed through air stacks, National Pollutant Discharge Elimination System (NPDES) outfalls, and Publically Owned Treatment Works (POTWs).
- ◆ Reducing the chances of releasing hazardous chemicals during their storage, handling, transportation, treatment, and disposal. The less waste managed, the fewer opportunities for spills.
- ◆ Decreasing the hazardous constituents in consumer products.
- ◆ Eliminating or decreasing the need for hazardous waste disposal capacity, thereby reducing the potential for releases from disposal units.

Other challenges facing DNREC include the following:

- ◆ Working with zoning and land-use planning agencies to encourage the siting of businesses managing hazardous materials away from residential areas, schools, day care centers and environmentally sensitive areas such as riparian zones, floodplains, wetlands, and Water Resource Protection Areas (see Map 5).
- ◆ Working with businesses and industries to locate in and/or re-use brownfields via the Voluntary Cleanup Program.
- ◆ Accelerating the rate of cleanup of RCRA Corrective Action sites.
- ◆ Accelerating the rate of cleanup of Hazardous Substance Cleanup Act (HSCA) sites.

- ◆ Helping hazardous waste generators achieve 100% compliance with the Delaware Regulations Governing Hazardous Waste.
- ◆ Identifying non-reporting hazardous waste generators.
- ◆ Identifying sites that release or may release hazardous substances.

## LAND USE

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There are many land-use issues in the Piedmont Basin. These are the selected issues for the preliminary assessment where DNREC has a role.

The growth in all Piedmont Basin watersheds is a result of easy access to the Washington, Baltimore, Philadelphia, and New York megalopolis and to population growth. Most of the growth that has occurred since 1982 has been related to suburban housing, office, and commercial development. The development of large tracts of land into large-lot suburban tracts consumes land quickly as compared to village centers, community integrated development, extension of existing communities, and infill. On a per-capita basis, urban development produces fewer environmental, infrastructure, and services costs as compared to sprawled development.

The Shellpot Creek and Naamans Creek watersheds are subject to flash floods due to the high percentage of impervious areas. Much of the development in these watersheds was built or approved before there were controls on floodplain development, filling of wetlands, and stormwater management.

Small communities such as Arden, Ardencroft, Ardentown, Bear, Bellefonte, Centerville, Christiana, Claymont, Elsmere, Hockessin, Newport, Stanton, and others may not have the ability to raise their quality of life through redevelopment, infill, joint governance districts, and annexations. They may lack information to make informed choices and not be organized. To facilitate desirable growth, many communities will require the assistance and cooperation of federal, state, and county governments.

### Land-Use Related Opportunities for DNREC

The greatest development pressure in the Piedmont Basin exists in the Hockessin, upper White Clay, Glasgow, and Pencader Hundred areas. These are areas where DNREC may have a limited window of opportunity to acquire and preserve important open space and guide development to attain environmental goals.

The Shellpot and Naamans watersheds appear to be almost completely built out, which means that providing waterway restorations to address flash-flooding may be prohibitively expensive throughout these watersheds.

Research may reveal cost-effective methods to ameliorate flash floods in these watersheds.

Nearly all undeveloped areas in the Piedmont Basin are zoned for some type of development or are in public open space. To achieve better land-use decisions, DNREC may find it in its best interest to focus its efforts where it may actually have some influence over important causes and effects. For instance, zoning has been associated with stream sedimentation, changes in flooding patterns, wetlands losses, habitat losses, toxicity in the food chain especially where fish consumption advisories are concerned, increases in the costs of services delivered to sprawled development, increases in infrastructure costs, increases in the extent of impervious area, reduced air quality, reduced habitat diversity, and decreases in the quality of life.

Improvements in land-use decision making could be made, and it appears that DNREC could focus on improving zoning because it is something for which we have some resources to work on and it can positively affect other areas of concern. Efforts are already under way in the state to improve the quality of information that is provided to local governments on planning issues. For the first time since 1967 as part of the Delaware Tomorrow Commission, the state of Delaware has developed planning goals and guiding principles as part of the 1995 Shaping Delaware's Future Act. DNREC has supported strengthening the link between growth management and capital improvements programming, sunsetting, infill, clustering, mixed-use zoning, municipal redevelopment, and historical structure adaptive re-use to promote sustainable uses of the Piedmont Basin's resources. This could be implemented by DNREC representatives attending planning and zoning meetings and providing information to support environmentally sensitive land-use decisions.

*Comment:*

*Zoning began in New Castle County in 1954. About two years later, the county established a planning department. At that time, most environmental issues were not as great a concern as they are today, either nationally or locally. However, much of our present settlement pattern was established as an outgrowth of the cumulative effect of all the development decisions made since the Swedes landed at the Rocks on the Christina River in 1638. Zoning is used to preserve property values and control nuisances by providing for separation of individual uses and wide separation of incompatible uses. After World War II, federal programs provided economic subsidies for sprawled suburban development, which had a substantial impact on current land-use patterns in New Castle County.*

There is a need to assess and thoughtfully weigh, along with other criteria, the environmental impacts of infrastructure plans before they are approved. The state Wastewater

Facilities Advisory Council is developing a methodology that can serve as an example for other infrastructure-enhancing programs. Modeling of the environmental impacts of projected probable build-out scenarios should lead to useful information for improved environmental decision making and management.

**Land-Use Related Opportunities for Other State Agencies**

The present Delaware GIS (DEGIS) map is not accurate for guiding land-use policies and decisions at the individual parcel level. But if it is refined, the DEGIS project can become a much more effective tool. More effort is needed from all state agencies to create a fortified, more comprehensive, and more refined state GIS map to make it a more useful decision-making tool for individual programs.

New infrastructure-building patterns could lead to inappropriate settlement/development (build-out) patterns. State agencies that provide or approve infrastructure should coordinate with DNREC and the Office of State Planning Coordination to ensure that the resulting development pattern is environmentally reasonable.

**Land-Use Related Opportunities Available in Water-Supply Planning Initiatives**

Land-use impacts in the White Clay Creek watershed would likely result from the building of a reservoir at Thompson Station or Corner Ketch. Creating waterfront property would attract people who may want to build on the water if sections of the shore are privately owned. If a possible reservoir is publicly owned, there would be an incentive to use it for recreation. These sites would require buffer areas and low-density development to control impacts to water quality in the reservoir.

Hoopoes Reservoir in the Red Clay Creek watershed provides emergency supply to the City of Wilmington and the Piedmont Basin. Wilmington's infrastructure once served 120,000 people and now serves 72,000 residents. Its reserve capacity and the lands that protect it will continue to be important to the Piedmont Basin.

The only public surface-water supply intake in the Christina watershed is at Smalley's Pond. Upstream of the pond, there are opportunities to protect this section of the Christina. Development pressure in the area, soils that stay suspended in water, and other nonpoint source problems including septic system failures all impact Smalley's Pond and the Becks and Sunset ponds that empty into it. Due to the public expense of building a major reservoir, additional protection of existing surface supplies such as Smalley's Pond should be evaluated. These sites require natural buffer areas and development controls to limit impacts on water quality and quantity.

## **Complying with the Shaping Delaware's Future Act: Watershed Issue Identification**

In each of the Piedmont Basin watersheds, the three most applicable state planning goals and priority watershed issues were identified to show which direction the monitoring phase, management plan, and other phases could take.

### *White Clay Creek Watershed*

*Goal: Protect critical natural resource areas from ill-advised development.* The White Clay is important for water supply and for recreation. It is also an area where strong pressure for development may infringe on DNREC's ability to provide for these needs unless land acquisition and other conservation efforts are strengthened.

*Goal: Encourage redevelopment and improve livability of existing communities and urban areas, and guide new employment into underused commercial and industrial sites.* Several vacant industrial sites in the City of Newark have high potential under initiatives such as the brownfields program to provide high-quality employment and other opportunities.

*Goal: Streamline regulatory processes and provide flexible incentives and disincentives to encourage growth in desired areas.* If strengthened, existing brownfields and other redevelopment programs could recycle more sites.

### *Red Clay Creek Watershed*

*Goal: Protect critical natural resource areas from ill-advised development.* Development pressure around the Hockessin area may limit the opportunity for land acquisition and conservation programs to protect ground- and surface-water supplies.

*Goal: Encourage redevelopment and improve livability of existing communities and urban areas, and guide new employment into underused commercial and industrial sites.* The Red Clay Creek has contamination from zinc in its sediments from the NVF operation and PCBs from a waste dump in Kennett Square. The fishery is not used, and little contact recreation occurs. Efforts to remediate Red Clay Creek could result in enhanced recreation and improve the quality of the water supply to United Water at Stanton.

*Goal: Promote mobility for people and goods through a balanced, multi-modal transportation system.* The historic investment in transportation infrastructure, if maintained and managed, could stimulate greater use of mass transit and reduce dispersion of development into more sensitive areas.

### *Brandywine Creek Watershed*

*Goal: Protect critical natural resource areas from ill-advised development.* The protection of the water supply for the City of Wilmington through land conservation is important to the county and to the state.

*Goal: Encourage redevelopment and improve livability of existing communities and urban areas, and guide new employment into underused commercial and industrial sites.* Brownfields along Brandywine Creek and in Wilmington present opportunities for economic growth and environmental improvements.

*Goal: Promote mobility for people and goods through a balanced, multi-modal transportation system.* Wilmington has the population density and the transportation infrastructure for an effective mass transit system.

### *Shellpot Creek Watershed*

*Goal: Encourage redevelopment and improve livability of existing communities and urban areas, and guide new employment into underused commercial and industrial sites.* Brownfields along the waterfront and in urban areas have redevelopment potential.

*Goal: Direct state investment and future development to existing communities, urban concentrations, and designated growth areas.* This watershed is almost completely built out. Improving the quality of life in existing communities reduces environmental stress on open land and increases benefits from existing infrastructure.

*Goal: Promote mobility for people and goods through a balanced, multi-modal transportation system.* This watershed has the population concentration and transportation infrastructure to facilitate mass transit.

### *Naamans Creek Watershed*

*Goal: Encourage redevelopment and improve livability of existing communities and urban areas, and guide new employment into underused commercial and industrial sites.* Brownfields along the waterfront and in urban areas have redevelopment potential.

*Goal: Promote mobility for people and goods through a balanced, multi-modal transportation system.* This watershed has the population concentration and transportation infrastructure to facilitate mass transit.

*Goal: Protect critical natural resource areas from ill-advised development.* High-quality wetlands along Naamans Creek in the Lancashire, Arden,

and Radnor Green areas are an important community asset in public and private open space. According to the Arden Office of Community Planning, the watershed's riparian habitat requires additional conservation efforts including preserving remaining forestlands, correcting mapping errors that deleted blueline streams, and transferring administration of stormwater management back to DNREC.

### *Christina River Watershed*

*Goal: Direct state investment and future development to existing communities, urban concentrations, and designated growth areas.* Wilmington's infrastructure once served more than 110,000 residents; now 72,000 people reside there. The Port of Wilmington is an important state economic asset.

*Goal: Encourage redevelopment and improve livability of existing communities and urban areas, and guide new employment into underused commercial and industrial sites.* Large brownfields in and around the urban waterfront and other areas are attractive for redevelopment.

*Goal: Promote mobility for people and goods through a balanced, multi-modal transportation system.* Wilmington, with its population concentration, and as a hub for rail, highway, air, and water transportation, is the state's best prospect for developing an effective mass transit system that can consume less energy and produce less pollution per person and ton mile.

## RECREATION

### **White Clay Creek Watershed**

#### *Parks and Recreation*

The White Clay Creek watershed possesses the greatest acreage of protected open space of any of the six watersheds in the Piedmont Basin. These protected lands represent nearly 4,350 acres, with 7.3 miles of undeveloped riparian habitat along the main stem of the White Clay Creek. Nearly all the protected land is dedicated to public recreation. The majority of the land is located in White Clay Creek State Park, the White Clay Creek Bi-State Preserve north of Newark, and the Middle Run Natural Area administered by New Castle County. These recreational resources are regional in scope, attracting visitors from throughout the tri-state region. The remaining open space areas are maintained by New Castle County and the City of Newark park systems. The watershed has a wide array of land-based recreation along with above-average access to water-based recreation.

The development of a possible reservoir in the White Clay Creek watershed at any of the proposed locations including Corner Ketch, Thompsons Station, or Churchmans Marsh, would have lasting impacts on recreation in this watershed. Should Corner Ketch or Thompsons Station be selected for the proposed reservoir, large areas of recreational land, much of which lies within White Clay Creek State Park, would be lost for public use. Generally, lands along Churchman's Marsh are privately held, restricting public recreation at present.

Demographically, residents of the watershed are younger than the county average; therefore, the recreation needs here differ from the other northernmost watersheds. The population is beginning to stabilize after a decade of rapid growth. As indicated by the 1995 Recreational Needs Survey, the majority of the residents believe that more lands should be protected for conservation and recreational pursuits. Residents also indicated the need for additional paved hiking and bicycle trails, more freshwater fishing opportunities, and additional programs for teens and residents with disabilities.

#### *Fish and Wildlife Recreation*

The White Clay Creek watershed contains three of the state's six designated freshwater trout streams: White Clay Creek, Pike Creek, and Mill Creek. These streams receive approximately 72% (22,220) of the annual stocking of legal-sized trout, with White Clay Creek receiving by far the most (69%, or 21,300 trout) and Mill Creek receiving the least (1%, or 360 trout). Due to the number of fish stocked and the public access provided along the entire length of the stream, White Clay Creek receives the greatest fishing pressure of all stocked streams and has the highest angler success rate. Mill Creek receives one of the lowest amounts of fishing pressure and has the lowest angler success rate. Pike Creek receives moderate fishing pressure and has the second-highest angler success rate. Although Pike Creek has a high angler success rate, private property signs and fencing erected along portions of the stream have greatly decreased the fishing area available to anglers. If additional access along this stream is not secured, stocking of this popular and successful stream might be discontinued. Public access to the other streams is not as immediate a concern; however, both streams have been hampered by the lack of adequate angler parking. This problem is especially evident at White Clay Creek during the opening weekend of the season.

The upper stretch of White Clay Creek is designated as a special Fly-Fishing Only Area and provides a fishing opportunity unlike any other in Delaware. In an effort to improve this unique fishing opportunity, the Division of Fish and Wildlife has proposed to protect, enhance, and restore a 1,000-foot section of stream habitat by modifying existing conditions in or along the stream using habitat improve-

ment devices. These devices would consist of natural materials such as rocks and logs, and although primarily designed to improve fish habitat, they would also benefit other aquatic species and improve the stream's water quality. This proposal was presented to the White Clay Creek Preserve Bi-State Advisory Council — consisting of members of special interest groups and organizations that make recommendations to state agencies on activities within the preserve — and rejected in February 1995. Although the council's decisions are not binding, the Division of Parks and Recreation's internal policy has been to endorse their decisions as much as possible. Therefore, the habitat improvement project has been shelved indefinitely.

The only other area that receives substantial recreational fishing within the White Clay Creek watershed is at the confluence of Churchman's Marsh, Christina River, and White Clay Creek. This area is a popular boating and fishing area with target species including striped bass, catfish, and white perch. However, a fish consumption advisory has been issued for the area due to the presence of contaminants in edible portions of these species. Several small private ponds provide additional, but limited fishing opportunities within the watershed, and several of these have received pond management consultation from the Division of Fish and Wildlife for weed control and other water-quality problems. No public boat ramp facilities are available within the watershed and none is currently proposed.

Public hunting areas in White Clay Creek watershed are limited to White Clay Creek State Park. This park implements a very successful controlled deer hunting program, which annually provides over 650 hunters with archery and firearm sporting opportunities. Success rates of hunters vary between years and among the different seasons, but on average, over 70 deer are harvested per year, yielding approximately an 11% success rate. Although no other public areas allow hunting within the watershed, a fair amount of recreational hunting does occur on numerous private properties throughout the region.

Increasing deer populations within other portions of the White Clay Creek watershed have caused browsing damage to crops and ornamental shrubs, have increased deer/vehicular collisions, and have been associated with an increased risk of Lyme disease. Another species whose population has increased beyond acceptable levels within the watershed is resident, non-migrating Canada geese. This species exceeds its social carrying-capacity by creating annoyances such as excessive noise, defecation on lawns, eutrophication of small ponds, and herbivory of lawns and ornamental plantings. Recreational hunting, where it can safely occur, is the recommended management tool to reduce deer and resident geese populations to socially acceptable levels on both public and private lands;

however, in order to increase the success of this management tool, more public and private areas within the watershed need to implement hunting programs.

Three of the four final reservoir alternatives proposed to alleviate water supply problems in northern New Castle County are within the White Clay watershed. The impact of these proposed reservoirs on fish and wildlife recreational opportunities would be both positive and negative. A Churchmans Marsh reservoir would benefit recreational fishing, if permitted within the reservoir, while its construction would impact current recreational uses of the marsh, such as fishing, boating, and waterfowl hunting. Construction of the reservoir would also eliminate access of recreationally important anadromous and estuarine fish species from entering the marsh to spawn and feed.

Construction of either the Thompsons Station or Corner Ketch reservoirs would similarly benefit recreational fishing within the proposed reservoir, but also benefit the White Clay Creek by creating a cold-water trout fishery. If water was periodically released from the bottom of either of these reservoirs, water temperatures within the White Clay Creek would remain colder, possibly supporting a year-round trout fishery. Currently, the White Clay Creek is limited to a spring "put-and-take" trout fishery because trout are unable to survive in the stream's warm water for extended periods. The negative impacts to fish and wildlife recreation associated with the construction of either of these reservoirs would be the loss of private hunting areas.

## **Red Clay Creek Watershed**

### *Parks and Recreation*

Although there are large tracts of protected open space in the Red Clay Creek watershed, many of these tracts are not open to the general public. At present, there are only 422 acres of public parkland in this watershed. The New Castle County Department of Parks and Recreation provides a good variety of recreational opportunities in the southern half of the watershed, which is the most densely populated area. Major recreational facilities include the Delcastle Recreation Area, which is located on the divide between the Red and White Clay Creek watersheds, Brandywine Springs Park, Greenbank Park, and Ford Powell Park.

Population demographics show an aging, stable population, which is reflected in the recreational needs voiced by the watershed's residents. Residents generally are happy with the level of recreational opportunities existing in the watershed but would like to see additional programs for the elderly, teens, and people with disabilities. Residents also indicated a desire for greater access to water-based recreation. Unfortunately, the water quality of Red Clay Creek does not support any type of contact recreation or fishing.

### *Fish and Wildlife Recreation*

Recreational fishing and boating opportunities in the Red Clay Creek watershed are currently limited to several small private ponds. However, two areas — Red Clay Creek and Hoopes Reservoir — have the potential to provide outstanding recreational fishing. Red Clay Creek was a popular trout fishing stream until studies in 1986 revealed that the tissue of recently stocked trout was becoming contaminated with PCBs and chlorinated pesticides. In response, the divisions of Fish and Wildlife and Public Health have issued and continue to issue a fish consumption advisory for this stream. The stream has since been deleted from the trout-stocking program. In order for this stream to be reconsidered as a public fishery, sources of these contaminants would have to be determined and addressed, and then a monitoring program implemented to update contaminant levels within selected fish species.

Hoopes Reservoir, a reservoir for the City of Wilmington in which fishing is prohibited, has been periodically identified as a potential public fishing area. Although there is little argument about the reservoir's recreation potential, land-owners in the surrounding area have vehemently opposed making it a public use area. Their primary concerns have been increases in traffic, litter, noise, and other negative attributes sometimes associated with the creation of a public recreation area.

Although there are no public hunting areas within the watershed, a fair amount of recreational hunting does occur on numerous private properties throughout the region. Increasing deer populations in portions of the Red Clay Creek watershed have caused unacceptable browsing damage to crops and ornamental shrubs, have increased deer/vehicular collisions, and have been associated with an increased risk of Lyme disease. Recreational hunting, where it can safely occur, is the recommended management tool to reduce deer populations to socially acceptable levels on both public and private lands. However, in order to increase the success of this management tool, more public and private areas within the watershed need to implement hunting programs.

The majority of the mosquito surveillance and control in the Red Clay Creek watershed has been targeted to the marshes and surrounding uplands at the confluence of the Red and White Clay creeks. These marshes and vestigial creek beds are frequently flooded by severe rain events, and require an average of 3.3 aerial applications of insecticide per year to control larval mosquito populations. Control measures, as determined by light trap counts in the Glenville area, annually afford residents an average nuisance-free night rate of 87%, or 93 nights. The hilly topography of the more northern sections of this watershed do not lend themselves to extensive mosquito breeding and require less surveillance and control and have a higher average nuisance-free night rate.

### **Brandywine Creek Watershed**

#### *Parks and Recreation*

Large portions of the Brandywine Creek watershed north of the City of Wilmington have been protected through a number of means. Additional lands have been added to Brandywine Creek State Park, and large tracts of land are protected through conservation easements or are privately held by institutions such as Winterthur Museum and non-profit organizations such as Woodlawn Trustees. There are also several large parks owned by the City of Wilmington and managed by Delaware State Parks. These include Alapocas Woods, Rockford Park, and Brandywine Park. The New Castle County Department of Parks and Recreation also operates several community parks within the older suburban developments west of Concord Pike. The protection of lands along Brandywine Creek is critical to Wilmington's water supply.

Demographics in this watershed indicate an aging population. The upper portion of the watershed shows the oldest average age in New Castle County while a much younger population resides in the southern half of the watershed in Wilmington. This mix of ages validates residents' requests for additional programs for children, teens, and the elderly. The need for additional opportunities for walking, hiking, and biking, as well as greater access to water-based recreation, was indicated in all areas of the watershed.

#### *Fish and Wildlife Recreation*

The Brandywine Creek watershed contains two of the state's six designated freshwater trout streams: Wilsons Run and Beaver Run. These streams receive approximately 14% (4,210) of the legal-sized trout stocked annually, with Wilsons Run receiving 10% (3,095 trout) and Beaver Run receiving 4% (1,115 trout). Beaver Run receives the lowest amounts of fishing pressure and the second lowest angler success rate. Wilsons Run receives moderate fishing pressure and has moderate angler success. The higher fishing pressure at Wilsons Run can be partially attributed to its better public access, as the majority of the stream flows through Brandywine Creek State Park. Public access to Beaver Run is not an immediate concern; however, both streams have been hampered by the lack of adequate angler parking.

The only other area that receives substantial recreational fishing within the Brandywine Creek watershed occurs within Brandywine Creek itself. The nontidal portion of this stream provides the only sustainable smallmouth bass fishery in the state. This water body also occasionally yields unusual catches — such as muskellunge, walleye, and other species — which are transients from nearby Pennsylvania. The tidal portion of this stream is a popular boating and fishing area with target species including striped bass, catfish, and white perch.

Unfortunately, the divisions of Fish and Wildlife and Public Health have issued a fish consumption advisory for this creek because of the contaminants found in edible portions of various fish species. A no-consumption-of-fish advisory is in place for the tidal portions of this stream, while a limited-consumption-of-fish advisory is in place in the stream's nontidal portion. A limited consumption advisory recommends limiting meals of fish from these waters to no more than one 8-ounce meal per month. Several small private ponds provide additional, but limited fishing opportunities within the watershed, and several of these have received pond management consultation from the Division of Fish and Wildlife for weed control and other water-quality problems. No public boat ramp facilities are available in the watershed, and none is currently proposed.

Public hunting areas in the Brandywine Creek watershed are limited to Brandywine Creek State Park. This park implements a special antlerless deer hunting program in which approximately 85 hunters participate each year, while also helping to maintain the deer herd within the park's carrying capacity. On average, 43 deer are harvested per year, yielding a success rate of approximately 57%. Although no other public areas allow hunting in the watershed, a fair amount of recreational hunting does occur on numerous private properties throughout the region.

Increasing deer populations in other portions of the Brandywine Creek watershed have caused unacceptable browsing damage to crops and ornamental shrubs, have increased deer-vehicular collisions, and have been associated within an increased risk of Lyme disease. Another species whose population has increased beyond acceptable levels within the watershed is resident, non-migrating Canada geese. This species exceeds its social carrying capacity by creating annoyances such as excessive noise, defecation on lawns, eutrophication of small ponds, and herbivory of lawns and ornamental plantings. Recreational hunting, where it can safely occur, is the recommended management tool to reduce deer and resident geese populations to socially acceptable levels on both public and private lands. However, in order to increase the success of this management tool, more public and private areas within the watershed need to implement hunting programs.

In an effort to introduce recreational hunting to youths, especially adolescents (ages 12 – 15 years) with single parents, the Division of Fish and Wildlife has initiated a special Youth Hunt in the Flint Woods Section of the Brandywine Creek watershed. This new hunter education program provides young people the opportunity to experience recreational deer hunting under the guidance of a hunter education instructor.

## **Shellpot Creek Watershed**

### *Parks and Recreation*

The Shellpot Creek watershed represents the most suburbanized drainage area in the Piedmont Basin. Demographically, the population is aging and very stable. The region is home to several large recreational facilities: Bellevue State Park, Fox Point State Park, Rockwood Museum, Bringham Woods Park, Rock Manor Golf Course, and over 30 community parks. In total, there are approximately 1,030 acres of land dedicated to public recreation in the watershed. New Castle County operates most of the community parks as well as Talley-Day Park, which functions as a regional park. Many of these facilities are or soon will be connected by a system of pedestrian/bicycle trails, which will maximize the recreational opportunities not only for the residents of the Shellpot watershed, but northern New Castle County as well.

Needs expressed by the residents of this sub-watershed were additional hiking and biking trails, increased access to the Delaware River shoreline, and more programs for the elderly and for teens.

### *Fish and Wildlife Recreation*

Fish and wildlife recreational opportunities are limited within the Shellpot Creek watershed because it represents one of the most suburbanized watersheds in Delaware. Recreational hunting in this watershed is extremely limited because of human population densities and safety concerns. Recreational fishing and boating opportunities here are primarily limited to a few tributaries of the Delaware River and several private ponds scattered throughout the area. Bellevue and Fox Point state parks provide the only public fishing areas in the watershed, and no public boating or hunting areas exist. The pond at Bellevue State Park, a popular fishing area, is annually the site of several youth fishing days and skills clinics. These programs, hosted by the Division of Fish and Wildlife's Aquatic Resources Education Center, Delaware Bassmasters, and Stren, are geared to providing urban minority youths and adults with a supervised fishing experience.

Fox Point State Park provides some shoreline fishing of the Delaware River and has been considered a potential site for an additional public boat launching facility. The preliminary plans are to design a ramp to accommodate small trailered boats and personal watercraft ("jet skis"). To date, these plans have been stymied because of potential contaminant problems within sections of the park and will not progress until these issues are resolved.

## **Naamans Creek Watershed**

### *Parks and Recreation*

Naamans Creek watershed is another highly suburbanized drainage area. As with most of Brandywine Hundred,

the residents of the watershed are aging, and the population is stable. Although small in size, the area is served by a good system of community parks operated by New Castle County, and the northern section of Fox Point State Park lies along a substantial portion of the Delaware River shoreline. This section of Fox Point State Park is not yet developed. Plans for the development of this section are under way. The towns of Arden, Ardentown, and Ardencroft also have parks and open space within their corporate boundaries. Many of these areas are connected by a system of pedestrian trails. Residents in this area have expressed a desire to create an extended greenway along Naamans Creek, protecting the Naamans Creek Natural Area and providing opportunities for passive recreation.

Needs expressed by the residents of this watershed were very similar to those of the residents of Shellpot Creek watershed, such as additional hiking and biking trails, increased access to the Delaware River shoreline, and additional programs for seniors.

### *Fish and Wildlife Recreation*

Fish and wildlife recreational opportunities are limited within Naamans Creek watershed because of its small size and high human population density. Recreational hunting is extremely limited here because of safety concerns. Recreational fishing and boating opportunities are primarily limited to a few tributaries of the Delaware River and several private ponds scattered throughout this highly suburbanized area. Fox Point State Park provides the only public fishing area in the watershed, and no public boating or hunting areas exist. This state park provides some shoreline fishing of the Delaware River and has been considered a potential site for an additional public boat launching facility. Preliminary plans are to design a ramp to accommodate small trailered boats and personal watercraft ("jet skis"). To date, these plans have been stymied because of potential contaminant problems in sections of the park and will not progress until these issues are resolved.

## **Christina River Watershed**

### *Parks and Recreation*

The Christina River watershed is the most rapidly growing watershed in the Piedmont Basin. The area is served by a number of parks and recreational facilities operated by the cities of Newark and Wilmington and by New Castle County. The New Castle County Department of Parks and Recreation is actively acquiring recreational land along the Christina River through the subdivision development process. Major recreational land holdings include Iron Hill Park, Becks Pond Park, Lewden Green, and Coventry Ridge parks in the upper and middle sections of the watershed and Banning and Canby parks in the lower watershed. Many of these

facilities will be linked by the Christina Greenway. These facilities offer a wide array of recreational opportunities. The City of Wilmington also operates many smaller neighborhood parks in the watershed.

Overall, the demographics of the Christina watershed are substantially different from those of the other watersheds in the basin. The population of this area is growing rapidly and is substantially younger than that of the county as a whole, although there are demographic differences in different portions of the watershed. The lower portion of the Christina watershed demographically is characterized as urban and densely populated, with extremes in terms of population age. Generally, the older suburban areas west of Wilmington including the towns of Newport and Elsmere support an aging population while the population within the City of Wilmington tends to be younger. The upper and middle reaches of the watershed west of the Christina River and southwest of Newark have been experiencing a development boom, attracting a young, family-oriented population. This growth has placed a strain on existing recreational facilities.

Recreational needs expressed by residents are in line with the demographics of the watershed. Residents indicated a need for more land acquisition for recreation and preservation, additional playground and sports facilities, opportunities for historic and nature education programs, and increased programs for teens. A need for additional spending by state and county governments for parks and land acquisitions was also indicated.

### *Fish and Wildlife Recreation*

The Christina River watershed contains the only state-managed warm-water pond in the Piedmont Basin: Becks Pond. This 25-acre pond is consistently ranked among Delaware's top five ponds (ranked second in 1994) in terms of popularity among anglers (33,000 angler days) and for the last 20 years has been consistently the most heavily fished pond (1,284 angler days per acre). This fishing pressure is triple that of any other managed pond in Delaware, with the most significant increase in pressure occurring between 1990 and 1994. As a consequence of this tremendous fishing pressure, Becks Pond has a low angler success rate, ranked 28th of the 36 ponds surveyed in 1994. Part of this low angling success can also be attributed to the decline in water quality of the pond caused by increasing development of the watershed.

In an effort to improve angler success on this heavily fished pond, the Division of Fish and Wildlife has implemented several management and research programs. These include developing a long-range management plan, monitoring game fish populations, promoting the implementation of better stormwater management practices in the watershed, improving habitat by constructing brush shelters,

increasing the minimum legal length of largemouth bass taken from the pond from 12 to 15 inches, and supplementing game fish populations by stocking lower water-quality tolerant species, such as channel catfish.

The Christina River watershed also contains one of the state's six designated freshwater trout streams, Christina Creek. This stream receives approximately 14% (4,470) of the annual stocking of legal-sized trout, second only to White Clay Creek. This stream is also the second most popular in terms of fishing pressure and has a moderate angler success rate. Public access to Christina Creek is not an immediate concern; however, access is hampered by the lack of adequate angler parking.

Other areas that support substantial recreational fishing within the Christina River watershed are the Christina River, Smalley's Dam, Sunset Lake, and the ponds in Banning Park. The Christina River is the most popular of these areas, with target species including striped bass, catfish, white perch, and largemouth bass. Unfortunately, the divisions of Fish and Wildlife and Public Health have issued a fish consumption advisory for this river due to contaminants found in edible portions of various fish species. A no-consumption-of-fish advisory is in place for the tidal portions of this river (from the mouth of the river up to Smalley's Dam), while a limited-consumption-of-fish advisory is in place for Smalley's Dam and the nontidal portion of the river (from Smalley's Dam to Interstate 95). A limited-consumption advisory recommends limiting meals of fish from these waters to no more than one 8-ounce meal per month. Several small private ponds and tributaries to the Christina River provide additional, but limited fishing opportunities within the watershed. Several of these small ponds have received pond management consultation from the Division of Fish and Wildlife for weed control.

All three of the public boat ramp facilities in the Piedmont Basin are located in this watershed — two on the Christina River and one at Becks Pond. These ramps receive tremendous boating pressure, with the Christina River ramps being considered inadequate to handle the ever-increasing boat traffic utilizing them. This increased boating pressure has been attributed to a number of factors including improvement in water quality and recreational fisheries in the Christina and Delaware Rivers, rejuvenation of the Christina River waterfront in Wilmington, and the advent of personal watercraft ("jet skis"). An additional public launching facility is currently being sought within this basin to accommodate small, trailered boats and personal watercraft access to the Delaware and Christina rivers.

The Christina River watershed also contains one of the four final reservoir alternatives proposed to alleviate water-supply problems in northern New Castle County. Artesian Marsh, located along Interstate 95 and the Christina River, has been

proposed not only as a reservoir alternative, but also as a wetland mitigation site if another alternative is chosen. Currently, Artesian Marsh provides little if any fish and wildlife recreational opportunities; however, the construction of a reservoir or the restoration of this former wetland to a tidal marsh or tidal impoundment would benefit recreational fishing. Therefore, the impact of the proposed reservoir or wetland mitigation at Artesian Marsh would have a positive impact on fish and wildlife recreational opportunities.

Approximately 2,100 acres of degraded tidal wetlands scattered among 12 sites within the Christina River watershed are currently proposed for restoration and enhancement under DNREC's Northern Delaware Wetlands Rehabilitation Program. These restoration sites include popular or formally popular fish and wildlife recreation areas such as Churchmans Marsh, Old Wilmington Marsh, and the Nonesuch Creek Wetland Complex (a popular muskrat trapping area). A regional objective of this program is to improve a wide variety of recreational opportunities in the wetland, riverine, and adjacent upland habitats of each project site. One method being used to accomplish this goal is to restore tidal exchange and fish passage by replacing the traditional one-way tide gates with automated or mechanical water-control structures that allow two-way tidal flow. Currently, several of these rehabilitation projects are in the planning and development stages. These projects include Old Wilmington Marsh, which is a joint project between DNREC and the City of Wilmington; NeCastro Marsh, which is a wetlands remediation site associated with the Newport Superfund Site; and Newport Marsh and the Nonesuch Creek Wetland Complex, which are both joint projects between the Delaware Department of Transportation and DNREC.

Although there are no public hunting areas within the watershed, a fair amount of recreational hunting does occur on numerous private properties throughout the region. Increasing deer populations in portions of the Christina River watershed have caused unacceptable browsing damage to crops and ornamental shrubs, have increased deer-vehicular collisions, and have been associated within an increased risk of Lyme disease. Another species whose population has increased beyond acceptable levels within the watershed is resident, non-migrating Canada geese. This species exceeds its social carrying capacity by creating annoyances such as excessive noise, defecation on lawns, eutrophication of small ponds, and herbivory of lawns and ornamental plantings. Recreational hunting, where it can safely occur, is the recommended management tool to reduce deer and resident geese populations to socially acceptable levels on both public and private lands. However, in order to increase the success of this management tool, more public and private areas within the watershed need to implement hunting programs.

Mosquito surveillance and control efforts in the Christina River watershed are concentrated in two distinct areas: the forested wetlands in the southwestern section of the watershed, and along the Christina River. The forested wetlands along the Maryland border produce a group of mosquito species that breed in seasonally flooded areas, usually influenced by snow melt or spring rains. These areas are annually treated with insecticides via helicopter in early spring. Control measures in this area, as determined by light trap counts in Hickory Woods, annually afford residents an average nuisance-free night rate of 73%, or 78 nights.

Several formally tidal marshes of the Christina River are extensive mosquito-breeding areas following significant rain events. The Artesian, Southbridge, Airport, and Cherry Island marsh complexes each annually require an average of three aerial applications of insecticide over a combined total of approximately 4,500 acres. These marshes are usually treated during the summer via fixed-wing aircraft. Control measures in this area, as determined by light trap counts in Banning Park, annually afford residents an average nuisance-free night rate of 92%, or 98 nights.