The Restoration of American Shad To the Brandywine River

A Feasibility Study

By the
Brandywine Conservancy

January 28, 2005

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The National Fish and Wildlife Foundation,
Delaware Estuary Program

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Cover painting - Shad fishing at Gloucester on the Delaware, by Thomas Eakins, 1881
Used with permission of the Ball State University Museum of Art, College of Fine Arts, Muncie, Indiana.

Executive Summary

American shad (*Alosa sapidisimma*) were once an abundant migratory fish found throughout East Coast rivers and streams of North America, including the Brandywine River in Delaware and Pennsylvania. Shad were an important part of Native Americans' and early colonialists' diets, and later, were the basis of an important commercial fishery in larger rivers like the Susquehanna and Delaware. Spring runs of shad comprised a unique and dramatic natural phenomenon, now a lost part of our cultural heritage.

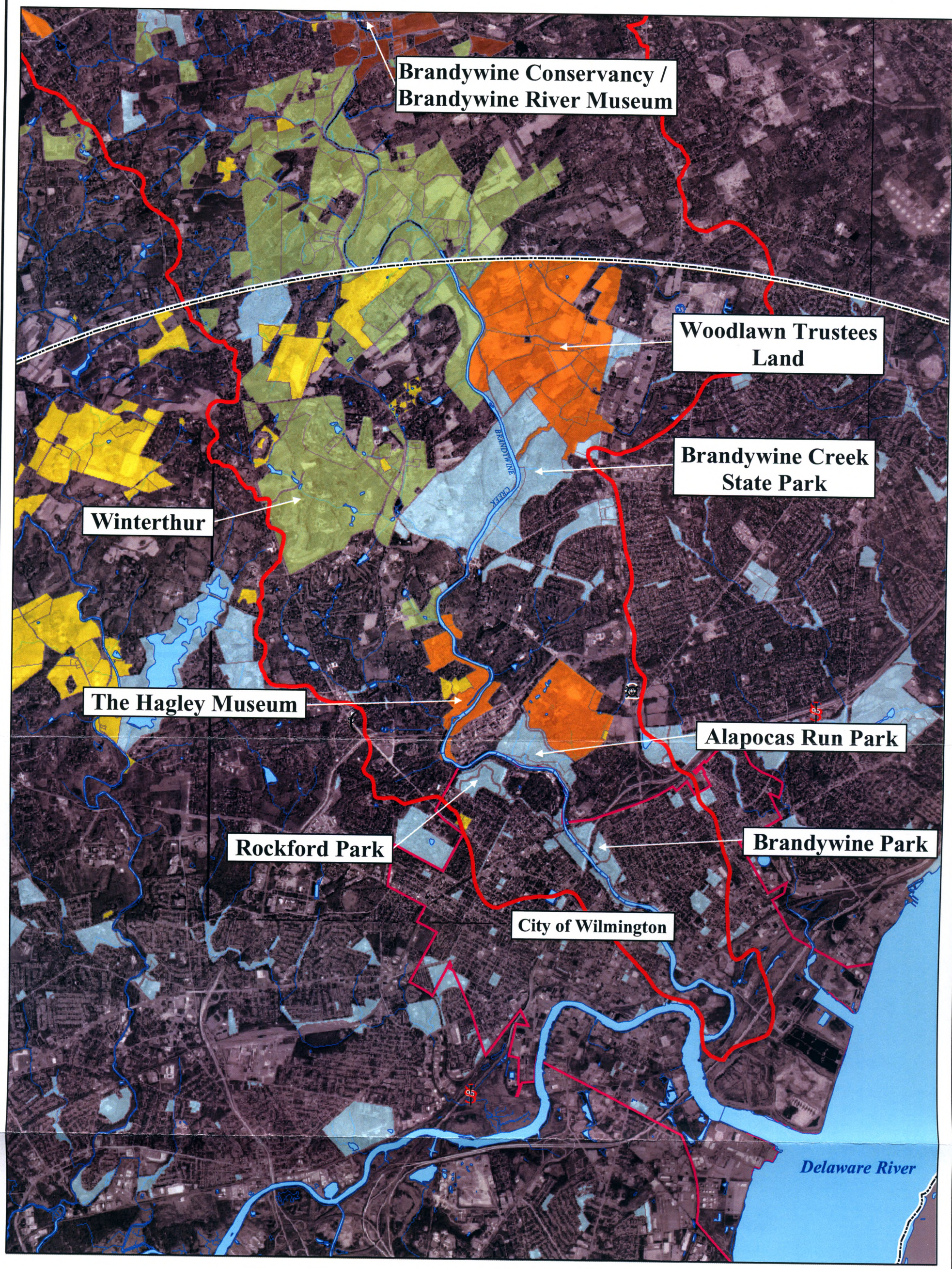
Shad restoration efforts are underway in numerous rivers and streams along the East Coast. A 1985 study called *A Review and Recommendations Relating to Fishways Within the Delaware Basin* commissioned by the Delaware Basin Fish and Wildlife Management Cooperative identified three tributaries historically used by shad for spawning which had "the greatest potential for restoration of the American shad." These include the Lehigh, the Schuylkill, and the Brandywine Rivers. System-wide shad restoration efforts are underway in both the Schuylkill and Lehigh Rivers, but not in the Brandywine.

Restoring shad to the Brandywine River could have important economic, ecological, and cultural benefits for the Brandywine Valley region generally and the Wilmington area specifically. With funding from the National Fish and Wildlife Foundation's Delaware Estuary Program, the Brandywine Conservancy has undertaken an analysis of the feasibility of restoring American shad to the Brandywine River, initially focusing on the State of Delaware where eleven dams currently block shad from access to upstream habitat.

The project's goals include establishing partnerships with dam owners and key stakeholders; identifying dam functions and fish passage options; and identifying technical and legal requirements, including costs and sources of funding for fish passage. Regional examples of successful fish passage projects were also researched and, in some cases, visited.

This report summarizes the results and findings of the project. Partnerships have been established and agreements secured with the owners of nine of the eleven dams as well as with key state and federal agencies. Dam owner-partners include the City of Wilmington (owner of dams #1 and 2); the State of Delaware (owner of dams #4 and 11); the Hagley Museum and Library (owner of dams #7, 8, 9, and 10), and the DuPont Company (owner of dam #6). One other dam (#3) is already breached, while the other (#5) recently changed ownership, and the new owner is in litigation. Therefore, the decision was made to wait before contacting them.

Results of this initial analysis indicate that there are technically feasible options for providing fish passage at all of the dams, which may include the following options: fish ladders, rock ramps, by-pass channels, or dam removals. These options are described and illustrated in the text. The Lower Brandywine River contains five historic districts on the National Register, one of which is also a National Historic Landmark. Five of the eleven dams on the Lower Brandywine (dam #s 7-11) are considered historic. At extra cost, it is possible to provide passage at historic dams using aesthetically sensitive materials (for example, granite stone facings) to blend, for example, a fish ladder into local surroundings. Choosing a specific implementation approach is, of course, at the discretion of the dam owner.



1 0.5 0 1 Miles

Environmental Management Center
BRANDYWINE CONSERVANCY
P.O. Box 141 Chadds Ford, Pennsylvania 19317 (610) 388-2700

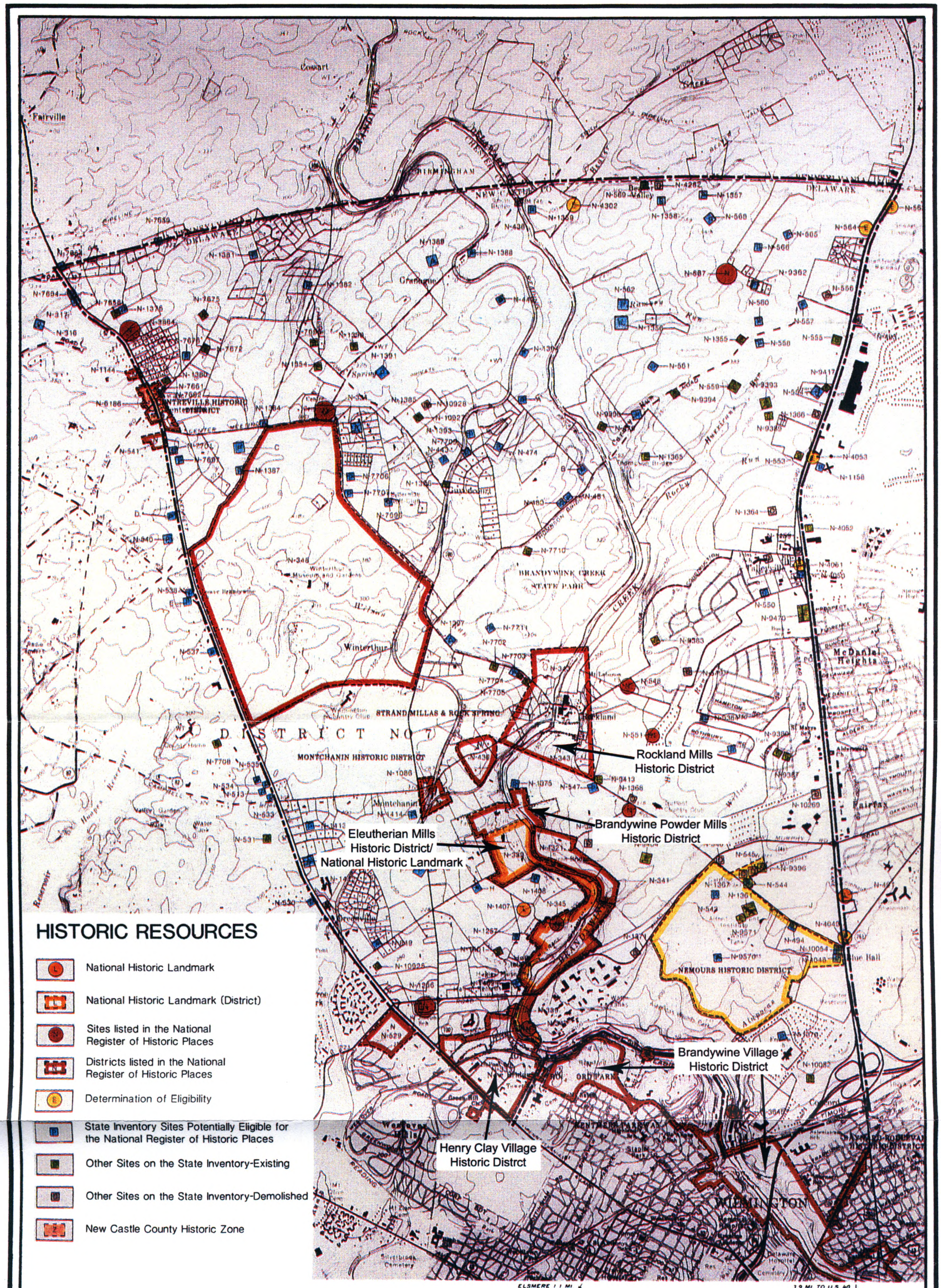
DATE SOURCE: Base data from Chester County GIS data distribution, 2001. Aerial photograph from PECO/ADR aerial photography, flown 2000. Delaware Hydrology data from USGS, 2004

Date: November 29, 2004

Map 1
Protected Lands
Lower Brandywine River Watershed

Legend

- State boundary
- Streams
- Water bodies
- City of Wilmington
- Brandywine Creek watershed
- Brandywine Conservancy easements
- Brandywine Conservancy owned lands
- Lands owned or eased by other land trusts
- Non-profit institution lands
- Public lands (federal, state, county, and municipal)



HISTORIC RESOURCES

- National Historic Landmark
- National Historic Landmark (District)
- Sites listed in the National Register of Historic Places
- Districts listed in the National Register of Historic Places
- Determination of Eligibility
- State Inventory Sites Potentially Eligible for the National Register of Historic Places
- Other Sites on the State Inventory-Existing
- Other Sites on the State Inventory-Demolished
- New Castle County Historic Zone

HISTORIC DISTRICTS ALONG LOWER BRANDYWINE RIVER

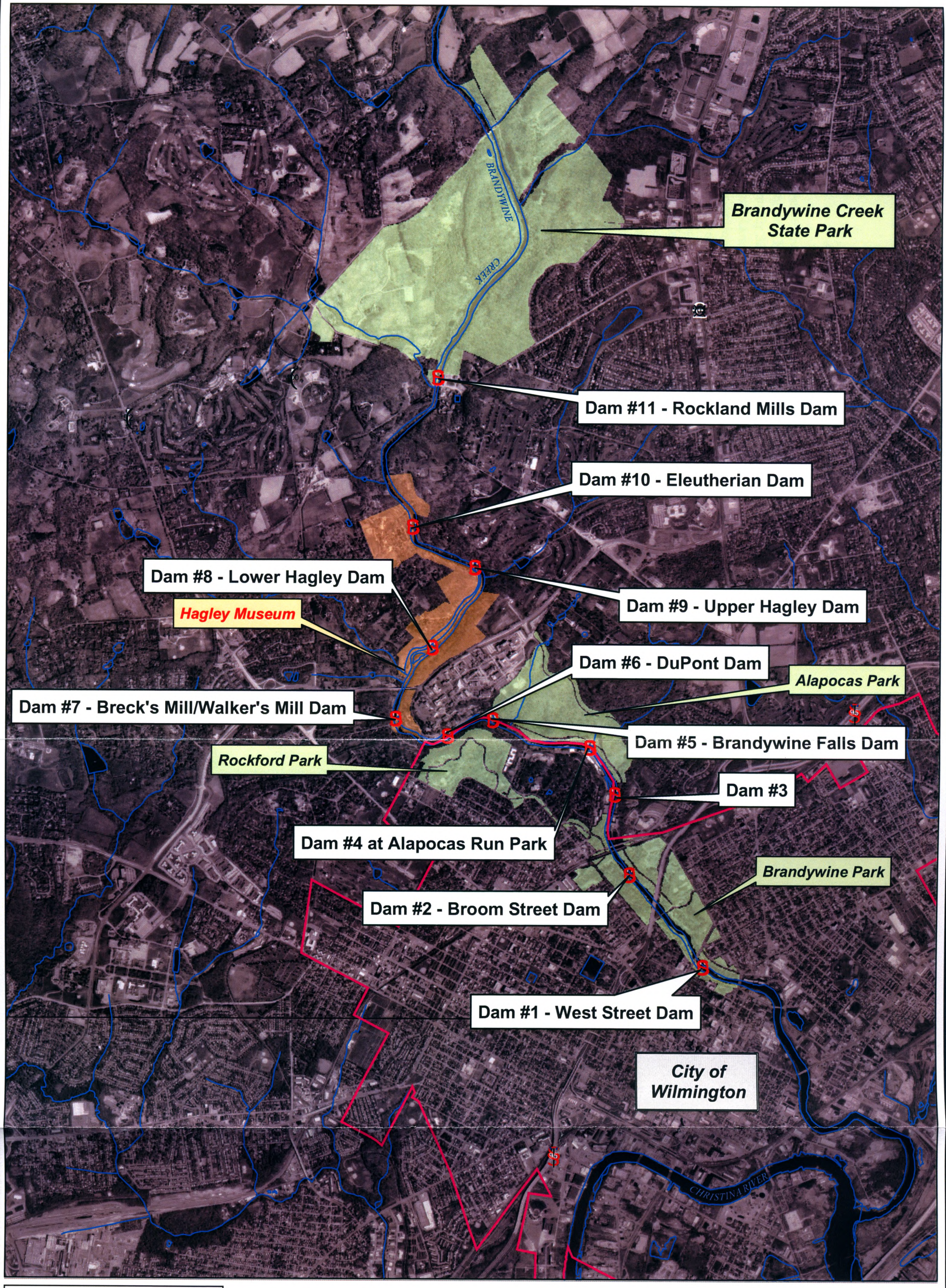
NEW CASTLE COUNTY DEPARTMENT OF PLANNING
NEW CASTLE COUNTY, DELAWARE

Map source: The Brandywine Valley Scenic River and Highway Study, New Castle County Department of Planning, September 1987.

Map 2

0 600 1200 2400 3600 Feet

Environmental Management Center
BRANDYWINE CONSERVANCY
P.O. Box 141 Chadds Ford, Pennsylvania 19317 (610) 388-2700



Legend

- Dam locations
- Streams
- Parks
- Hagley Museum lands
- City of Wilmington

Map 3 Delaware Dams of the Brandywine River

0 0.25 0.5 1 Miles

Environmental Management Center
BRANDYWINE CONSERVANCY
P.O. Box 141 Chadds Ford, Pennsylvania 19317 (610) 388-2700

DATE SOURCE: Base data from Chester County GIS data distribution, 2001. Aerial photograph from PECO/ADR aerial photography, flown 2000. Delaware Hydrology data from USGS, 2004.

Date: January 19, 2005

Chapter One

The Lower Brandywine River

The lower Brandywine River flows through an historic and developed landscape, including the City of Wilmington, Delaware, and the I-95 northeast corridor. The entire watershed measures approximately 325 square miles (208,000 acres). The headwaters are located in northern Chester and Lancaster counties in the Pennsylvania Piedmont. The Delaware portion of the Brandywine is about 15 miles long and falls about 138 feet in elevation from the state line to the mouth with the Christina River on the Atlantic Coastal Plain. From there, it is about one mile to the Delaware River and the fresh- and salt-water mix of the "Ecological Transition Zone" of the Delaware Estuary[1].

The State of Delaware has designated the Brandywine as a "Water of Exceptional Recreational or Ecological Significance."[2] The area possesses a wealth of highly scenic and historic areas. In addition, there are thousands of acres of protected and publicly-accessible land and trails, including several state and city-owned parks. The largest of these public lands is the Brandywine Creek State Park, which contains "one of the most beautiful high-canopied woody communities" found anywhere in the eastern United States Piedmont.[3] There are also large blocks of protected private land owned by the Woodlawn Trustees and other private lands protected through conservation easements held by the Brandywine Conservancy (see Map 1, *Protected Lands, Lower Brandywine River Watershed*).

As the steepest river in Delaware, the Brandywine River was heavily utilized as a source of water power for mills in the colonial period and early America. It is estimated that there were as many as 100 mills on the Brandywine during this period. The industrial legacy remains today in the river's poor water quality: it is included on state and federal government lists of polluted streams [the 303(d) list, named after the relevant section of the Clean Water Act] for –

- PCBs (polychlorinated biphenyls);
- Dioxins;
- Nutrients;
- Bacteria; and,

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[1] Delaware Estuary Management Committee, *Comprehensive Conservation and Management Plan for the Delaware Estuary*, Figure 10. September, 1996. The Transition Zone lies between the tidal freshwater of the Upper Zone and the open bay of the Lower Zone.

[2] According to DNREC, the Brandywine was selected in the late 1980's for the following reasons:

1. It supplies drinking water to the City of Wilmington;
2. It is socially and culturally significant;
3. It is an important recreational resource;
4. It is an example of a relatively ecologically healthy urban waterway; and,
5. It flows out of the Piedmont physiographic province, of which there is little in the State.

[3] "The trees are magnificent specimens … with some of record size," according to Dr. Albert E. Radford, Professor of Botany from the University of North Carolina, Chapel Hill. As quoted in Godfrey, Michael A., 1980, *The Piedmont, A Sierra Club Naturalist's Guide*, Sierra Club Books, San Francisco, CA.

- Habitat degradation.[4]

The Brandywine is part of a U.S. EPA-led clean up process for the Christina Basin. There are Delaware Fish Advisories in effect for PCBs in both the tidal and non-tidal portions of the river and for dioxins in the non-tidal portion. The Advisory recommends no fish consumption in the tidal portion and severely limited consumption (no more than two 8-ounce meals per year) in the non-tidal portion. According to one local fisherman, "You can tell the ones that are toxic. They have spots all over, or they're yellow inside."[5]

Still, "the Brandywine Valley," is a regional East Coast tourist destination and is collectively marketed as such by the Greater Wilmington Convention and Visitor's Bureau and other organizations. There are a number of non-profit institutions, museums, and gardens including Winterthur: An American Country Estate, the Hagley Museum and Library, the Delaware Art Museum, and the Delaware Museum of Natural History. The Lower Brandywine Valley itself is very historic, with five recognized Historic Districts (one of which is a National Historic Landmark) along the river, more historic districts close by, and a number of additional historic sites in the vicinity (see Map 2, *Historic Districts along the Lower Brandywine Valley*). From north to south, the five Historic Districts along the Brandywine are:

- Rockland Mills Historic District
- Brandywine Powder Mills Historic District
- Eleutherian Mills Historic District (also a National Historic Landmark)
- The Henry Clay Village Historic District
- Brandywine Village Historic District

Each of these districts represents historic uses of the Brandywine for water power and mills. Many of the mill buildings, mill races, and dams have survived. There are eleven dams and eight mill races still in existence on the Delaware portion of the Brandywine (see Map 3, *Delaware Dams of the Brandywine River,* and Table 1, found at the end of this chapter). Of the eleven dams, five are considered historic, while a sixth is a central part of an historic site, Brandywine Park, which was designed by famous landscape architect Frederick Law Olmstead. At this point the river serves as the primary drinking water supply for the City of Wilmington, and the dam (Dam #2) diverts water into a mill race and backs up water for a pump station, both of which feed into the primary City water filtration plant. The City has a current maximum demand of 30 million gallons per day.

Of the eleven dams, the first two are owned by the City of Wilmington and are associated with City infrastructure (sewer lines and water supply, respectively). Dam #2 is located within the Brandywine Village Historic District.

Two more dams (#s 3 and 5) are associated with property recently purchased by the O'Neill Brothers, a commercial real estate investment and re-development company. This company

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[4] Source: Chester County Water Resources Authority, et al, 2002. *Brandywine Creek Watershed Action Plan, Table 8,* West Chester, Pennsylvania.

[5] Fisherman Louis Bailey as quoted in the *Wilmington News Journal*, August 23, 1998, page A1.

purchased a former industrial site (Wilmington Piece Dye and Bancroft Mills) in the winter of 2003-04 and is in the process of re-developing the property as residential apartments. A hazardous waste cleanup is underway on the site, though according to DNREC information the contaminated soils are apparently localized and stable, and present a low likelihood of spreading toxins to the river. Dam #3 is currently breached.

The Delaware Department of Natural Resources and Environmental Control (DNREC) owns two dams (#s 4 and 11). They are managed by the Division of Parks and Recreation as a part of Alapocas Woods State Park and Brandywine Creek State Park, respectively. Dam #11 is a part of the Rockland Mill Historic District and is currently breached.

Dam (#6) is owned by the DuPont Company and is located at their Experimental Station. DuPont established the Experimental Station in 1903 to conduct and promote scientific research. The facility was DuPont's first general scientific laboratory and the site of many of the company's notable research achievements[6]. The dam once diverted water into a company water supply pump station.

Dam #7 runs between two historic mills and feeds two separate races. It is co-owned by the Hagley Museum and Library, which owns the historic Breck's Mill, and by Ashford Capital Management, which owns the historic Walker's Mill. Both mills, their races, and the dam are a part of the Henry Clay Village Historic District.

The remaining three dams (#s 8, 9, 10) are owned by the Hagley Museum and Library, which offers public tours of the original DuPont Company powder mills and yards, DuPont family home, and worker village complex. The Museum grounds are a part of both Brandywine Powder Mills Historic District and the Eleutherian Mills Historic District. There are mill races associated with each dam.

All eleven dams are concentrated on the river between river miles 2.1 and 7.2. They are considered small dams; none is higher than 10' and five are in the 2-4' range. This should simplify fish passage design, as well as reduce costs for providing fish passage. The dams are discussed in more detail in Chapter Three.

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[6] See the DuPont Corporation website - **http://www1.dupont.com/.** The company invented compounds such as neoprene, nylon and Lycra® here, among others.

Table 1. Current dams on the Brandywine in Delaware

Dam Name	Location (river miles)	Owner	Present Function/s	Approx. Height (ft)	With Mill Race?	Estimated Shad Production Potential (cumulative)[7]
1) West Street	2.1	City of Wilmington	Protect water supply from tidal influences and encloses two sewer pipes	3	No	3,300
2) Brandywine Park/ Broom Street	2.9	City of Wilmington	City water intake; aesthetic (waterfall and mill race supply); part of Historic District	7	Yes	3,600
3) None	3.35	O'Neill; may be orphaned	None known; was for industrial water supply.	3	No	4,600
4) Alapocas Run Park and Bancroft Mills	3.6	DNREC*	None known; was for water supply	3-4	No	6,700
5) Brandywine Falls	4.2	O'Neill	Mill race supply; aesthetic; was for industrial water supply	8–10	Yes	7,700
6) DuPont	4.5	DuPont Exp. Station	None known; possible back-up water source	4-6	No	9,000
7) Breck's Mill/ Walker's Mill	4.8	Hagley Museum/ Walker's Mill	Historical. Aesthetic. Once fed two mill races.	6	Yes (2)	10,700
8) Henry Clay Mill/ Lower Hagley	5.2	Hagley Museum	Historical; part of National Historic Landmark. Aesthetic (waterfall). Feeds mill race.	6-8	Yes	12,100
9) Upper Hagley/ Birkenhead	5.7	Hagley Museum	Historical; part of National Historic Landmark. Feeds mill race.	2	Yes	13,000
10) Eleutherian Mills	6.2	Hagley Museum	Historical; part of National Historic Landmark. Feeds mill race.	3	Yes	16,400
11) Rockland Mills	7.2	DNREC*	Historical; part of Historic District. Once fed mill race. Aesthetic.	7-8	Yes	26,600

* DNREC – Delaware Division of Natural Resources and Environmental Control

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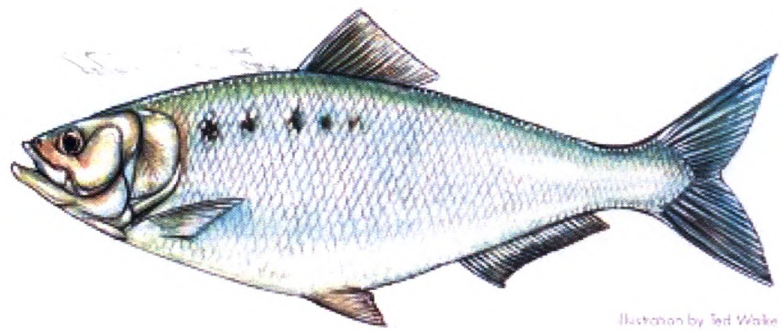
Source for shad production estimates - Delaware Division of Fish and Wildlife, et al, 1985. *A Review and Recommendations Relating to Fishways within the Delaware Basin*, the Delaware Basin Fish and Wildlife Management Cooperative

Chapter Two

Contemporary Efforts to Restore Shad

Since the 19th century there has been significant interest in restoring American shad. In fact, the initial and now national model effort for shad restoration began in Pennsylvania on the Susquehanna River with the formation in 1866 of the predecessor of the Pennsylvania Fish and Boat Commission (PFBC). Early efforts on smaller Susquehanna tributary dams have shifted to the mainstem, where trapping and transporting shad have been replaced by the operation of four fish elevators on the large energy-producing dams there. Supplementary efforts are continuing on several tributaries.

The natural range of this 30", 8-pound, and full-flavored fish spans the east coast from northern Florida to Newfoundland. Today, efforts to restore migratory fish are underway on rivers in Maine, Massachusetts, Connecticut, New York, Pennsylvania, New Jersey, Maryland, Virginia, and North Carolina. Shad is not the only targeted migratory fish, but it is the main focus south of the Hudson River, where the Atlantic salmon's range ends.[8] All fifteen east coast states and the District of Columbia annually monitor returning American shad populations. To support this work, the Atlantic States Marine Fisheries Council is strictly regulating ocean shad catches under an inter-state agreement, and many of the 15 states are raising shad in state-run hatcheries for release back into streams.



American shad (Alosa sapidissima)

One of the main forces behind this restoration effort is the realization of the enormous natural, cultural, and economic legacy that has been lost. Today, many people have never heard of shad. But Native Americans and early settlers to the New World experienced spring migratory runs that once numbered in *the tens of millions* overall, in the millions on a large river like the Delaware, and in the tens of thousands on a river like the Brandywine. Glowing historical accounts reach back to the earliest colonial days, where the "innumerable" fish, both fresh and preserved through pickling or salting, was a central part

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[8] Other migratory fish which could benefit from a restoration effort are other, smaller members of the herring family. In the Brandywine, this would include blueback herring, alewife, and hickory shad. Additionally, striped bass, and white and yellow perch may be modestly benefited. Source: DNREC and PFBC staff, personal communications.

of settlers' diets, as it was for Native Americans before them. [9] The Latin name for the species is *Alosa sapidissima*, meaning "most delicious, or savory, herring," the family of which shad is a member.

Fishing and trading for shad was so widespread in colonial America it is said that "no family was without its share."[10] Settlements were named after shad, such as Shad Landing, Maryland, and Shadwell, Virginia, where Thomas Jefferson was born. A small tree that blooms at the same time as the spring shad runs was named shadbush. According to lore, the spring run shad may have helped General Washington and the troops survive at Valley Forge in 1778.[11] Shad have been called "the Founding Fish" due to their central role in early American life.[12]

American shadbush blooms in the spring at the same time as the shad runs

Shad were so prolific and desirable that eventually commercial shad fisheries were established, especially on larger rivers. Despite an increasing number of dams and water quality problems, this industry lasted until the early 20th century. In fact, American shad

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[9] Weslanger, C. A., 1953, *Red Man on the Brandywine*, Wilmington, DE, Chapter 13, page 1.
[10] Ibid, Chapter 13, p. 1.
[11] "The most memorable day was the one early in spring when schools of shad came swimming up the Schuylkill --- thousands upon thousands of beautiful, fat shining shad. The whole camp turned out to catch shad. The river so swarmed with fish that each haul of the net brought in hundreds. That night for the first time since the army had moved to Valley Forge there was not a hungry man in camp; each solider went to bed with a belly stuffed with shad." (p. 179 of a chapter called "The Revolution" in "The Pennsylvania Dutch" by Frederic Klees, published 1951 by Macmillan Co.) Some scholars doubt the authenticity of this report, though from a cultural perspective it is notable that such a story exists at all.
[12] See McPhee, 2002, *The Founding Fish.*

were the basis of the largest commercial fishery in the mid-Atlantic (see Thomas Eakins' 1881 painting, *Shad fishing at Gloucester on the Delaware*, on the cover of this report, and the picture below).

A commercial shad haul on the Susquehanna River, circa 1900.

While a commercial shad fishery of the sort that once existed may not be restorable, shad still fire the popular imagination and ignite passionate enthusiasm among sport fishermen. Sport fishing is big business. The Pennsylvania Fish and Boat Commission estimates that recreational shad fishing on the Susquehanna River will result in some $30 million in annual economic revenues.[13] Despite local water quality conditions and resulting health advisories, migrating shad are edible since they only spend a brief time in the river.

Because it has no blockages on it, shad have been able to spawn in the Delaware River itself continuously. In the 1960s and early 1970s, however, there was a "pollution block" in the Delaware River below Philadelphia, a section of the river that was devoid of oxygen, which prevented fish from passing through. This pollution block probably diverted Delaware River shad into the Brandywine, however. Starting in the late 1960s, the Delaware Department of Natural Resources and Environmental Control (DNREC) attempted to take advantage of this "run" by installing fish ladders at three Brandywine dams. Meanwhile, Philadelphia completed an upgraded sewage treatment plant that cleared the block, and by the mid-1970s the shad were back in the Delaware and had moved up the Schuylkill as far as the Fairmount Dam, the Schuylkill's first dam, which supplies water to the City by the

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[13] From U.S. Fish and Wildlife Service, et al, undated, "Migratory Fish restoration and Passage on the Susquehanna River," p. 3.

Philadelphia Art Museum. Plans were quickly put in place for a fish ladder at the Fairmount Dam, and the ladder was installed in 1979. Fish passage was spotty, though, on both the Schuylkill and Brandywine Rivers, and comprehensive system-wide efforts were neither mounted nor sustained. The PFBC instead focused its efforts to restoring shad to the Lehigh and Susquehanna Rivers.

Efforts to restore shad in the Delaware Basin were further advanced in 1985, when a study entitled *A Review and Recommendations Relating to Fishways Within the Delaware Basin* was completed by the Delaware Basin Fish and Wildlife Management Cooperative, a group of agencies from each of the four states within the Delaware Basin (Delaware, Pennsylvania, New Jersey, and New York) and two federal agencies, the National Marine Fisheries Service and the Fish and Wildlife Service. The study specifically addressed fish passage needs for American shad in the Delaware Basin and identified three tributaries historically used by shad for spawning which had "the greatest potential for restoration of the American shad."[14] These are the Delaware River's three largest tributaries: the Lehigh, the Schuylkill, and the Brandywine Rivers. The study estimated that up to 26,600 shad could be produced in the Delaware portion of the Brandywine alone.[15] This report is supported by the 1996 *Comprehensive Conservation and Management Plan for the Delaware Estuary* which identified American shad as a "priority species" and the importance of the Brandywine for potential shad restoration.[16]

Today, shad restoration work is well underway on the Lehigh and Schuylkill Rivers, though it takes a long time and is still early in the process (see Appendix Five for a summary of the work on the Schuylkill River). There are three major aspects common to both projects.

1) Shad stocking. Shad restoration involves stocking large numbers of shad fry in the rivers in order to "imprint" them so that they return to that river during subsequent migrations. These efforts are aimed at jump-starting a sustainable native population.

2) Fish passage agreements. Agreements with the dam owners must be developed to provide for fish passage at their dam(s), either through dam modification or dam removal. The PFBC has taken the lead, and both rivers have shad management plans.[17] The goals for each river are to "restore and manage American shad … for optimum sustainable yield and public benefit."[18] For each river, this translates into making about 100 miles of the mainstems (not including select tributaries) available as spawning habitat for an estimated 850,000 shad. This is to be accomplished primarily through the installation of various fish passage devices, such as fish ladders, but also by dam removals, where feasible. More details

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[14] Delaware Division of Fish and Wildlife, et al, *A Review and Recommendations Relating to Fishways Within the Delaware Basin*, the Delaware Basin Fish and Wildlife Management Cooperative, 1985, p. 5.
[15] Ibid, Table 2, p. 28
[16] Delaware Estuary Management Committee, *Comprehensive Conservation and Management Plan for the Delaware Estuary*, pp.60-61; 191-192 and Figure 40. September, 1996.
[17] *Strategic Fishery Management Plan for American Shad Restoration in the Lehigh and Schuylkill River Basins*, Commonwealth of Pennsylvania, Pennsylvania Fish and Boat Commission, 1984, revised 1988. This Plan is compatible with Delaware Basin Fish and Wildlife Cooperative's *Management Plan for the American Shad in the Delaware River Basin* (date unknown, but pre-1988), and with the goals and objectives of the Atlantic States Marine Fisheries Commission's *Fishery Management Plan for American Shad and River Herrings* (date unknown, but pre-1988).
[18] Ibid, p. 2

about shad restoration efforts on the Schuylkill River, the Brandywine's nearest neighbor, are presented in Appendix 3.

3) Monitoring. The third major aspect of these shad restoration projects is the monitoring of results. This is accomplished for the Schuylkill and Lehigh Rivers both by a special chemical marking of the released fish developed by the PFBC and by a subsequent sampling of returned fish to determine how many came from the original stocked populations. It is also accomplished by counting migrating fish as they pass a special viewing window found at the first fish ladders.

Stocked shad have begun to return to the Schuylkill and Lehigh Rivers. Currently, shad have not yet returned in numbers equivalent to the goals for those rivers; however, the entire process takes many years as the populations slowly build. There are better years and worse years for shad reproduction, survival, and migration, though numbers appear to be increasing over time.

The restoration of migratory fish represents a powerfully positive story, with implications for education and celebration. A popular (and lucrative) spin-off of shad restoration for a growing number of communities is an annual shad festival, held during their migrations, typically sponsored by local business interests, with musical, educational, and culinary events. These can be well-attended affairs, sometimes attended by high-ranking elected officials, and are often located in the downtowns of those communities along the shad-bearing rivers which flow through them.[19] A list and description of shad festivals is included as Appendix Six.

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[19] The annual shad festival in Lambertville, NJ, along the Delaware River, has attracted 30,000 people, including the Governor of New Jersey, over just one April weekend. It has helped turn the town around, according to a spokesperson from the Lambertville Chamber of Commerce: "We said, if the shad can make a comeback, so can we."

Chapter Three

Restoring Passage for Shad[20]

Although shad are strong long-distance swimmers, they cannot jump. Unlike their more famous migratory cousins, salmon, shad can be blocked by an obstruction only one foot high. Moreover, shad exhibit distinct behavioral traits that affect them during migration, which are increasingly taken into account in passage options. For example, they move in groups or shoals, so fish passage facilities should be as wide as possible to accommodate this behavior. They need water with a definite current to orientate properly, and prefer a "streaming" flow to "plunging" flows which have turbulent, aerated water zones. Additionally, they are easily trapped in corners, exhibit frequent "fallback" behavior during migration, do not exhibit strong exploratory behavior at an obstruction, and appear to be very sensitive to sudden changes in light.[21]

Still, thousands of shad successfully pass through an increasing variety of fishways or fish passages. Given all the attention shad, salmon, and other migratory fish restoration is presently receiving in the United States, Canada, Europe, Australia, and northern Asia, the art and science of fish passage technology is undergoing worldwide invigoration and innovation in designs. New techniques are being tested, and older ones are being improved and updated.

Every blockage in a river represents a unique situation and challenge. Each fishway must be carefully designed and installed. There are many factors to consider, including several related to hydraulics and physical considerations: volume and velocity of streamflows; energy dissipation; arrangement and size of resting areas; drop in elevation between pools; the use of "attraction" waters and their velocities; entrance eddies; and space in pools.

Fishways are often designed according to the "optimization" model, where the goal is to pass the most fish at the peak time of year – for shad in the Mid-Atlantic that is mid-April to early June. This involves designing passageways that will operate at the range of river flows normally experienced at that time. If a ladder does not pass sufficient water, fish will not be attracted to the fishway. If flows are too high, the migrating fish will be deterred from using the fishway. Unfortunately, the most efficient and effective fishways only pass a percentage of migrating fish, even in the best of years.

Numerous methods of getting fish past a dam have been tried – including trapping and trucking the fish, sending them through lock systems, up elevators or lifts, and through pumps. Considering the size of the Brandywine River and the blockages to be overcome

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[20] Much of the substance of this chapter was gathered through discussions with and the assistance of Sara Nicholas, American Rivers; Chris Frese, Kleinschmidt & Associates; Scott Carney, Pennsylvania Fish and Boat Commission; Mark Pennell, URS Corporation; Connecticut River Watershed Council website; Dick Quinn, USFWS, Hadley MA; and Alex Haro, Ecologist, U. S. Geological Survey, S. O. Conte Anadromous Fish Research Center.

[21] M. Larinier and F. Travade, *The Design of Fishways for Shad*, 2002

(both relatively small), fishway designs can focus on two simple, major types – technical and natural.

The discussion presented here is meant as a brief introduction to the art and science of fish passages. A qualified professional is required to design a site-specific fishway. The following information is intended to help guide this process.

A. Technical Fishways

For the size and volume of the Brandywine River, relevant technical fishways include the different types of fish ladders. Fish ladders consist of a series of gradually inclining steps with resting pools located at regular intervals. These provide the fish with a means for active migration that is intended to simulate natural river conditions. Fish ladders are generally built of concrete, wood or aluminum, or a combination of these materials. If desired, they can be faced with stone or wood to blend harmoniously with their environment.

There are two main types of fish ladders – chute types and pool types. Chute types include Alaskan steeppass and denil ladders; pool types include pool and weir and vertical slot fish ladders. Both types have been used to pass shad, some less successfully than others. Still, there is not universal agreement about which type is best. Pool type fishways are generally recommended for large dams on rivers larger than the Brandywine.

A ***steeppass fish ladder*** is typically a pre-fabricated aluminum chute with vanes along the sides and bottom to create turbulence, which lowers water velocity. Steeppass fishways are particularly well-suited for small dams and small streams, and they are relatively inexpensive.

A steeppass fish ladder

A ***denil fish ladder*** is generally larger and wider than a steeppass fishway. A narrow entrance, placed near the bottom or "toe" of the dam, creates high water velocity to attract fish. The ladder consists of a channel about three to four feet wide, which, like a wheelchair ramp, extends along one bank or the shore, and then doubles back and upward, conveying the fish over the top of the dam. Inside are a series of sloped channels with wooden baffles placed at regular intervals and typically at a 45 percent slope. Water sluices through the

channel and over the wooden baffles, reducing the energy and velocity of the flowing water. Resting pools may be located between segments of the fishway.

A denil fish ladder

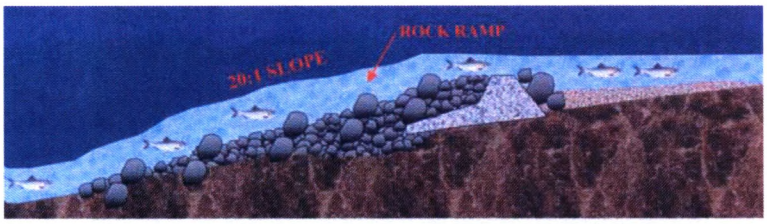
Regardless of the type of fish ladder used, one important design challenge is attracting fish to use it. The concept of "***attraction flows***," those that are designed to attract the fish into the ladder relative to the general flows pouring over the dam, are being designed into new and upgraded ladders. Most migratory fish will swim up the main channel of the river until they can swim no further, such as at a dam wall. Migrating fish can apparently be confused by the water pouring over the dam and not find the fish ladder entrance. A new design feature is to block off that portion of the dam overflow that is near the ladder entrance, and then supplement the through-ladder flow with additional attraction flows that make the ladder seem like the main channel, thereby guiding or attracting the fish into it.

B. Natural Fishways

The use of natural or nature-like fishways has increased worldwide in recent years, as a means of providing additional aquatic habitat in addition to providing fish passage. These nature-mimicking facilities have been constructed in Europe, Canada, Australia, and Japan and are now gaining favor in the United States. These facilities are intended to embody a natural aesthetic and blend in with their specific riverine surroundings so that they are hardly noticeable to the casual observer.

There are two main types of natural or "nature-like" fishways: ***rock ramps*** and ***by-pass channels***. Both approaches are intended to create conditions similar to a natural river channel that at the same time allow the migrating fish to pass over (rock ramp) or around (by-pass channel) an existing barrier. These fishway designs incorporate natural materials and provide for passage over a range of streamflows for a wide variety of fish species and other aquatic organisms.

Simply described, a ***rock ramp*** modifies the riverbed by the strategic placement of rocks and other suitable materials within the stream banks to create a stable incline that blends into the surrounding stream environment while enabling fish to swim up and over the barrier. The rocks must be carefully sized to fit stream flow and velocity conditions. Such ramps have been installed at both full and partial stream widths. If less than the entire stream width is ramped, costs are reduced and streamflows can be concentrated to create adequate water depth through the fishway. One additional technique sometimes employed is to lower the dam/blockage on one side (see discussion of notching below) to use the existing shoreline as one of the "containment" walls. Rock ramps can incorporate local existing stream rocks, which would reduce costs and allow them to better blend into local surroundings.

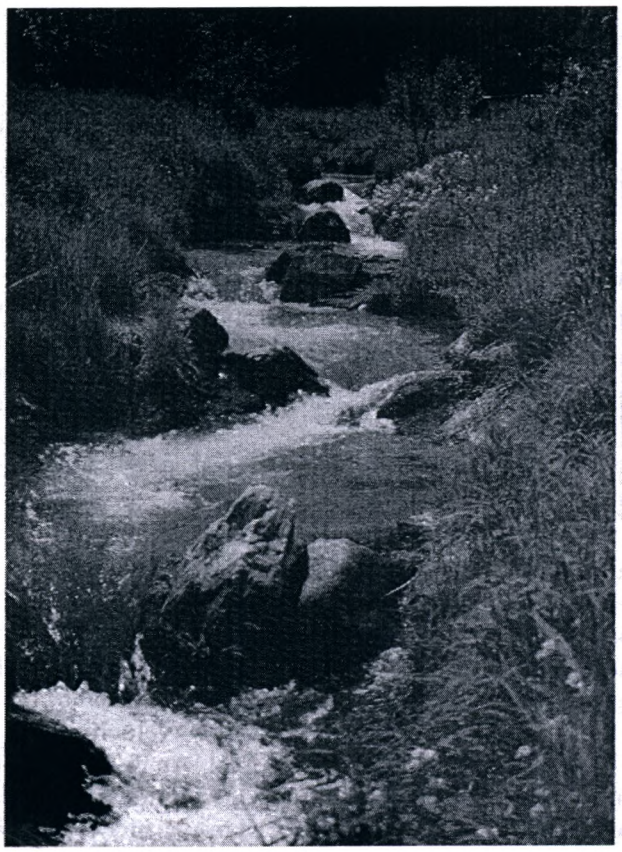


A rock ramp, showing how fish can swim over a dam without removing it.

A rock ramp has been put in place here. Neither ramp nor dam are very visible.

A ***by-pass channel*** involves the construction of a new simulated streambed, usually in suitable land in the floodplain adjacent to the dam or blockage, circumventing the stream barrier. The new stream channel, slope, and banks can be designed to be similar to, though perhaps smaller than, the natural stream. This would involve creating a new system of stream riffles and pools in a combination and with depths and rock sizes that mimic the natural stream. By-pass channels will more effectively pass fish if they incorporate 'fish attraction' techniques that regulate flows through a special headgate, for example, to draw

the fish into the entrance of the new channel. Considerations must be made for stream flood conditions.



This German by-pass channel has been successfully in use for about twenty years.

Along with these distinct approaches to fish passage, some designs combine approaches creating a ***hybrid approach***. For example, a rock ramp could take migrating fish part of the way up the face of a dam, from which point the fish could be directed into a shorter fish ladder.

Mill races are essentially by-pass channels around dams. The Brandywine contains numerous mill races, some of which could possibly be used as ready-made by-pass channels, as discussed in more detail below. The successful use of a mill race for fish passage depends on factors such as the exact configuration of the race and the possibility of attracting fish into it (e.g., by skillful rock placement, such as a rock "jetty" or weir, and by supplementing the mill race flow with additional attraction flows).

There are advantages and disadvantages to each approach. These are outlined in Table 2 below.

Table 2. Advantages and disadvantages of different fishway systems.

Nature-like Fishways		*Technical Fishways*	
Advantages +	***Disadvantages -***	***Advantages +***	***Disadvantages -***
Fish and ecosystem "friendly"	Considered experimental in the U.S., though may pass more fish than ladders	"Proven" technology	Not fish or ecosystem friendly
Can easily pass fish both up and down river	Requires in-stream work	More easily manipulated for different flows	Generally only passes fish upstream
Tends to be relatively inexpensive to construct	Use of by-passes consumes more land	Requires limited space/land	Expensive to very expensive to construct
More natural aesthetic			Man-made modern aesthetic, though can be masked or blended in
Little management; Low maintenance			Requires management and maintenance

C. Dam Removal and Notching

Removal of an existing dam, in whole or in part, is another passage alternative. Dam removal is not always feasible for a variety of reasons including difficult-to-replace dam functions, the desire to preserve an historic dam, the perceived aesthetics of a dam and its waterfall and/or mill race system, or industrial and residential infrastructure in the vicinity of a dam or immediately downstream. Still, it is sometimes advantageous and agreeable to a landowner to remove an existing dam rather than construct a fishway.

Outright dam removal is often the best solution to restoring streams and migratory fish runs in that it permanently restores the waterway. Moreover, it is relatively inexpensive, can have considerable government support, and does not require ongoing management and maintenance costs. Dam removal may also be advantageous to a dam owner in that it removes a source of liability. Dams can be considered an "attractive nuisance" and the hydraulic currents they create can be dangerous.

The main advantages are that dam removal:

- creates an open river system and restores the ecosystem;

- is relatively inexpensive; and,
- eliminates liability, management, and maintenance concerns.

The clear disadvantage of dam removal is if it eliminates the function the dam performed, though some functions may be replaceable by other means. For example, water can be supplied through a pumping station. This will, however, require additional expenditures. Other functions, such as the aesthetics of a waterfall or the use of an impoundment for flat-water recreation, are not replaceable.

Approximately 600 dams have been removed across the country, most in the last twenty years.

The historic resource value of dams cannot be fully replaced if that dam is removed. In cases when historic dams have been removed, historic resource mitigation is often involved, including full photo-documentation of the existing dam, placement of a plaque describing the dam, and sometimes retention of a portion of the dam itself, such as one of the abutments.

A compromise to dam removal can be achieved through a practice called ***dam notching***. Notching involves removing only a portion of the dam rim, lowering water levels and the height of the barrier that the fish must pass. If the full height of a dam is no longer needed to perform its intended function, notching can reduce fish passage costs in an unobtrusive way. Notching can increase the success of fish passage by reducing the difficulties and stresses involved. Notching can also be made temporary, for the duration of a migratory run for example, by the installation of **flashboards**, boards usually made of wood that can be put in or removed at will. Dam notching is an alternative that could supplement many fish passage alternatives on many of the dams on the Brandywine.

Sometimes streams will eventually cut around a dam, or an existing dam will develop a small break called a breach. Rather than be repaired or neglected, these ***dam breaches*** can be incorporated into a fish passage strategy. The breach can be secured as is or modified to accommodate the overall plan. Taking advantage of a breach can dramatically reduce the cost of providing fish passage and greatly increases overall effectiveness.

Both notching and breaching techniques can be incorporated into a strategy for historic dams. Such "historic mitigation" involves leaving at least part of a dam intact, photo-documenting it, and then incorporating a fish passage solution.

Another alternative to the full removal of a dam that is gaining support is to remove an existing dam and replace it with an ***inflatable dam***. The use of an inflatable dam can be strategically limited to when it is most needed. At other times, such as during migratory fish runs, it can be deflated, allowing for natural stream dynamics to predominate. For example, an inflatable dam is used on the lower White Clay Creek in Delaware by United Water Delaware. The rubber dam secures fresh water that is backed up by high tides and makes it available for water supply. The PFBC is also contemplating permitting an inflatable dam on the middle Susquehanna River that would create a recreational impoundment most of the year, but could be deflated and removed during shad migrations.

D. Alternatives for Shad Passage on the Brandywine

The following discussion presents options for providing fish passage for American shad at the eleven dams on the Brandywine River in Delaware. These options were determined through a series of site visits to each of the dams and incorporate observations from several people knowledgeable about fish passage issues (see Footnote #16). A range of fish passage alternatives are proposed with consideration given to current dam functions and physical settings. The first two dams, owned by the City of Wilmington, still perform the functions for which they were originally constructed. At least five dams (Numbers 7-11) are deemed historic, and are now considered an important aesthetic component of the landscape. Two dams (Numbers 3 and 11) are breached.

These recommendations should be considered preliminary in nature and intended to stimulate further discussion, research and analysis. The next phase of this project would involve detailed site-specific engineering investigations of specific dams.

Dam #1 (West Street Dam, owned by the City of Wilmington) – This low (2-3') dam, currently in some disrepair (several cracks are evident) contains two public sewer pipes

Dam #1, West Street Dam.

embedded in concrete. This dam is set where the tidal influences end. Fish passage options include installing a rock ramp, a fish ladder, or, contingent on re-routing the sewer lines, dam removal.

Dam #2 (Broom Street Dam, owned by the City of Wilmington) – This dam is located within Brandywine Park, and, with its waterfall and adjoining mill race system, is not only a scenic part of the park, but is a central component of the City's primary drinking water supply. Diversions into the adjacent mill race are conducted into a City treatment plant. Additional water is obtained from the river at the Compton Mills Water Supply pump station located about 75 yards upstream. The dam sets the height of the water (the hydraulic head) for the pump station.

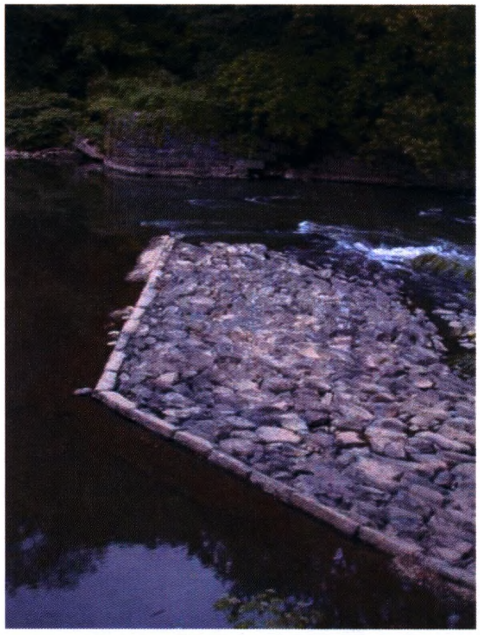
Dam #2, Broom Street Dam, diverts water into a mill race and supplies water to the City of Wilmington.

The park was designed by the famous landscape architect Frederick Law Olmstead. It is located within the nationally-recognized Brandywine Village Historic District. Fish passage options are probably limited to a fish ladder, with a possible inclusion of an aesthetically blended rock facing to blend it into the park setting. A partial (2-3' high) rock ramp could be employed in a hybrid approach to reduce the height of a fish ladder. The adjacent floodplain is narrow and may not support a by-pass channel. The concrete wall of a former fish ladder from the 1970s still exists and might be incorporated into a new passage. [22] Being a public park, this site would be a good location for incorporating a viewing window into a fish ladder.

Dam #3 (breached, ownership unclear) – This dam was a 3' industrial water supply dam but has been partially breached, and fish can already pass. Therefore, no additional fish passage work is needed. However, a full removal of the dam would widen the opening and

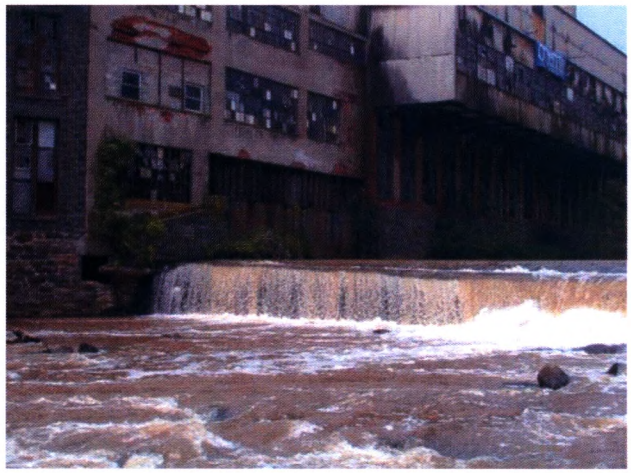
[22] DNREC established fish ladders at dams 1, 2, and 4 in the late 1970s when American shad were coming up the Brandywine, possibly to avoid the pollution block that occurred on the mainstem Delaware River downstream of Philadelphia. A sustained shad run never materialized, however, and after several years the ladders were removed (dams 1 and 2) or 'mothballed' (dam #4).

potentially improve the water flows for the migrating fish. Certainly this work is a low priority compared to the rest of the fish blockages, but it should be considered as a part of any comprehensive or master plan for restoring shad to the river.



Dam #3, because it is breached, will now pass fish.

Dam #4 (at Alapocas Run Park and Bancroft Mills, owned by the State of Delaware) – This dam already has a fish ladder put in place by DNREC in the 1970s (see Footnote 19). The ladder has not been maintained since about 1980 and would need some refurbishment



Dam #4 spans the river between Alapocas Run State Park and the now abandoned Bancroft Mills Building.

before operating. An excellent opportunity exists to upgrade the ladder to more modern standards, for example, by providing an additional volume of flow as an attractant for the

fish. This would likely involve partially blocking the spillway next to the ladder, so as to reduce turbulence there and increasing flow near the mouth of the ladder. This could likely be accomplished at a relatively low cost. A long-term solution would be to remove the dam and ladder entirely, since the dam no longer serves its original function.

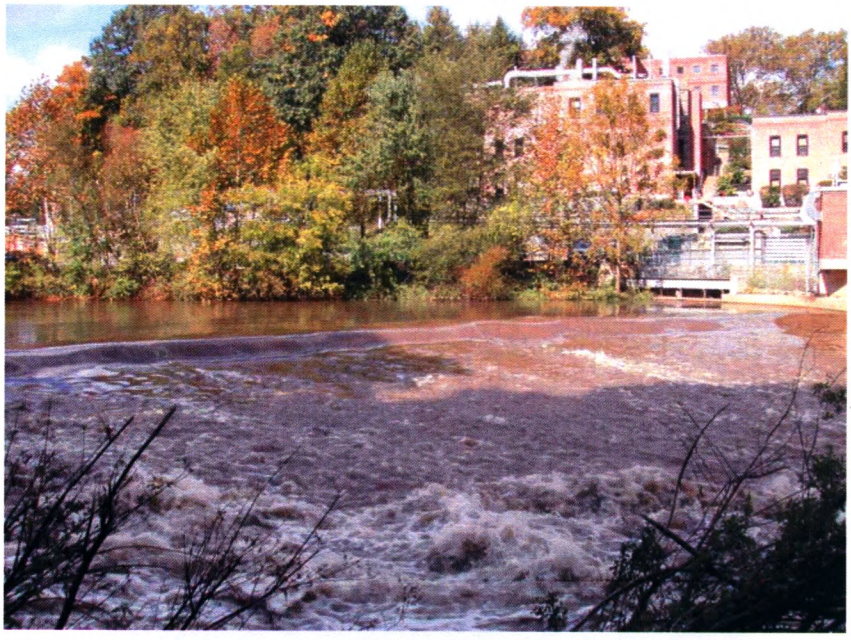
Dam #5 (Brandywine Falls/Bancroft Mills Dam), owned by the O'Neill Company) – This dam still diverts water to a mill race that runs behind condominiums at Brandywine Falls. This water had been used for different businesses engaged in the textile industry for decades. After passing down the mill race, most of the diverted water enters an old industrial water treatment plant building before continuing into the old mill buildings. This area is undergoing extensive redevelopment and adaptive reuse. Although Bancroft Mills once owned this whole area, it has now been sold into multiple holdings. The dam and associated infrastructure is probably owned by the O'Neill Company, which purchases and adapts old industrial and commercial buildings. The previous owner of a portion of the site, Wilmington Piece and Dye, held a water allocation permit from the State. O'Neill has not yet reactivated the permit, though they do have the option to do so. O'Neill is engaged in a lawsuit with several adjacent landowners over rights of access to their new property from the north. They are also engaged in a hazardous waste cleanup process under State oversight.

Dam #5 feeds a mill race that supplied water to the textile factory at Bancroft Mills.

At 8-10', dam #5 is the tallest dam on the lower Brandywine, and is built into a large rock outcropping on the river's east side (opposite the mill race headgate). The two primary structural solutions are a fish ladder or, using a hybrid approach, building a rock ramp to raise the level of the stream, and adding a fish ladder, perhaps tying it into the existing rock outcropping. An alternative would be to remove the entire dam with the option of maintaining water flow in the mill race by installing a diversion channel or diversion pump in the river.

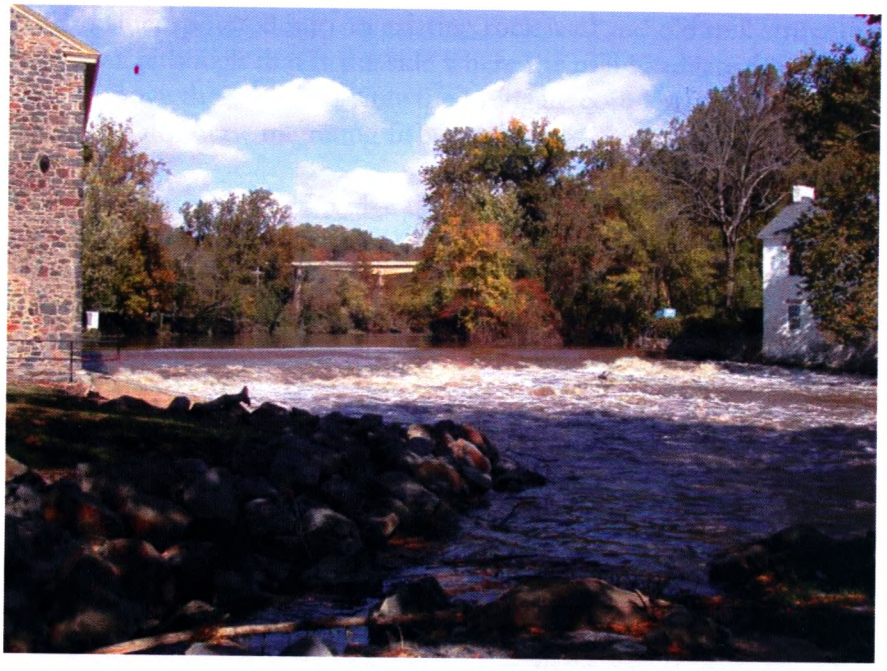
Due to the complexity of this situation, and the fact that O'Neill tends to sell their properties after rehabilitation, contact regarding this project will be postponed and made with the subsequent owners.

Dam #6 (Rockford Park dam, owned by the DuPont Company) – This 4-6' dam is located adjacent to the DuPont Experimental Station south of State Route 141 opposite Rockford Park. The dam was originally used for water supply purposes for the DuPont Company. The company now receives its water from the City of Wilmington. There are several reasonable fishway options available at this site: a fish ladder could be installed, a rock ramp could be built, or the dam could be removed. The adjacent land in Rockford Park is probably too narrow, steep, and rocky for a by-pass channel. If the dam does not serve any irreplaceable function, it could be removed. If the dam is intended to provide back-up water for the facility, it could potentially be replaced by an in-stream pump.



Dam #6 once supplied water to the DuPont Experimental Station.

Dam #7 (Breck's Mill/Walker's Mill Dam, co-owned by the Hagley Museum and Ashford Capital Management) – This 6' dam is located between two mills which are part of the Henry Clay Village Historic District. The dam once fed two mill races on each side of the river. Neither mill race contains or conducts water today. Breck's Mill is owned by the Hagley Museum and houses a U.S. Post Office and art gallery. Walker's Mill is a private office owned by Ashford Capital Management, and its race runs underneath the mill building. There are many rocks piled downstream and in front of the dam, suggesting the basis for a rock ramp fishway. A rock ramp might fit in aesthetically, as well. A fish ladder is another possibility, as is the modification and adaptation of one of the existing mill races. The race at Walker's Mill is better configured for this purpose, as it is shorter, has a wider opening, and could readily have a rock weir placed by it to direct fish into it.



Dam #7 spans the river between two historic mills, Breck's Mill (left) and Walker's Mill (right).

Dam #8 (Henry Clay Mill/Lower Hagley Dam), owned by the Hagley Museum) – This 6-7' dam is the visual centerpiece of the Hagley Museum at the main visitor entrance, and it feeds a lower mill race that runs past several old mills. The grounds and facilities here are a part of the Brandywine Powder Mills Historic District, a subset of which is the Eleutherian Mills Historic District (which is also a National Historic Landmark).

Dam #8 fed the Henry Clay Mill at the Hagley Museum

One fish passage option would be to install a fish ladder, including an aesthetically appropriate natural rock facing to blend into the historic environment. Hagley has indicated

an interest in a public viewing window attached to the ladder structure at this site. This could potentially be incorporated into an existing rock wall and old mill structure on river right side of the dam, although that is the side where the mill headgate draws water into the millrace a few feet above the dam. Possibly the headgate could still feed the mill race from below water level and not draw migrating fish into it.

Another fish passage option would involve the construction of a by-pass channel on the opposite bank, on land which is also owned by Hagley.

Dam #9 (Upper Hagley/Birkenhead Mill Dam), owned by the Hagley Museum) – This small 2' dam diverts water into an adjacent mill race which runs past, and is used to feed, many of the historic structures featured at the museum. Three fish passage options appear to be suitable for this dam: a simple rock ramp; a short fish ladder (potentially combined with dam notching); or a partial dam breach.

Dam #9 at the Hagley Museum

Dam #10 (Eleutherian Mills Dam, owned by the Hagley Museum) – This small 3' dam is the original DuPont dam. Similar to Dam #9, this blockage could be overcome through the development of a simple rock ramp or a small fish ladder. The dam today diverts water into a raceway located on the opposite bank from the main public area (river left). It may be possible to adapt the raceway into a by-pass channel.

Due to its relatively remote location, there is no picture of dam #10, though it looks substantially like dam #9, above.

Dam #11 (Rockland Mills Dam, owned by the State of Delaware) – This 7-8' dam, part of the Rockland Mills Historic District, is owned by DNREC as part of the Brandywine Creek State Park. The dam developed a small breach which increased in size and flow over the winter of 2003-04 on the river right side of the dam, opposite the mill race. One passage alternative would be to secure and utilize this breach. This could entail stabilizing the dam

and the new water channel to prevent any further damage or erosion. The existing dam would be left as is, leaving water levels roughly where they are now.

Dam #11, the Rockland Mills dam.

Another alternative, which has already been considered by DNREC is, after repairing the breach, to use of the dam's short mill race as a by-pass channel. The mouth of the mill race is near the toe of the dam and, by placing large river rocks into a weir shape to create attracting flows, migrating fish could be directed into the mill race.

Chapter Four

Fish Passage Cost Estimates

There are several general cost categories and project components to consider in relation to developing and implementing a fish passage alternative. These include:

- Design and Engineering;
- Permits;
- Fishway construction, including dam removal or notching;
- Fishway accessories;
- Shad stocking; and,
- Monitoring and Maintenance.

A. Design and Engineering

Designing and engineering a fishway involves performing site-specific background research to determine, for example, if underground infrastructure pipelines are located in a project area, where the regulated floodplain is, and if there is any other relevant information that may impact fishway construction or operation. This research would be coupled with an evaluation of site-specific physical characteristics, including location of stream and dam access for construction equipment. The condition of the dam, as well as all its associated structures would also need to be evaluated. With this information, the fishway plan would be created based on the preferred type of fishway. The planning process would involve three phases: 1) a preliminary concept or sketch plan; 2) a preliminary construction plan; and, 3) a final construction plan. These plans would also be the basis for negotiating any necessary permits. The costs for developing the engineering design and construction plans for a fish passage would range from $20,000 to $50,000 per dam, with an estimated cost of $3,000 - $6,000 per dam for developing the concept plan, based on an informal survey of similar costs for other fish passage projects.

B. Permits

Local, state, and federal permits would be required for implementing fish passage projects on the Brandywine River. There is a Joint Permitting Process committee that meets monthly in Dover, Delaware, to coordinate and discuss permit applications and policies. This committee includes representatives from all relevant state and federal regulatory and advisory agencies. The lead state agency is DNREC, Division of Water Resources, Subaqueous Lands section, which regulates such projects under Title 7 (Conservation), Part VII (Natural Resources), Chapter 72 (Subaqueous Lands), or 7 Del. C. 7203. A federal permit would be needed from the Army Corps of Engineers under Section 404 of the Clean Water Act. The New Castle County Conservation District would have to issue a stormwater management and Erosion and Sedimentation Control Permit for the construction phase of the project. In the case of historic dams, Delaware's State Historic Preservation Officer must be consulted. The permitting process is discussed in more detail in Appendix Four.

To streamline the process and minimize or eliminate concerns with regards to receiving permits, pre-application discussions with the regulators through the Joint Permitting Process committee would be advisable. Permit costs including filing fees, permit preparation, meeting time, etc., would range from $10,000 to $30,000 per permit. If stream sediment sampling is required, an additional $10,000 to $20,000 would be added to the permitting costs. If sediments need to be removed, dredging costs would be very high, due to disposal fees. However, in Pennsylvania, regulators in the Department of Environmental Protection normally allow the sediments to simply go on downstream, especially if the river has similar background levels of the pollutants in question. The reasoning is essentially that the river is not being made more polluted by the project.[23]

C. *Fishway construction*

Fishway construction would be the biggest single cost and would depend not only on the type of fishway but also on site factors such as access for heavy equipment, sources of local rock if needed, and possible infrastructure (e.g., sewer line) relocation costs. Special aesthetic considerations for historic dams could add considerably to costs at some sites, yet might be necessary in the rich historic Brandywine corridor. Those costs are considered further under the discussion of fishway accessories below.

There are three primary types of passageways considered suitable for the lower Brandywine dams: fish ladders; rock ramps; and by-pass channels. Since all of these approaches have been implemented elsewhere, construction cost estimates can be easily estimated.

Fish ladders have been widely used in the United States for shad, including on the Schuylkill and Lehigh Rivers. The two main types recommended for shad on the Brandywine are steeppass and denil ladders. Steeppass ladders are the smaller and less expensive of the two and are estimated to cost about $15,000 per vertical foot of rise.

The cost of denil ladders, which are larger and a little more complicated than steeppass ladders, range from about $25,000 to as high as $40,000 per vertical foot. The per foot unit costs tends to increase over about six feet in height. For example, for a 6' high dam, the cost would range from $150,000 to $240,000, with the final cost likely being closer to $240,000.

The cost of constructing a **rock ramp** varies with the size of the project. The most significant expenses are the rock itself and the equipment required to move and install it. There is a relatively abundant supply of large rocks available near most dam sites in the Brandywine which might reduce the costs of this approach. The typical construction cost for a rock ramp is approximately $20,000 per vertical foot.

The first use of a **by-pass channel** for migratory fish in the United States is being constructed on the Conodoguinet River, a tributary of the Susquehanna in central Pennsylvania. The Conodoguinet is about the same size as the Brandywine, so the by-pass channel size and components should be equivalent.

The known costs for this work in progress are:

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[23] Sara Nicholas, American Rivers, personal communication

Engineering design	$15,000
Contractor and materials	$56,000
(Includes digging, rock-laying, grading, road-building, culvert-laying.)	
Hydraulic gates	$4,900
Cement culvert for hydraulic gates	$2,400
On-site engineering services	$10,000 (est.)
In-kind labor, materials	$6,000 (est.)
Working total:	$92,000, including design and engineering.

The by-pass is being built as a series of six riffles and six pools to provide slope breaks (the riffles) and resting areas (the pools) for the shad. The dam is about 10' tall, and the length of the by-pass will be about 500 feet; the width varies from 6 to 10 feet based on the channel habitat type. The land involved was donated. The costs per vertical foot are under $10,000.

There are three construction stages to the project: 1) Site preparation, including clearing the land and pumping excess water out; 2) channel construction, including channel digging and lining it with rock; and, 3) channel entrance and exit construction, including the installation of the hydraulic gates that will help regulate flows through the channel. The total time to design and construct the channel is estimated at three months.

Dam removal has occurred to some 600 dams across the Untied States since 1912. The majority of these removals occurred in the 1980s and 1990s, though many more are being removed every year. Generally, the process involves drawing down the reservoir; removing the sediment built up behind the dam, if necessary; removing the structure; and, mitigating for downstream effects of increased flow and sediment re-suspension. Nevertheless, determining the costs to remove a dam is a new art and science. In the past, the costs were often over-estimated. However, even conservative cost estimates for dam removal tend to be lower than those for dam repair – only 37 percent on average of the estimated repair costs.[24] Dam removal costs vary widely depending on size of dam, site conditions (e.g., accessibility, sediments, possible contaminants, type of dam), disposal, and other ancillary costs. Although the State of Delaware has never gone through a dam removal permitting process, the Commonwealth of Pennsylvania has been involved in so many dam removals that it has developed a streamlined approach to permitting.

All eleven of the Brandywine's Delaware dams are considered small and do not have large reservoirs, which could greatly simplify removal procedures. A report summarizing case studies for more than 30 dam removal projects throughout the United States indicates that the removal of dams of sizes similar to those on the Brandywine should cost less than $100,000, and more likely in the range of $30,000 to $75,000 per dam, including revegetation of the stream banks and riparian zone. Some small dams could be removed for as little as $10,000.[25]

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[24] Source: Friends of the Earth, American Rivers, Trout Unlimited. 1999. *Dam Removal Success Stories: Restoring Rivers Through Selective Removal of Dams that Don't Make Sense.*

[25] Ibid.

Table 3. Fish passage options and estimated costs

Dam Name	Present Function/s	Preliminary Passage Options	Estimated Cost Range (in thousands of dollars)*
1) West Street dam	Protects water supply/ sewer pipe	Fish ladder, Rock ramp, Remove	$50-120
2) Brandywine Park/ Broom Street dam	City water intake; aesthetic mill race supply; part of a Historic District	Fish ladder	$200-250
3) None	None known	Leave as is (breached), remove	$0-30
4) Old Bancroft Mills	None known	Renew/ Improve existing fish ladder, remove	$20-50
5) Brandywine Falls	Mill race supply	Fish ladder, rock ramp/ fish ladder hybrid, remove (pump water into mill race)	$100-400
6) DuPont	None known	Fish ladder, rock ramp, by-pass channel, remove	$30-240
7) Breck's Mill/ Walker's Mill	Historical; part of a National Historic Landmark	Modify existing mill race, fish ladder, remove	$30-240
8) Henry Clay Mill/ Lower Hagley	Historical; part of a National Historic Landmark	Fish ladder, by-pass channel on opposite bank/with attractant	$100-400
9) Upper Hagley/ Birkenhead	Historical; part of a National Historic Landmark	Fish ladder, rock ramp, by-pass channel	$75-120
10) Eleutherian Mills	Historical; part of a National Historic Landmark	Fish ladder, rock-ramp, by-pass channel	$75-120
11) Rockland	Historical; part of a Historic District	Secure existing breach, use mill race as by-pass	$50-150

* Does not include costs for engineering designs, flow attractants, viewing windows, or blending fish ladders into surroundings with rock facing, etc.

Combining the above-estimated costs and cost ranges with the fishway options for each Brandywine dam as discussed above results in the table above (Table 3, *Fish passage options and estimated costs*) summarizing the options for each dam and estimating the costs associated with those options. These cost estimates do not include the fishway accessories discussed below.

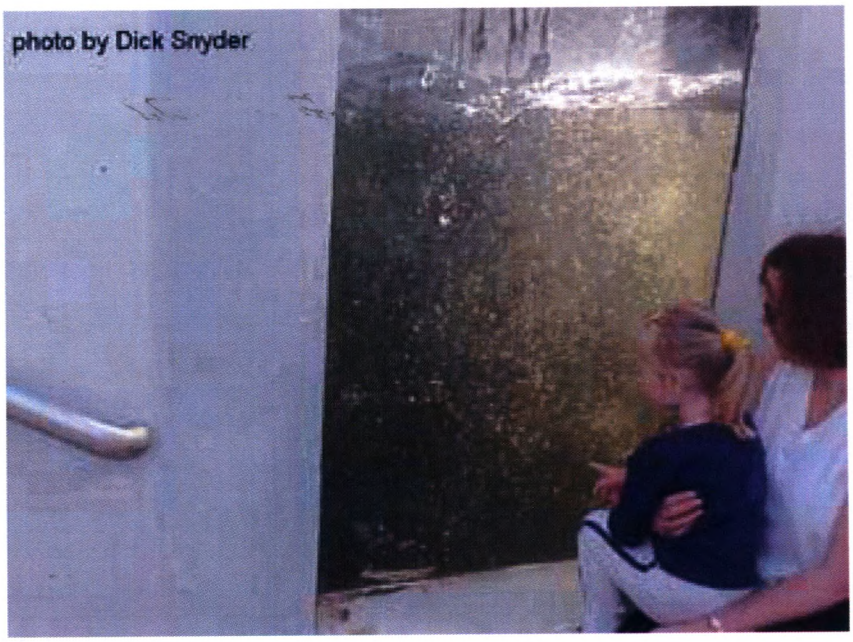
D. Fishway Accessories

There are two main fish passage accessories that may be important with respect to restoring shad to the Brandywine:

1) **Viewing windows**, where the public and/or fish monitors can watch migrating fish swim by, as discussed above, and,

2) Special aesthetically acceptable **covers or facing for fish ladders** that would allow the modern-looking structures to blend into an historic and/or natural setting.

Fortunately, there are examples of similar kinds of projects nearby. One involves the upgrading of the Fairmount dam fish ladder to include the fish viewing window on the Schuylkill River in Philadelphia. **Viewing windows** not only allow for fish monitoring – they also can allow the public the chance to enjoy a first-hand look at the drama of fish migration. If incorporated into the original fish ladder design, a viewing window would not



Fish viewing windows allow the public to enjoy the drama of fish migration.

require considerable additional excavating and structural concrete, and so would cost in the range of $50,000 to $100,000.[26] The additional costs include the design and fabrication of the reinforcements for the opening, the glass or synthetic window material, and the viewing

[26] Jason Cruz, Philadelphia Water Department, personal communication.

room itself. Costs could range widely depending on specific designs and if and how well it could be built into existing site conditions.

Special facing materials were recently added for aesthetic purposes to one fish ladder in the Mid-Atlantic and will soon be added to another. A fish ladder has been planned for a dam in a state historic park in Batsto, in the New Jersey Pinelands, with a removable wooden cover over the top to help the structure blend in with the historic surroundings. The entire fish ladder will be enclosed in a wooden structure to make it look like an old mill race. The wooden cover will be hinged so that park staff can lift sections of it up and climb into the fish ladder to perform maintenance. The wooden cover and ladder enclosure will cost approximately $100,000. The exposed concrete will be dyed with an epoxy coating to match the existing color of other structures nearby for about $5,000. Lastly, a vegetative screen will be planted alongside the fishway for about $3,000 to further blend it in with the historic and natural aspects of the park. A second case involves a dam on Rock Creek, in the District of Columbia which, though not considered historic, is located in a prominent city park area where aesthetics are considered very important. The cost of this special rock-facing project is projected to be approximately $100,000.

By using similar rock to the dam itself, the fish ladder on the far bank is hardly noticeable.

E. Shad Stocking

The goal of restoring shad to the Brandywine is to create a self-sustaining population of the fish that is resilient to some recreational fishing pressure. In order to do so, thousands of young shad, called fry, will have to be stocked into the Brandywine over many years. The fry

will imprint on the Brandywine as their birth river, and most of those still alive after three to five years in the ocean will return to it to spawn. The Pennsylvania Fish and Boat Commission is a national leader in culturing and restocking shad. The process involves collecting fertile eggs from spawning females during their migratory runs, transporting them to a nursery, and raising them in controlled conditions into fry over several weeks. The fry are then transported to their target release site and released. Much of their work to date has focused on releasing approximately 500,000 shad fry per year into the Lehigh and Schuylkill Rivers. Since the Brandywine is smaller than these rivers, the goal in restocking the Brandywine would be to release approximately 200,000 fry per year. The entire process of rebuilding a new Brandywine shad stock should take between five to ten years, depending in large part of how successful fish passage efforts are, but on other factors too, including weather during spawning runs and the stock's survival rates in the ocean.

Based on PFBC hatchery and egg-collection expenditures, the costs of this process in the Brandywine would be approximately $50,000 per year.[27] Therefore, the costs over five to ten years time would be $250,000 to $500,000.

F. Monitoring and Maintenance

Monitoring the results of restoring American shad to the Brandywine River will be a necessary component of the overall Brandywine shad restoration project. The goals of monitoring are to determine how successful efforts have been in both passing fish up the river and in re-establishing a local sustainably reproducing and returning shad population. It is recommended that state and federal agencies develop and oversee implementation of a monitoring plan for the entire project, as happens on other rivers where shad are restored.

A full monitoring plan is not needed at every fish passage. On the Susquehanna, Schuylkill, and Lehigh Rivers this entails counting migrating fish at a viewing window, using either visual or video camera-based means. Video monitoring equipment is often included in a migratory fish viewing room and window. This equipment can range from a few thousand dollars for a simple video camera surveillance system to $30-$50,000 for a modern digital automated system such as the Philadelphia Water Department is using at their Fairmount dam. This camera only photographs fish when triggered by their movement across the window. Approximately $15,000 of staff time would be required to analyze the photos taken.

The PFBC supplements these counts by chemically "tagging" the nursery shad that are released into the stream or river system. When shad return to that stream, a sample is captured and analyzed to determine whether they are nursery fish that are returning to their natal stream or are wild strays that do not represent members of a local shad population.

A simpler and less expensive method to determine presence or absence and relative abundance of American shad would be electro fishing and/or netting. This could be used to determine both upstream and downstream migration success. These are standard fish sampling techniques that would involve sampling at least two times each in the spring and

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[27] Mike Hendricks, Pennsylvania Fish and Boat Commission, 2004, *Delaware River American Shad Egg Take Stock Replenishment Plan*, p. 2.

fall, according to DNREC. This sampling would cost approximately $15,000 to $30,000 per year.

Regular maintenance is required for fish ladders. They can clog or be damaged by debris or vandalism. Less maintenance is necessary for the nature-like fishways. Fish ladders require daily visits during their operation over the course of a migratory run - about a six-week period. DNREC has performed all such maintenance on similar projects and estimates such work to cost between $10,000 and $15,000 per year for the Brandywine.

The combined costs of restoring shad to Brandywine are summarized and discussed in the next chapter. This includes a discussion of possible funding sources and possible next steps.

Chapter Five

Conclusions and Possible Next Steps

This report summarizes the findings and results of the Brandywine Conservancy's Brandywine River Shad Restoration Feasibility study, funded through the National Fish and Wildlife Foundation's Delaware Estuary Program. Through this effort, the Conservancy has:

1) Established partnerships for the purpose of this study with nine of the eleven dam owners along the Delaware portion of the Brandywine River. This includes the City of Wilmington; the State of Delaware, Department of Natural Resources and Environmental Control (DNREC); the Hagley Museum and Library; Ashford Capital Management; and the DuPont Company

2) Established partnerships with key state and federal agencies with a stake in this project, including DNREC, the Pennsylvania Fish and Boat Commission, the U.S. Fish and Wildlife Service, and the National Oceanic and Atmospheric Administration (NOAA)

3) Established partnerships with select other relevant and interested parties and landowners, including the Woodlawn Trustees, the President of the Board of the Brandywine Falls Condominium Association, American Rivers, and the Greater Wilmington Convention and Visitor's Bureau

4) Secured informal support for the project with additional relevant and interested parties including the Christina Conservancy, the Delaware Nature Society, Delaware Greenways, and others

5) Identified fish passage options for all dams, as well as the steps and approximate costs for implementing those options; we have also identified potential funding sources for moving forward (see discussion below and Appendix Three)

6) Researched regional examples of successful fish passage and shad restoration programs, specifically including the Susquehanna, Lehigh, and Schuylkill Rivers, and used examples from those regional efforts, where appropriate

7) Finally, prepared a PowerPoint presentation on this feasibility study to show to interested parties in addition to this report.

The primary finding of this study is that the establishment of fish passage for the dams of the Brandywine River in Delaware for the restoration of American shad appears to be technically feasible. The table below summarizes estimated costs to provide this fish passage.

Table 4. Estimated preliminary costs (all 11 Delaware dams) for establishing fish passage for American shad on the Brandywine River

	Low End Cost	High End Cost
Design	$220,000	$550,000
Permitting	$110,000	$330,000
Construction	$730,000	$2,120,000
Accessories	$0	$500,000
Totals	**$1.06 million**	**$3.5 million**

Even using the high-end estimated cost figure of **$3.5 million**, the costs are well within what is currently being spent to restore shad to other rivers. Funding for fish passage projects would likely come one site specific project at a time but within the context of the entire project. Most fish passage projects would probably be funded through multiple sources. Appendix Three identifies 24 potential sources of funding for migratory fish restoration/fish passage projects, divided into 15 federal, 1 state, and 8 private sources. Federal agencies are probably the best source for major funding needs. The State of Delaware does not currently have any funding for which projects along these lines are a priority. DNREC is expecting to play a leadership role in the project however, and funding opportunities could develop as progress on the project develops.

Table 5. Costs other than fishway construction for restoring shad to the Brandywine River.

	Low-end, per year costs	Low-end, 5-year costs	High-end, Per year costs	High-end, 10-year costs
Shad stocking	$50,000	$250,000	$50,000	$500,000
Monitoring*	$15,000	$75,000	$30,000	$500,000
Fishway Maintenance	$10,000	$50,000	$15,000	$150,000
10- year totals	$75,000	$375,000	$95,000	$1,150,000

*Could involve purchase of video monitoring camera at a cost of between $30,000 and $50,000, which is not reflected in the table.

The question remains whether or not such a large effort, which would require considerable resources and likely take 10 or more years to complete, is culturally and politically desirable. Notably, every dam owner asked to support this effort has agreed to cooperate in the assessment of his dam or dams and to consider the findings and recommendations of this report. This includes the City of Wilmington (owner of two dams), the State of Delaware (owner of two dams), the Hagley Museum and Library (owner of four dams), and the DuPont Company (owner of one dam). The partnership with the Hagley Museum is particularly notable, not only because it owns more dams on the lower Brandywine than any other organization, but also because its organizational mission is tied to historic and cultural values which depend on those dams – the mills, raceways, and associated structures of the old DuPont gunpowder works. Given the significant historical mill-related resources found on the lower Brandywine, opportunities for providing fish passage while protecting those resources is probably critical to the success of this project.

Clearly, this partnership can be strengthened by being strategically broadened to include state and federal representatives; New Castle County and City Council members; neighborhood groups and landowners; private businesses; the New Castle County Chamber of Commerce; and other not-for profit organizations including for example the Delaware Natural History Museum, the Delaware Museum of Nature Society, and the Christina Conservancy.

Using this report as a foundation, this process could be furthered by the dam owners and other key stakeholders, especially relevant state and federal agencies, meeting and reaching agreement on the overall goals and methods for migratory fish restoration. This agreement could include the signing of a non-binding Memorandum of Understanding.

A clearly needed next step would be for individual dam owners to work with technical consultants who could elaborate on the site-specific issues and opportunities associated with their respective dams and their fish passage options. The result could be preliminary concept designs and technical reports by the consulting firms that could form the basis of further fund-raising efforts to implement approved designs. This preliminary design work would still be non-binding on the dam owners. If the dam owners decided to move forward with a project, these preliminary plans could be the basis for permit applications and discussions. Clearly, the dam owners would need to proceed in a coordinated fashion. As the owner of the two lower-most dams in the system, the City of Wilmington is in a unique position to move this effort forward or halt it entirely.

The federal agencies would appropriately play a lead role in providing funds for this enterprise. The Commonwealth of Pennsylvania through the Fish and Boat Commission could have a significant role in "seeding" shad in the upper reaches of the watershed in Pennsylvania, as it has done on the Susquehanna, Schuylkill, and Lehigh Rivers. The State of Delaware, as the owner of two dams and the leading regulator of dam modification and permitting, will be a critical partner. As mentioned in the appendix on Funding Sources, Delaware could also provide funds needed to match federal funds.

Research and outreach for this project has focused initially on Delaware since there are 11 dams on the Brandywine in Delaware. The Brandywine River clearly supports much potential shad habitat in Pennsylvania as well, and research and outreach has been initiated for the Pennsylvania portion of the watershed. If shad restoration progresses in Delaware, the Conservancy intends to make further appropriate efforts in Pennsylvania to ensure the fish can have as full access to the watershed as possible.

American shad were once a central part of American culture and an important component of our watersheds. Through a sustained partnership of federal, state, regional, and local stakeholders, the unique and dramatic phenomenon of migrating shad could be restored.

Appendices

Appendix One

A Brief History of the Brandywine River in Delaware

The Brandywine River is the steepest river in Delaware. From its sources in the Welsh Mountains of the Piedmont Province in northern Chester and Lancaster Counties, it flows south through central Chester County, Pennsylvania, and enters New Castle County, Delaware, at an elevation of about 138 feet above sea level. It continues about 12 more miles before crossing the "fall line" where the Piedmont meets the flat Atlantic Coastal Plain in the City of Wilmington. The Brandywine winds through Wilmington about two more river miles as a tidally-influenced river before reaching its confluence with the Christina River, approximately one mile short of the Delaware River.

This confluence of the fall line with access to the deep waters of a larger river is where many early East Coast settlements were founded, including the City of Wilmington. The larger river provided access for ocean-going ships to dock, while the steep Piedmont streams provided ample water power.

The Brandywine was almost immediately put to work – dams and mills sprang up in large numbers during the colonial period, and the historical accounts of great fish abundance from the 1600s were replaced by complaints of decreases in the numbers of fish.[28] Early dams and mills date back to the late 1600s. For example, in 1682 Jacob Vandever was given permission to build a gristmill along the Brandywine in present-day Wilmington, the same year William Penn named Chester, Bucks, and Philadelphia as his three original colonies.[29] In 1683, Penn bought land from the Native Americans, but by 1705, Lenni-Lenape chiefs unsuccessfully insisted they were deeded land a mile on either side of the Brandywine, and fought to regain it from its mouth to the river's West Branch in northern Chester County.[30]

In an age of water-powered industry, Wilmington soon rose to become an important industrial force. Led by Quaker businessmen, Wilmington became a flour-milling center in the decades prior to the American Revolution, and a paper-making center afterwards.[31] Industry along the Brandywine diversified, and by 1797, some "60-80 mills, almost all of different descriptions, such as paper, powder, tobacco, sawing, fulling, and flour" were operating along the small but powerful river, according to a French visitor. [32] In 1802, new techniques were imported to improve an existing industry – gunpowder making, as the DuPont Company was organized in America.

The Brandywine River had become an industrial millstream, and the shad runs ceased.

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[28] From Kalm, Peter, *Travels in North America, 1748-1750*, 1966, Dover Publications, New York. Vol. 1, pp.154-56, 273, as reported in Raasch, 1991, p. 15.
[29] Humphrey, Elizabeth, *Brandywine*, 1990, the Jared Company, p. 204.
[30] Ibid, p. 204.
[31] No author, *The Hagley Museum, A Story of Early industry on the Brandywine*, 1957, Eleutherian Mills – Hagley Foundation, Wilmington, Delaware.
[32] Ibid, p. 31

Appendix Two

A Natural and Cultural History of Shad

The huge numbers and excellent flavor of the American shad were once legendary along the East Coast of the United States. From long before the arrival of settlers to the New World, the spring migratory runs of this 20-30" full-flavored silver fish once numbered in *the tens of millions*, featuring so many fish that the rivers were described as "black" and "boiling." Their range included accessible eastern streams lying between Newfoundland, Canada and northern Florida. The Latin name for the species is *Alosa sapidissima*, meaning "most delicious, or savory, herring." Glowing historical accounts reach back to the earliest colonial days, where the "innumerable" fish, both fresh and preserved through pickling or salting, was a central part of settlers' diets, as it was for Native Americans before them.[33]

Today, many people have never heard of the fish. Once denied access to its former spawning streams through dam blockages and pollution, the fish's numbers plummeted. At the same time, they were over-harvested in the ocean. Now, through a national restoration effort, this important symbol of our natural and cultural heritage is making a comeback.

The American shad is the largest North American member of the herring family, commonly reaching about 30" and 4-8 pounds. It is an anadromous fish that spends the majority of its adult life at sea, returning only to freshwater in the spring to spawn. Like salmon, shad return to the stream of their birth, their "natal" stream, to spawn.

Beginning in March or April, shad congregate in the bays, sounds, and estuaries below their natal rivers, adjusting their physiology from salt- to fresh water. Then, about the same time as the shadbush (*Amelanchier spp.*) blooms, they stop eating and move en masse upstream, sometimes traveling hundreds of miles before spawning (for example, into upstate New York on both the Delaware and Susquehanna Rivers). Not all shad die after spawning, instead returning downstream to the ocean where the cycle may begin again.

During the migratory runs, the males travel upriver in schools ahead of the females. Shad spawn over sandbars or rocky riffles at night. Females, which are larger than the males, produce 100,000 eggs on average, with 300,000 a documented high. Shad eggs are not adhesive and are just slightly heavier than water, so they do not readily sink. Instead, they drift along with the current, settling to the bottom as they gain weight and lodge in place. The eggs develop and hatch in eight to twelve days, depending on water temperature. The young shad or fry feed on freshwater plankton and aquatic insects throughout the summer. When the fall rains arrive and the water cools, surviving young descend their birth streams in large numbers, eventually heading out into the open ocean. East Coast shad then form large schools, wintering more or less together off the mid-Atlantic. Over the summer months, they range as far north as the Bay of Fundy, off Nova Scotia. They feed exclusively on oceanic plankton. After three-to-five years at sea, the natural phenomenon cycles around

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[33] Weslanger, C. A., 1953. *Red Man on the Brandywine*, Wilmington, DE., Chapter 13, page 1.

again, and those shad ready to spawn congregate in the bays, sounds, and estuaries below their natal rivers.

Such an abundant and tasty fish naturally caught the attention of settlers. For example, early Swedish settlers in Wilmington, Delaware, are reported to have brought their fish planks with them among other household effects.[34] The planking of fish was and is a favorite method of cooking shad, used by Native Americans as well as settlers. Traditionally, the fish is nailed or attached to a previously warmed oak plank and baked by placing the plank close to the coals of a fire. An engineer with the Swedish colony, Peter Lindestrom, wrote in his *Geographica Americae* (1654-56), "shad … is a very fine flavored and excellent tasting fish."[35]

Shad continued to be as important to the colonists as they were to the Native Americans. Using fishing skills such as brush nets and rock-crib traps learned from the Indians, the early settlers salted the fish away for the rest of the year. When Connecticut settlers laid claim to the northern tier of Pennsylvania in the 1750s, they quickly tried to establish commercial fishing rights to the shad runs in the Susquehanna, which was only resolved by war. Meanwhile, the settlers introduced the use of nets and seines for large-scale harvesting.[36] Overall, fishing or trading for shad was so widespread in colonial America, it is said that "no family was without its share."[37] Settlements and areas on rivers were named after shad, such as Shad Landing, Maryland, and Shadwell, Virginia, where Thomas Jefferson was born. Shad even had a role to play in the American Revolution: they have been credited with helping to save General Washington's troops at Valley Forge. The spring run of 1778 arrived in time to feed and strengthen the starving troops.[38] Shad have even been named "the Founding Fish" by author John McPhee, due to their central role in early American life.[39]

The importance of shad continued in the early decades of the new American Republic. It is reported, for example, that the annual harvest of shad in the upper Susquehanna River was limited only by the availability of salt needed for their preservation.[40] Yet during this time, the increasing blockage of spawning rivers by dams and other impediments, combined with degradation of water quality by new industries and relative overfishing, initiated a downward spiral in shad populations. Still, a commercial shad industry was able to establish and maintain itself, especially in larger rivers, until the early 20th century. In fact, American shad were the largest commercial fishery in the mid-Atlantic. "Just as the sacred cod of

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[34] From Ellwanger, G.H., 1902. *The Pleasures of the Table.* Doubleday, Page, & Co., New York, p. 255, as reported in Raasch, 1991, p. 12.

[35] Also as reported in Raasch, 1991, p. 13.

[36] From U.S. Fish and Wildlife Service, et al, undated, "Migratory Fish restoration and Passage on the Susquehanna River," p. 1.

[37] Ibid, p. 1.

[38] "The most memorable day was the one early in spring when schools of shad came swimming up the Schuylkill --- thousands upon thousands of beautiful, fat shining shad. The whole camp turned out to catch shad. The river so swarmed with fish that each haul of the net brought in hundreds. That night for the first time since the army had moved to Valley Forge there was not a hungry man in camp; each solider went to bed with a belly stuffed with shad." (p. 179 of a chapter called "The Revolution" in "The Pennsylvania Dutch" by Frederic Klees, published 1951 by Macmillan Co.)

[39] See McPhee, 2002, *The Founding Fish.*

[40] From U.S. Fish and Wildlife Service, et al, undated, "Migratory Fish restoration and Passage on the Susquehanna River," p. 1.

Massachusetts is the accepted emblem of the Bay State, so the shad may rightly be considered the piscatorial representative of the states bordering the Chesapeake," wrote Rachel Carson in the Baltimore Sun in 1936. Shad is the state fish of Connecticut today.

Still, shad are naturally most abundant in the middle Atlantic region. In fact, the Delaware River and its tributaries are considered to have historically supported the largest population of American shad over all East Coast rivers.[41] Consequently, the Susquehanna and Delaware Rivers were among the most abundant commercial fisheries, supporting fish hauls of over 6 million and 10 million pounds respectively in the late 1890s and early 1900s. The well-known Philadelphia painter, Thomas Eakins, depicted shad fishermen at work in his *Shad fishing at Gloucester on the Delaware River* (1881). Today, these fisheries are a tiny fraction of what they were due to habitat loss and fishing pressure. There are no commercial shad fisheries left on the Susquehanna and only one on the Delaware River at Lambertville, New Jersey. Even today, though shad numbers are far below their 1900 levels, shad and its roe are the most popular springtime fishery on the Delaware River and are marketed commercially, with the annual harvest ranging from $30,000 to $150,000 dockside value between 1980 and 1989.

[41] From U.S. Fish and Wildlife Service, et al, undated, "American Shad Restoration in the Delaware River Basin," fact sheet.

Appendix Three

Potential Funding Sources For Shad Restoration and Dam Modification

Funding for individual fish passage projects is likely to require multiple sources. Twenty-four funding sources have been identified that either have a history of funding similar projects, or the mission of the organization may support this effort. The sources described below have been divided into federal, state, and private categories. Due to current availability, the best sources for funding would be from a combination of federal agency programs and private foundations.

Some agencies and foundations offer multiple grant programs that are relevant to shad restoration projects. In addition to regular grant programs described below, some federal agencies may have discretionary funds that can be used to help finance dam removals, studies associated with dam removals, and related restoration work. Another source of federal funds can be Natural Resource Damage Assessments (i.e., violation penalties) and mitigation-related funds.

There are many different forms of in-kind (i.e., non-monetary) assistance provided by federal agencies. First, some federal agency personnel who have managed programs for dam removal and related restoration projects (e.g., U.S. Fish and Wildlife Service, National Marine Fisheries Service, and Natural Resources Conservation Service) can offer expertise in fisheries, aquatic ecosystem restoration, dam deconstruction, and fish passage design and construction.

There are several funding possibilities within the State of Delaware ranging from grants, agency-level discretionary funds, general appropriations, or use of environmental violation fines. Under current rules, if an environmental penalty is levied, 25% of it must go back into the communities where the violation occurred. The Delaware Coastal Program within DNREC Division of Soil and Water may have grants available for restoring migratory fish passage on the Brandywine River (see #17 below). It is not a large program and has not yet provided grants for work such as this, but program leaders are willing to consider migratory fish-related projects. Since two of the dams are owned by the State, it may be possible to seek an appropriation for their removal or construction of fish passage. Another possibility would be to work with state legislators and the Governor to approve a General Fund allocation to be used as matching funds toward federal or private grants. Examples of such conditional appropriations can be found in Pennsylvania.

The eight private funding sources listed below are private foundations, many located in the Wilmington area. Corporations are another potential source of funding. In fact, funding from local corporations is significant in the shad restoration efforts occurring on the Susquehanna and Schuylkill Rivers. The process for identifying, applying for, and receiving funds from a combination of sources is likely to take a relatively long time, in some cases, as long as one year.

I. Federal Funding Sources

1. **National Fish and Wildlife Foundation** - *Bring Back the Natives* grant program (U.S. Fish and Wildlife Service, Bureau Land Management, USDA Forest Service)
    - The program seeks projects that initiate partnerships with private landowners, demonstrate successful collaborative efforts, address watershed health issues that would lead to restoring habitats that are key to restoring native aquatic species and their migration corridors, promote stewardship on private lands, and that can demonstrate a 2:1 non-federal to federal match.
    - Awards 12-15 grants per year, averaging $60,000
    - http://www.nfwf.org/programs/bbn.htm

2. **National Fish and Wildlife Foundation -** *Delaware Estuary Grants Program*
    - This grant program seeks to: encourage innovative, locally-based programs or projects that restore important habitats and improve water quality within the Delaware Estuary; support communities in developing and implementing watershed management plans; develop the capacity of local governments, citizens groups and other organizations to promote community based stewardship and enhance local watershed management; promote a greater understanding of the Delaware Estuary and the interrelationship between the health of the Estuary and the condition of local watersheds; and strengthen the link between communities and the Delaware Estuary Program.
    - Awards approximately $500,000/year in grants (efforts are underway to increase funding).
    - American shad is a priority species of interest.
    - http://www.nfwf.org/programs/delaware.htm

3. **National Fish and Wildlife Foundation** - *General Matching Grants Program* (U.S. Fish and Wildlife Service, Agency for International Development, Bureau of Land Management, Bureau of Reclamation, National Oceanic and Atmospheric Administration, and USDA-Forest Service)
    - The National Fish and Wildlife Foundation operates a conservation grants program that awards matching grants, on a competitive basis, to eligible grant recipients, including federal, tribal, state, and local governments, educational institutions, and non-profit conservation organizations. Matching grants are awarded to projects that: address priority actions promoting fish and wildlife conservation and the habitats on which they depend; work proactively to involve other conservation and community interests; leverage available funding; and evaluate project outcomes.
    - Grants typically range from $10,000-$150,000, based upon need.
    - http://nfwf.org/programs/guidelines.htm

4. **National Fish and Wildlife Foundation** - *Five Star Matching Grants Program* (Funding through U.S. Environmental Protection Agency, and the Community-Based Restoration Program within National Oceanographic Administrative Association (NOAA)
    - Projects must involve diverse partnerships of organizations that contribute funding, land, technical assistance, workforce support, and/or other in-kind services. Projects must include a strong on-the-ground wetland, riparian, or coastal habitat restoration component and should also include training, education, outreach, monitoring, and community stewardship components. Applicants must demonstrate that measurable ecological, educational, social, and/or economic benefits are expected to result from the completion of the project. Projects may be a discrete part of a larger restoration effort but must be ready to complete within a one-year time-frame upon receipt of funding. Preference will be given to projects that: are part of a larger watershed or community stewardship effort; include specific provisions for long-term management, monitoring, and protection; and demonstrate the value of innovative, collaborative approaches to restoring the nation's waters.
    - Grant awards are between $5,000 and $20,000.
    - http://nfwf.org/programs/5star-rfp.htm

5. **FishAmerica Foundation** – *Community-Based Marine and Anadromous Fish Habitat Restoration Projects* (partnership with NOAA)
    - The FishAmerica Foundation unites the sportfishing industry with conservation groups, government natural resource agencies, corporations, and charitable foundations to invest in fish and habitat conservation and research across the country.
    - Projects must result in on-the-ground habitat restoration, clearly demonstrate significant benefits to marine, estuarine or anadromous fisheries resources, particularly sportfish, and must involve community participation through an educational or volunteer component tied to the restoration activities. Emphasis is on using a hands-on, grassroots approach to restore fish habitat across coastal America.
    - The FishAmerica Foundation and the NOAA Restoration Center anticipate the availability of approximately $600,000 per year under this solicitation.
    - http://www.fishamerica.org/faf/grants/index.html

6. **NOAA** - *Community-based Restoration Program Direct Grants*
    - The NOAA Community-based Restoration Program (CRP) provides funding to catalyze the implementation of locally-driven, grassroots habitat restoration projects that will benefit living marine resources, including anadromous fish. Projects funded through the CRP will be expected to have strong on-the-ground habitat restoration components that provide educational and social benefits for people and the communities in addition to long-term ecological habitat improvements for NOAA priority resources. Proposals selected for funding through

this program will be implemented through a project grant or cooperative agreement mechanism.

- Funding of up to $3,000,000 is expected to be available for community-based habitat restoration projects in FY 2005. The NOAA Restoration Center (RC) anticipates that typical awards will range from $50,000 to $200,000.
- http://www.nmfs.noaa.gov/habitat/restoration/projects_programs/crp/partners_funding/callforprojects.html

7. **NOAA** - *Community-based Habitat Restoration Program*
   - Multi-year proposals for establishing innovative partnerships for up to 3 years with the NOAA Restoration Center (RC) at a national or regional level to further community-based habitat restoration that will benefit living marine resources including anadromous fish. The CRP's objective is to bring together citizens groups, public and nonprofit organizations, watershed groups, industry, corporations and businesses, youth conservation corps, students, landowners, academic institutions and local government, state, and federal agencies to cooperatively implement habitat restoration projects to benefit NOAA trust resources.
   - Funding of up to $7,000,000 is expected to be available for establishing habitat restoration partnerships in FY 2004, and annual funding is anticipated to maintain them for up to 3 years. The NOAA Restoration Center anticipates that typical partnership awards will range from $200,000 to $600,000 per year.
   - http://www.nmfs.noaa.gov/habitat/restoration/projects_programs/crp/partners_funding/CRPpartners_ffo.html

8. **USDA, Natural Resources Conservation Service (NRCS)** - *Conservation Technical Assistance Program*
   - Technical assistance funding includes planning and implementing natural resource solutions to reduce erosion, improve soil health, improve water quantity and quality, improve and conserve wetlands, enhance fish and wildlife habitat, improve air quality, improve pasture and range health, reduce upstream flooding, improve woodlands, and address other natural resource issues. Assistance is provided to land owners voluntarily implementing conservation measures and to those who must comply with local or State laws and regulations. Available to groups or individuals.
   - To obtain Conservation Technical Assistance, contact local USDA, NRCS office: East region website – http://www.ea.nrcs.usda.gov
   - Mitch Flanagan, acting national program manager: (202) 690-5988

9. **USDA, Natural Resources Conservation Service (NRCS)** - *Resource Conservation & Development Program*
    - Current program objectives focus on quality of life through natural resources conservation and community development which leads to sustainable communities, prudent use (development), and the management and conservation of natural resources. RC&D areas must be locally sponsored areas *designated* by the Secretary of Agriculture for RC&D technical and financial assistance program funds.
    - Terry D'Addio, National RC&D Program Manager, 202-720-0557 OR http://www.nrcs.usda.gov/programs/rcd/

10. **USDA, Natural Resources Conservation Service** - *Wildlife Habitat Incentives Program (WHIP)*
    - Provides both technical assistance and up to 75 percent cost-share assistance to establish and improve fish and wildlife habitat. To be eligible, an applicant must own or have control of the land to be enrolled in the program for the duration of the agreement period.
    - http://www.nrcs.usda.gov/programs/whip/
    - Contact local/state Nat. Resources and Conservation office:
        - Newark Service Center:
          2430 Old Country Rd
          Newark, DR 19702-4702
          (302) 832-3100 ext 3

          West Chester Service Center
          601 Westtown Rd
          West Chester, PA 19380-0990
          (610) 696-8750

11. **U.S. Fish and Wildlife Service** - *Partners for Fish and Wildlife Program*
    - The U.S. Fish and Wildlife Service focuses on projects in watersheds where conservation efforts will provide the greatest benefits for Federal trust species which include: migratory birds, anadromous (migratory) fish, and threatened and endangered species. Individual landowners (or anyone in possession of non-federal land) may contact the State Partners for Fish and Wildlife coordinator to discuss proposed restoration projects. Before beginning a habitat restoration project, the Service and the landowner must sign an agreement that states that the landowner will not return the project area to its former use, or damage or destroy the restoration project, during the agreement period without reimbursing the Service for the funds spent on the project. Cost share is normally 50% but is flexible.
    - http://partners.fws.gov/index.htm
      Delaware (and Maryland) contact:
      Al Rizzo
      177 Admiral Cochrane Drive
      Annapolis, MD 21401
      410/573 4500 [FAX: 410/269 0832]

12. **U.S. Fish and Wildlife Service** - *National Fish Passage Program*
    - A fish passage project can be any activity that directly improves the ability of fish or other aquatic species to move by reconnecting habitat that has been fragmented by barriers. Fish passage project proposals may be initiated by any individual, organization, or agency, in cooperation with the Service's Fish and Wildlife Management Assistance Offices. The following information is requested with all project proposals: title; associated planning documents (e.g. recovery plan, watershed management plan); partners; requested funds and matching contributions; and a project description that briefly identifies the need, problem, objective and methods, and includes the waterbody, location, river miles or acres to be opened up; and the species affected and how they are benefitted. Project proposals must be provided to the local Fish and Wildlife Management Office for entry into an internal database. Projects will be reviewed and prioritized on a regional basis.
    - Funding is administered through the Fish and Wildlife Service office that is coordinating the project with partners. The Program has flexibility from project to project but strives to achieve a 50% match, including in-kind contributions.
    - Contact: Dick St. Pierre (email) Richard_StPierre@fws.gov
      (phone) (717) 705-7838
      OR David Perkins (email) Dave_Perkins@fws.gov
      (phone) (413) 253-8405
      http://fisheries.fws.gov/FWSMA/fishpassage/

13. **Army Corps of Engineers** - *Continuing Authorities Program (CAP), Section 1135*
    (Habitat Restoration for Fish and Wildlife Resources)
    - The U.S. Army Corps of Engineers is authorized by Congress to review the operation of water resources projects to determine possibilities for structural or operational modification. Modification plans that are consistent with the authorized purpose of water resource projects and will improve the quality of the environment are usually considered eligible for the section 1135 program. A sponsor's restoration idea must meet the following criteria: the habitat restoration must involve a Corps of Engineers project on lands contiguous to or in the area impacted by the original project; the economic benefits must outweigh the costs and be associated with fish and wildlife resource restoration; the non-federal sponsor may be a public agency or large non-profit organization.
    - Up to $25 million is available annually to carry out this program with a $5 million maximum per individual project without Congressional approval. 25% of the project costs and 100% of the operation and maintenance total costs are assumed by the sponsor. Private interests and not-for-profit organizations may sponsor if no future O & M is required.
    - http://www.mvr.usace.army.mil/pdw/sect1135.htm#program
      Contact Info: Ms. Dorie Bollman (email)
      Dorene.A.Bollman@usace.army.mil OR (phone) (309) 794-5590

14. **Army Corps of Engineers**---*Continuing Authorities Program (CAP), section 206* (Aquatic Ecosystem Restoration and Protection)
    - The objective should be restoring degraded ecosystem structure, function, and dynamic processes to a less-degraded, more natural condition, which will involve consideration of the ecosystem's natural integrity, productivity, stability and biological diversity. Typical projects could include removal of low-head dams, restoration or creation of fish habitat, and wetland creation. The interested non-Federal sponsor should present its ideas to the District for consideration.
    - Federal costs are limited to $5 million per project. The non-Federal share of the costs of aquatic ecosystem restoration projects shall be 35%. The non-Federal sponsor shall provide all lands, easements, rights-of-way, and necessary relocations required for the restoration project. If those values exceed the government's share of the total project costs, the government shall reimburse the non-Federal sponsor for the excess amount. Operations, maintenance, repair, replacement and rehabilitation and lands, easements, rights-of-way and relocations and disposal/borrow areas must be funded with non-Federal dollars.
    - http://www.saw.usace.army.mil/floodplain/Section%20206.htm
      Contact Info: Noel Clay
      (email): noel.c.clay@saw02.usace.army.mil
      (phone): (910) 251-4706
      (mailing address): Chief, Planning Services Section
      U.S. Army Corps of Engineers, Wilmington
      Post Office Box 1890
      Wilmington, North Carolina 28402-1890

15. **Delaware Estuary Program Minigrants** (funded through USEPA under the National Estuary Program), *Delaware Estuary Program.* Administered through the Partnership for the Delaware Estuary, Inc.
    - One of the main goals of the mini-grant program is to motivate citizens to become involved in protecting the Delaware Estuary. In FY 2004, preference was given to habitat-oriented (restoration, enhancement, and/or protection) mini-grant projects, such as streambank stabilization, native plantings, and habitat enhancement projects. Upon receipt of the signed contract and proof of insurance, the Partnership will issue a check for half of the grant. The second half of the grant is reimbursed and will be issued only upon receipt of a final report, which must include a detailed budget of expenditures totaling the full amount of the grant and at least a 10% match.
    - Contact Delaware Estuary Program at 1-800-445-4935 ext. 19
      OR Martha Doyle, director at (phone): (609) 883-9500 ext. 215
      (email): mmaxwell@drbc.state.nj.gov
      http://www.state.nj.us/dep/watershedmgt/DOCS/delep/Draft%20RFP%202004.pdf

II. State Funding Sources

16. **DNREC Division of Soil and Conservation---DE Coastal Programs**, *The Community and Local Government Natural Resource Management Grant Program*
    - Seeks proposals that will improve the management of natural resources in the State of Delaware. This grant program provides an opportunity for local governments and communities to plan for preservation and enhancement of natural and community resources within their boundaries, as well as to improve management of habitat and community residential open space. These grants are available to Communities, County and Municipal governments, as well as to civic associations and maintenance corporations.
    - Total anticipated funding for this program is estimated to be $100,000. Past awards ranged from $2,000 -$25,000.
    - Contacts: Susan Love or David Carter at (302) 739-3451 http://www.dnrec.state.de.us/dnrec2000/Divisions/Soil/dcmp/RFP2004.htm

III. Private Foundation Funding Sources

17. **William Penn Foundation** - *Environment and Communities, Sustainable Watershed Assets Programs*, Philadelphia, PA
    - The Foundation has a long history of grant making to advance protection and restoration of watersheds. Funded projects in targeted areas should demonstrate model practices and policies. Local areas that achieve measurable advances in land and water protection can serve as models for other communities. The program will target support to geographic areas where locally based projects and policies can leverage regional change. Past initiatives have included major grant programs to protect and restore the Delaware and Schuylkill Rivers – waterways that historically have played important roles in shaping the growth and development of Greater Philadelphia and serve as major sources for drinking water. Projects on the Brandywine River may be eligible.
    - For more information: http://www.williampennfoundation.org/info-url_nocat3569/info-url_nocat_show.htm?doc_id=117091

18. **The Fair Play Foundation**, Wilmington, DE
    - Fields of interest include preservation and protection, animals and wildlife, water resources, and the environment. Types of support include: building and renovation, equipment, land acquisition. Application forms are not required. Write a letter as an initial approach.
    - Fair Play Foundation---(302) 777-4711
      Contact: Blaine T. Phillips, Pres.
      100 W. 10th St., Ste 1010, Wilmington, DE 19801

19. **Chichester duPont Foundation Inc.**, Wilmington, DE
    - Independent foundation giving primarily to projects in DE and MD. Focus on child welfare but with some support for conservation. No application form.
    - Average grants $10,000-$100,000
    - 3120 Kennett Pike/ Wilmington, DE 19807-3052
      Contact: Gregory F. Fields, Secy. (302) 658-5244

20. **Crystal Trust**, Montchanin, DE
    - Independent foundation giving to a wide range of projects including conservation projects. Emphasis on Delaware-related projects. Does not give to individuals. Types of support includes: building and renovation, capital campaigns, equipment, and land acquisition. Application form not required.
    - Average grants $10,000-$100,000
    - P.O. Box 39, Montchanin, DE 19710-0039
      Contact: Stephen C. Doberstein, Dir. (302) 651-0533

21. **The Marmot Foundation,** Wilmington, DE
    - Independent foundation located in Wilmington, DE. Focus on giving for, among other things, environmental and ecological organizations. Does not give to individuals. Application form not required, approach with letter. Giving primarily in DE and FL; support includes: building and renovation, capital campaigns, equipment, land acquisition, matching/challenge support, and research.
    - 100 W. 10th St., Ste. 1109/ Wilmington, DE 19801-1694
      DE Contact: Charles F. Gummey, Jr., Secy. (302) 654-2477

22. **MBNA Community Grants Program,** Wilmington, DE
    - The Community Grants Program responds to identified needs and involves MBNA employees when determining the level of support. Funding includes volunteer programs, executive assistance, in-kind donations, and monetary grants. The program typically supports organizational programs dedicated to: human services, health services and environmental conservation and preservation. Grants are available for both individuals and organizations.
    - For additional information about the Foundation's Community Grants Program, please call (302) 432-5205 or 1-800-441-7048, extension 25205.

23. **Ederic Foundation,** Wilmington, DE
    - Independent foundation in Wilmington, DE. Giving primarily to projects in Wilmington area. Interests include environment and natural resources. Initial approach to be done by letter. No grants given to individuals.
    - Contact Info: John E. Riegel, President.
      The Ederic Foundation
      P.O. Box 4420/ Wilmington, DE 19807-0420

24. **Prospect Hill Foundation,** New York, NY

- A private foundation with broad range of philanthropic interests. The foundation's environmental grants concentrate on habitat and water protection in the northeastern region of the United States. It encourages proposals from organizations exhibiting leadership that: offers strategies and policies for the conservation of significant private and public lands and strengthen policies and initiate means of improving water quality and protecting coastal areas. Applicants may submit grant requests to the Executive Director at any time of year. The request should be in the form of a letter (three pages maximum) that summarizes the applicant organization's history and goals; the project for which funding is sought; and the contribution of the project to other work in the field and/or to the organization's own development.
- Grants paid during 2003 totaled $3,132,250 and were awarded to 103 organizations for 114 activities.
- Contact Info:
  (http://fdncenter.org/grantmaker/prospecthill/index.html)
  The Prospect Hill Foundation
  99 Park Avenue, Suite 2220
  New York, New York 10016-1601
  (212) 370-1165

Appendix Four

The Permitting Process For Fish Passage Projects

State and federal permits are required for implementing fish passage projects on the Brandywine River. The two primary permits required are issued by DNREC (Division of Water Resources, Subaqueous Lands section), and the U.S. Army Corps of Engineers (Corps). Additionally, an applicant *may* need a state water quality certification, and *may* need to show that the project is consistent with the federal Coastal Zone Act. In the case of historic dams, Delaware's State Historic Preservation Officer, located within the Bureau of Archaeology and Historical Preservation, Division of Cultural Affairs, must be consulted in an advisory capacity. Local stormwater management and soil erosion/sedimentation control permits may also be necessary for dam-related construction activities from the New Castle County Conservation District, but these are relatively easy to obtain compared with the state and federal permits.

There are no formal submission guidelines, but federal and state permit applications are discussed monthly by a Joint Permit Processing Committee in Dover, Delaware. The Committee coordinates permit applications and policies and includes representatives from all relevant state and federal regulatory and advisory agencies. The lead state agency is DNREC (Division of Water Resources, Subaqueous Lands section), which regulates such projects and issues permits under Title 7 (Conservation), Part VII (Natural Resources), Chapter 72 (Subaqueous Lands), or 7 Del. C. 7203. The other regulatory agency, the Corps, normally regulates fish passage activities under Section 404 of the Clean Water Act. Where there are navigable rivers, which the Corps defines as all waterways with a tidal influence, the activity is also regulated under Section 10 of the River and Harbors Act. On the Brandywine, this could include Dam #1, which is located at the "head of tide," where tidal influences end.

Other agencies represented at Joint Permit Processing Committee meetings include the U.S. Fish and Wildlife Service; the National Marine Fisheries Service; the U.S. Environmental Protection Agency; the National Oceanographic and Atmospheric Administration; the National Park Service; DNREC, Division of Fish and Wildlife; DNREC, Soil and Water Conservation; DNREC, Division of Parks and Recreation and, as mentioned above, the Bureau of Archaeology and Historical Preservation, Division of Cultural Affairs.

Pre-application conceptual discussions with the Committee at the very beginning of the process may minimize or eliminate certain regulatory concerns. This can save an applicant considerable time and money. For example, Committee members can point out details of a proposal that may not be allowable or, may require additional permitting or an increased level of scrutiny. This is particularly true with regards to Corps permits. Under the Clean Water Act, there are two types or levels of permitting – nationwide and individual.[42]

[42] Army Corps permit forms are available at - http://www.nap.usace.army.mil/cenap-op/regulatory/forms.html

Nationwide permits are more general in nature, and are used for projects with minimal or less significant resource impacts. *Individual permits* are for those projects that exceed certain thresholds (e.g., more than a one-half acre impact) or are considered to have significant resource impacts, and are more detailed, time-consuming, and expensive. Moreover, if an individual permit is required from the Corps, a State Water Quality certification and Coastal Zone consistency determination is also usually required. The Corps and the Joint Committee generally attempt to guide projects towards a nationwide permit where possible.

There are no separate DNREC Water Quality certification forms. Rather, they are issued after reviewing the Subaqueous and Corps permits.

Established in 1979, the Delaware Coastal Management Program protects and manages the state's coastal resources by reviewing federal and state projects to ensure that they are consistent with state coastal policies, special area management planning, assistance to state and local governments for local land-use planning, and other special on-the-ground projects related to Delaware's coastal resources. The program seeks to implement the national policy to "achieve wise use of the land and water resources of the coastal zone, giving full consideration to ecological, cultural, historic, and esthetic values as well as the needs for compatible economic development."[43]

This program is administered in Delaware by DNREC's Division of Soil and Water. All coastal states are required to identify their "Coastal Zone" and to establish policies that are consistent with appropriate coastal management. In Delaware, the official coastal zone comprises the entire state. Under federal Coastal Zone consistency requirements, applicants make their own consistency determination after reviewing the state's policies. They then submit a statement regarding their consistency to the Coastal Management Program staff members for review and comment. There is no specific permit form. While Program staff have reviewed fish ladder proposals in the past and found them consistent with Coastal Zone policies (indicating that the restoration of migratory fish should be consistent with those policies) they have not specifically reviewed a natural fishway or dam removal project.

As discussed in the text of this report, dams #7 - 11 all may be considered historic dams, since they are all associated with historic mill districts and with historic mill buildings and raceways that are registered on the National Register of Historic Places. Modifications to historic dams have occurred in Delaware and elsewhere. Projects with federal funding or licensing of activities that affect historic properties are regulated by Sections 106 and 110(f) of the National Historic Preservation Act. Under these provisions, federal agencies must take into account the effects of their undertakings on historic properties and afford an Advisory Council on Historic Preservation the opportunity to comment on the undertaking and its effects. Implementing regulations of the Council may be found in 36 CFR Part 800, "Protection of Historic Properties," which establishes a process of consultation with the State Historic Preservation Officer and the Council, leading, in most instances, to agreement on how the undertaking will proceed. Steps in the process include identification and

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[2]Coastal Zone Management Act Of 1972, as amended through P.L. 104-150, The Coastal Zone Protection Act of 1996, Section 303. More information is available at:
http://www.dnrec.state.de.us/dnrec2000/Divisions/Soil/dcmp/fedcon.htm

evaluation of historic properties that may be affected, assessment of the effects of the federal action, and resolution of any adverse effects that would occur.

The Eleutherian Mills Historic District (located on the Hagley Museum grounds) is also a National Historic Landmark. If a federal activity will "directly and adversely affect" a National Historic Landmark, Section 110(f) of the Act also calls for federal agencies to undertake "such planning and actions as may be necessary to minimize harm to such Landmark." As with Section 106, the agency must provide the Council with a reasonable opportunity to comment in accordance with 36 CFR Part 800.

Appendix Five

Shad Restoration in the Schuylkill River

As a nearby river with a large city straddling its banks, the Schuylkill River makes for a valuable comparison to the Brandywine with regard to shad restoration efforts. There are ten dams on the Schuylkill River, and four major partners working to restore shad to the Schuylkill: the City of Philadelphia through its Water Department (which owns dams #1 and co-owns #2); the Pennsylvania Department of Environmental Protection (which co-owns dam #2 and has inherited abandoned dams #3, 7, 8, 9, and 10); PECO Energy (which owns dams #4 and 6); and the Pennsylvania Fish and Boat Commission (PFBC), which is stocking shad and overseeing the restoration project as a whole.[44]

While native to the Schuylkill River and its tributaries, American shad have not ascended the Schuylkill since 1818 when the Fairmount Dam was constructed to supply drinking water to the growing metropolis. Plans for the restoration of American shad and other river herring to the Schuylkill River began in the mid-1970s when biologists discovered that, on their own, some adult shad were moving up the river as far as the Fairmount Dam. Subsequently, in 1979 a fish ladder was installed at the dam, itself part of the Fairmount Water Works National Historic Landmark.

Throughout the 1980s and much of the 1990s, the PFBC focused mainly on shad reintroduction in the Lehigh River rather than the Schuylkill. But, motivated by success with passing shad on the Susquehanna and Lehigh Rivers, where fish elevators and fish ladders had been installed, the Commonwealth once again returned to shad restoration efforts in the Schuylkill River.

PFBC's current restoration goals for the Schuylkill include: opening 100 miles of spawning habitat (through dam #8); providing up to 850,000 American shad; and, provide up to 170,000 shad angler trips. These goals will be met at an approximate cost of $8 million in public and private monies, not including the fish stocking costs. Fish ladders will be built or re-built on four of the dams (#s 1, 2, 4, and 6).

To that end, in 1999, the Commonwealth authorized $2.2 million to construct a fish ladder on Flat Rock Dam, dam #2, located in Gladwyne, Montgomery County. At the same time, the PFBC began stocking the river with American shad fry (raised in the PFBC Nursery from eggs from wild Delaware River shad). In 2003, a large number of adult shad returned to the Schuylkill River, revealing that the restocking efforts since 1999 have been largely successful. Now, with funds from the Army Corps of Engineers matched by city funds (at a 75% federal - 25% local ratio), the 25-year old Fairmount Dam fish ladder is undergoing a $1.5 million upgrade to modernize it by adding newer technologies including attraction flows (see Chapter Three for more information on attraction flows).

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[44] Two of these dams were built for industrial water supply but are no longer used for that purpose, while three others were built to capture silt discharging from abandoned mines in the upper Schuylkill anthracite coal fields.

Meanwhile, PECO Energy has agreed to construct fish ladders at its two dams (#s 4 and 6) in Norristown and Pottstown. The goal for completing fishway construction on the two dams is in time for the 2007 shad run. Three additional dams (#s 5, 7, and 8) have begun to naturally breach (fall apart), and two may be removed. Dam #3, Plymouth Dam at Norristown, will be removed by the Department of Environmental Protection. In all, approximately 100 miles of the Schuylkill River will then be open to anadromous and resident fish migration. Work is underway to provide fish passage on select Schuylkill tributaries as well.

Appendix Six

Shad Festivals: A Cultural Celebration

Shad are highly prized in many East Coast states, not only for their economic or culinary values, but also as a joyous symbol of nature's bountiful cycles and a species that has made a dramatic comeback. Their spring runs are often accompanied by numerous shad festivals held along the East Coast of the United States and Canada every year. Below is a list of eight of them, though the websites referred to sometimes reference other festivals making this list incomplete. For example, the Hudson River Celebration described below is only one of a series of festivities held from Westchester to near Albany, NY, celebrating the traditional return of shad to the river.

In Connecticut, shad festivals and derbies are held in several towns during the yearly shad run in May, according to the state website. The American shad is venerated in Connecticut as the state fish, a designation conferred by the State General Assembly in 2003. It was selected because: "1) it is a native Connecticut fish; 2) it has great historical significance in that it provided food for Native Americans and colonists; 3) it was, and continues to be, of great commercial value to the State; and 4) because the hardiness of this migratory fish reflects the true Connecticut spirit as stated in our motto *Qui Transtulit Sustinet (He Who Transplanted Still Sustains)*."

Some shad festivals are hosted by local Chambers of Commerce, some by the towns themselves, and others by environmental groups. Most have numerous business sponsors, and most are composed of the same elements: food, music, arts and crafts, children's events, speakers and performers, fishing contests, and environmental education within the context of general celebration.

1. **Riverkeeper Shad Festival and Hudson River Celebration**—Garrison, NY

Billed as a "celebration of the revival of the Hudson River," on May 23, 2004 the 15th annual Shad Festival was held in Garrison, New York and hosted by the Hudson Riverkeepers and Hudson River Foundation. Festival locations are changed annually to different towns on the Hudson River. Activities in 2004 included flyfishing; harnessed tree climbing; folk, jazz, and reggae live music performances; environmental speakers, and various other performances held on stage. Numerous vendors provided a variety of types of food, including grilled shad.

For more information - http://riverkeeper.org/events_story.php/861

2. **Annual Shad Derby** - Windsor, CT, on the Farmington River

Part of a fishing contest for kids, held in the middle of May.

For more information - http://www.kids.state.ct.us/symbols/fish.htm

3. **Lambertville Shad Festival**—Lambertville, NJ, on the Delaware River

Lambertville, New Jersey's Shad Festival is held over one weekend in late April. This festival is hosted by the Lambertville Chamber of Commerce, and has attracted as many as 30,000 people. According to the Chamber spokesperson it's been a big economic and morale boost, and, "It helped turn the town around." Activities included a commercial-style shad hauling demonstration at Lewis Island and traditional shad plank cooking demonstrations.

For more information - http://www.lambertville.org/

4. **Forks of the Delaware Shad Fishing Tournament & Festival**—Easton, PA, on the Lehigh and Delaware Rivers.

2004 marked the 22nd annual shad fishing tournament and festival in Easton, PA, along the Delaware River. The tournament is a week-long affair and includes competitions for adults and kids with prizes awarded for the largest catch each day. The top prize is $1,500. Other activities throughout the week include a parade, live music, and a shad cookout-festival on the last Saturday of the tournament.

For more information - http://mgfx.com/delaware/

5. **Nanticoke River Shad Festival**—Vienna, MD, on the Nanticoke River

In April 2004 the Nanticoke Watershed Alliance, Chesapeake Bay Foundation, the town of Vienna, and other partnering organizations hosted the 9th Annual Nanticoke River Shad Festival on the banks of the Nanticoke in historic Vienna, Maryland. The event is planned each year to coincide with and celebrate the spring spawning runs of American Shad, thus bringing attention to the species and efforts to restore its population. This past year, the over 2,000 visitors enjoyed music, boat rides, the Nanticoke River Canoe and Kayak Race, arts & crafts, educational exhibits, historical artifacts, a local author's tent, and food (including traditionally-cooked planked shad).

For more information - http://www.nanticokeriver.org/shad.html

6. **Rappahannock River Shad Festival** – Near Fredericksburg, VA, on the Rappahannock River.

Friends of the Rappahannock conducts occasional shad festivals at a park along the river to promote public awareness about the dam and the fish. Shad plankings and educational games that focused on migratory fish and dams were part of the events.

For more information - http://for.communitypoint.org/for_and_embrey3.htm

7. **Grifton Shad Festival**—Grifton, NC, on the Neuse River.

Held since 1972, the Grifton Shad Festival is now a regional attraction with over 30 events from clogging and crafts to historical exhibits. The festival is a multi-day affair, occurring in 2004 from March 30 through April 4.

For more information, see the Grifton town website - http://www.grifton.com/shadfest.html

8. **Middleton Annual Shad Festival**—Middleton, Nova Scotia, Canada

A late May shad festival held over a weekend. Note that due to their far northern location, their shad run is relatively late in the year.

For more information - http://www.evangelinetrail.com/festivals_events.shtml