

**Brandywine Shad 2020:  
The Nation's Founding Fish returns to  
America's Most Historic Small Watershed**

Dec 8, 2020

**The Athenaeum of Philadelphia**

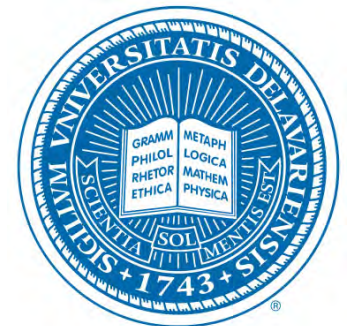
Gerald McAdams Kauffman, Ph.D.

University of Delaware

Water Resources Center

Biden School of Public Policy & Administration

Newark, Del.



# What is a diadromous fish?

- Fish that spend portions of their life cycle in fresh water and a portion of their life cycle in salt water
  - Atlantic Sturgeon – Endangered
  - Atlantic Striped Bass – Overfished coastwide
  - American Shad – Unsustainable in Delaware River Estuary
  - River Herring – Depleted in Delaware River Estuary

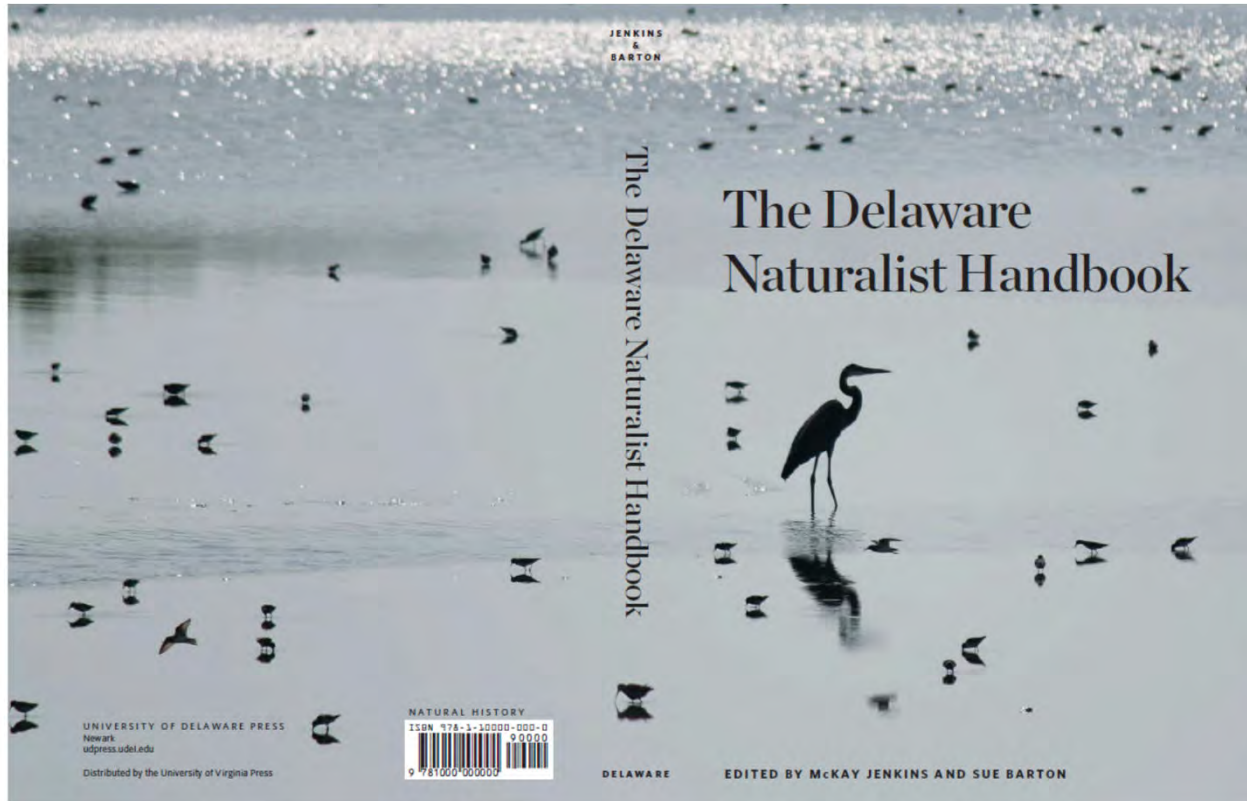


Publication of this book has been aided by grants from

[Names of patrons to come]

Cover: A great blue heron surrounded by shorebirds at Bombay Hook. (Photo courtesy of Ian Stewart.)

Jacket design by Robert L. Wiser



So you want to become a Delaware Master Naturalist. Congratulations, and welcome to the team!

As you may know, or as you will soon surely discover, Delaware is a state of great and varied natural beauty, and also a state that needs considerable help in returning to full ecological health and resilience. We hope that in reading this book, you will join the growing number of people exploring our state's many wonders; committing themselves to deepening their understanding of environmental systems; and adding their hearts, minds, and bodies to our state's ecological restoration efforts.

In this volume, you will learn from experts in a wide variety of fields who have made the observation, study, and rehabilitation of the natural world their life's work and their life's passion. These professional scientists and veteran environmental educators offer their wisdom on everything from Delaware's geological foundations and its changing meteorology to the complex ecological systems formed by the state's forests, rivers, and soils. You will learn about the region's myriad species of birds, insects, reptiles and amphibians, and how skilled naturalists can train themselves to notice, identify, and photograph (or draw) what they see.

As anyone who has visited scoped shorebirds at Bombay Hook National Wildlife Refuge, or canoed the Brandywine River, or watched hawks migrating over Cape Henlopen State Park knows, Delaware is a world-class place to study and appreciate the natural world. Hearing a wood thrush sing the forest to sleep in White Clay Creek State Park, watching the arrival of horseshoe crabs along the Atlantic Coast, listening to spring peepers emerge in a vernal pool along the Delaware River—these are among the many magical events that make Delaware a wonderfully rich place to explore.



# Watershed Ecology

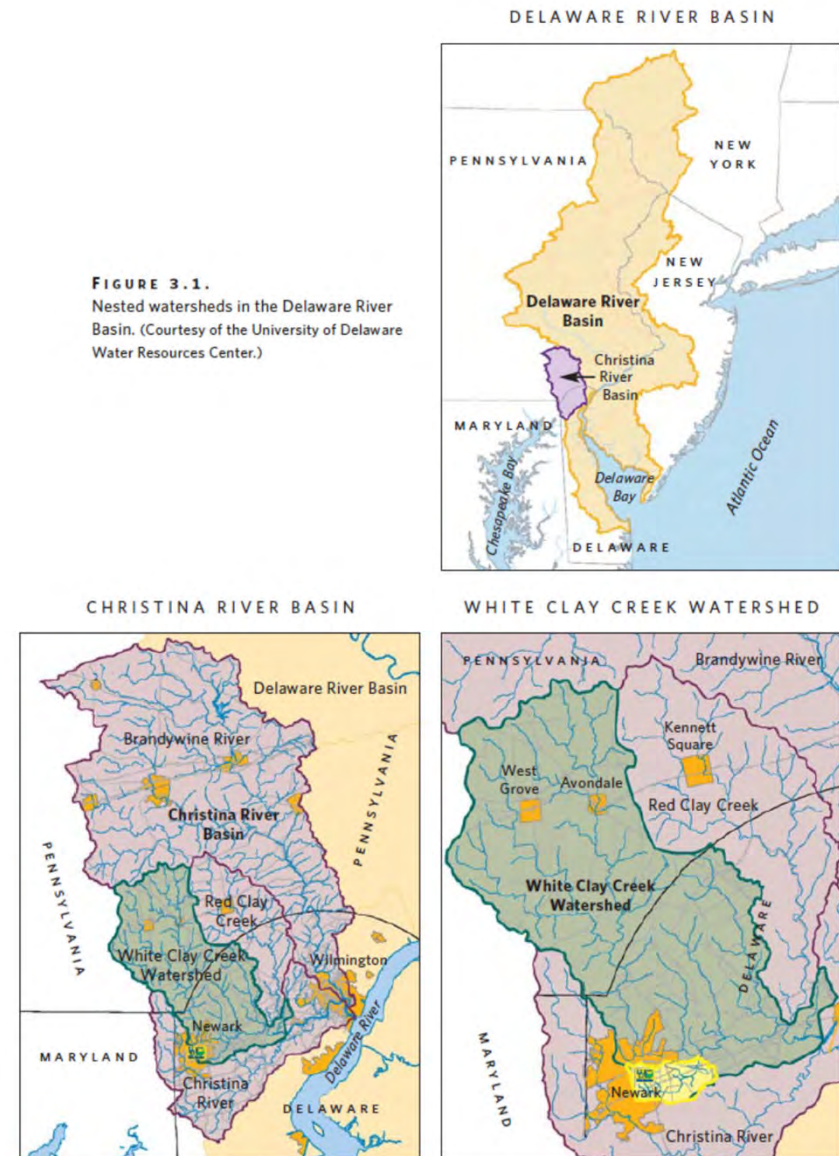
GERALD McADAMS KAUFFMAN

## THE WATER STATE

Delaware is a water state. Sitting on the Delmarva Peninsula and surrounded on three sides by water, it is one of just three *peninsular* states, and with the 1829 cutting of the C&D Canal, many consider it to be technically an *island*. At a mean elevation of only sixty feet above sea level, the First State is also the lowest state in the United States, with a beautiful and bounteous coastline along the Atlantic Ocean. But this profile also leaves the state vulnerable to worsening coastal storms and accelerating sea level rise—perhaps more so than most other places. It is fortuitously situated by geography and hydrology between two great estuary systems in America, the Chesapeake and the Delaware, that support abundant ecology and economy. In 2010, more than three hundred million gallons per day of drinking water and industrial water supplies were drawn from the rivers, streams, and aquifers in Delaware’s watersheds to sustain the state’s domestic, commercial, and industrial economy. But more than 90 percent of Delaware water is also so polluted it does not pass federal standards, largely due to a high population density in the metropolitan corridor to the north and the substantial agricultural economy to the south. While only the second smallest state in the Union, almost a million people in Delaware draw drinking water from just four small streams that originate upstream in the Appalachian Piedmont of Pennsylvania, and from Atlantic Coastal Plain aquifers that reach a mile down to bedrock. Delaware is diminutive, but its waters run deep.

The state owes its history and formative years to the waters that surround it. About fifteen thousand years ago, the North American glaciers melted and the sea rose to form more or less the watershed geography of present-day Delaware. Before the last ice age, ocean waters covered most of what is now Delaware. Over time, as the polar ice caps grew and continental glaciers drifted southward, sea level dropped significantly to a point about four hundred feet lower than present-day sea level. Since then, with increasing

FIGURE 3.1.  
Nested watersheds in the Delaware River Basin. (Courtesy of the University of Delaware Water Resources Center.)





## *After Centuries of Obscurity, Wilmington Is Having a Moment*

Joe Biden's hometown, known chiefly for its dull, corporate vibe, has become the center of the political universe. Residents are

2/26/2020

In Delaware, Dams Are Being Removed to Spur Fish Migration - The New York Times

The New York Times

<https://nyti.ms/37YzwWF>

### *In Delaware, Dams Are Being Removed to Spur Fish Migration*

Will American shad, striped bass and other fish return to early spawning grounds that were blocked off starting in the mid-1700s by early settlers?

By **Jon Hurdle**

Feb. 25, 2020

WILMINGTON, Del. — When migratory fish follow their ancestral instinct to swim up Delaware's Brandywine Creek during this spring's spawning season, they will find, for the first time in more than 200 years, that their route is not blocked by a dam.

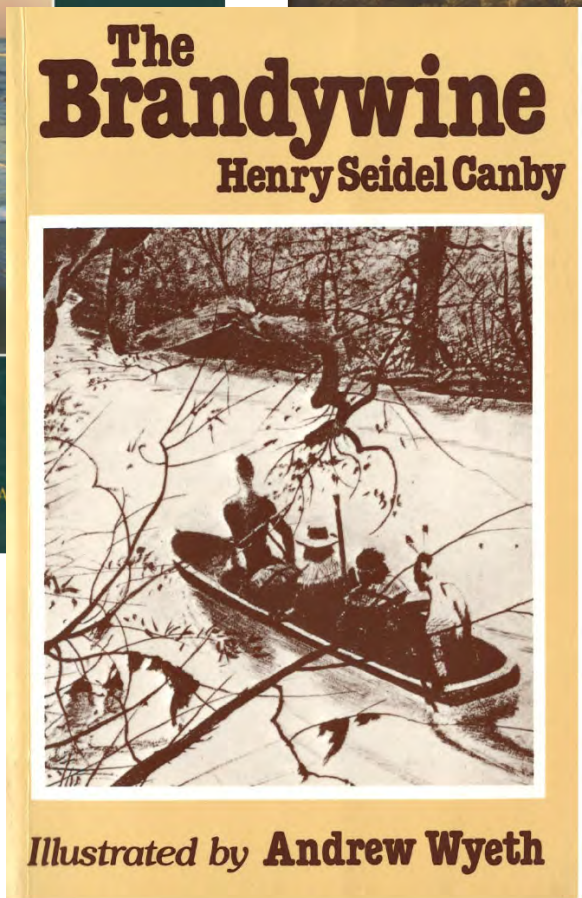
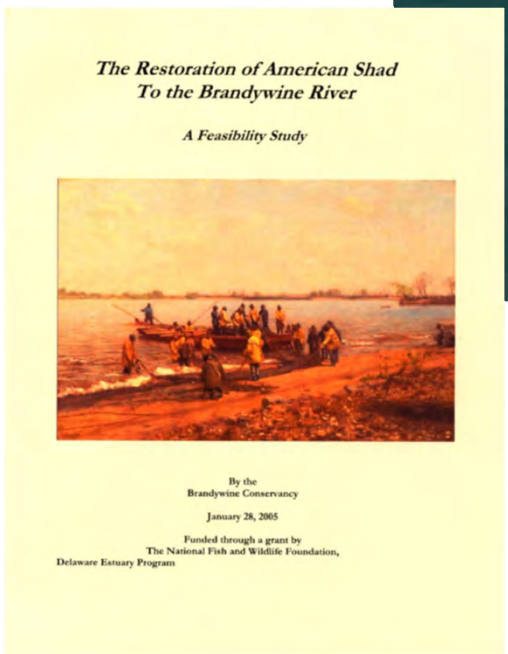
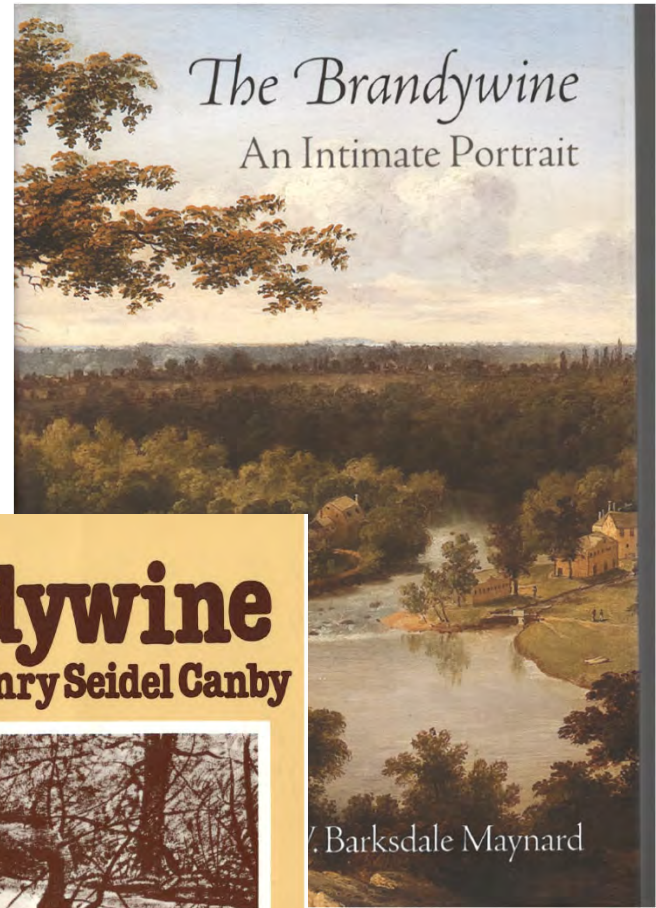
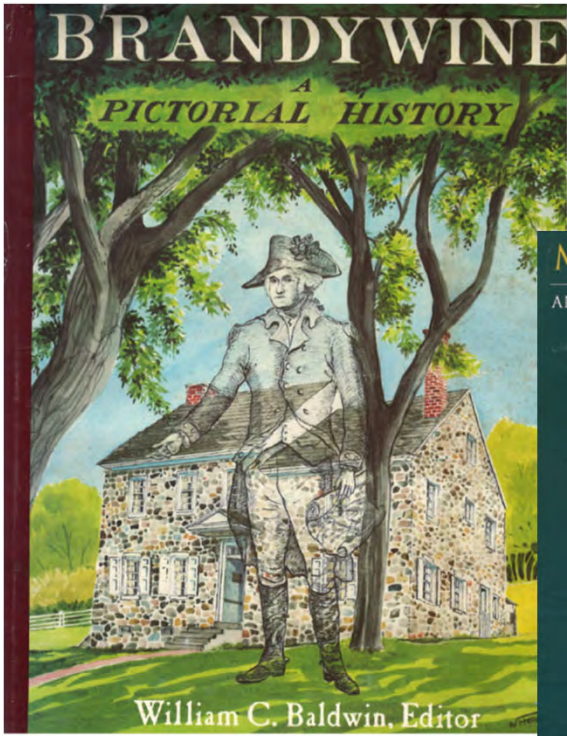
The fish — American shad, hickory shad and striped bass — have been unable to return to their traditional spawning grounds in the Pennsylvania section of the creek about 25 miles to the north since a series of dams was built across the creek by early American settlers, starting in the mid-18th century.

This year, the fish will be able to swim past the site of a dam that was demolished by the city of Wilmington last fall, allowing them to move as far as the next barrier, Dam 2, about three-quarters of a mile upstream, where large numbers are expected to create a sudden bonanza for anglers.

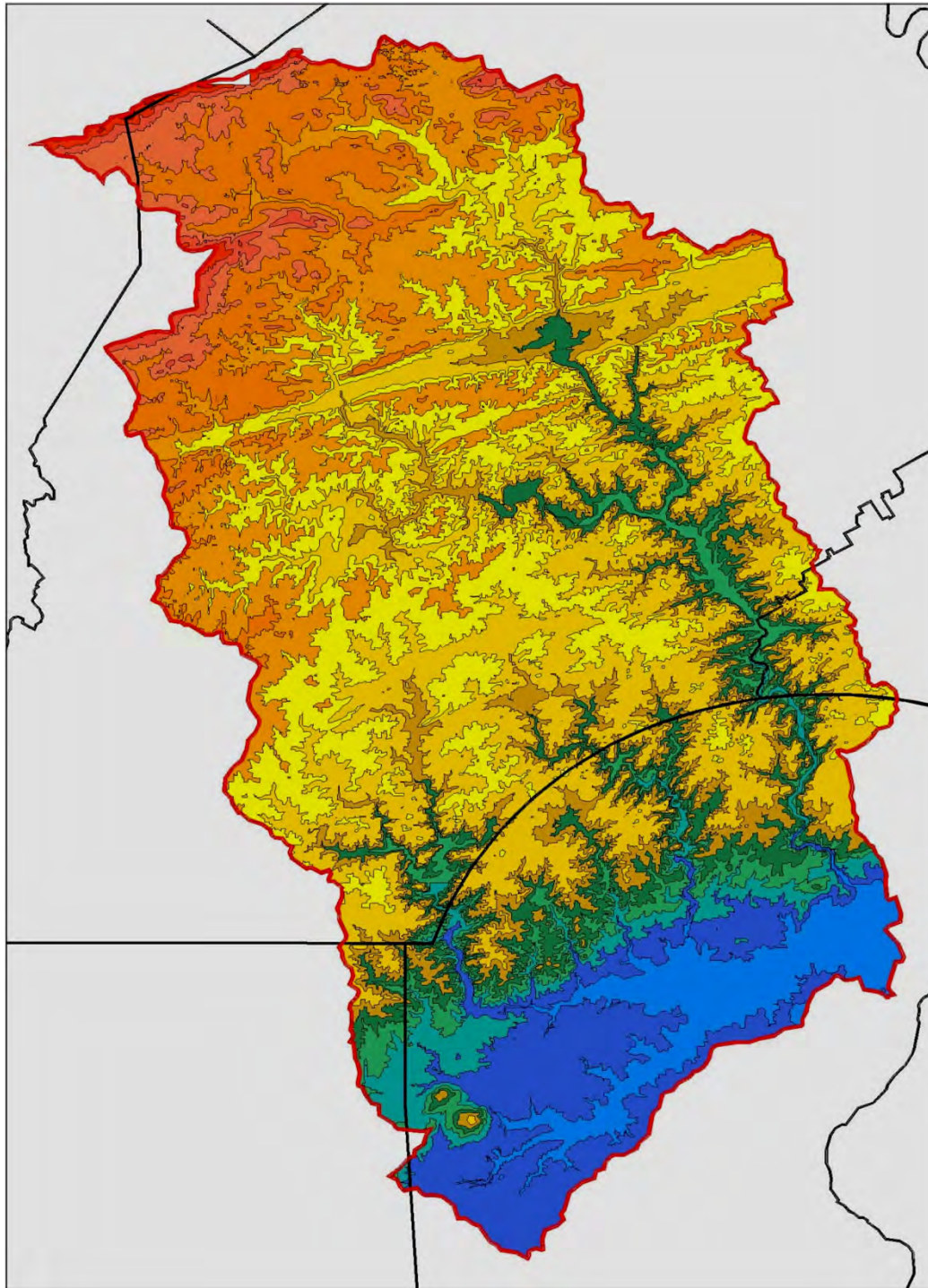
Beginning next month, "there will be thousands of American shad sitting here," said Jerry Kauffman, a University of Delaware professor. "This area will be full of fishermen because it will be a big fish magnet. It's going to be like Christmas."

Dr. Kauffman, who leads the university's Water Resources Center, is part of Brandywine Shad 2020, a nonprofit that hopes to remove or modify all 10 remaining dams on the 23-mile Delaware section of the creek over the next three years.

Dam 2 won't immediately be removed because that project would be bigger and more expensive. Dr. Kauffman and his associates want to remove or modify four other dams this year, kicking off one of the nation's biggest dam-removal programs across a single watershed.









BRANDYWINE DAM REMOVAL

# Making strides in conservation



## Demolishing historic Brandywine dams could make for healthier future

Maddy Lauria Delaware News Journal | USA TODAY NETWORK

Wilmington residents Hunter Lott and Jim Shanahan have a simple vision for the future of the Brandywine River.

In a few years, they imagine young public school students pressing their noses to the side of a classroom tank, watching fish grow from microscopic zygotes. Then the students might return their swimming friends to the Brandywine to help spawn the next generation of Delaware born and bred fish.

For that vision to become reality, a series of historical dams that date back hundreds of years must be removed, from Market Street in Wilmington into Pennsylvania.

Demolition continues on the dam and replacement of a water main across the Brandywine in Wilmington, just downstream from the Washington Street Bridge.

WILLIAM BRETZGER/ THE NEWS JOURNAL

See BRANDYWINE, Page 9A

### Brandywine

Continued from Page 1A

These sometimes scenic relics built from a time when mills were used to power flour, paper, cotton and gunpowder production.

"If we are successful — when we are successful — in the removal of the dams, it would have been 300 years since the fish have been able to swim freely up into the Brandywine and into their historical breeding grounds," Lott said.

The Brandywine Shad 2020 dam removal plan, spearheaded with research by the University of Delaware, is one of 25 conservation projects in Delaware, New Jersey, New York and Pennsylvania that have been awarded more than \$4 million in federal funding. All are within the Delaware River basin.

"Not only is it good for fish... it's good for conservation in general. It's good for the habitat, it's really good for the economy," said Wendt Weber, northeast regional director for the U.S. Fish & Wildlife Service at the grants announcement on Friday. "It's good for the health of the people in the watershed."

Wilmington residents and visitors may have noticed heavy equipment already working on the river banks near Market Street in recent months. Dam No. 11 there will be the first to go, for reasons more than just freeing the waterway's historic roots, city officials said.

In 1994, the concrete dam now surrounded by construction was built to encase the city's water mains. Today, they provide fresh drinking water to more than 100,000 customers every day, officials said.

"They literally brought clean water from one side of the river to the other side of the river," said Kelly Williams, Wilmington's public works commissioner.

Now, the time has come to upgrade and replace those mains, and the city is spending \$2.7 million to do so and remove the dam, Williams said.

New water mains are being laid below the bedrock under the creek. Once they're online, the old mains that make up the dam will be removed, she said.

Fish that migrate, such as the American shad and river herring, which live in saltwater but breed in upstream freshwater, will benefit from the dam's removal. Hardened structures are like roadblocks when the fish are trying to swim upstream, said Gerald Kauffman, director of the Water Resources Center at the University of Delaware.

"Now the river is getting healthier, so much so that the fish are returning," Kauffman said. "The obstacles that remain are these 19th and 18th century dams."

The shad that instinctively want to swim upstream to breed the next generation literally get bruises on their noses from bumping into the concrete, Weber said.

Just a few decades ago, those fish couldn't even reach the dams, though, because industrial pollution created dead zones in places like the mouth of the Delaware River. But things have



Crews are relocating a water main under Brandywine Creek as they remove a dam that has been blocking fish passage for 200 years. PHOTOS BY JENNIFER CORRETT/THE NEWS JOURNAL



Removal of the dam is part of the work that is underway on the Brandywine river in Wilmington to restore the waterway to its historic roots.

changed, Kauffman said. He and his colleagues now will use \$244,000 in federal funding to lay the groundwork needed to remove the dams along 17.6 miles of the Brandywine River.

They will match that money with private funds to study the feasibility of removing most of the remaining intact Brandywine dams left in Delaware. One dam near Hagley Museum will likely remain intact for historical purposes while Dam No. 2 will continue operating as a source of drinking water. That means scientists will have to find another way to help fish get by these obstacles, he said.

Once the remaining dams are removed, area residents could see fewer flooding problems, have additional access to the river through new boat ramps and maybe even enjoy a white-water rafting experience, Kauffman said.

Four years ago, he also was part of the push to remove a colonial-era dam on White Clay Creek that dated back to 1777 when George Washington was march-

ing through, around the time he was planning the Battle of the Brandywine. "Now we're finding the fish are swimming up and spawning, after two centuries," he said. "It's about fish and it's about history, but it's also about water, too. If the quality of the water is good enough for these sensitive fish, that's great news because that's the water we drink."

However, even after Dam No. 11 is removed, the fish will still be blocked by several others that dot the river from Delaware into Pennsylvania. That includes Dam No. 2, near the headgates of the Brandywine Raceway, which creates the pooling necessary to provide drinking water to people living in the area.

North of the Delaware-Pennsylvania state line, experts have located at least three dams that will need to be studied for removal in a future project, Kauffman said.

Other complications are likely to stymie the romantic story of reconnecting these native creatures to their centuries-old breeding grounds. Some of the larger dams, like Brandywine Falls at Alapocas Run State Park, are beloved scenic features that some residents may want to keep just as they are.

"You're going to get that push back, there's no question," Lott said, noting that an argument was made against removing Dam No. 11 had historical value by providing a pool of water that would freeze in the winter to create an all-natural ice-skating rink.

"There will be a certain amount of people used to looking at a pool of flat water," said Shanahan, who said he frequently swims in the Brandywine like it's his own backyard pool. "But it's only been like that for 100 years and the river's been there for thousands of years." The plan to remove the Brandywine's

series of Delaware dams is an effort to remove human interference from the Industrial Age and restore the ecology of the river, Shanahan said.

"That abstract, pure aspect of bringing the river back actually has a larger appeal than I anticipated," he said. "Just to bring it back to its natural state really tugs at heartstrings."

The Brandywine Shad 2020 projects and 24 other projects will be partially funded by the Delaware River Basin Conservation Act. It's a relatively new grant and technical assistance program, introduced by Delaware Sen. Tom Carper and Chris Coons, as well as then-Congressman John Carney.

Beyond the Brandywine, that \$41 million in federal funding, matched by \$7.5 million in private funds, will go to projects such as forest management on 1,400 acres, 630 acres of restored wetlands, 550 acres of restored floodplain and more than 1,800 acres of public access that is key to recreation, said Holly Bamford, chief conservation officer for the National Fish and Wildlife Foundation.

Those projects include tidal marsh restoration at the John Heinz National Wildlife Refuge near Philadelphia, shorbelly and horseshoe crab restoration in New Jersey and a plan to reduce microplastics in the watershed.

"This protects the river, it provides water quality, water quantity and also protects the community and their economy," Bamford said.

Contact reporter Maddy Lauria at (302) 345-0608, mlauria@delawareonline.com or on Twitter @MaddyinMiford.

#### Want to know more?

For more, including the full list of projects, go to [www.delriverwatershed.org](http://www.delriverwatershed.org).





**IN THIS ISSUE**

# Returning the Brandywine to a Free-Flowing State

PAGE 6

Philadelphia Art Contest 20th Anniversary PAGE 8

The Egypt Diaries: Tales from 10 Days on the Nile PAGE 12

**ESTUARY NEWS**

Newsletter of the Partnership for the Delaware Estuary - Host of the Delaware Estuary Program

**The Partnership for the Delaware Estuary**  
Connecting people, science, and nature for a healthy Delaware River and Bay

WINTER 2020  
VOL. 30 | NO. 1

**SPECIES SPECIFIC**

## Back to a Free-flowing State for the Brandywine Creek

It happens every spring. Waters get warmer, and American shad heed the call to leave their ocean homes and head toward fresh water. Instinct drives these fish to swim against the current to spawn in the places where they were born. One of those waterways is the Brandywine Creek.

Shad have spawned in the Brandywine for centuries. For the last 300 years, however, man-made dams have hindered these spawning grounds. A non-profit organization called Brandywine Shad 2020 feels the time is long overdue to free the waters for fish passage and recreational opportunities for fishing, kayaking, and more.

"Here in Delaware, we are making a difference in restoring this important and historic habitat back to before the Europeans got here and made decisions to harness water power for their mills. Those decisions that hold Shad hostage, we want to reverse," said Hunter Lott III, the co-founder, and co-director of Brandywine Shad 2020.

The Brandywine Creek – sometimes referred to as a river – is a tributary of the Christina River and part of the Delaware River Watershed. It's nearly 75 miles long and spans between Delaware and Pennsylvania. Settlers built dams for mills that produced flour, paper, cotton, and gunpowder. The significance of 2020 in the organization's name, Lott said, is this year marks

**"Shad have spawned in the Brandywine for centuries. For the last 300 years, however, man-made dams have hindered these spawning grounds."**

the 300th anniversary since the first dam went up in 1720.

Over time, the mills went away while many of the dams stayed. Brandywine Shad 2020 would like to see 10 dams removed or modified on more than 17 miles of Delaware's portion of the creek and restore the waterway to a pre-colonial, free-flowing state.

**ECOLOGICAL BENEFIT**

Shad spawning season spans from March to June. After they migrate, female shad lay hundreds of thousands of eggs in the water to be fertilized by male fish. About 10 percent of the eggs hatch a week or so later.

**"If we can do what we can to allow them to return to their homes, their natal spawning grounds, that would be a real plus for the state of Delaware."**

—Mike Stangl

"Anything that we can do to open up more habitat for [the shad] is going to be beneficial to the ecology of the system," said Mike Stangl, program manager for freshwater and anadromous species at Delaware's Department of Natural Resources and Environmental

Control (DNREC). He has been working with Brandywine Shad 2020 on the biological and ecological aspects of the project. "If we can do what we can to allow them to return to their homes, their natal spawning grounds, that would be a real plus for the state of Delaware."

**THE RIGHT THING TO DO**

Lott and fellow Wilmington resident Jim Shanahan co-founded Brandywine Shad 2020 in 2017. Founding member organizations include



OPINION

# For 300 years, Philly's 'founding fish' has been missing from the Brandywine. Meet the folks trying to bring it back | Mike Newall

Updated: July 18, 2019 - 3:18 PM

Mike Newall | @MikeNewall | mnewall@inquirer.com



LESLIE BARBARO

I stood less than 10 miles from the Pennsylvania state line, watching the mighty rapids of the Brandywine River fade — ebb and pool against the dam blocking one of the most historic rivers in the country. Somewhere below the surface of the West Street Dam in downtown Wilmington, my companions assured me, schools of shad — the founding fish! — have been bumping their poor noses against a man-made barrier for nearly three centuries.

Like many Pennsylvanians who leave our fine state, the shad just want to come home.

But for almost exactly 300 years, the fish that fed Native Americans and colonial settlers, too, has been stuck in Delaware. That's thanks to — you guessed it — a white guy looking to line his pockets, who threw up the first dam across the Brandywine in 1720, and put in a mill to boot.



LESLIE BARBARO

Joe Shanahan, left, and Mike Hunter Lott II are co-founders of Brandywine Shad 2020, an organization working to remove dams from the Brandywine River to restore shad migration. Behind them is a mill race, which previously used the diverted river water to power mills.



DAVID SWANSON / STAFF PHOTOGRAPHER

In 2016, staff scientist Joe Perillo and aquatic biologist Steve Ostrowski built a shad hatchery on the Schuylkill with salvage parts and help from Philadelphia Water Department maintenance crews. The effort encouraged conservationists in Delaware to return shad to the Brandywine River.

An ordinary person might read that story and think, *Cool. Hope the shad come back.* Lott, a retired real estate broker with experience in historical conservation, thought, *Time to get to work.*

He and Shanahan assembled a cohort of conservancy heavyweights, including scientists from the Water Resources Center at the University of Delaware and officials from the Hagley Museum and Library in Wilmington and the Brandywine Conservancy in Chadds Ford. In March, the group won a \$241,000 grant from the U.S. Fish & Wildlife Service. With matching funds from the state in hand, they hope to raise enough to have the Delaware dams down by the end of 2020.

That would leave at least four dams on the Pennsylvania side of the border. And the Pennsylvania Fish & Boat Commission told me they would be willing to take a hard look at getting rid of those if Lott and Shanahan can uncork the plug in Delaware.

For now, on the banks of the Brandywine, Shanahan talks about the project in reverent terms. "This is God's work," he says — returning a river to its natural state.

Spend enough time with Shanahan and Lott, and you come to feel the same way, too — walking by the river that still pushes its way from the steel towns to the sea, and imagining my dam buddies' delight if it were fat with shad.



DAVID SWANSON / STAFF PHOTOGRAPHER

Joe Perillo, a staff scientist at the Fairmount Fish Ladder on the Schuylkill, watches a gizzard shad pass by an observation window Friday, May 11, 2016.

Posted: July 18, 2019 - 3:18 PM  
Mike Newall | @MikeNewall | mnewall@inquirer.com



[The Green](#) (/programs/green)

## They're back! Migratory fish return to Brandywine Creek after dam-removal starts

By JON HURDLE (/PEOPLE/JON-HURDLE) • MAY 1, 2020

✚ [Share](http://facebook.com/sharer.php?u=http%3A%2F%2Ftinyurl.com%2Fyaz3bwj36&t=They%E2%80%99re%20back%21%20Migratory%20fish%20return%20to%20Brandywine%20Creek%20after%20dam-removal%20starts) ([http://facebook.com/sharer.php?](http://facebook.com/sharer.php?u=http%3A%2F%2Ftinyurl.com%2Fyaz3bwj36&t=They%E2%80%99re%20back%21%20Migratory%20fish%20return%20to%20Brandywine%20Creek%20after%20dam-removal%20starts)

[u=http%3A%2F%2Ftinyurl.com%2Fyaz3bwj36&t=They%E2%80%99re%20back%21%20Migratory%20fish%20return%20to%20Brandywine%20Creek%20after%20dam-removal%20starts](http://facebook.com/sharer.php?u=http%3A%2F%2Ftinyurl.com%2Fyaz3bwj36&t=They%E2%80%99re%20back%21%20Migratory%20fish%20return%20to%20Brandywine%20Creek%20after%20dam-removal%20starts))

✚ [Tweet](http://twitter.com/intent/tweet?url=http%3A%2F%2Ftinyurl.com%2Fyaz3bwj36&text=They%E2%80%99re%20back%21%20Migratory%20fish%20return%20to%20Brandywine%20Creek%20after%20dam-removal%20starts) ([http://twitter.com/intent/tweet?](http://twitter.com/intent/tweet?url=http%3A%2F%2Ftinyurl.com%2Fyaz3bwj36&text=They%E2%80%99re%20back%21%20Migratory%20fish%20return%20to%20Brandywine%20Creek%20after%20dam-removal%20starts)

[url=http%3A%2F%2Ftinyurl.com%2Fyaz3bwj36&text=They%E2%80%99re%20back%21%20Migratory%20fish%20return%20to%20Brandywine%20Creek%20after%20dam-removal%20starts](http://twitter.com/intent/tweet?url=http%3A%2F%2Ftinyurl.com%2Fyaz3bwj36&text=They%E2%80%99re%20back%21%20Migratory%20fish%20return%20to%20Brandywine%20Creek%20after%20dam-removal%20starts))

✚ [Email](mailto:subject=They%E2%80%99re%20back%21%20Migratory%20fish%20return%20to%20Brandywine%20Creek%20after%20dam-removal%20starts&body=http%3A%2F%2Ftinyurl.com%2Fyaz3bwj3) ([mailto:subject=They%E2%80%99re%20back%21%20Migratory%20fish%20return%20to%20Brandywine%20Creek%20after%20dam-](mailto:subject=They%E2%80%99re%20back%21%20Migratory%20fish%20return%20to%20Brandywine%20Creek%20after%20dam-removal%20starts&body=http%3A%2F%2Ftinyurl.com%2Fyaz3bwj3)

[removal%20starts&body=http%3A%2F%2Ftinyurl.com%2Fyaz3bwj3](mailto:subject=They%E2%80%99re%20back%21%20Migratory%20fish%20return%20to%20Brandywine%20Creek%20after%20dam-removal%20starts&body=http%3A%2F%2Ftinyurl.com%2Fyaz3bwj3))



(//www.delawarepublic.org/sites/wdde/files/styles/x\_large/public/202005/brandywine\_dam\_gone.JPG)

*The site of the former West Street dam on the Brandywine Creek at Wilmington; its removal last year has allowed many more migratory fish like the American shad to swim upstream toward their ancestral spawning grounds.*

Territories  Languages  Treaties

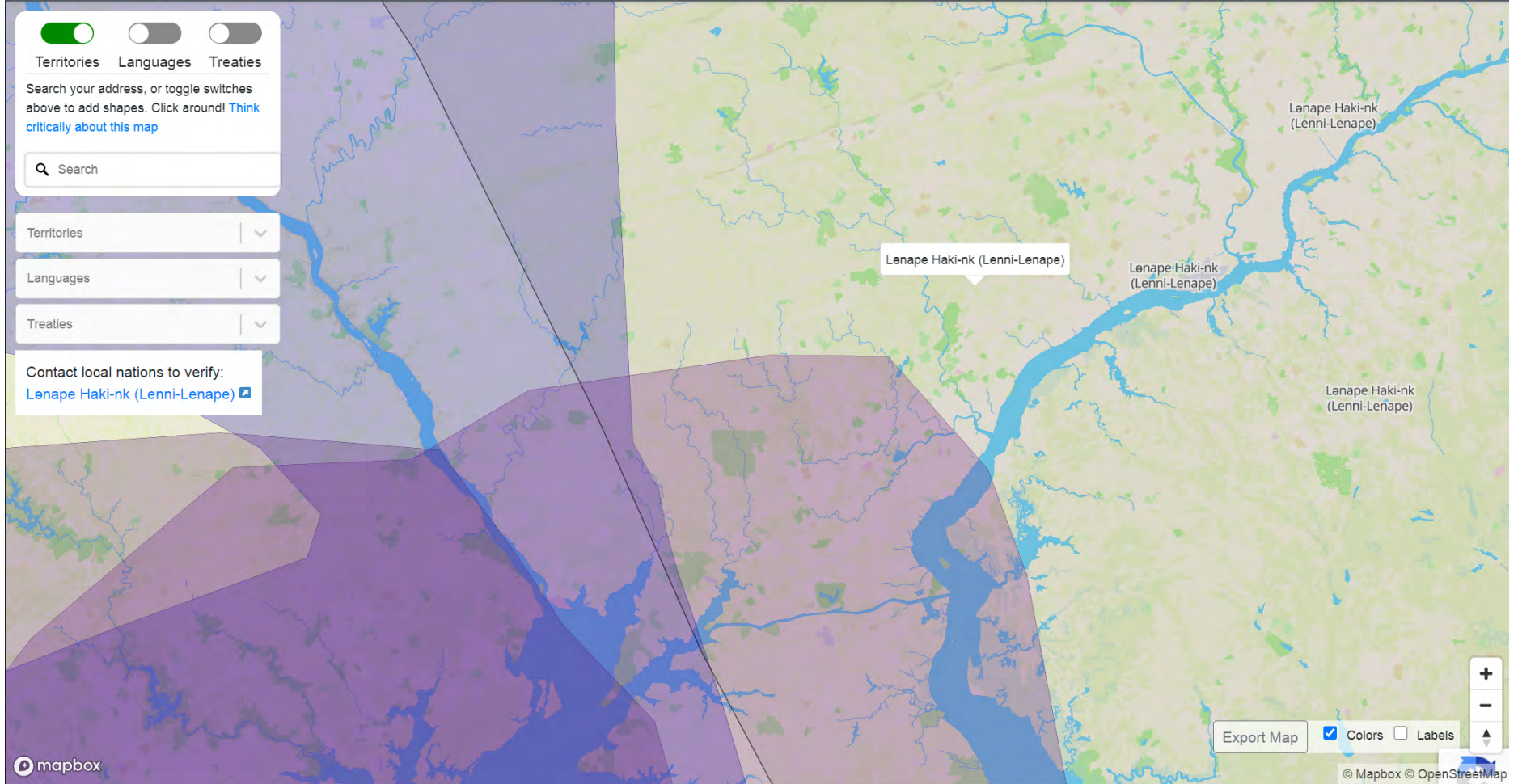
Search your address, or toggle switches above to add shapes. Click around! [Think critically about this map](#)

Territories

Languages

Treaties

Contact local nations to verify:  
[Lenape Haki-nk \(Lenni-Lenape\)](#)



Export Map  Colors  Labels







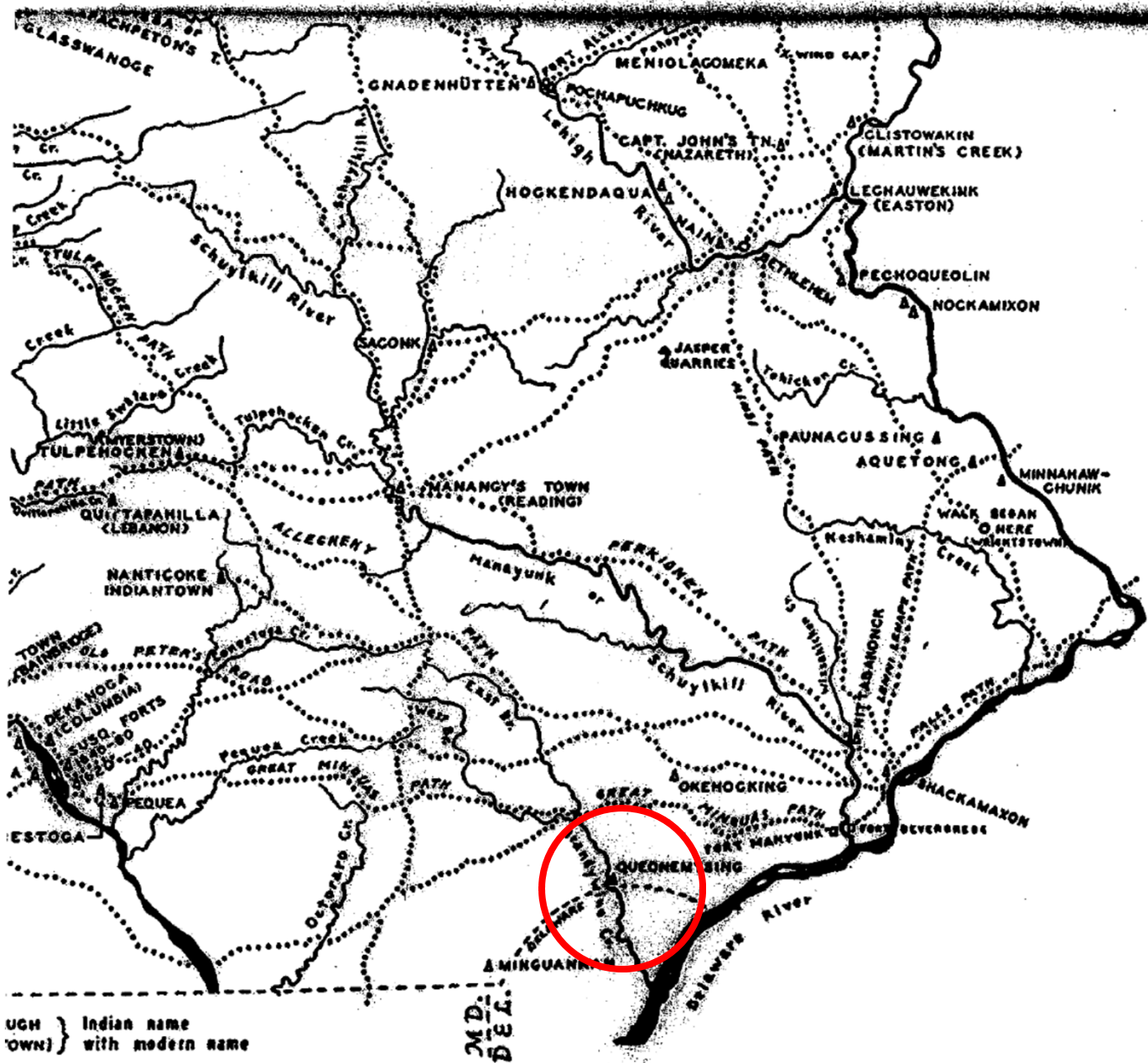
Swedes settle at mouth of Christinakill  
1638 AD





Brandy Wine flows into Christian Creek and the Delaware River 1687 AD





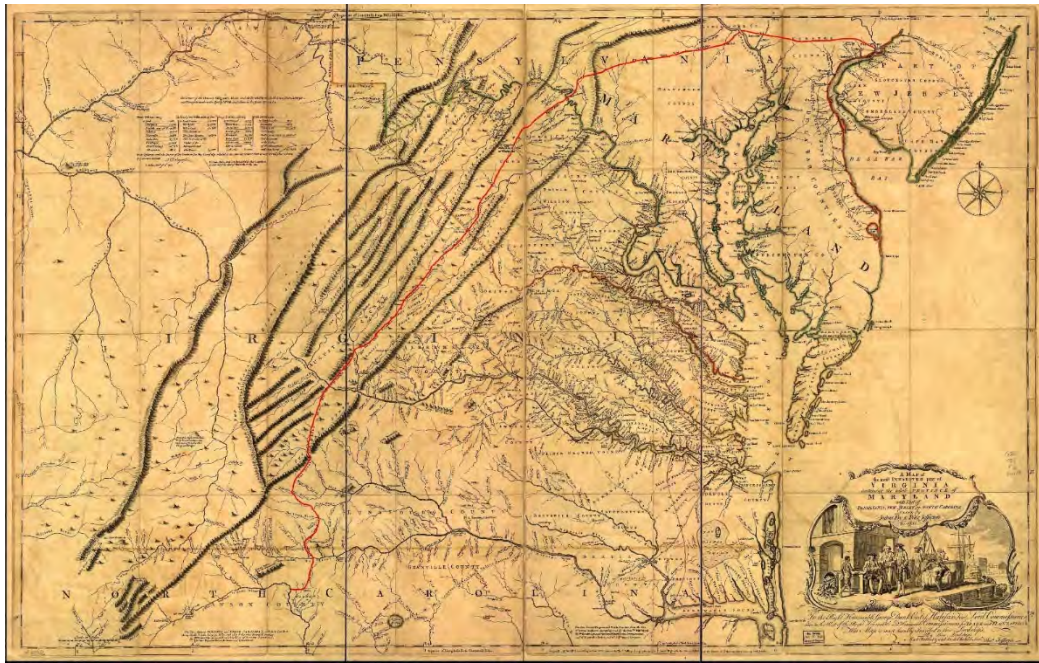
1688  
Queonemysing





3 Lower Counties of Pennsylvania 1749 AD





Great Conestoga Wagon Road  
1751 AD





“Nation Makers”

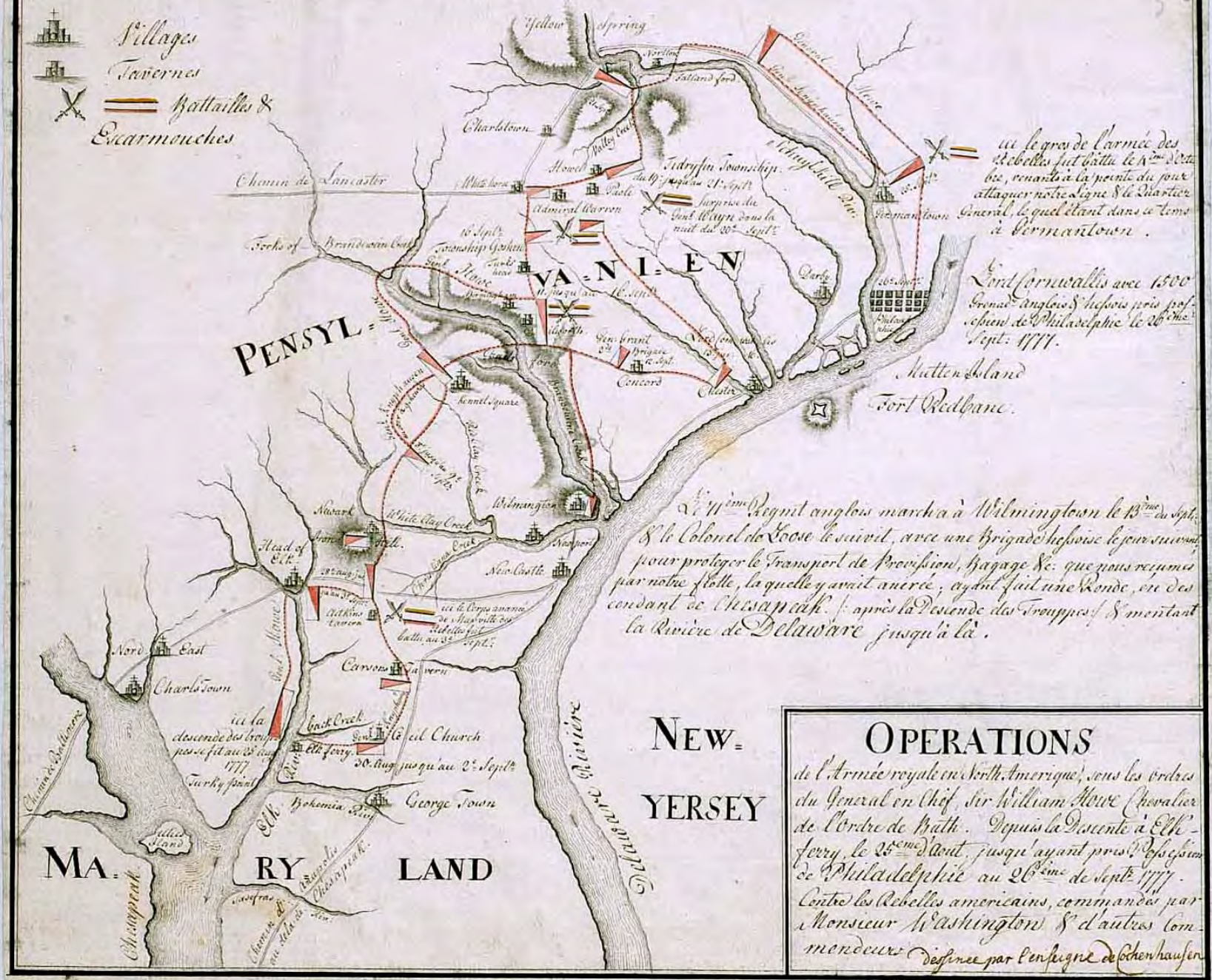
H. Pyle

Battle of the Brandywine

1777 AD



 Villages  
 Tavernes  
 Batailles & Escarmouches



Ici le gros de l'armée des  
 rebelles fut battue le 26<sup>me</sup> de  
 sept, venant à la pointe du jour  
 attaquer notre ligne & le Quartier  
 Général, le quel étoit dans le bois  
 à Germantown.

Fort Mifflin tenu avec 1500  
 hommes Anglois & hispanis pris par  
 l'ennemi de Philadelphie le 26<sup>me</sup>  
 de Sept: 1777.

Le 11<sup>me</sup> de Sept l'Anglois marcha à Wilmington le 13<sup>me</sup> de Sept  
 & le Colonel de Coxe le suivit, avec une brigade hispanis le jour suivant  
 pour protéger le transport de provisions, bagage &c. que nous recevions  
 par notre flotte, la quelle y avoit ancré, ayant fait une Ronde, en des  
 cendant de Chesapeake: après la Descente des troupes & montant  
 la Rivière de Delaware jusqu'à là.

**OPERATIONS**  
 de l'Armée royale en North. Amérique, sous les ordres  
 du Général en Chef Sir William Howe Chevalier  
 de l'Ordre de Bath. Depuis la Descente à Elk-  
 ferry, le 26<sup>me</sup> de Sept, jusqu'ayant pris Philadelphie  
 de Philadelphie au 26<sup>me</sup> de Sept: 1777.  
 Contre les Rebelles américains, commandés par  
 Monsieur Washington & d'autres Com-  
 mandeurs dessinée par l'enseigne de Chenhausen





**British Invasion of Delaware, August – September 1777**



## Hessians at Unicorn Tavern



*How the old Unicorn Inn might have appeared when the British and Hessian troops prepared to march to Chadds Ford for the Battle of the Brandywine. The Inn was the headquarters of Baron Wilhelm von Knyphausen when the Hessians camped in Kennett Square. (Oil on gesso painting entitled "Early Morning at Kennett Square, September 11, 1777," by Barclay Rubincam and owned by Southeast National Bank.)*

# DuPont Mills 1802 AD

*Lee, Mass. Nov. 3-1905*



Powder Mill on Brandywine near Wilmington, Del.

*These blow  
up occasion-  
ally and  
then?*



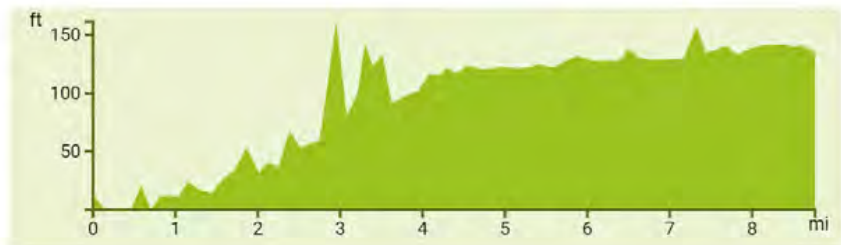




Brandywine Falls are higher than Niagara Falls



Elevation profile



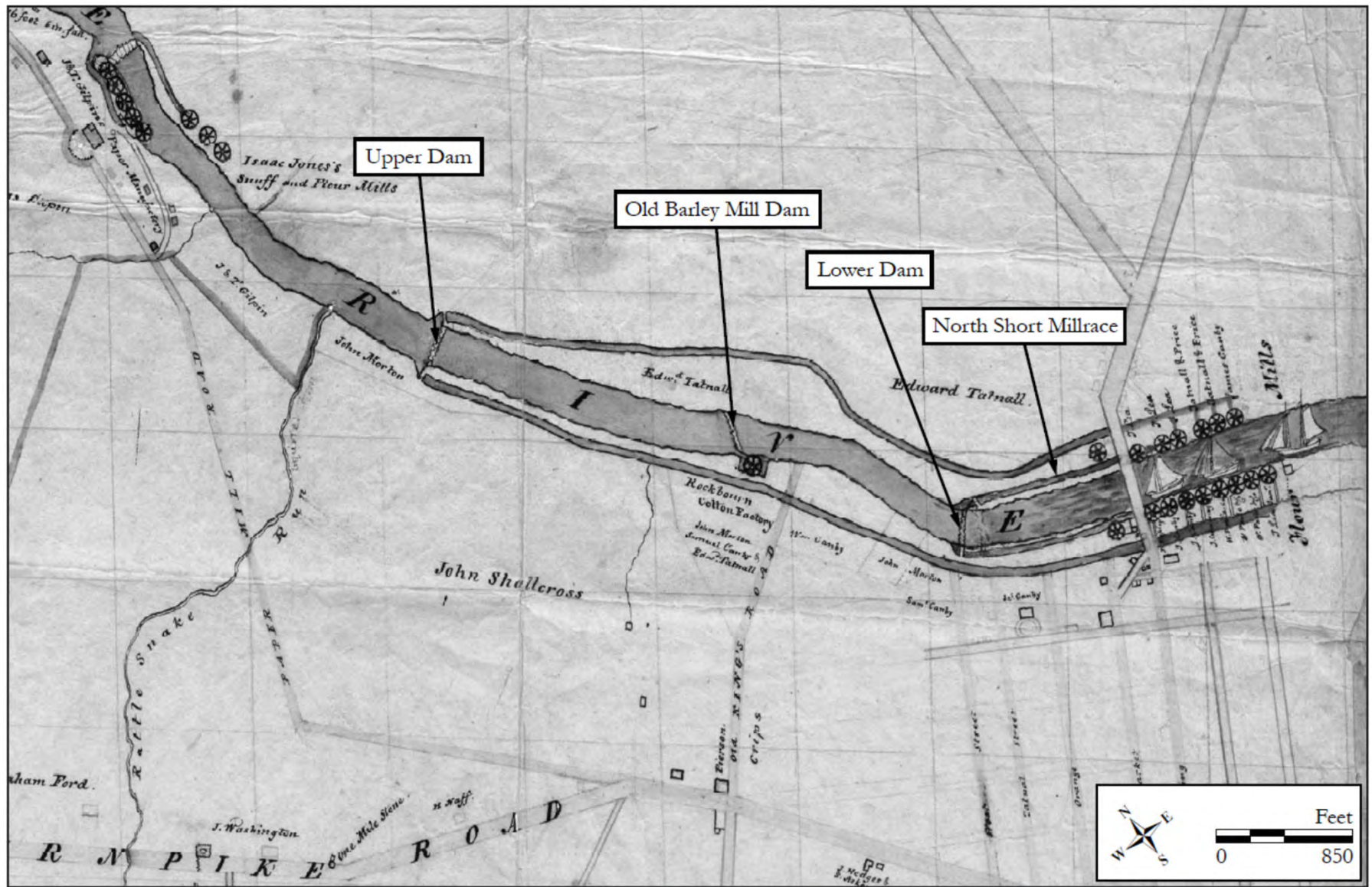


Figure 2: Circa 1816 Fairlamb & Reid, *Mill Seats on the Brandywine River*. This map illustrates the concentration of commercial flour mills located at the tidewater of Brandywine Creek by the early nineteenth century, as well as the locations of the dams and millraces that powered these businesses.



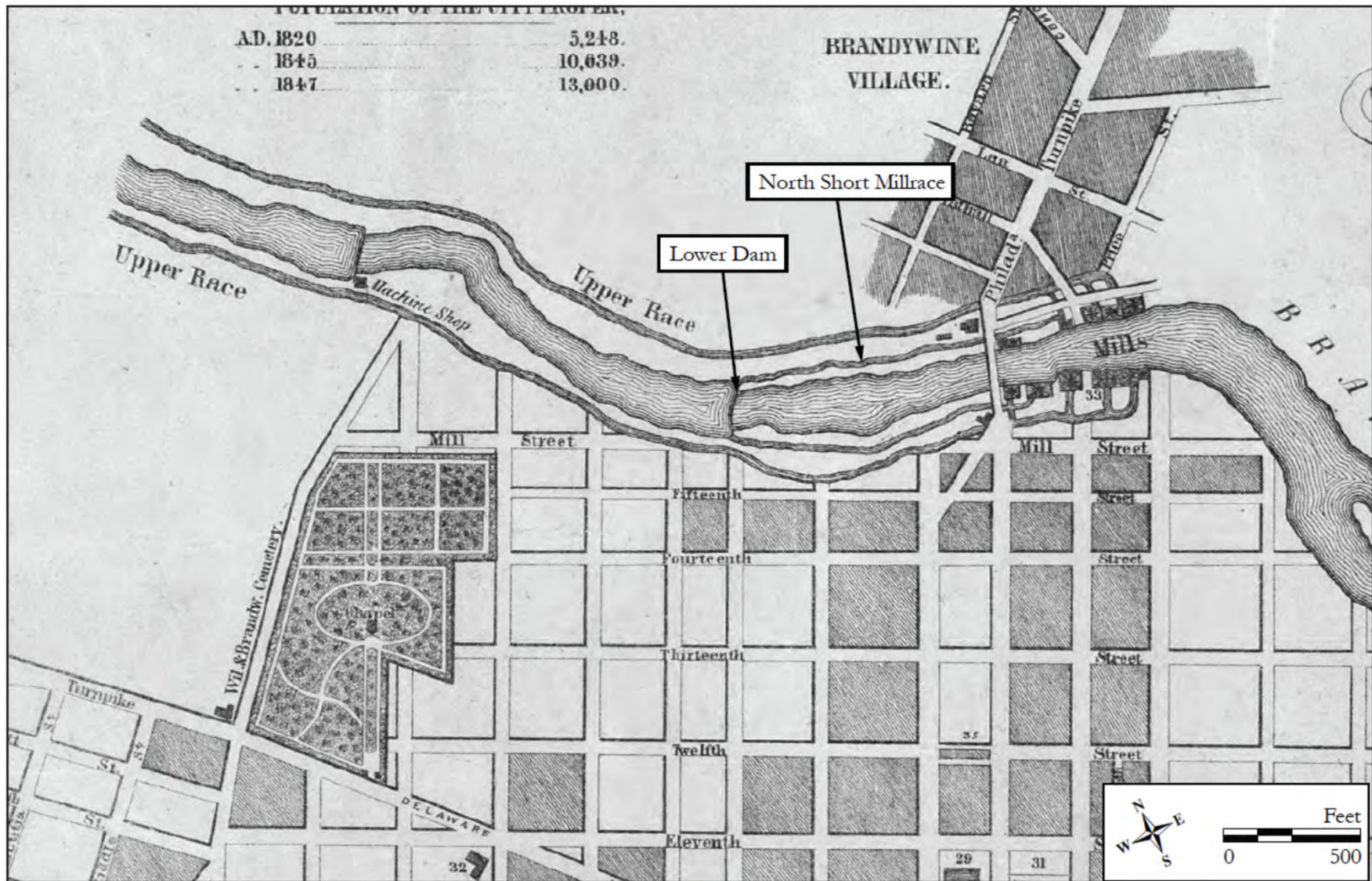


Figure 3: 1847 Rea and Price, *Map of New Castle County, Delaware.*



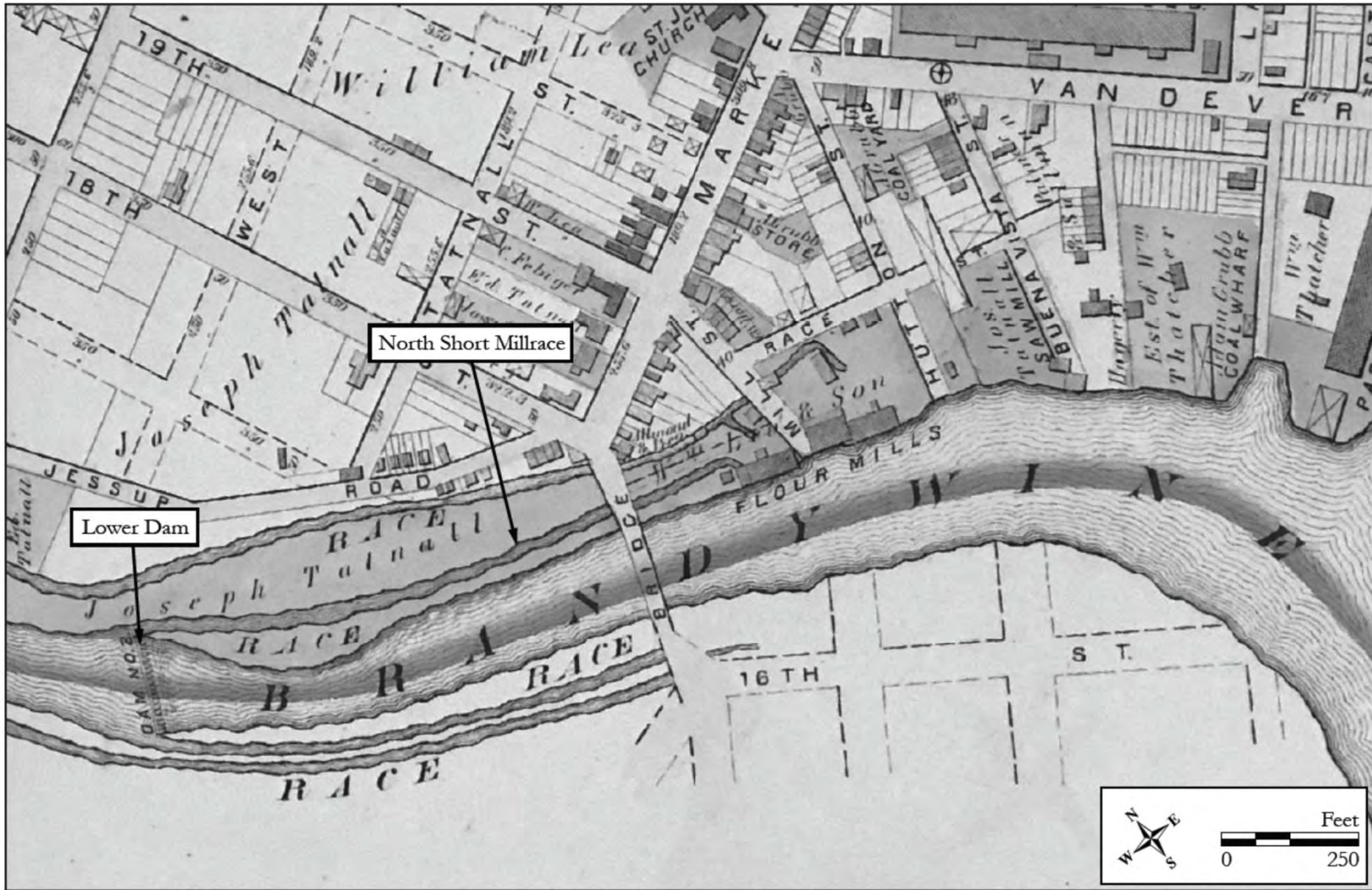


Figure 4: 1876 G.M. Hopkins, *City Atlas of Wilmington*. By this time, the Lower Dam was identified as “Dam No. 2” and the North Short Millrace continued to provide water to the Lea family’s flour milling company on the north side of Brandywine Creek.



# Underground Railroad between the Brandywine and Christina at Wilmington, Harriet Tubman 1830-1865 AD





1864 AD

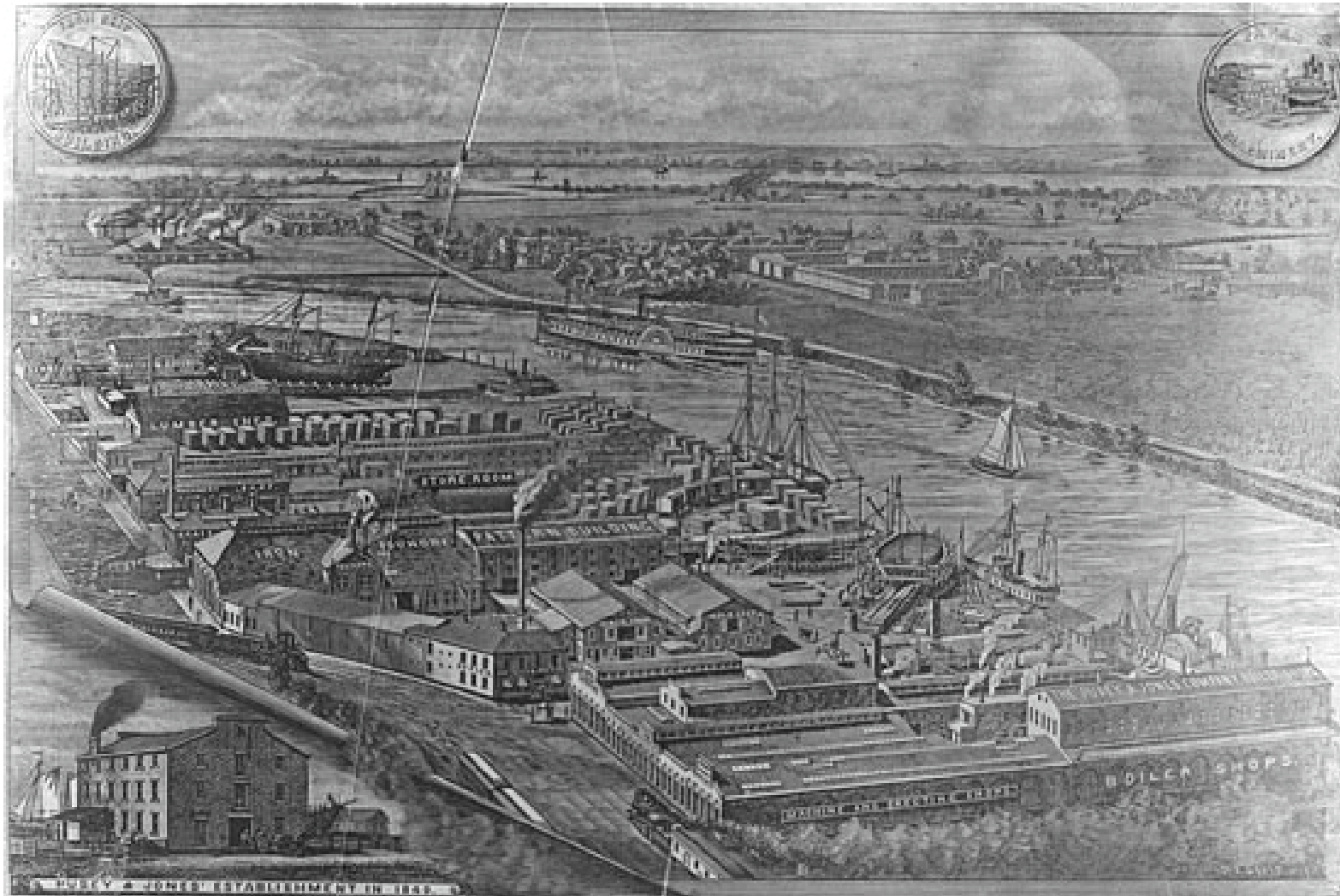


# Wilmington 1874 AD



*Bird's-eye view of Wilmington, H. H. Bailey, 1874.*

# Pusey and Jones Shipyard 1887 AD



View of the Works of  
**THE PUSEY & JONES COMPANY,**  
WILMINGTON, DELAWARE.





Frederick Law Olmsted designed Central Park in NYC and Brandywine Park in Wilmington, Del. during the 19<sup>th</sup> century



# Brandywine Plant 1929 AD



*Brandywine Plant from the air, 1929.*



# Hoopes Reservoir

## 1931 AD



*Hoopes Reservoir under construction, 1931.*

# Christiana River Tunnel

## 1931 AD



"It's quittin' time!"



CHRISTIANA RIVER TUNNEL  
EVENING SHIFT COMING OFF SEPT. 9-1931



# Hoopes Reservoir

## 1932 AD



*Hoopes Reservoir, Dam, and Pumping Station from the air, ca. 1932.*

**FIGURE 1.1.** Rockford and Kentmere cotton mills, Wilmington, 1937.  
(Joseph Bancroft & Sons photographs. Dallin Aerial Survey, Hagley Museum.)





# Brandywine Creek 1940 AD



*Brandywine Creek above city dam, 1940.*

*July, 27*



**FLOW GAUGE** installed on lower Brandywine measures and records volume of water going down the stream. These data help in compiling topsoil loss.



**TWELVE RAINFALL GAUGES**, like one above, record precipitation at various locations in the Valley.



**FARM PONDS** provide water for farm animals, fish, and fire protection, help retard flood water run-off. Soil conservation technicians look on while check is made of growth rate of stocked fish.

## THE WORK OF THE BRANDYWINE VALLEY ASSOCIATION

**STATE FARM FORESTER**, working with Brandywine Valley Association staff member, explains wood-land management to class in agriculture.

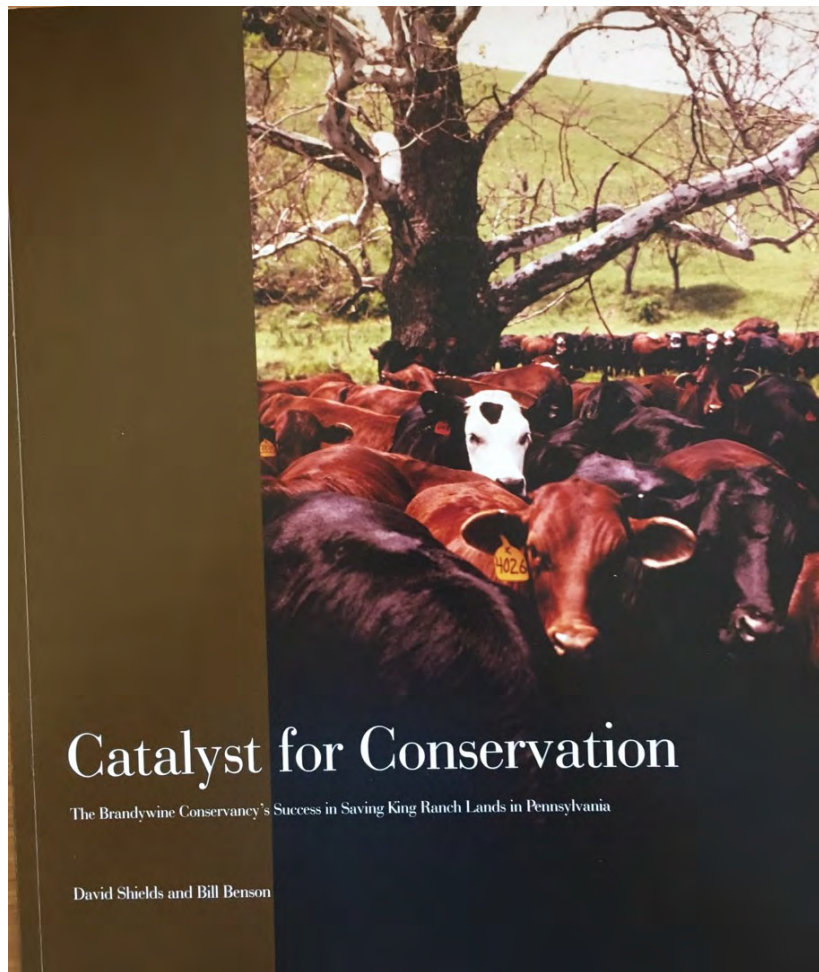


**ASSOCIATION** staff member shows slides of conservation methods to family group in farm home.

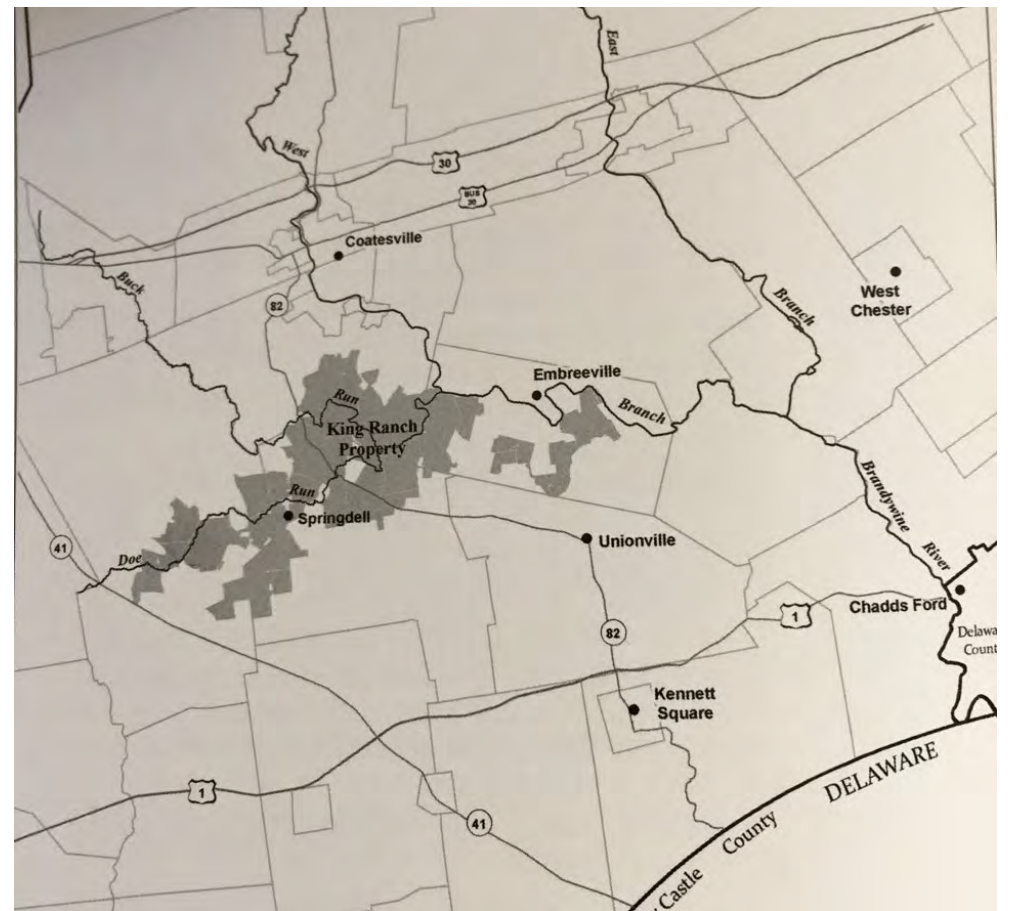


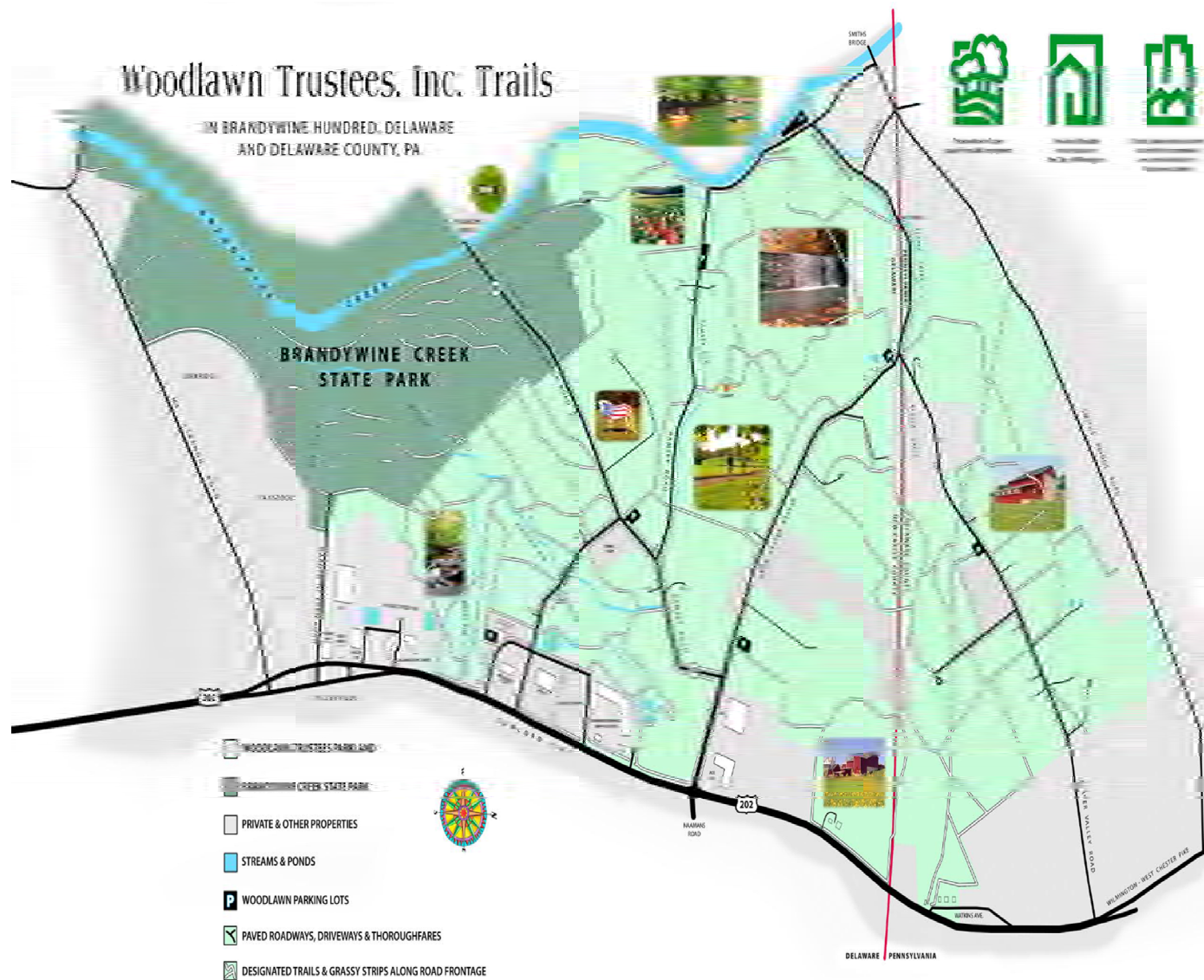
Brandywine Valley Association, America's first small watershed association, est. 1945 AD





## Brandywine Conservancy conserves King Ranch 1984 AD





Woodlawn Trustees provide land for First State National Monument along Brandywine River, 2013 AD



TELEPHOTO ZOOM  
CAPTURE IT THE WAY YOU WANT IT



## Delaware Gets Its First National Monument

The National Park System finally reaches all 50 states.

2013 AD



A lone sycamore tree stands at Woodlawn, the heart of Delaware's newly declared national monument.

PHOTOGRAPH BY MICHAEL MELFORD, NATIONAL GEOGRAPHIC

By **Brad Scriber**, [National Geographic News](#)

PUBLISHED MARCH 27, 2013

**Shortly after noon on Monday, with a declaration from President Obama designating the First State National Monument, the [National Park Service](#) welcomed Delaware into its fold for the first time. (Related: "[Obama Declares Monuments to Preserve Pieces of U.S. Heritage.](#)")**

President Obama created the monument along with four other national monuments in an Oval Office ceremony alongside Vice President [Joe Biden](#) and Secretary of the Interior [Ken Salazar](#), using powers designated under the Antiquities Act of 1906 to recognize historically significant

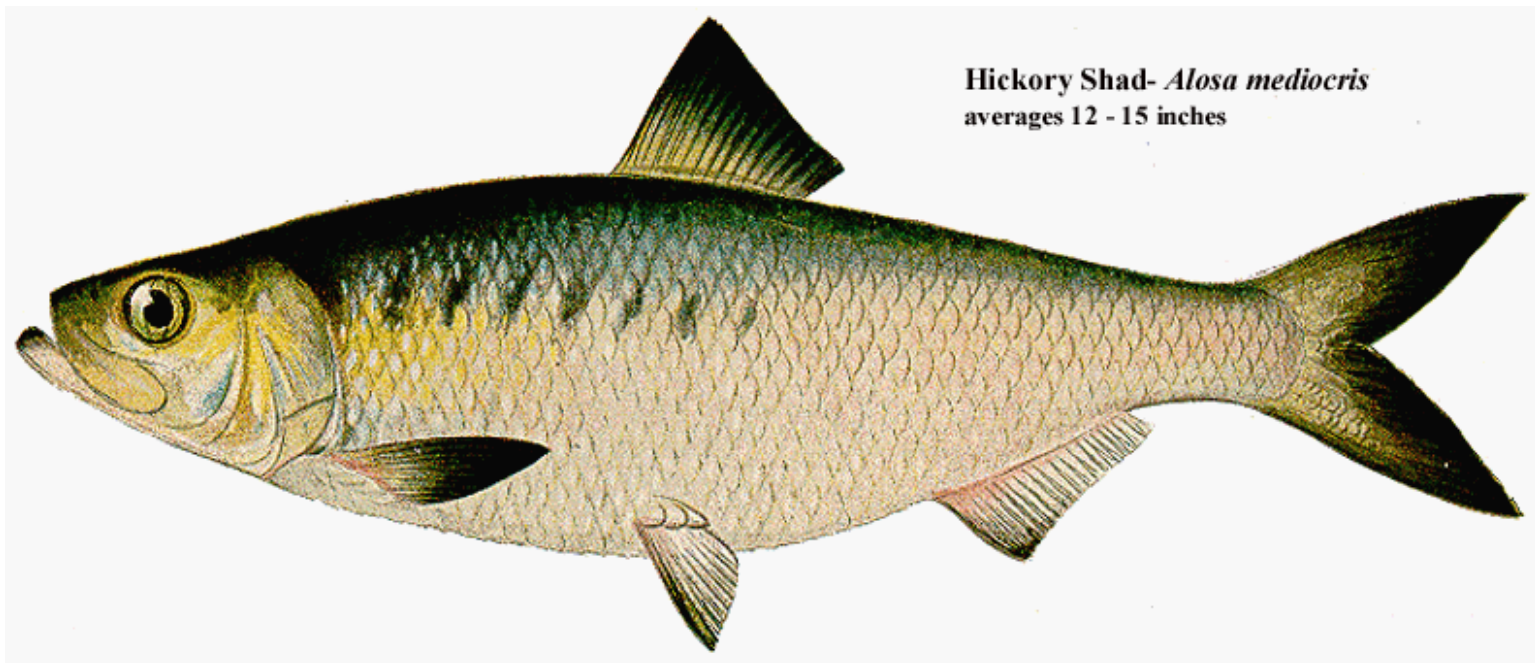
# First State National Monument 2014 AD







# America's Founding Fish

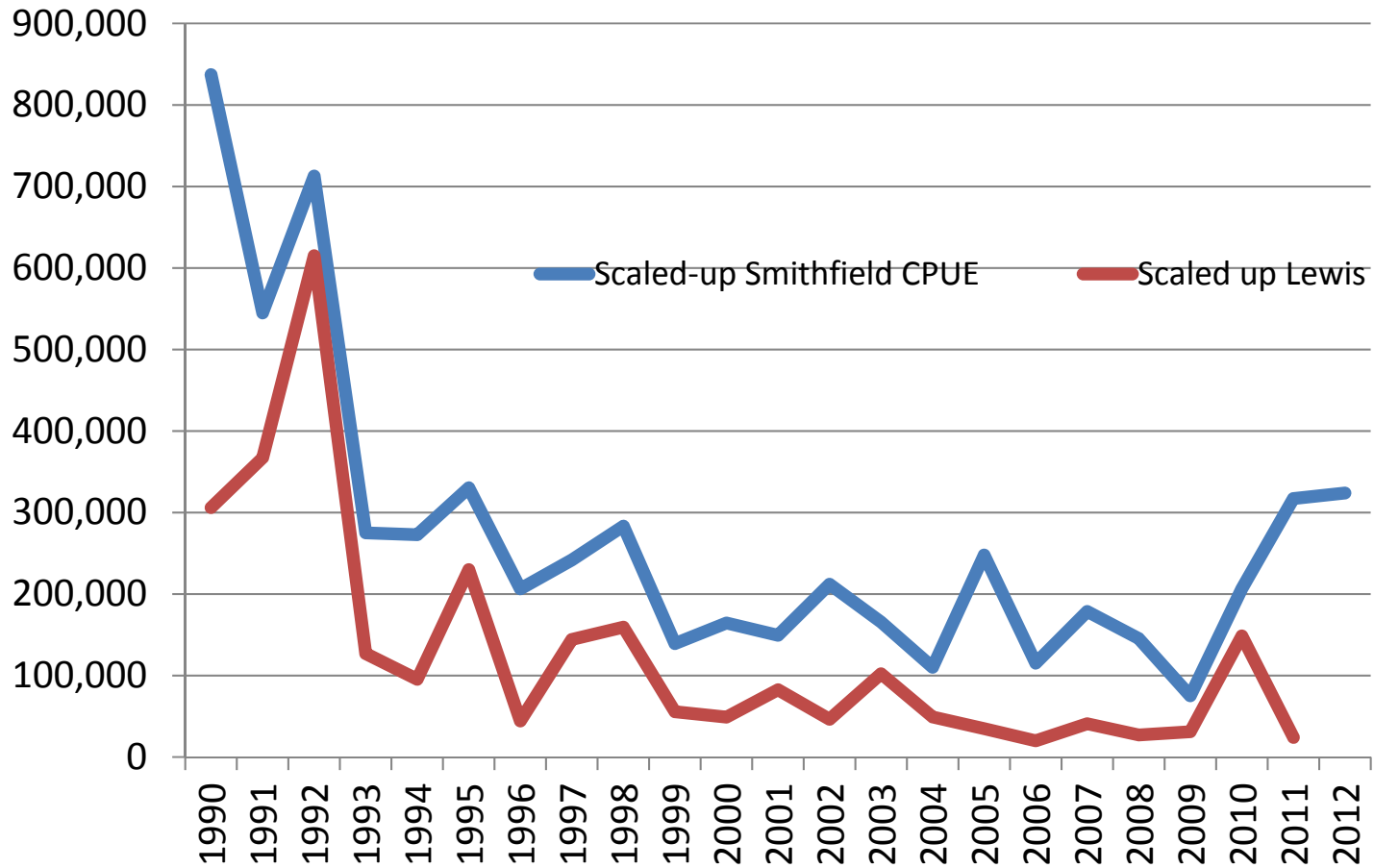


# A Delaware River American shad

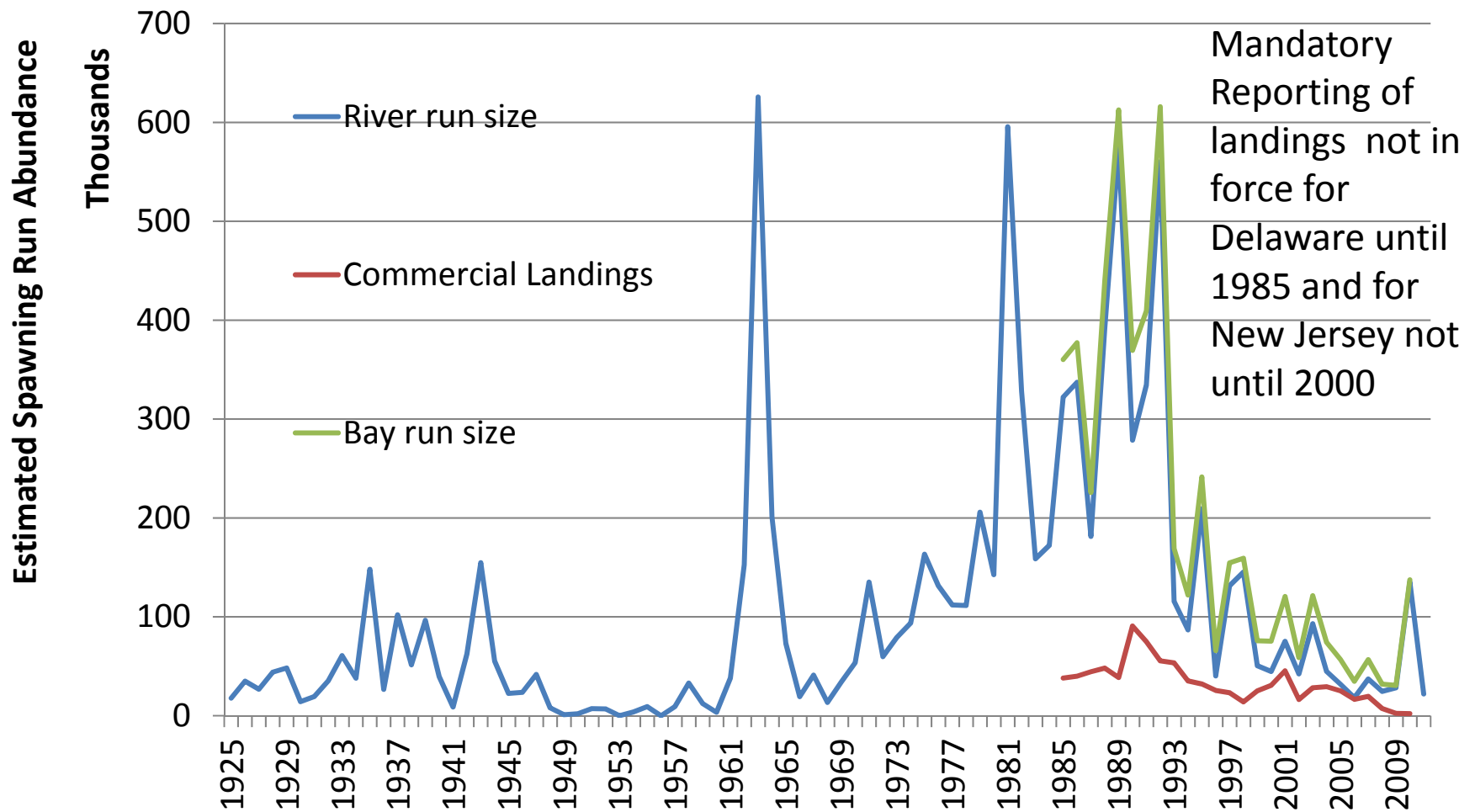




# Two estimates of shad spawning run absolute abundance, 1990- 2012

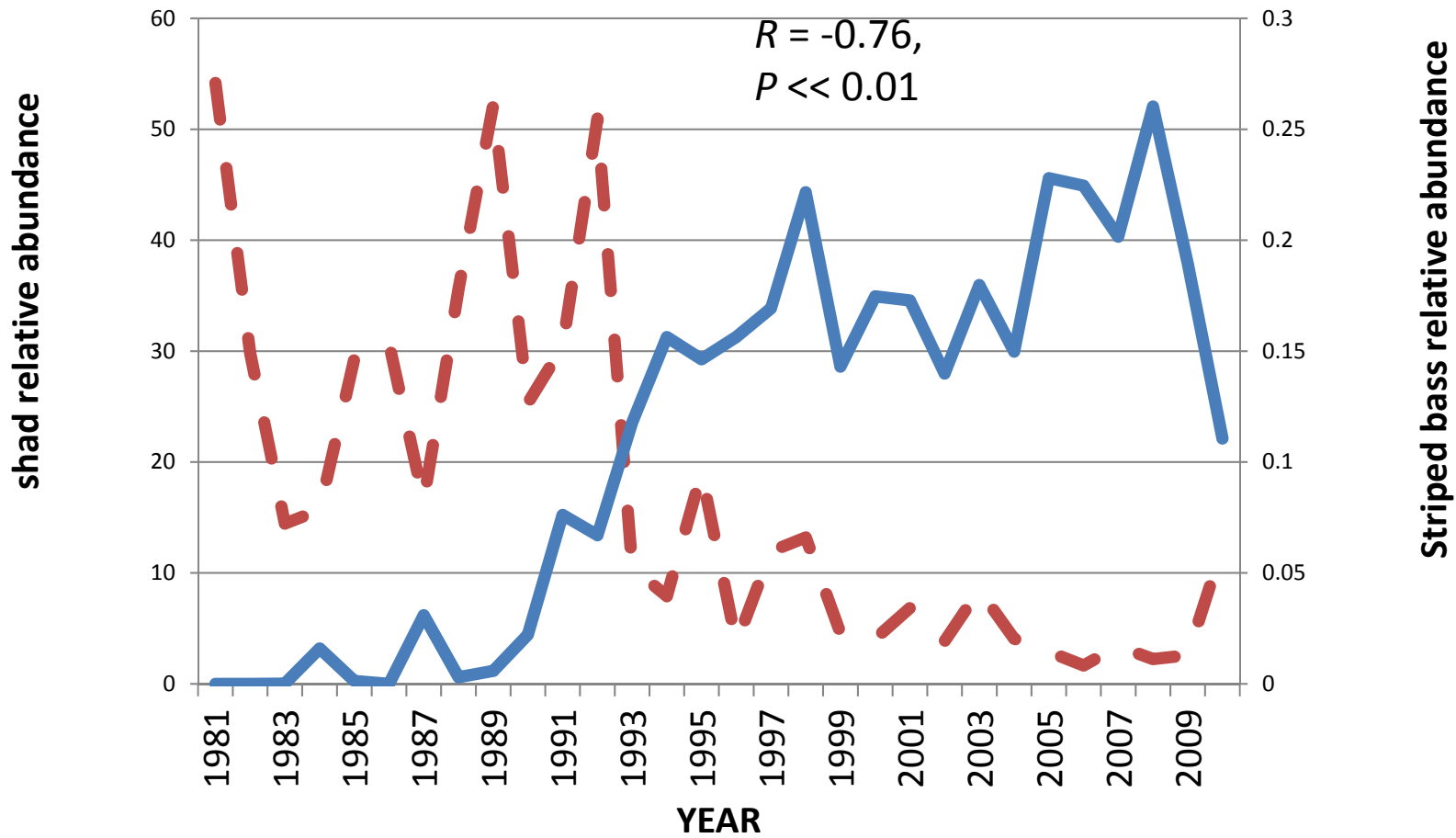


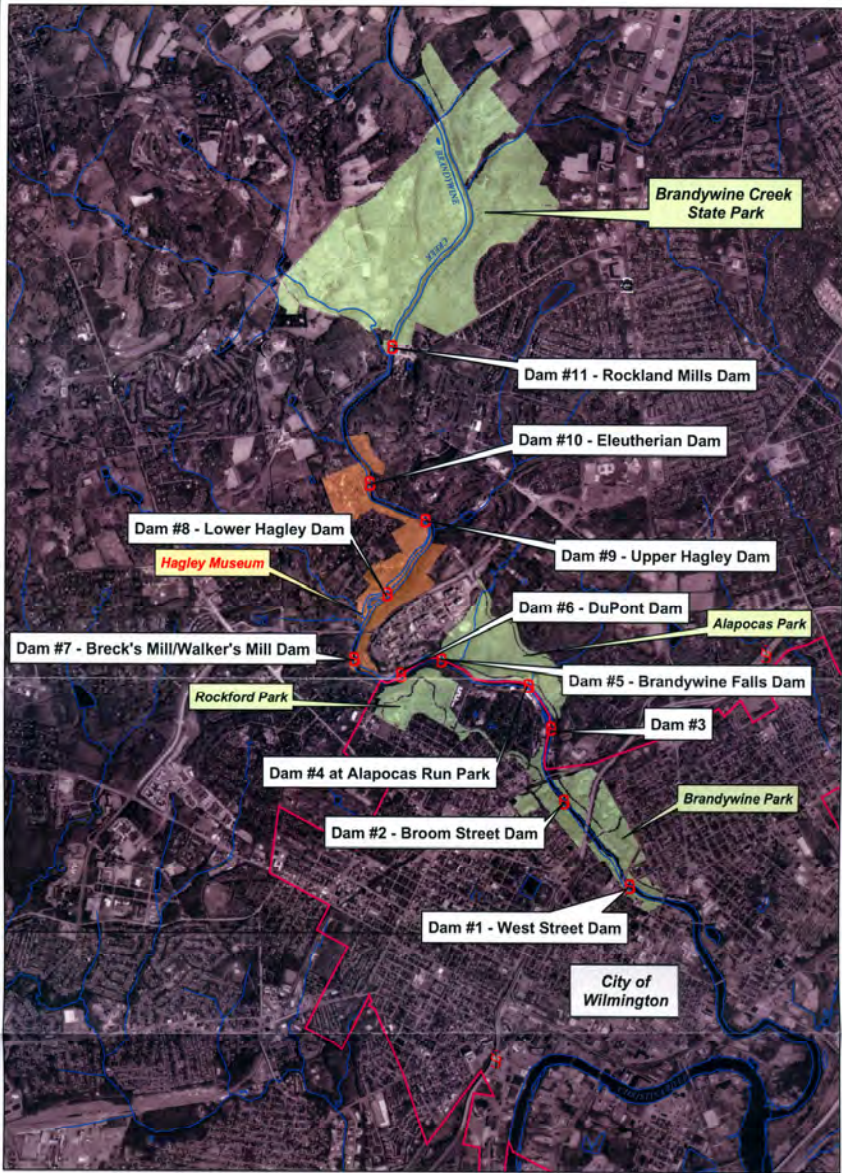
# Estimated Spawning Run Abundance, 1925 – 2011, with commercial fishery landings 1985-2011





Shad abundance peaked in the 1980s and early 1990s, when striped bass had declined severely. When bass abundance rebounded, shad declined steeply.





**Legend**

- S 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 101, Swan Park, Newmarket, NH 03854  
STATE SCENIC RIVER AND ANTI-DRIFT CHANNEL CUTOFF (SIC) DATA DISTRIBUTION, 2001.  
Aerial photography from PLECO/ALM aerial photography, Dover 2000, Delaware  
Technology data from USGS, 2000.

Date: January 15, 2007

**Elevation profile**

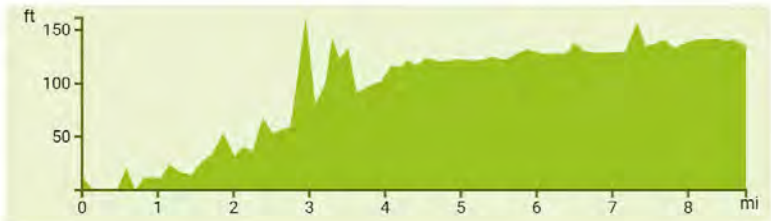














Table 4. The geometric mean number taken per haul of alosine species in the Christina River and Brandywine Creek.

	Alewife	American Shad	Blueback Herring
2014	0.02	0.45	0.61
2015	2.11	2.58	1.34
2016	0.15	0.20	0.58
2017	0.14	4.74	1.24
2018	0.27	6.67	1.49
2019	0.13	0.18	0.40

Table 5. Daily catch per unit effort (CPUE: fish/haul) of alosine fish species collected in the Christina River during the juvenile abundance estimate in 2019 using haul seine gear.

Date	Species	Catch Frequency	CPUE (fish/haul)	Average Total Length (size range)(mm)
7/8/2019	Alewife	7	1.2	87 (84-90)
7/24/2019	Alewife	2	0.3	98 (96-100)
8/6/2019	Alewife	0	0.0	
8/26/2019	Alewife	0	0.0	
9/4/2019	Alewife	8	1.3	96 (87-105)
9/23/2019	Alewife	0	0.0	
10/4/2019	Alewife	1	0.2	99
10/22/2019	Alewife	0	0.0	
2019 Total	Alewife	18	0.3	
7/8/2019	American Shad	0	0.0	
7/24/2019	American Shad	0	0.0	
8/6/2019	American Shad	8	1.3	72.8 (67-77)
8/26/2019	American Shad	3	0.5	90.3 (72-105)
9/4/2019	American Shad	4	0.7	108.5 (69-182)
9/23/2019	American Shad	3	0.5	96.3 (92-99)
10/4/2019	American Shad	3	0.5	85.6 (82-91)
10/22/2019	American Shad	0	0.0	
2019 Total	American Shad	21	0.4	
7/8/2019	Blueback Herring	1	0.2	31
7/24/2019	Blueback Herring	9	1.5	50.2 (44-60)
8/6/2019	Blueback Herring	5	0.8	42 (36-48)
8/26/2019	Blueback Herring	8	1.3	57.4 (50-71)
9/4/2019	Blueback Herring	8	1.3	63.4 (57-67)
9/23/2019	Blueback Herring	12	2.0	69.8 (60-94)
10/4/2019	Blueback Herring	14	2.3	62.4 (51-71)
10/22/2019	Blueback Herring	1	0.2	67
2019 Total	Blueback Herring	58	1.2	

Table 2. Species and the number observed during Christina River haul seine in 2019.

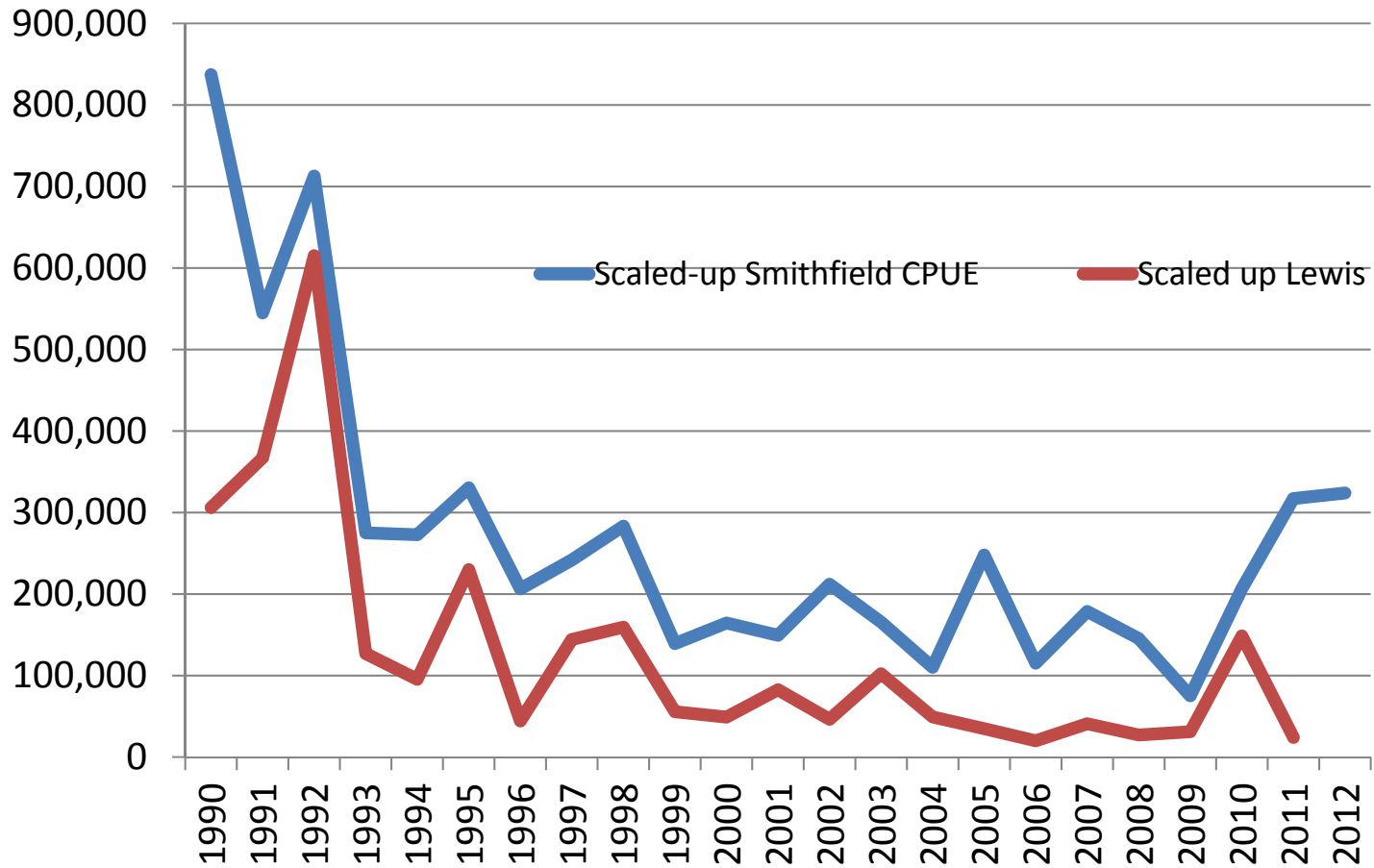
Family	Scientific Name	Common Name	Number Captured
Achiridae	<i>Trinectes maculatus</i>	Hogchocker	20
Anguillidae	<i>Anguilla rostrata</i>	American Eel	3
Atherinopsidae	<i>Menidia beryllina</i>	Inland Silverside	2
Catostomidae	<i>Catostomus commersonii</i>	White Sucker	5
Centrarchidae	<i>Lepomis cyanellus</i>	Green Sunfish	3
	<i>Lepomis gibbosus</i>	Pumpkinseed	6
	<i>Lepomis macrochirus</i>	Bluegill	29
	<i>Micropterus salmoides</i>	Largemouth Bass	10
Clupeidae	<i>Micropterus dolomieu</i>	Smallmouth Bass	6
	<i>Alosa aestivalis</i>	Blueback Herring	58
	<i>Alosa pseudoharengus</i>	Alewife	18
	<i>Alosa sapidissima</i>	American Shad	21
	<i>Brevoortia tyrannus</i>	Atlantic Menhaden	5
	<i>Dorosoma cepedianum</i>	Gizzard Shad	16
Cyprinidae	<i>Cyprinella analostana</i>	Satinfin Shiner	3
	<i>Cyprinus carpio</i>	Common Carp	5
	<i>Hybognathus regius</i>	Eastern Silvery Minnow	345
	<i>Notropis hudsonius</i>	Spottail Shiner	286
	<i>Notemigonus crysoleucas</i>	Golden Shiner	3
	<i>Semotilus corporalis</i>	Fallfish	2
Engraulidae	<i>Anchoa mitchilli</i>	Bay Anchovy	1142
Fundulidae	<i>Fundulus diaphanus</i>	Banded Killifish	71
	<i>Fundulus heteroclitus</i>	Mummichog	26
Ictaluridae	<i>Ictalurus punctatus</i>	Channel Catfish	13
	<i>Ictalurus furcatus</i>	Blue Catfish	2
Moronidae	<i>Morone americana</i>	White Perch	812
	<i>Morone saxatilis</i>	Striped Bass	51
Percidae	<i>Etheostoma olmstedi</i>	Tessellated Darter	63
	<i>Perca flavescens</i>	Yellow Perch	12
Perciformes	<i>Pomoxis nigromaculatus</i>	Black Crappie	2
Poeciliidae	<i>Gambusia affinis</i>	Mosquito Fish	1
Portunidae	<i>Callinectes sapidus</i>	Blue Crab	14
Sciaenidae	<i>Micropogonias undulatus</i>	Atlantic Croaker	8



# A Delaware River American shad

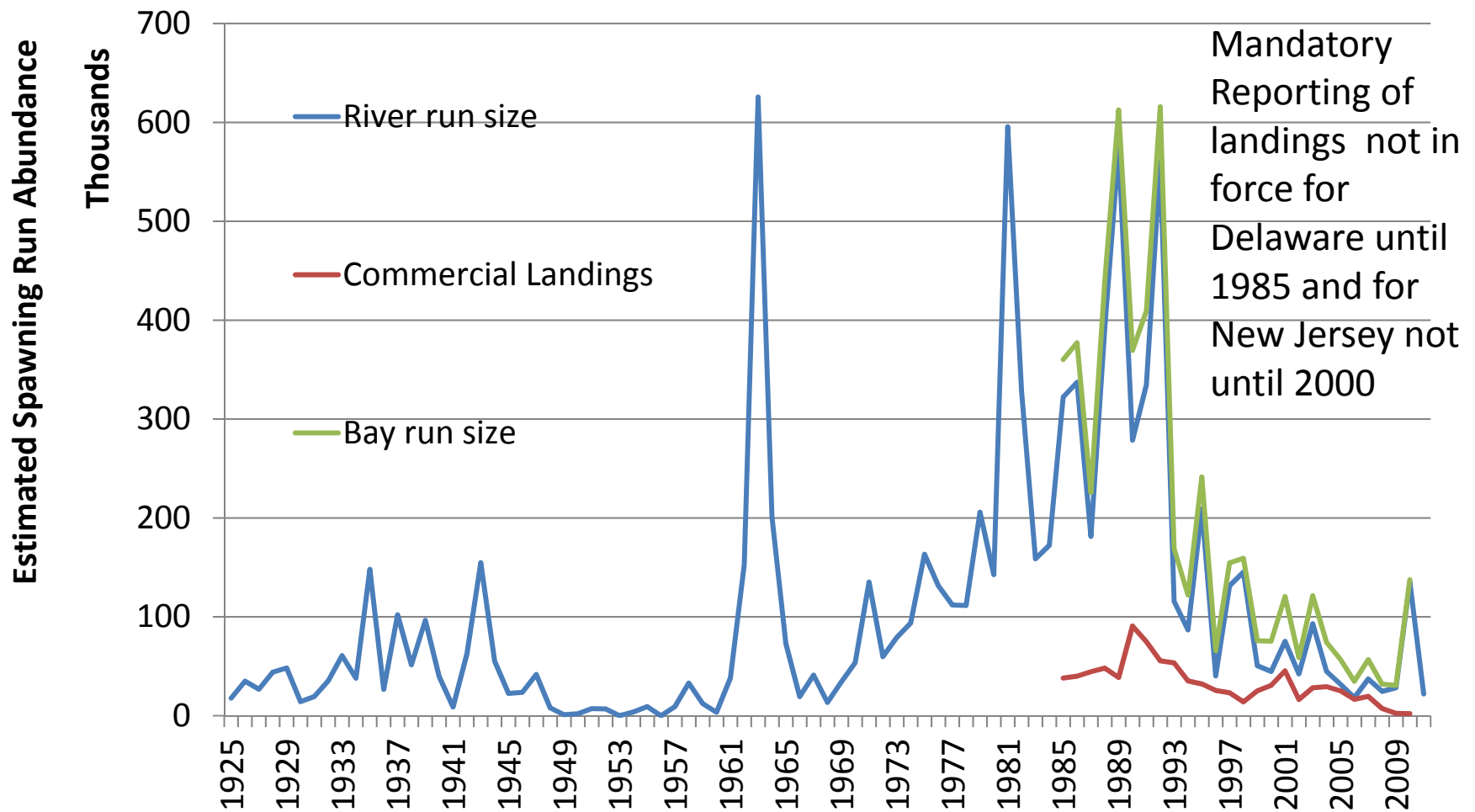


# Two estimates of shad spawning run absolute abundance, 1990- 2012

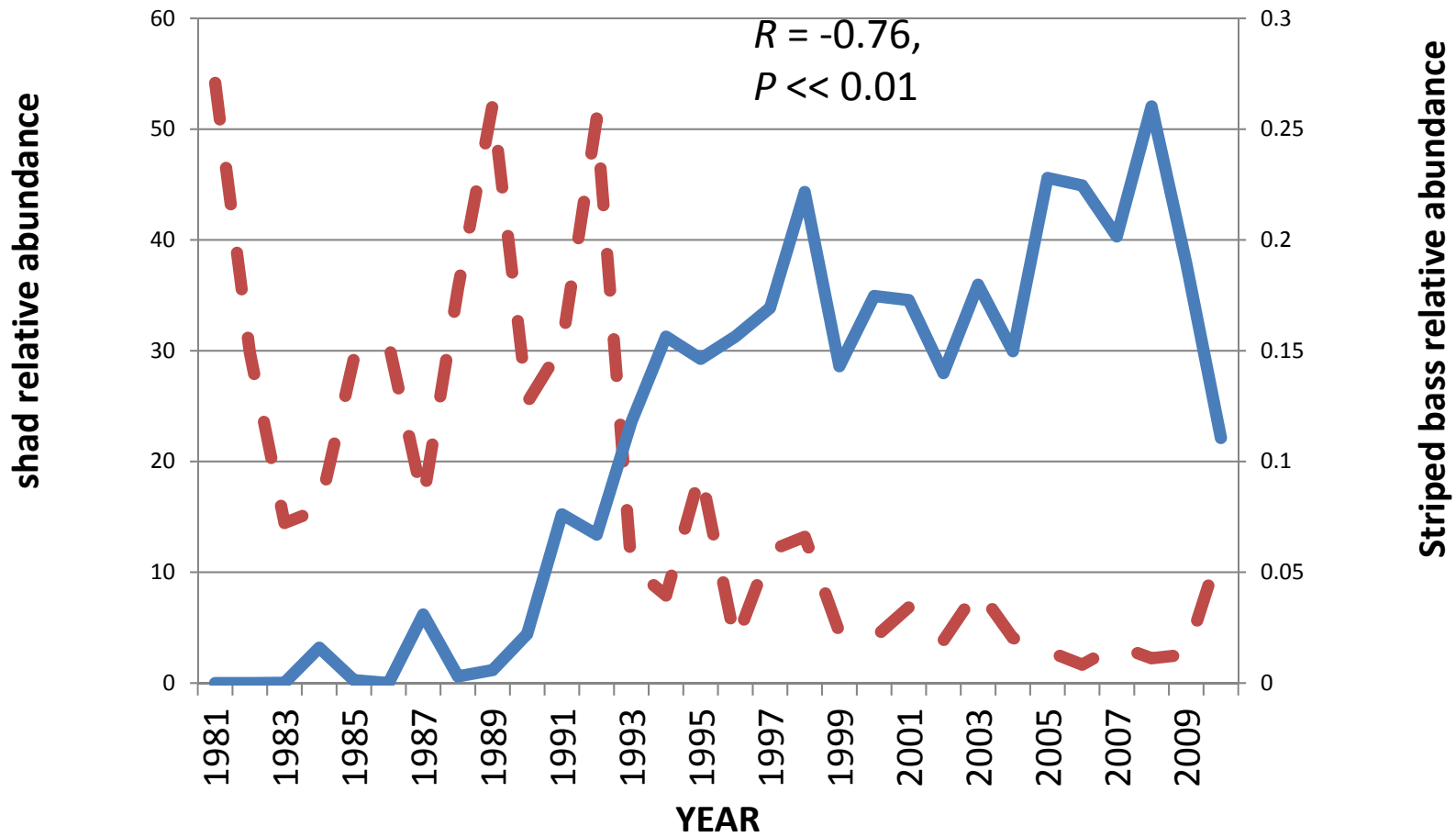




# Estimated Spawning Run Abundance, 1925 – 2011, with commercial fishery landings 1985-2011



Shad abundance peaked in the 1980s and early 1990s, when striped bass had declined severely. When bass abundance rebounded, shad declined steeply.









# American Shad are using Brandywine Creek above former Dam #1





# How are we examining fish passage on Brandywine Creek?

















Strasburg, PA 17579  
(717) 687-7211

Project: 3452-001  
Date: 12/12/2019

Project: **Brandywine Shad 2020 - Fish Passage Feasibility Assessment at Dams 2-6**  
Subject: **Brandywine River Dams 2-6 Fish Passage - Order of Magnitude Costs**

By: GSM/LDS  
Reviewed: JEW/TAK

This is a Class 5 (order of magnitude) cost estimate and could be affected by sediment condition/extent upstream of the dam, upstream utilities, adjoining landowners, time of construction, means of accessing the site, and weather conditions during construction. The estimates are based on preliminary concepts discussed during the November 12, 2019 kick-off meeting, an initial site visit, Kleinschmidt cost databases of completed fish passage projects, and a NOAA database on fish passage costs. Final construction costs may vary from these estimates (higher or lower), depending on the final fish passage design at each dam and site conditions. Allowances should be made to account for these unknowns.

Dam #	Fish Passage Option	Stated Dam Head (ft)	95% EP Flow Hyd. Model Head (ft)	Stated Dam Width (ft)	Base Order of Magnitude Price (2020 Cost)*
2	Technical Fishway (Denil fishway)	7	8.5	176	\$510,000
	Natural Bypass Channel (~20' wide, 3.3% slope)	7	8.5	176	\$1,400,000
	Rock Ramp Fishway (full width, 3.3% slope)	7	8.5	176	\$2,000,000
3	Dam Removal (minor re-shaping of center 1/3 of channel)	3	7.4	135	\$60,000
	No Action (if passable based on hydraulic model)	3	7.4	135	\$0
4	Dam Removal (removal of center 80% and fishway, leaving abutments)	4	13	150	\$410,000
5	Technical Fishway (Denil fishway)	10	9.6	200	\$630,000
	Natural Bypass Channel (~20' wide, 3.3% slope)	10	9.6	200	\$1,000,000
	Dam Removal (remove center 70% of dam, no sediment management)	10	9.6	200	\$410,000
6	Dam Removal (minor re-shaping of center 1/3 of channel)	6	9.6	182	\$110,000
	No Action (if passable based on hydraulic model)	6	9.6	182	\$0

# FISH PASSAGE ENGINEERING DESIGN CRITERIA

February 2017

U.S. Fish and Wildlife Service  
Region 5

BURST

PROLONGED

CRUISING

**Burst or Dart or Sprint Speed** is the swim speed that a fish can maintain for mere seconds  $V_B$

- Burst speed engages anaerobic white muscle tissues
- Bell (1990) suggests can be maintained for 5-10 sec.; Bain (1999) 2-3 sec.; Beamish (1978) < 20 sec.
- Speed used for predator avoidance or feeding; in fishways, use to ascend weir crests
- For fish passage design, velocities should be kept below  $V_B$  for the weakest target species at all times

Many published swimming speeds are derived from lab tests on handled fish, such values may underestimate *in situ* performance.  $V_B = 2 V_P$      $2 \text{ sec} \leq \Delta t \leq 10 \text{ sec}$

**Prolonged (or Sustained Speed \*)** is the swim speed that a fish can maintain for minutes;  $V_P$

- Prolonged speed engages both red and white muscle tissues
- Bain (1999) suggests speed can be maintained for 5-8 minutes; Beamish (1978) suggests 20 sec. to 200 min.
- Critical swim speed,  $U_{crit}$  is a sub-category of prolonged speed measured by Brett (1964)
- For fish passage design,  $V_P$  can be used in conjunction with  $\Delta t$  to estimate travel distance,  $D$ , before fatigue

$4BL \text{ sec}^{-1} \leq V_P \leq 7BL \text{ sec}^{-1}$      $V_g = V_w - V_P$      $D = V_g \Delta t$      $5 \text{ min} \leq \Delta t \leq 8 \text{ min}$

**Cruising or Sustained Speed** is the swim speed that a fish can maintain for hours;  $V_C$

- Cruising speed engages aerobic red muscle tissues
- Speed used for extended periods of travel at low speeds
- Influenced by temperature, oxygen; Bell (1990) suggested swim speeds reduced by 50% at temp. extremes
- For fish passage design,  $V_C$  should be used for transport flumes, holding pools, etc.

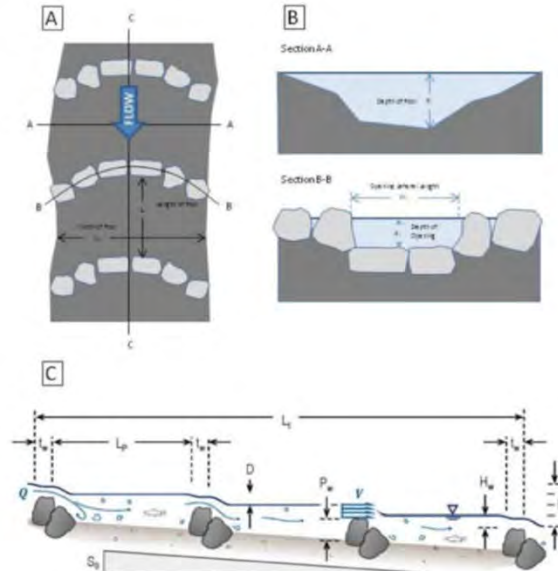
\* Literature on the definition of Sustained Speed is inconsistent. e.g., Bain (1999) refers to the speed that fish can maintain for minutes as "sustained"; contradicting Bell (1990) and others. For this reason, the cruising-prolonged-burst naming convention is used here.  $V_C = \frac{1}{3} V_P = \frac{1}{6} V_B$

Bell, M. (1990). "Fisheries Handbook of Engineering Requirements and Biological Criteria"  
 Beamish, F. (1978) Swimming capacity. In "Fish Physiology, Vol. VII. Locomotion"  
 Bain, M. and Stevenson, N. (1999) "Aquatic Habitat Assessment: Common Methods"  
 Brett, J. (1964) "The respiratory metabolism and swimming performance of young sockeye salmon"



USFWS Northeast Region (R5), FAC  
 Fish Passage Engineering, B. Towler  
 Issued 1/6/2017; replaces "Swim Speeds" 7/23/2014

## SWIM SPEED CATEGORIES REFERENCE PLATE 5-1





**Figure 2.** Captioned photographs of nature-like fishways (NLFs) in the Northeast targeting passage of Atlantic coast diadromous fishes (Photo sources: J. Turek, M. Bernier)



Saw Mill Park step-pool fishway,  
Acushnet River, Acushnet, MA



Fields Pond step-pool fishway,  
Sedgeunkedunk Stream, Orrington, ME



Kenyon Mill step-pool fishway,  
Pawcatuck River, Richmond, RI



Homestead dam removal and NLF cross-vanes,  
Ashuelot River, West Swanzey, NH

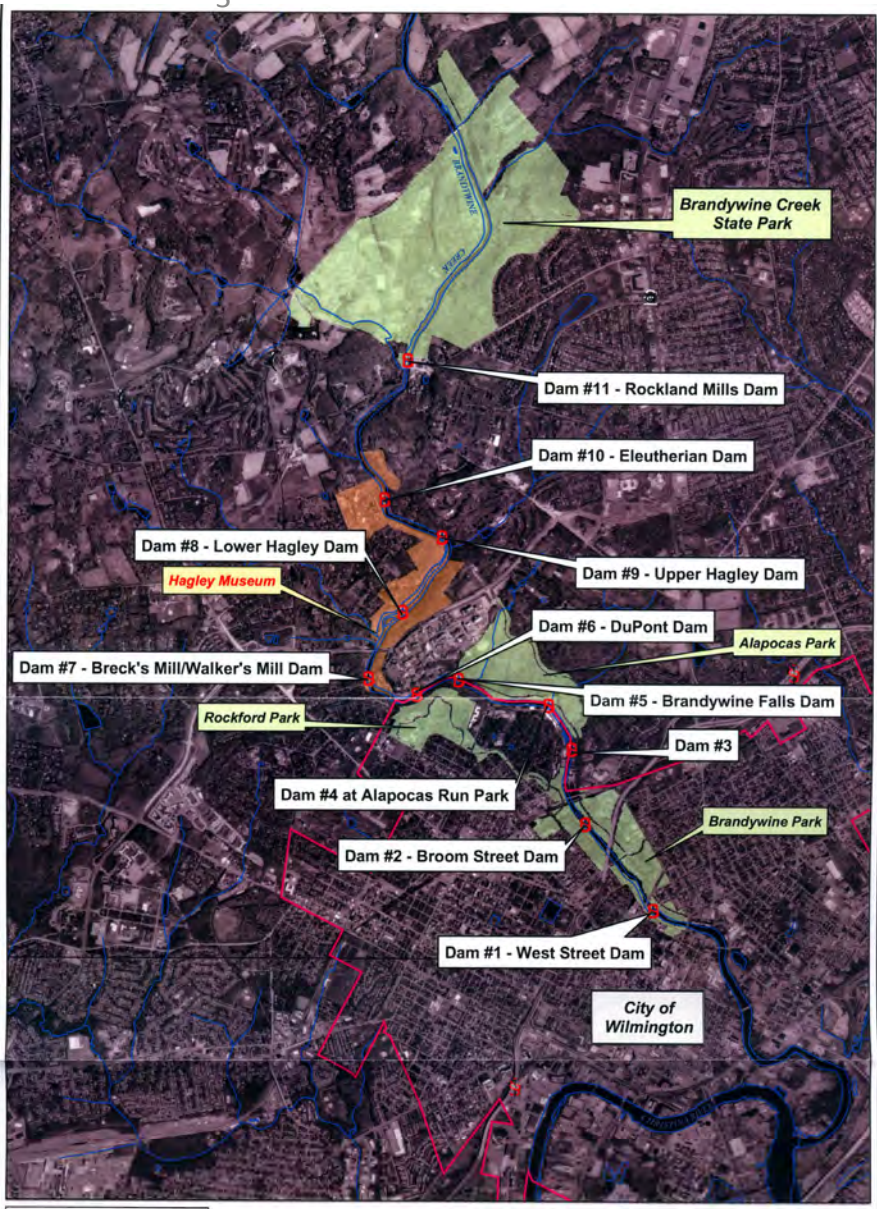


Water Street tidal rock ramp,  
Town Brook, Plymouth, MA



Lower Shannock Falls NLF weirs,  
Pawcatuck River, Richmond, RI






**Legend**

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

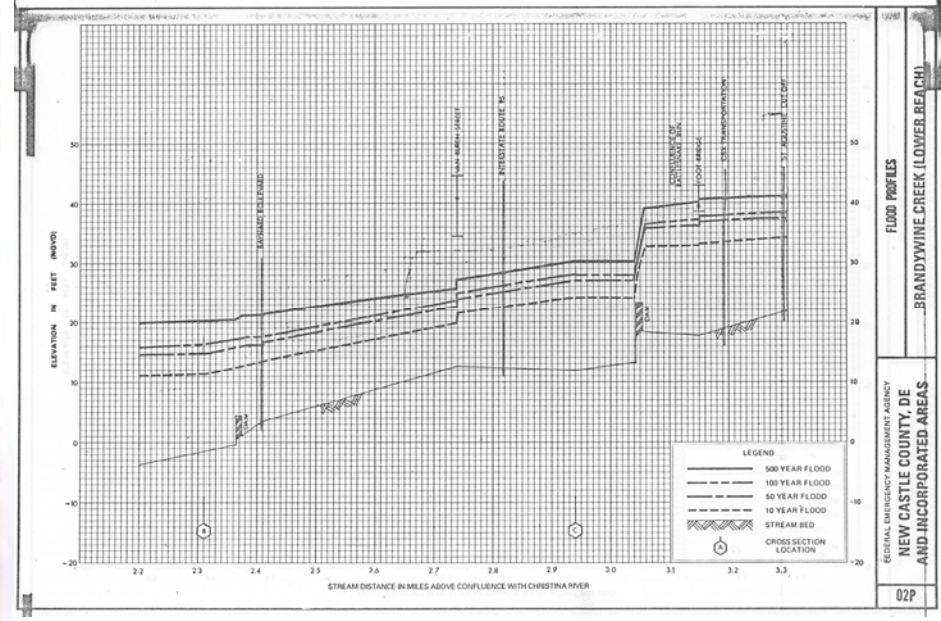
**Map 3**  
**Delaware Dams**  
**of the**  
**Brandywine River**

0 0.25 0.5 1  
Miles

  
 Environmental Management Center  
**BRANDYWINE CONSERVANCY**  
P.O. Box 141, Chadds Ford, Pennsylvania 19317-0141

DATA SOURCE: Base data from Chester County GIS data distribution, 2001. Aerial photograph from FLEXAIR aerial photography, Reno 2006. Delaware Hydrology data from USGS, 2004.

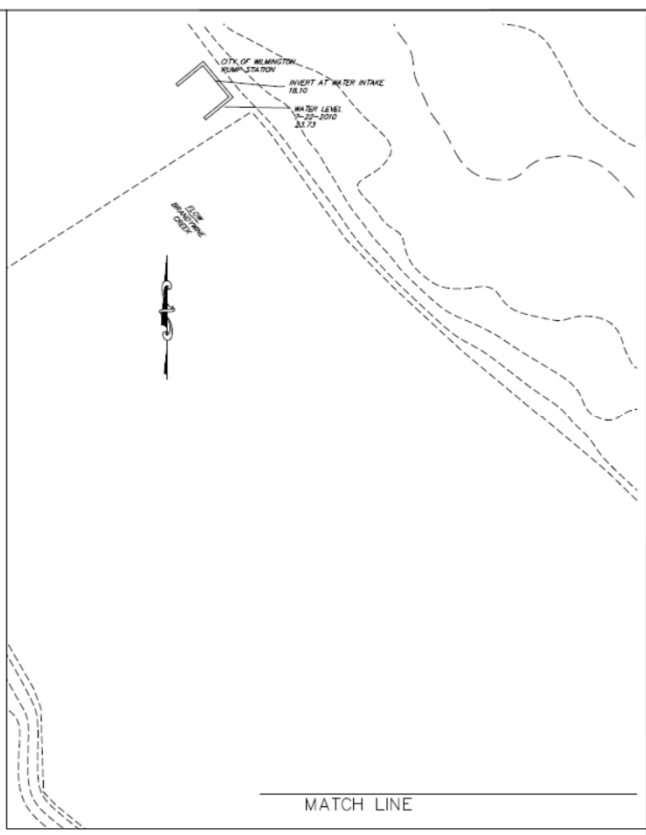
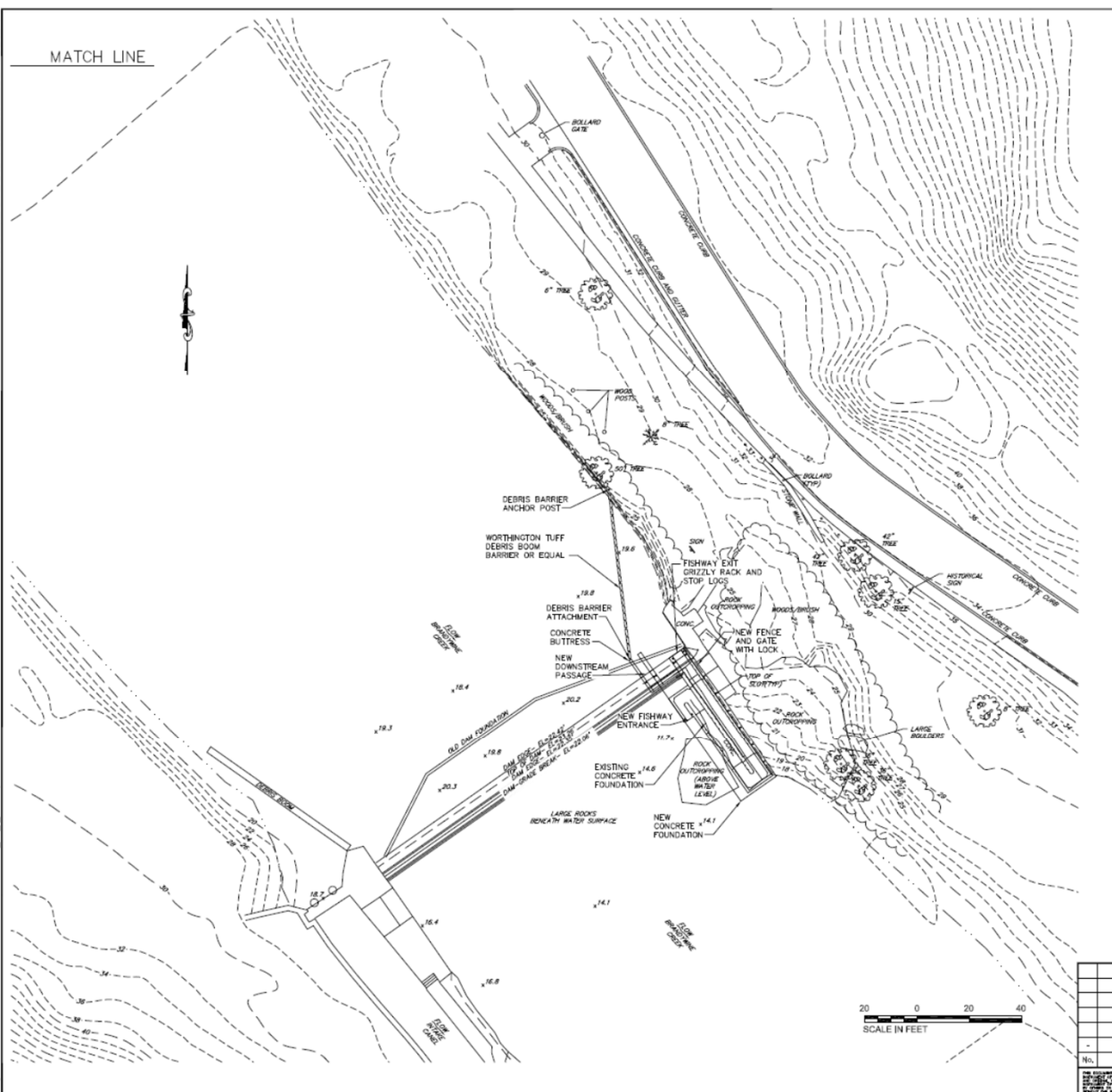
Date: January 14, 2005





22x34 = FULL SCALE / 11x17 = HALF SCALE

Aug. 12, 2010 - 4:50 PM - Z:\AS\1081000\BRANDWINCONSERV\1081\_005\_2\_SITE.dwg



SCALE IN FEET

No.	Revision	Date	Drawn	Checked
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				
21				
22				
23				
24				
25				
26				
27				
28				
29				
30				
31				
32				
33				
34				
35				
36				
37				
38				
39				
40				
41				
42				
43				
44				
45				
46				
47				
48				
49				
50				
51				
52				
53				
54				
55				
56				
57				
58				
59				
60				



**Augustine Dam 3, breached**



**Augustine Dam 3, breached**





**Bancroft Dam 4, damaged in center of dam**



**Bancroft Dam 4, damaged in center of dam**



**DuPont Dam 6, breached**



**DuPont Dam 6, breached**



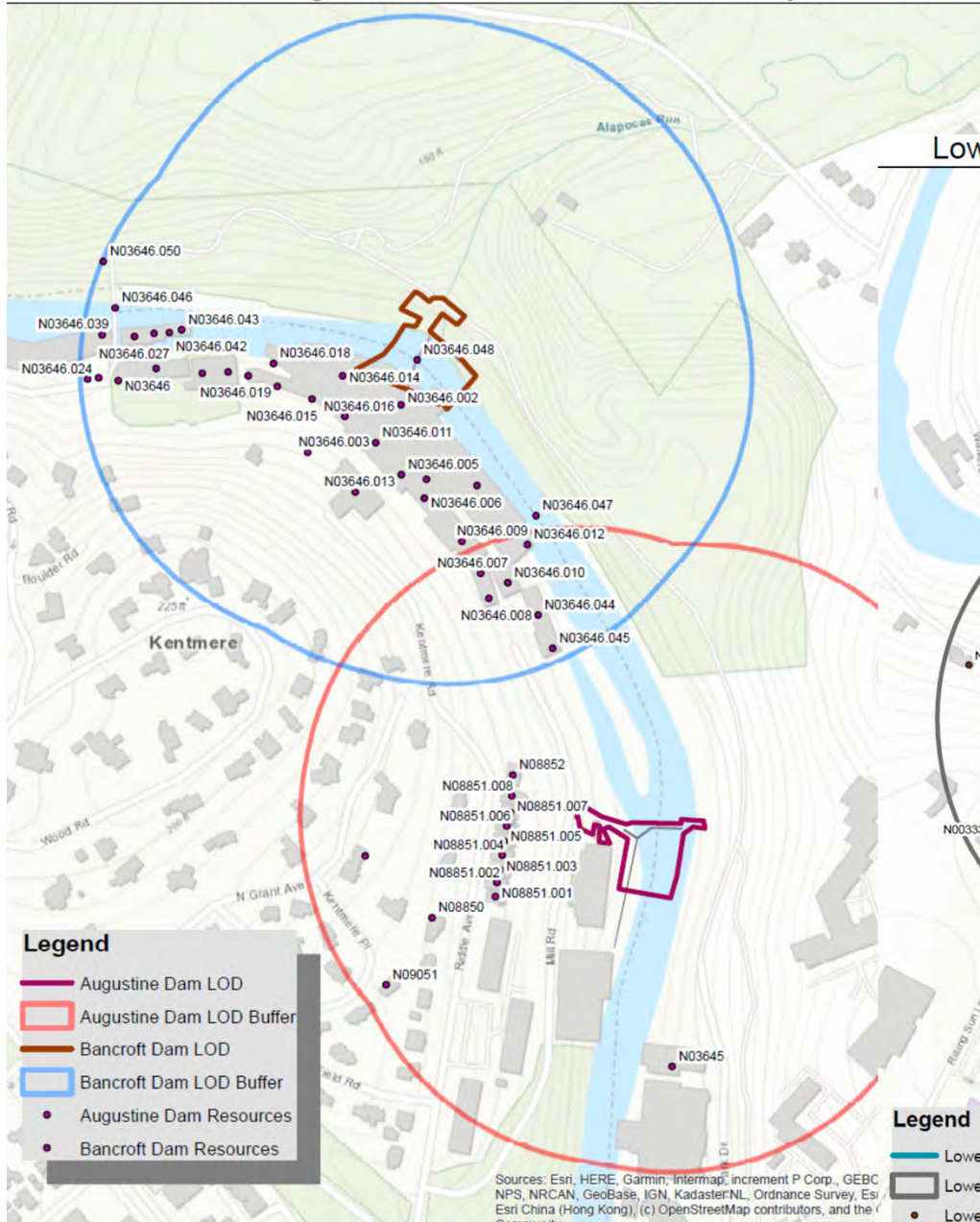


Hickory shad downstream of Brandywine River Dam 2, May 2020

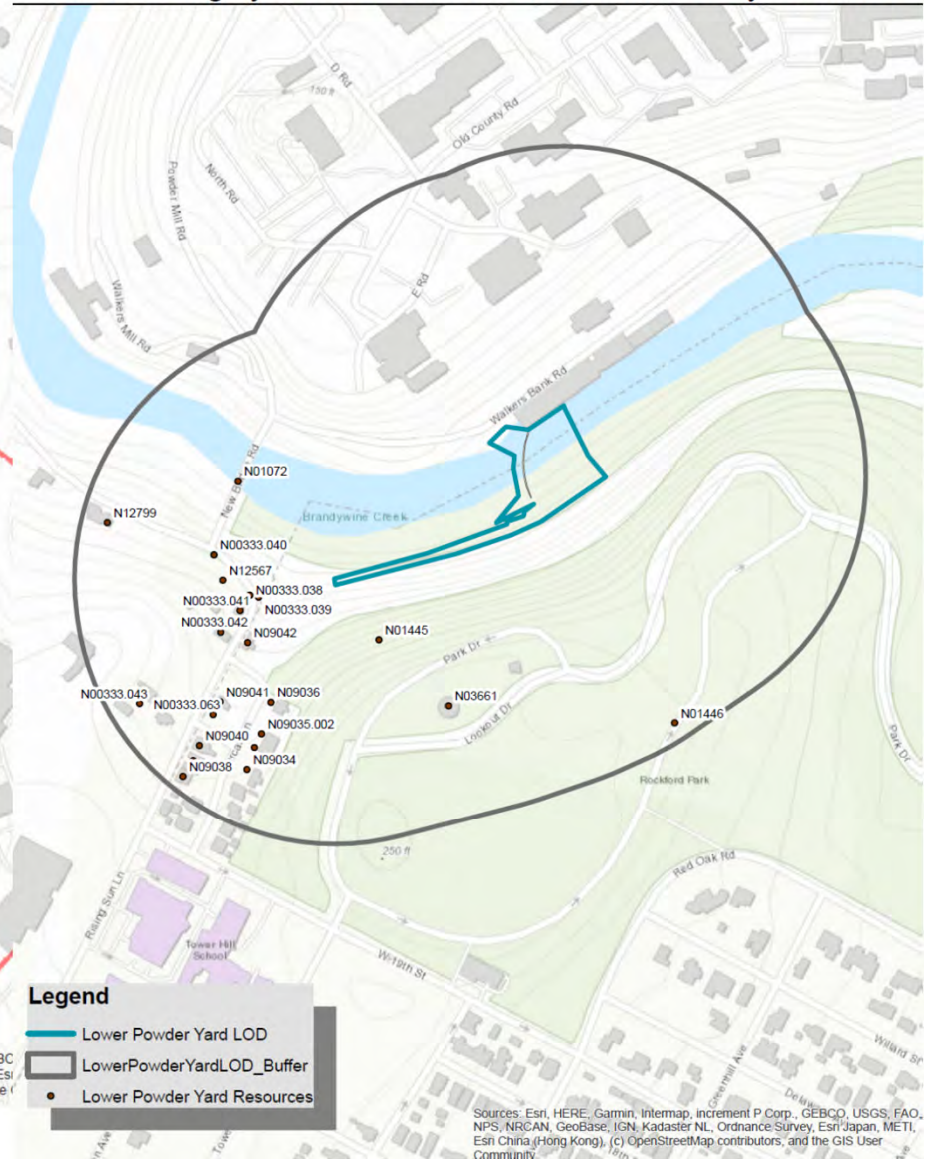


American shad downstream of Brandywine River Dam 2, May 2020

## Bancroft and Augustine Mill Dam LOD with 300 yard buffer

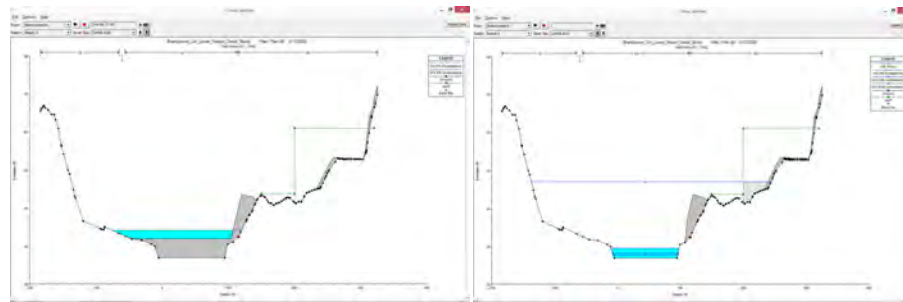


## Lower Hagley Powder Yard Dam LOD with 300 yard buffer



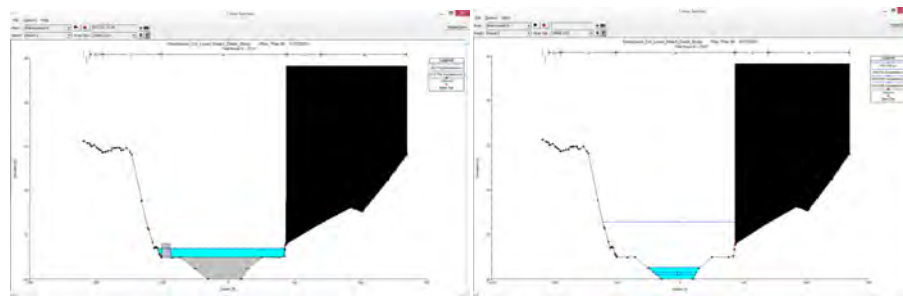
Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community.





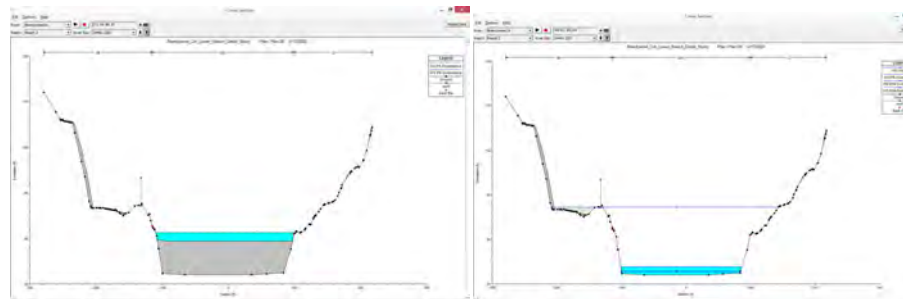
Dam 3

Dam 3 removed



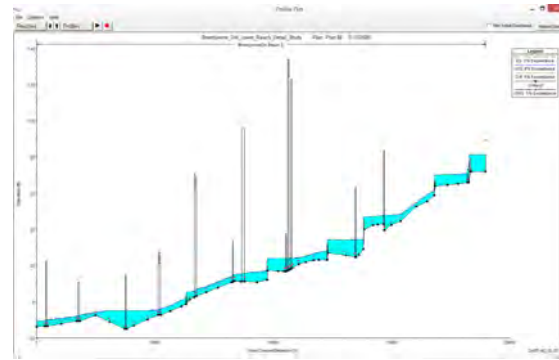
Dam 4

Dam 4 Removed

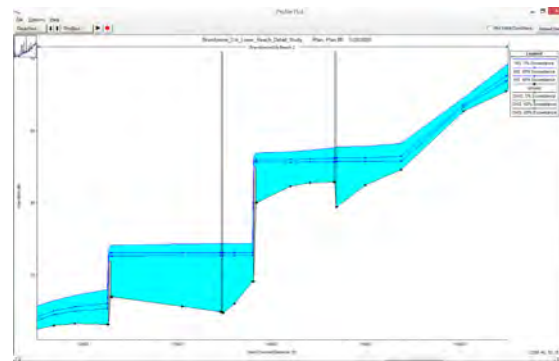


Dam 6

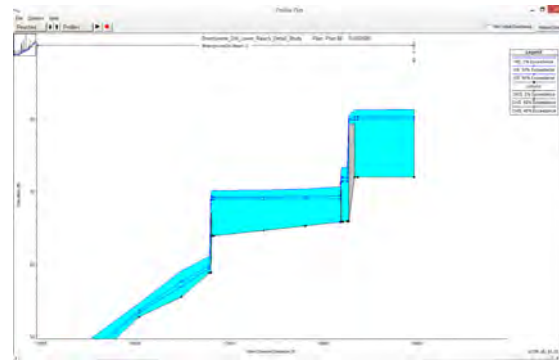
Dam 6 removed



**Brandywine River Profile Existing**



**Brandywine River Dam 3 and 4 Existing**



**Brandywine River Dams 5 and 6 Existing**

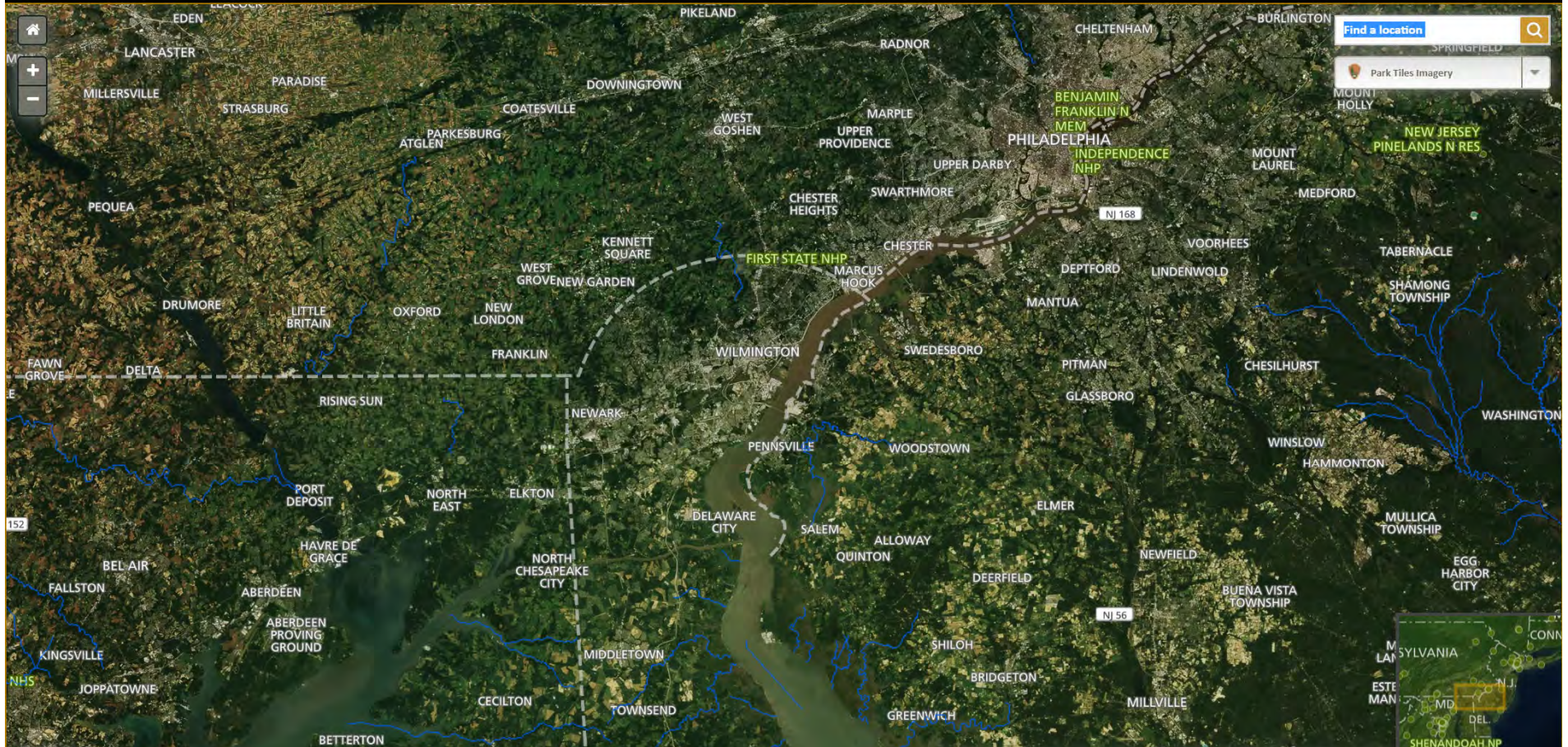


# Nationwide Rivers Inventory

National Park Service  
U.S. Department of the Interior



This is a listing of more than 3,200 free-flowing river segments in the U.S. that are believed to possess one or more "outstandingly remarkable" values.



2020 AD

Brandywine River National Wild and Scenic River?



# Questions?

