

**Reconnaissance Study of Potentially Eligible National Wild & Scenic Rivers in Delaware**

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## Chapter 1 Introduction

### Background

The University of Delaware Water Resources Center (UDWRC) worked with the Coalition for the Delaware River Watershed (CDRW) and National Park Service (NPS) and to evaluate the potential eligibility and suitability of designating streams on the Nationwide Rivers Inventory (NRI) to the National Wild & Scenic River system (W&S) in Delaware. During the 1970s and 1980s, the NPS mapped the NRI that listed 41 river segments in Delaware as potentially eligible for W&S river designation (Figure 1). Since 2000, the White Clay Creek has been the sole W&S river in Delaware and after 20 years of successful management the thought is more rivers could be added to the system. UDWRC research students (Figure 2) assisted with the reconnaissance study that began in summer 2021 with delivery of a December 2021 draft report.

**Eligible and Suitable Wild & Scenic Rivers:** The 1968 Wild and Scenic Rivers Act provided three ways to add a W&S river system through studies of eligibility and suitability:

- Section 2(a)(ii) upon application of a governor of a state.
- Section 5(a) directs agencies to study specific rivers as authorized by Congress
- Section 5(d)(1) directs land agencies (NPS) to initiate wild & scenic river studies as planning processes.

**Eligibility:** To be eligible for designation, a river must be free-flowing and possess outstandingly remarkable values (ORV) that are river-dependent natural, cultural, or recreational resources and unique, rare, or exemplary at a regional or national scale. The eligibility analysis examines the river's hydrology, including man-made alterations, and an inventory of its natural, cultural, and recreational resources.

**Suitability:** The final step in the river assessment process for wild and scenic designation is determination of suitability which rivers should be recommended for addition to the National System and an agency's recommendation to Congress. The recommendation to Congress is made by the National Park Service via a document that complies with the National Environmental Policy Act (NEPA).

### Scope

The UDWRC conducted the reconnaissance study in accordance with the following scope of work:

1. **National Rivers Inventory:** Map 41 rivers on the NPS NRI in Delaware and add Red Clay Creek and Christina River or 43 rivers total. Characterize river segment by land use, population, soils, geology, dams, demographics (diversity, equity, inclusion, and justice indicators), and political boundaries.
2. **Outstanding Resource Values:** Identify ORVs such as scenery, recreation, geology, fish, wildlife, prehistory, history, cultural (DEIJ) and for each of the 43 rivers.
3. **Local Partners:** Identify local environmental committees, watershed organizations/associations, nonprofits, NGOs, and stakeholders for each NRI who may support W&S designation.
4. **Eligibility/Suitability:** Prioritize and recommend rivers for further Phase I study of W&S eligibility by the NPS and Phase II study of suitability based on conserved land and local support in each NRI.
5. **Report:** Prepare report recommending NPS study of Delaware rivers most eligible & suitable for W&S river designation.



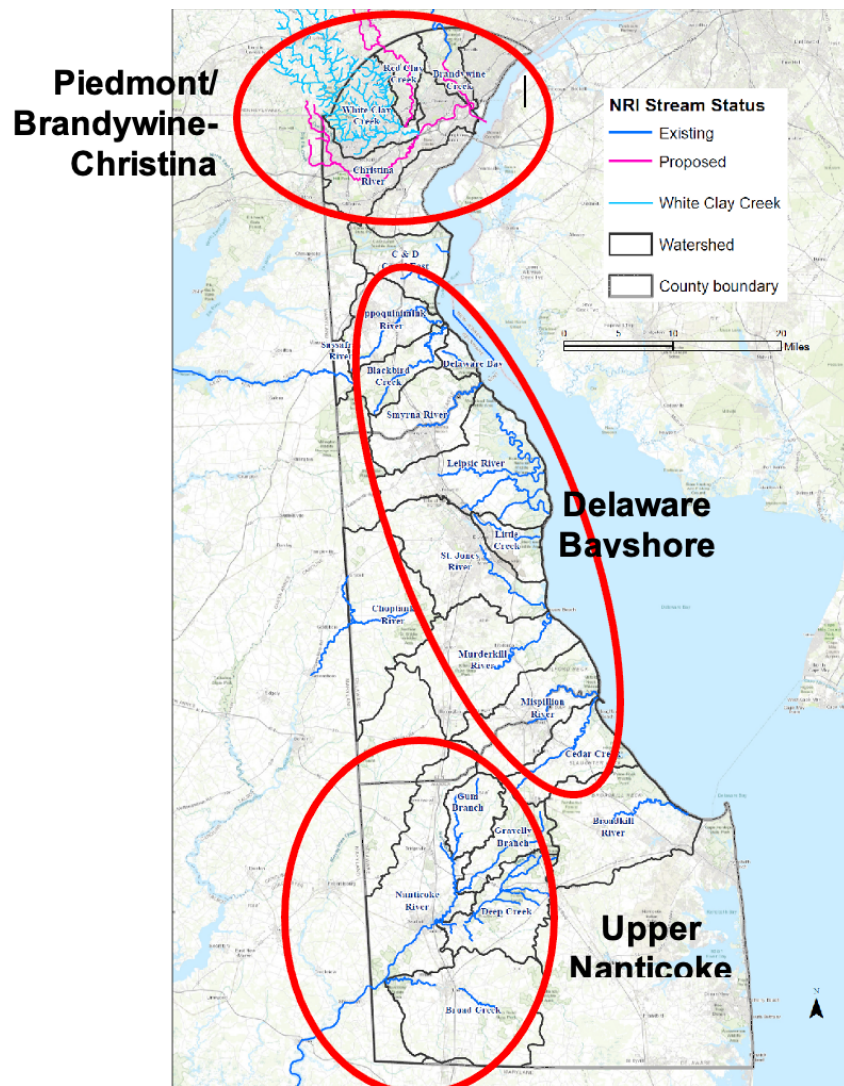


Figure 1. Nationwide Rivers Inventory in Delaware



Figure 2. UDWRC water research students White Clay Creek State Park, Delaware (2021)

## Chapter 2 National Wild and Scenic River System

### National Wild and Scenic Rivers Act of 1968

The National Park Service describes that Public Law 90-542 (National Wild and Scenic Rivers Act of 1968) was passed to preserve and protect rivers of America that possess valuable, unique qualities for the benefit of current and future generations (Figure 3). To complement policies focused on dams and other construction in or near watersheds of the U.S., the National Wild and Scenic Rivers Act seeks to protect and bolster water quality and similar conservation efforts of rivers or sections of rivers and watersheds. Outstanding Remarkable Values (ORVs) relating to scenery, recreation, geology, culture, fish and wildlife, and historic relevance that are river-related (within ¼ mile of the river), contribute to functioning of the river ecosystem, and owe existence to the presence of the river are organized under three classifications: Wild, Scenic, or Recreational.

Wild rivers are defined as being without impoundments and only accessible by trails with shorelines “essentially primitive” maintaining clean, unpolluted water (NPS 1994). Scenic rivers are similar to wild rivers but can be reached by road. Recreational rivers are accessible by road and railway and have previous development and/or diversion. Along with protection and advocacy for waterways, the National Wild and Scenic Rivers Act also determines best use practices and potential development planning in protected areas. The Act exists as a successful model of bipartisan cooperation for conservation efforts across the country.

Rivers in their free-flowing state are considered eligible for induction to the Act through a blueprint for the process by which rivers around the country can be considered for the Wild and Scenic Rivers System. This monumental victory for conservation provided many successes of river restoration and protection.

From its implementation under the National Wild and Scenic Rivers Act over six decades ago, the National Wild and Scenic River System has grown to include 13,413 miles of 226 rivers in 41 states and the Commonwealth of Puerto Rico. Most recently in 2019 amendments and additional designations extended recognition of the Wild and Scenic Rivers System to 18 new rivers and sections across the country. The White Clay Creek watershed, the sole W&S river in the First State, was designated by President Clinton and Congress in 2000. In the White Clay Creek watershed in Delaware and Pennsylvania, 26 stream miles are designated scenic and 173 miles are recreational for a total of 199 miles protected and in Delaware, 95 miles are designated as wild and scenic or 4% of the state's river miles.

### Outstandingly Remarkable Values

Outstandingly Remarkable Values (ORVs) include Scenic, Recreational, Geologic, Fish, Wildlife, Cultural, Historic, and Other Similar Values such as Diversity, Equity, and Inclusion (DEIJ) values. The following eligibility criteria set minimum thresholds to establish ORVs and are illustrative but not inclusive.

**Scenic:** These rivers have landform, vegetation, water, and color that result in landscapes that are rare, unique, or exemplary. When analyzing scenic values the seasonality of flow variations, ice, and snow cover, and vegetation can also be considered, along with the impact of human development on the landscape. Scenery and visual attractions may be highly diverse over different parts of the river or river segment.

**Recreational:** High quality recreational opportunities attract visitors from throughout the region; or the recreational opportunities are unique, rare, or exemplary within the region. Additional rivers may provide highly valued settings and opportunities for healthy, active outdoor activities for people close to where they live. Others may uniquely connect communities, support or diversify local economies and provide needed access to open space and the outdoors. Activities may include sightseeing, wildlife observation, camping, photography, hiking, fishing, hunting, boating, and exceptional interpretive opportunities.

**Geologic:** Geologic features along the river corridor may be in an unusually active stage of development, represent a textbook example of geologic processes, or represent a unique or rare combination of geologic features (erosional,

cave formation, volcanic, glacial, or other geologic structures).

**Fish:** The river is nationally or regionally an important producer of resident and/or migratory fish species. Of particular significance are a diversity of fish species or the presence of wild stocks and/or federal or state listed (or candidate) threatened, endangered or species of conservation concern. The river provides uniquely diverse or exceptionally high quality habitat for fish species indigenous to the region of comparison. Of particular significance is habitat for wild stocks and/or federal or state listed (or candidate) threatened, endangered or species of conservation concern.

**Wildlife:** The river, or area within the river corridor, contains nationally or regionally important populations of indigenous wildlife species. Of particular significance are species diversity, species considered to be unique, and/or populations of federal or state listed (or candidate) threatened or endangered or species of conservation concern. The river, or area within the river corridor, provides uniquely diverse or exceptionally high quality habitat for wildlife of national or regional significance, and/or may provide unique habitat for federal or state listed (or candidate) threatened, endangered, or species of conservation concern. The river or riparian area may provide critical habitat connectivity for migratory species or for wildlife that utilizes a variety of habitat types during different life stages.

**Cultural:** The river corridor contains evidence of significant river-related occupation and use (e.g. pre-contact sites, ceremonial area, fishing area, sacred religious sites), by Native Americans in the past or at present. Site integrity may enhance education and interpretation significance (e.g. sites that are unmodified and retain their original character; important sites or river crossings; features that are in excellent condition). Sites or features currently listed in or eligible for listing in the National Register of Historic Places, particularly in abundance such as Archeological Districts and Cultural Landscapes, and National Historic Landmarks, contribute to the value. Not all listed/eligible resources equate to an ORV, but will still be afforded protections under cultural and historic resource protection laws

**Historic:** Sites or features are associated with historically significant river-related events, activity (e.g. major railroad sites, early settlement), or associated with exceptional people (e.g. John Wesley Powell, Brigham Young). A historic feature is at least 50 years old. Site integrity may enhance education and interpretation significance. The presence of exceptional examples of river-related structure architecture from a significant period of history, sites that are unmodified and retain their original character, or features that are exceptional examples within the region are also relevant considerations. Sites or features currently listed in or eligible for listing in the National Register of Historic Places, particularly in abundance such as Historic Districts and designated as National Historic Landmarks contribute to the value. Not all listed/eligible resources equate to an ORV, but will still have protections under cultural and historic resource protection laws.

**Other Similar Value:** Other similar outstandingly remarkable values can include, but are not limited to, botany, hydrology, ecology, paleontology, and science.

Potential Classifications include:

**Wild:** River areas are free of impoundments and generally inaccessible except by trail, with watersheds or shorelines essentially primitive and waters unpolluted. These represent vestiges of primitive America."

**Scenic:** River areas are "free of impoundments, with shorelines or watersheds still largely primitive and shorelines largely undeveloped, but accessible in places by roads."

**Recreational:** River areas are "readily accessible by road or railroad, that may have some shoreline development, and that may have undergone some impoundment or diversion in the past."

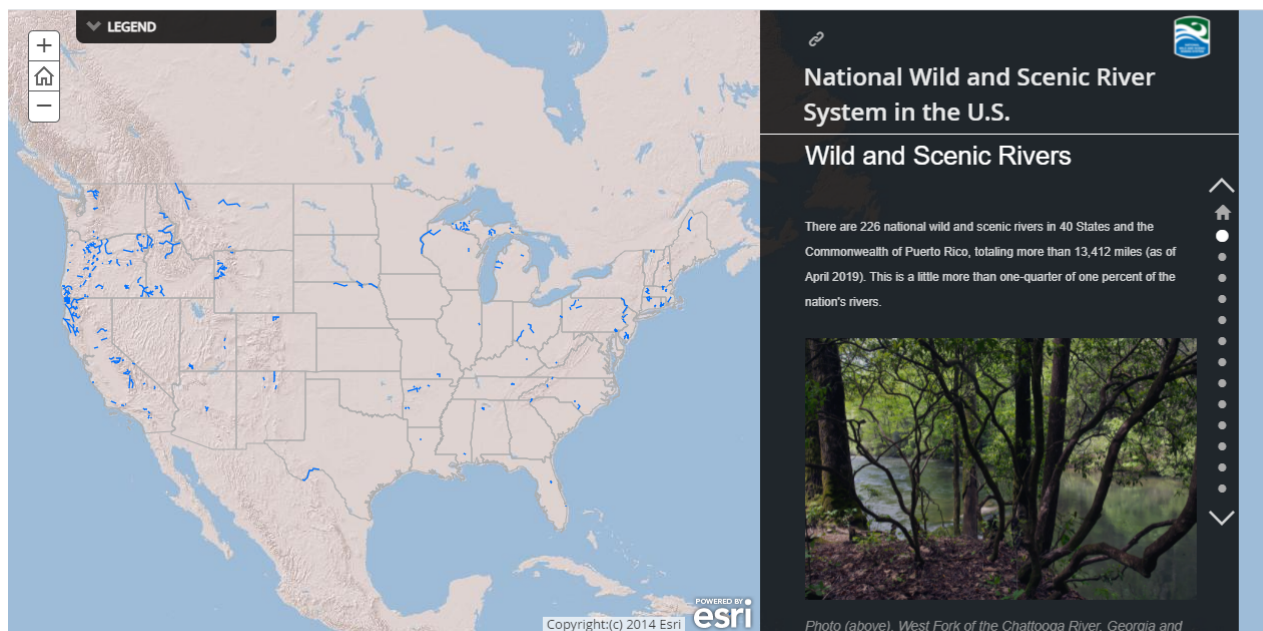


Figure 3. National wild and scenic rivers in the U.S.

### Eligibility and Suitability

Before a river can be granted recognition under the National Wild and Scenic Rivers Act, it must meet standards of eligibility and suitability. Rivers and river segments in Delaware that already have status as part of the Nationwide Rivers Inventory, explored and defined in Section 2, are prominent and exist as having great potential for future introduction to the national system. Reconnaissance may be initiated in one of three ways: (1) submitted application by a state's governor, (2) Congressional authorization of study to be carried out by an agency, or (3) study by the National Park Service as part of routine planning process (NPS 2021b). Section 2(a)(ii) of the National Wild and Scenic Rivers Act allows the governor of a state to submit application to the Secretary of the Interior, which is then evaluated by the National Park Service who prepares a draft report and assessment of the environmental impacts of designation under the National Environmental Policy Act (NEPA). The Federal Registration listing process begins in Section 5(a) of the Act states agency studies of specific rivers as authorized by Congress. Section 5(d)(1) states the National Park Service can study river segments as a part of typical planning procedure where water and land resources are involved. Potential wild, scenic, and recreational designations may be decided upon review by Congress.

Clear definitions and factors for eligibility and suitability are provided by the National Park Service. For eligibility, there are two main requirements that must be met by any river under consideration for the national system: (1) existing in a free-flowing state and (2) bearing one or more river-dependent ORV. Eligibility is tested through a river's hydrology and a listing of associated cultural, natural, and recreational resources. Suitability, the final step in the assessment process for rivers under consideration, involves the decision making process of which rivers to recommend for selection, as well as the action by agencies to recommend those selections to Congress via NPS with appropriate documentation as determined by NEPA (NPS 2021b). It is through the successful completion of this process that a river may be deemed eligible and suitable for recommendation to join the National Wild and Scenic Rivers System.

**Wild and Scenic River Reconnaissance Surveys:** In cases when there is strong local interest in authorizing a formal study of a river's eligibility and suitability for designation under Section 5(a) of the WSRA, but where Congress has not yet approved such legislation, local congressional members may request that the NPS perform a preliminary evaluation of the river's qualifications. Such studies are commonly known as "reconnaissance surveys," which gather existing information about the river. Requests for these surveys are routed through the NPS. Authority for conducting reconnaissance surveys comes from 54 USC 100507(b)(5), "Additional Areas for the NPS

System,” which limits the cost to \$25,000. These costs are normally covered by the SRS fund source. Initiation of a reconnaissance survey may need to be phased due to competing funding and staffing needs from congressionally-authorized studies and other kinds of special studies.

**Survey Scope and Findings:** While WSR reconnaissance surveys utilize the same eligibility and suitability criteria that apply to all candidate rivers, the survey is far more limited in scope than a 5(a) study. Survey findings focus on the candidate river’s likely eligibility for WSR designation and are based solely on existing information, which may be quite limited. The survey report should note such limitations to help inform future work (e.g., a 2(a)(ii) designation nomination or Section 5(a) study) should the community choose to support such efforts.<sup>19</sup> Notably, reconnaissance surveys are not subject to NEPA because they do not involve major federal decisions affecting the environment. Thus, while existing local and state land-use controls and the conservation status of riverfront lands will be described, if possible, along with gaps in available information, the survey’s findings with respect to suitability are very preliminary in nature. The WSR reconnaissance survey report should clearly and objectively explain the NPS’s river eligibility and suitability findings, while noting information gaps.

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- Section 2(a)(ii) upon application of a governor of a state.
- Section 5(a) directs agencies to study specific rivers as authorized by Congress
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**Suitability:** The final step in the river assessment process for wild and scenic designation is determination of suitability which rivers should be recommended for addition to the National System and an agency’s recommendation to Congress. The recommendation to Congress is made by the National Park Service via a document that complies with the National Environmental Policy Act (NEPA).

The National Wild and Scenic River System includes 212 rivers flowing along 12,734 miles. Important sections of the National Wild and Scenic Rivers Act of 1968 include:

- Section 1. Protects a river’s free flow, water quality, and “Outstandingly Remarkable” values.
- Section 7. No federally assisted water resource development projects permitted that have an adverse effect on designated river values.
- Section 10. Protects and enhances some “Outstandingly Remarkable” values.
- Section 11. Agreements allow flow of Federal funding to river partner organizations.

### **Wild and Scenic River Management Models**

Successful governance and management models of W&S rivers include:

**The Federal Administered Model:** Managed as traditional administrative units of the National Park System such as Upper Delaware and Delaware Water Gap where the NPS owns adjoining lands. Staffing includes superintendent and law enforcement. Only the NPS has direct resource management responsibilities. A permitting system is established for special uses and recreation.

**The Partnership Model:** Not managed as units of the National Park System. The NPS provides technical assistance to local governments and NGOs. Rivers run through local, state, private, and tribal lands. No NPS land and no federal land acquisition. The NPS works in partnership with local governments and NGOs.

Partnership Wild and Scenic Rivers (PWSRs) are managed through long-term partnerships and collaboration between federal, state, and local stakeholders. A key component of the PWSR governance model is the increasing and active leadership role that Congress plays in the management of these rivers where rivers are designated as PWSRs to be administered by the Secretary of the Interior through the NPS in partnership with local governments, councils, watershed groups, and non-governmental organizations (NPS 2021a).

Over the last several decades those at the local, state, and federal level with watershed and river conservation interests have worked in cooperation to modify the National Wild and Scenic Rivers Act to establish an effective, partnership-based approach to Nationwide Rivers Inventory (NRI) management. These partnerships are conducted through cooperative agreements describing the collaborative approach. Currently, PWSR include 16 rivers, which share certain common criteria and principles in their management approach with the goals of meeting standards of river conservation mandated at the federal level, while also considering the local needs and traditional uses (Fosburgh et al. 2008).

Among the shared principles and management systems of the PWSRs is that there is no federal ownership or management of lands, and federal ownership is not authorized in the legislation or recommended in the management plan. Additionally, the Wild and Scenic designation does not automatically establish the area comprising the PWSR and surrounding area as a federal park or locally undesired federal land ownership and the National Park Service does not procure or plan to acquire the land in the river corridor or watershed. T

Due to the restricted role of the federal government, there is an increased focus on a more local management strategy founded on the actions of local governments in partnership with the county and state governments. The local-based strategy endeavors to minimize the concerns of local citizens regarding potential government regulation and loss of private lands, and also encourages local citizens to have a more active and participatory role in the PWSR management process. PWSR management strategies are designed and implemented through the local study committee and responsibilities related to managing and protecting the river and associated resources are shared amongst all the stakeholders - local, state, federal, and non-governmental (Molfetta 2016).



## Chapter 3 River Reconnaissance

### Nationwide River Inventory

Public Law 90-542 established the Wild and Scenic Rivers Act of 1968 which designated specific rivers for inclusion in the Wild and Scenic Rivers system. After the Wild and Scenic Rivers Act was established, the Department of the Interior Associate Solicitor for Parks and Recreation informed the Acting Director of the Bureau of Outdoor Recreation (BOR) that Section 5(d) of the Wild and Scenic Rivers Act authorized the Secretary of the Interior to conduct studies and investigate potential additional wild, scenic, and recreational river areas. In 1969, a memo was sent to all Regional Directors proposing 44 rivers for inclusion on a national list and in 1970 the assistant Director for State Grants and Resource Studies developed a further memo providing the necessary procedures for adding and deleting rivers on the Section 5(d) list, and an outline for compiling a Summary Report to determine a river's eligibility for inclusion on the list. The outline described the required information to be included in the Summary reports such as detailed river length, significant Outstanding Remarkable Values (ORVs), and surrounding land ownership.

The inventory process was initiated in the mid-1970's and proposed a national inventory of potential wild and scenic rivers. The NRI was first conducted in eastern states, with the National Park Service publishing and distributing an initial draft of the eastern states' segments in 1980, and evaluating the western states in the following years. The final version of the NRI with eastern and western segments was mapped in 1982.

Today, the NRI is a listing of more than 3,200 free-flowing river segments across the U.S. having one or more ORVs significant to the region or the United States at large (Figure 4). The NRI is also a source of information for statewide river assessments and federal agencies involved with stream-related projects, any group concerned with ecosystem management, as the inventory can provide the location of the nearest naturally-functioning system which might serve as a reference for monitoring activities, and for the recreationalist as it provides a listing of free-flowing, relatively undisturbed river segments. The NRI also serves as a listing of plant and animal species for restoration efforts on similar sections of river.

### Nationwide Rivers Inventory

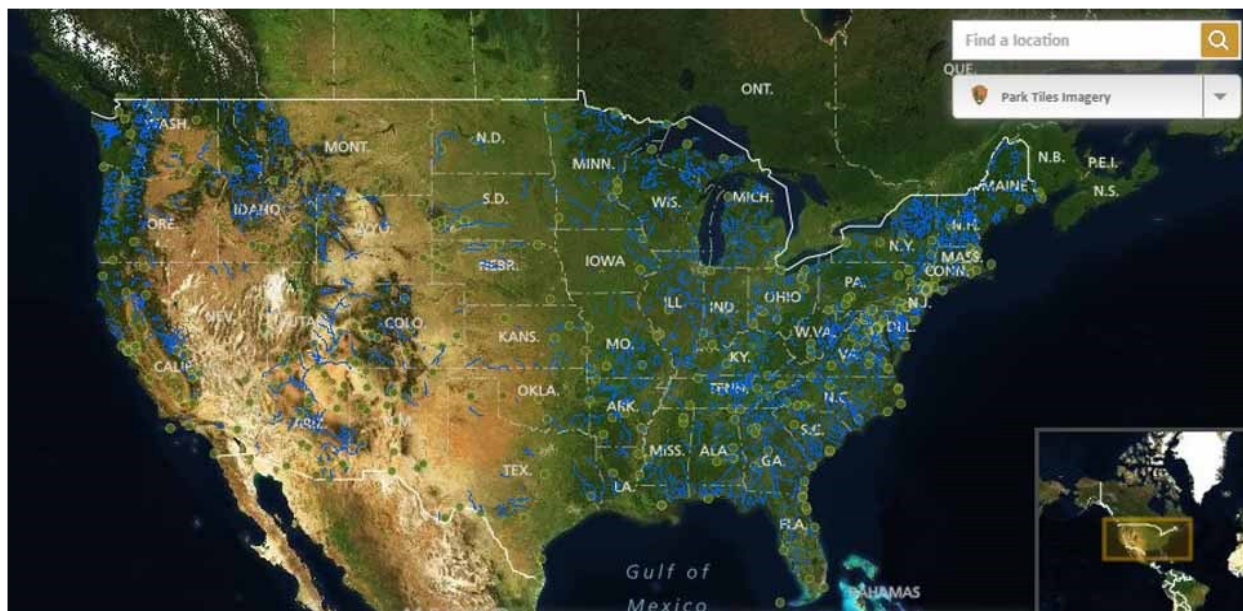


Figure 4. Nationwide Rivers Inventory in the U.S.

## First State Rivers

The University of Delaware examined 41 rivers on the NRI (Figure 5) plus the Christina River and Red Clay Creek or 43 streams that cover 393 river miles (5% of the state's rivers), 1,650 square miles of watershed and a population of 755,000 home to  $\frac{3}{4}$  of the state's residents (Table 1). The rivers in Delaware can be grouped into 3 watershed systems by geography, hydrology, and geologic province: (1) Brandywine-Christina or Piedmont, (2) Delaware Bayshore, and (3) Upper Nanticoke (Figures 6 and 7).

### Brandywine-Christina (Piedmont)

Brandywine Creek  
Red Clay Creek  
Christina River  
White Clay Creek (Existing W&S)

### Delaware Bayshore

Blackbird Creek  
Delaware Bay  
Smyrna River  
Leipsic River  
Mispillion River  
Cedar Creek  
Broadkill River  
Little Creek  
St. Jones River  
Murderkill River

### Upper Nanticoke System

Gum Branch  
Gravelley Branch  
Deep Creek  
Broad Creek  
Nanticoke River

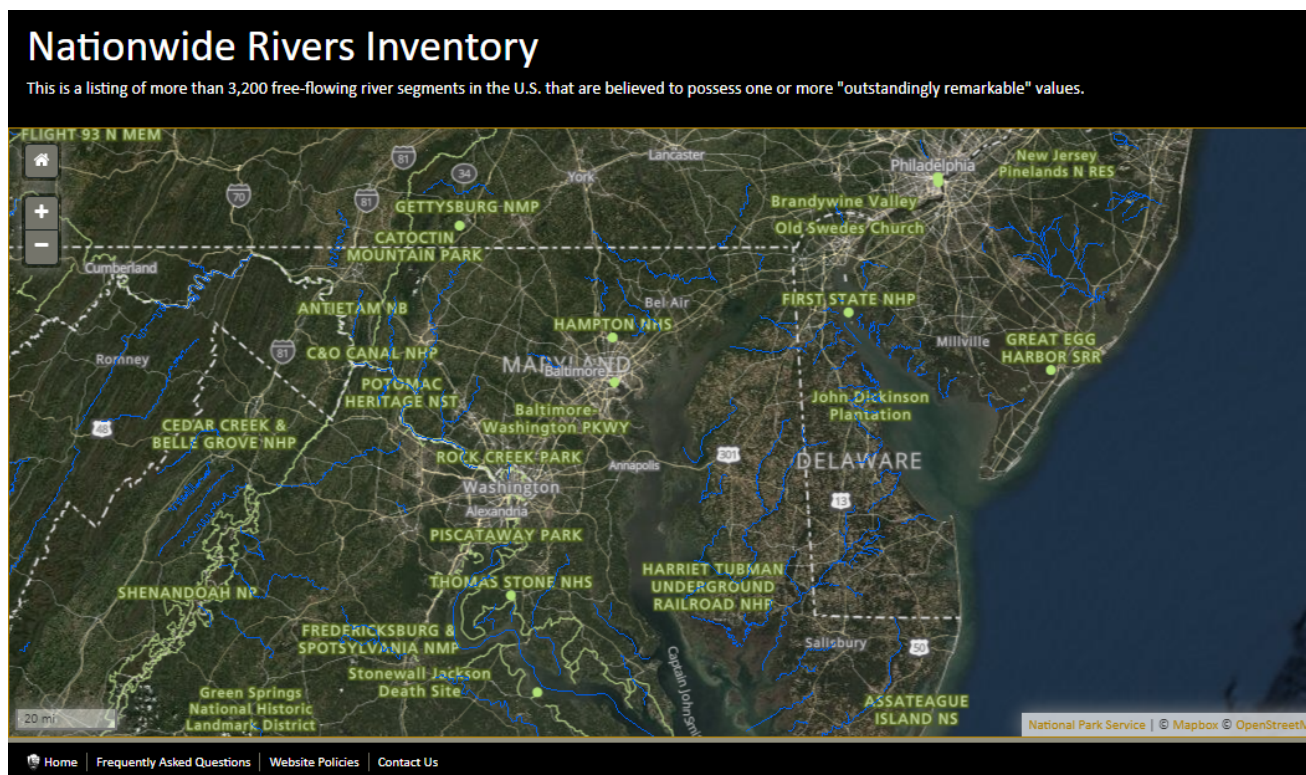


Figure 5. Nationwide Rivers Inventory in and around Delaware



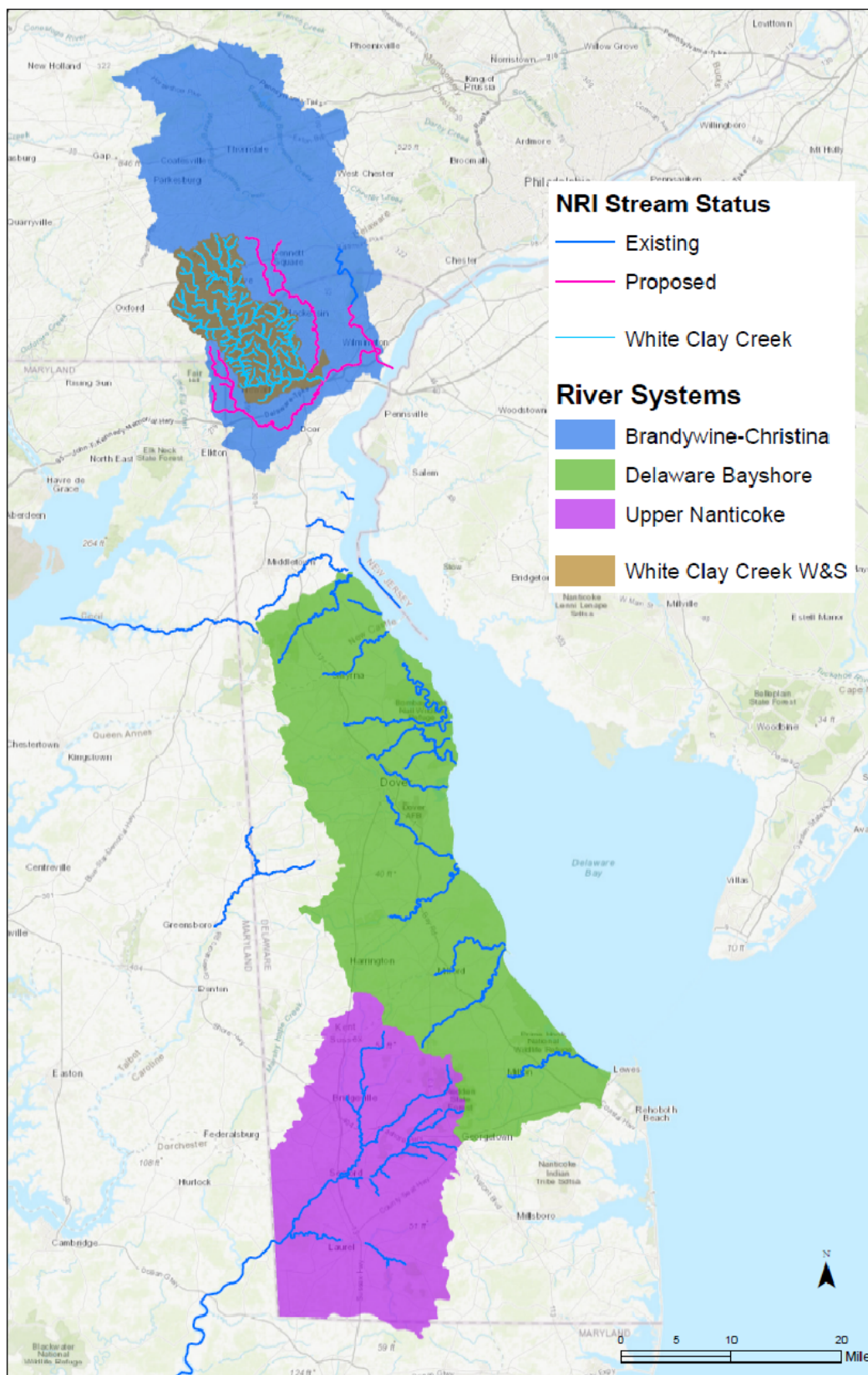


Figure 6. Nationwide Rivers Inventory stream systems in Delaware

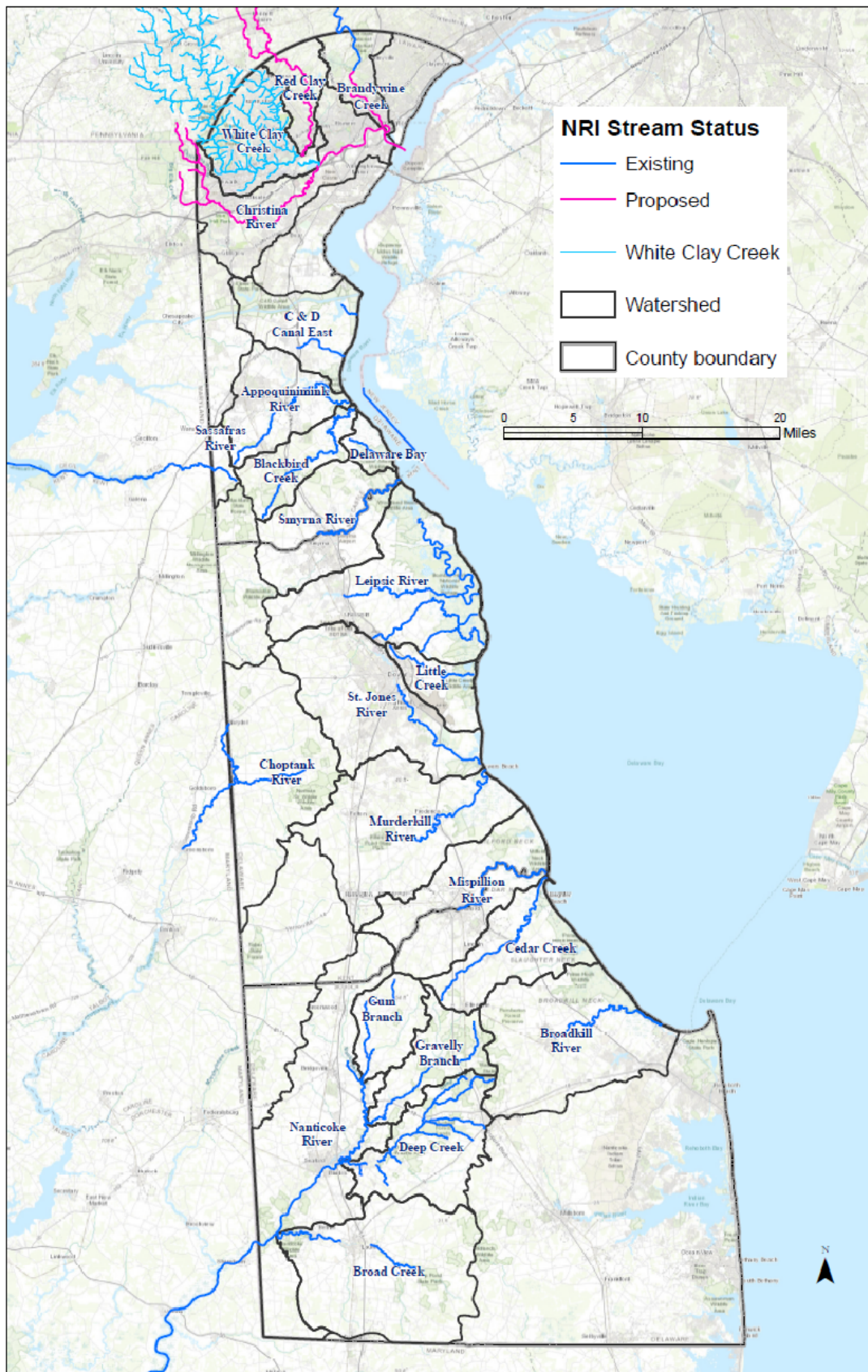


Figure 7. Nationwide Rivers Inventory segments in Delaware



Table 1. Nationwide Rivers Inventory segments in Delaware

The Nationwide Rivers Inventory 41 Segments for the State of Delaware								
Reference Source: <a href="http://www.nps.gov/nrcr/programs/rtea/nri/">http://www.nps.gov/nrcr/programs/rtea/nri/</a> Note: Outstanding Resource Values (ORVs) Definitions at List Bottom								
For More Information Contact: Jamie Fosburgh, National Park Service, Rivers, Trails & Conservation Assistance, (617) 223-5191								
River	County	Reach	Length (miles)	Year Listed/Updated	Potential Classification	Description	ORVs	Other States
Brandywine Creek	New Castle	Rockland to Chadds Ford Junction.	6	1982		See Brandywine Creek Comments	R,H,C	PA
<b>Brandywine Creek Comments:</b> <b>Historic</b> -(Segment includes a National Historic Register District in Rockland.) <b>Recreation</b> -(Unique proximity to urban populations in Wilmington, Newark, and Philadelphia.) <b>Cultural</b> -(Creek and area renowned as the stream valley home of artists in the Wyeth family.)								
Choptank River	Caroline	Greensboro to headwaters of Tidy Island Creek at Marydel	16	1982		See Choptank River comments.	H,O	MD
<b>Choptank River Comments:</b> <b>Botanic</b> -(76% of the segment is an extensive undeveloped freshwater river swamp in a predominantly agricultural region.) <b>Archeological</b> -(Within corridor is the site of a buried forest estimated at 9,000 to 10,000 years of age which is believed to be the earliest appearance of Pleistocene oak forest in this region.) <b>Historic</b> -(Willow Grove, in the vicinity of Greensboro is on the National Register of Historic Places.)								
Cow Marsh Creek	Kent	Confluence with Choptank River to northeast of Petersburg	4	1982		See Cow Marsh Creek comments.	H,O	MD
<b>Cow Marsh Creek Comments:</b> <b>Botanic</b> -(76% of the segment is an extensive undeveloped freshwater river swamp in a predominantly agricultural region.) <b>Archeologic</b> -(Within corridor is the site of a buried forest estimated at 9,000 to 10,000 years of age which is believed to be the earliest appearance of Pleistocene oak forest in this region.) <b>Historic</b> -(Willow Grove, in the vicinity of Greensboro is on the National Register of Historic Places.)								
River	County	Reach	Length (miles)	Year Listed/Updated	Potential Classification	Description	ORVs	Other States
Delaware River	New Castle, Salem	Delaware Bay to Salem Nuclear Power Plant.	4	1982		See Delaware River comments.	S,R,G,F,W,H,C,O	NJ
Appoquinimink River	New Castle	Mouth to headwaters.	15	1982		See Delaware River comments.	S,R,G,F,W,H,C,O	
Augustine Creek	New Castle	Confluence with the Delaware River to headwaters.	4	1982		See Delaware River comments.	S,R,G,F,W,H,C,O	
Blackbird Creek	New Castle	Mouth to headwaters.	15	1982		See Delaware River comments.	S,R,G,F,W,H,C,O	
Broadkill River	Sussex	Mouth of Milton.	10	1982		See Delaware River comments.	S,R,G,F,W,H,C,O	
Cedar Creek	Sussex	Mouth to headwaters.	7	1982		See Delaware River comments.	S,R,G,F,W,H,C,O	
Cedar Swamp	New Castle	Confluence with the Delaware River to Headwaters.	5	1982		See Delaware River comments.	S,R,G,F,W,H,C,O	
Little River	Kent	Confluence with the Delaware Bay to Dover.	5	1982		See Delaware River comments.	S,R,G,F,W,H,C,O	
Mispillion River	Sussex	Mouth to Silver Lake in Milford.	9	1982		See Delaware River comments.	S,R,G,F,W,H,C,O	

Murderkill River	Kent	Delaware Bay to Coursey Pond.	21	1982		See Delaware River comments.	S,R,G,F, W,H,C,O	
Smyrna River	New Castle, Kent	Mouth to Duck Creek Pond	11	1982		See Delaware River comments.	S,R,G,F, W,H,C,O	
St. Georges Creek	New Castle	Confluence with the Delaware River to Thousand Acre Marsh.	3	1982		See Delaware River comments.	S,R,G,F, W,H,C,O	
St. Jones River	Kent	Delaware Bay to Route 13 Bridge in Dover.	13	1982		See Delaware River comments.	S,R,G,F, W,H,C,O	

**Delaware River Comments:** **General**-(The Delaware River-Bay System represents an example of undeveloped rivers in an estuarine area. The area in total is composed of several distinct sub-areas which in combination form a highly exemplary, productive and important river mouth estuarine system. The area is the least developed of 16 similar identified areas in the northwest.) **Geologic**-(The main segment of the Delaware River is an outstanding example of a high order drowned river mouth.) **Cultural**-(Rivers and river segments include remnants of the once productive Middle Atlantic fishing industry.) **Historic**-(Segments include numerous National Historic Register Sites.) **Wild**-(System includes almost totally undeveloped river segments, dominated by tidal marsh, in a largely agricultural area.) **Recreation**-(System is accessible to high concentrations of urban populations in Wilmington, Del., Philadelphia, Pa., and Camden, N.J.) **Hydrologic**-(The Delaware River segment is a sparsely developed high order tidal river area.) **Wildlife**-(Areas within and adjacent to river corridors are important nesting, feeding, migrating and wintering sites for waterfowl along the Atlantic flyway.)

River	County	Reach	Length (miles)	Year Listed/Updated	Potential Classification	Description	ORVs	Other States
Leipsic River	Kent	Delaware Bay to DuPont Blvd.	19	1982		See Leipsic River comments.	W,H,O	
Herr Branch	Kent	Confluence with the Simons River to headwaters above Rte. 9.	3	1982		See Leipsic River comments.	W,H,O	
Duck Creek	Kent	Leipsic River to the Woodland Beach Area.	12	1982		See Leipsic River comments.	W,H,O	

Mahon River	Kent	Confluence with the Delaware Bay to the confluence with the Herr Branch.	3	1982		See Leipsic River comments.	W,H,O	
Muddy Branch	Kent	Confluence with the Leipsic River to headwaters above DE Rte. 9.	4	1982		See Leipsic River comments.	W,H,O	
Simons River and Green Creek	Kent	Delaware Bay to Boat Gut Bay.	5	1982		See Leipsic River comments.	W,H,O	

**Leipsic River Comments:** **Historic**-(3 National Historic Register sites in Leipsic.) **Wild**-(Almost totally undeveloped section of tidal marsh in a predominantly agricultural area. National Wildlife Refuge proposed Wilderness area.) **Botanic**-(63% of the segment flows through ecologically significant tidal wetlands which are significant contributors to the Delaware Bay estuarine system and possess excellent examples of a northern cordgrass prairie.) **Wildlife**-(A nationally recognized sanctuary for migratory waterfowl, birds of prey, and passerine species.)

River	County	Reach	Length (miles)	Year Listed/Updated	Potential Classification	Description	ORVs	Other States
Nanticoke River	Dorchester, Sussex	Tangier Sound to Seaford.	35	1982		See Nanticoke River comments.	H,O	MD
Nanticoke River	Sussex	Route 13 to Bridgeville.	10	1982		See Nanticoke River comments.	H,O	
Baker Mill Branch	Sussex	Concord Pond to Black Savannah Ditch.	2	1982		See Nanticoke River comments.	H,O	
Broad Creek	Sussex	Confluence with the Nanticoke River to near Laurel.	6	1982		See Nanticoke River comments.	H,O	
Deep Creek	Sussex	Confluence with Nanticoke near Route 13 to headwaters.	12	1982		See Nanticoke River comments.	H,O	
Gravelly Branch	Sussex	Confluence with Nanticoke to headwaters in Redden State Forest.	12	1982		See Nanticoke River comments.	H,O	

Gum Branch	Sussex	Confluence with Nanticoke to Rye Hole.	3	1982		See Nanticoke River comments.	H,O	
James Branch	Sussex	Records Pond to Trussum Pond to Trap Pond.	3	1982		See Nanticoke River comments.	W,H,O	
Layton-Vaughn Ditch	Sussex	Confluence with New Ditch to Route 28.	5	1982		See Nanticoke River comments.	H,O	
Marshy Hope Creek	Sussex	Confluence with the Nanticoke River to South of Federalsburg.	15	1982		See Nanticoke River comments.	H,O	
Mifflin Ditch	Sussex	Confluence with Deep Creek to headwaters in Redden State Forest.	5	1982		See Nanticoke River comments.	H,O	
New Ditch	Sussex	Confluence with Deep Creek to Route 28.	4	1982		See Nanticoke River comments.	H,O	
Rum Bridge Branch	Sussex	Confluence with Deep Creek to headwaters.	3	1982		See Nanticoke River comments.	H,O	
Toms Dam Branch	Sussex	Confluence with Gum Branch to headwaters.	7	1982		See Nanticoke River comments.	H,O	
Tubbs Branch	Sussex	Confluence with Deep Creek to headwaters.	4	1982		See Nanticoke River comments.	H,O	
Tyndall Branch	Sussex	Confluence/Deep Creek to Fleetwood Pond.	2	1982		See Nanticoke River comments.	H,O	

**Nanticoke River Comments:** **Archeological**-(Rare site which contains features of primarily Late Woodland Period occupation A.D. 900 to 1600)) **Botanic**-(Rare and endangered Box Huckleberry Shrub, which is possibly the oldest living plant present.) **Botanic**-(Segment includes one of the few remaining remnants of Cypress Gum forests in this region.) **Historic**-(Segment includes a river-related National Historic Register district at Bethel, a ship building and trading community. Also the site of the invention of the traditional Chesapeake Bay sailing vessel.)

River	County	Reach	Length (miles)	Year Listed/Updated	Potential Classification	Description	ORVs	Other States
White Clay Creek	New Castle, Chester	Northern boundary of the City of Newark to the confluence with Egypt Run.	10	1982		See White Clay Creek comments.	R,O	PA
White Clay Creek, Middle Branch	Chester	Confluence with the West Branch to Rt. 841 Cridge.	3	1982		See White Clay Creek comments.	R,O	
White Clay Creek, West Branch	Chester	Confluence with the main branch to the headwaters.	10	1982		See White Clay Creek comments.	R,O	

**White Clay Creek Comments:** **Botanic**-(Area includes the rare and endangered purple fringeless orchid. Segment is also recognized for the diversity of habitats and biota within such a small area at the edge of suburban and urban development.) **Recreation**-(Proximity to urban populations in Wilmington, Newark and Philadelphia.)

### Outstanding Resource Values (ORV) Definitions:

**Scenery (S):** The landscape elements of landform, vegetation, water, color, and related factors result in notable or exemplary visual features and/or attractions. When analyzing scenic values, additional factors -- such as seasonal variations in vegetation, scale of cultural modifications, and the length of time negative intrusions are viewed -- may be considered. Scenery and visual attractions may be highly diverse over the majority of the river or river segment.

**Recreation (R):** Recreational opportunities are, or have the potential to be, popular enough to attract visitors from throughout or beyond the region of comparison or are unique or rare within the region. Visitors are willing to travel long distances to use the river resources for recreational purposes. River-related opportunities could include, but are not limited to, sightseeing, wildlife observation, camping, photography, hiking, fishing and boating.

- o Interpretive opportunities may be exceptional and attract, or have the potential to attract, visitors from outside the region of comparison.
- o The river may provide, or have the potential to provide, settings for national or regional usage or competitive events.

**Geology (G):** The river, or the area within the river corridor, contains one or more example of a geologic feature, process or phenomenon that is unique or rare within the region of comparison. The feature(s) may be in an unusually active stage of development, represent a "textbook" example, and/or represent a unique or rare combination of geologic features (erosional, volcanic, glacial, or other geologic structures).

<p><b>Fish (F):</b> Fish values may be judged on the relative merits of either fish populations, habitat, or a combination of these river-related conditions.</p> <ul style="list-style-type: none"> <li>○ <i>Populations:</i> The river is nationally or regionally an important producer of resident and/or anadromous fish species. Of particular significance is the presence of wild stocks and/or federal or state listed (or candidate) threatened, endangered or sensitive species. Diversity of species is an important consideration and could, in itself, lead to a determination of "outstandingly remarkable."</li> <li>○ <i>Habitat:</i> The river provides exceptionally high quality habitat for fish species indigenous to the region of comparison. Of particular significance is habitat for wild stocks and/or federal or state listed (or candidate) threatened, endangered or sensitive species. Diversity of habitats is an important consideration and could, in itself, lead to a determination of "outstandingly remarkable."</li> </ul>
<p><b>Wildlife (W):</b> Wildlife values may be judged on the relative merits of either terrestrial or aquatic wildlife populations or habitat or a combination of these conditions.</p> <ul style="list-style-type: none"> <li>○ <i>Populations:</i> The river, or area within the river corridor, contains nationally or regionally important populations of indigenous wildlife species. Of particular significance are species considered to be unique, and/or populations of federal or state listed (or candidate) threatened, endangered or sensitive species. Diversity of species is an important consideration and could, in itself, lead to a determination of "outstandingly remarkable."</li> <li>○ <i>Habitat:</i> The river, or area within the river corridor, provides exceptionally high quality habitat for wildlife of national or regional significance, and/or may provide unique habitat or a critical link in habitat conditions for federal or state listed (or candidate) threatened, endangered or sensitive species. Contiguous habitat conditions are such that the biological needs of the species are met. Diversity of habitats is an important consideration and could, in itself, lead to a determination of "outstandingly remarkable."</li> </ul>
<p><b>Prehistory (P):</b> The river, or area within the river corridor, contains a site(s) where there is evidence of occupation or use by Native Americans. Sites must have unique or rare characteristics or exceptional human interest value(s). Sites may have national or regional importance for interpreting prehistory; may be rare and represent an area where a culture or cultural period was first identified and described; may have been used concurrently by two or more cultural groups; and/or may have been used by cultural groups for rare sacred purposes. Many such sites are listed on the National Register of Historic Places, which is administered by the NPS.</p>
<p><b>History (H):</b> The river or area within the river corridor contains a site(s) or feature(s) associated with a significant event, an important person, or a cultural activity of the past that was rare or one-of-a-kind in the region. Many such sites are listed on the National Register of Historic Places. A historic site(s) and/or features(s) is 50 years old or older in most cases.</p>
<p><b>Cultural (C):</b> The river or area within the river corridor contains archaeological sites or areas significant to traditional cultures. Examples might be American Indian burial grounds, petroglyphs, the oldest known human use site in a region, or streams that support traditional agriculture, subsistence fishing, or religious ceremonies.</p>
<p><b>Other Values (O):</b> While no specific national evaluation guidelines have been developed for the "other similar values" category, assessments of additional river-related values consistent with the foregoing guidance may be developed -- including, but not limited to, hydrology, paleontology and botany resources.</p>

**Brandywine River:** Tributary of the Christina River in southeastern Pennsylvania and New Castle County in Delaware. The 6-mile reach of the Brandywine in Delaware stretches from Rockland to Chadds Ford and is characterized by its Historic, Recreational, and Cultural Outstandingly Remarkable Values (ORVs). It includes a National Historic Register District in Rockland, is close in proximity to Newark, Wilmington, and Philadelphia, and is the location of the stream valley home of the Wyeth family artists. The Brandywine River watershed drains an area of 23 square miles, has a population density of 2,057 people per square mile, and is 37.6% wetlands and forest. Portions of the Brandywine River are included under the floodplain/drainage ordinances of the City of Wilmington, DE (see Table 9).

**Choptank River:** Tributary of the Chesapeake Bay in Kent County, Delaware and runs through Caroline County, Maryland. The 16-mile portion of the Choptank River in Delaware begins at Choptank Mills near Tidy Island Creek and is characterized by its Historic and Other Values ORVs given that 76% of the segment is an extensive, undeveloped freshwater river swamp. Estimated at 9,000-10,000 years of age, this is the site of a buried forest believed to be the earliest appearance of Pleistocene oak forest. The Choptank River watershed drains an area of 97.1 square miles, has a population density of 107 people per miles squared, and is 44.8% wetlands and forest.

**Cow Marsh Creek:** Tributary of the Choptank River and runs from its confluence with the Choptank River to northeast of Petersburg in Kent County, Delaware. The creek is four miles long and is characterized by its Historic and Other Values ORVs with 76% of the creek is undeveloped freshwater river swamp area. This site includes a buried forest estimated at 9,000-10,000 years of age which is believed to be the earliest appearance of Pleistocene oak forest. The Choptank River watershed drains an area of 97.1 square miles, has a population density of 107 people per square mile, and is 44.8% wetlands and forest.

**Delaware River:** Major river on the East Coast and runs through New York, New Jersey, Pennsylvania, and Delaware. The four mile section running through New Castle County, Delaware from the Delaware Bay to the Salem Nuclear Power Plant is characterized by numerous ORVs related to the Scenery, Recreation, Geology, Fish, History, and Culture of the river and surrounding area. The Delaware River-Bay system represents an example of

undeveloped rivers in an estuarine area and includes an example of a high order drowned river mouth. Additionally, the river includes numerous National Historic Register Sites in close proximity to Wilmington, Philadelphia, and Camden, and provides important nesting, migrating, and wintering sites for waterfowl along the Atlantic flyway.

**Appoquinimink River:** Runs to the Delaware Bay starting near Townsend in New Castle County, Delaware. The 15 miles of the Appoquinimink run from mouth to headwaters entirely in New Castle County, Delaware and are characterized by numerous ORVs related to the Scenery, Recreation, Geology, Fish, History, and Culture of the river and surrounding area. The Appoquinimink River watershed drains an area of 46.3 square miles, has a population density of 623 people per square mile, and is 23.9% wetlands and forest. Portions of the Appoquinimink River are included in the floodplain/drainage ordinances of Odessa, Delaware (see Table 9).

**Augustine Creek:** Runs through Middletown, Delaware where it joins with the Delaware River to the headwaters in New Castle County, Delaware. The Augustine Creek is four miles long and is characterized by numerous ORVs related to the Scenery, Recreation, Geology, Fish, History, and Culture of the river and surrounding area. The ORVs associated with the Augustine Creek are similar to those of the Delaware River due to its confluence with the Delaware River (See Delaware River ORV description). The river is located in the C & D Canal East watershed which drains an area of 44 square miles, has a population density of 368 people per square mile, and is 36.6% wetlands and forest.

**Blackbird Creek:** Runs through New Castle County, Delaware with its headwaters at the Delaware River. The 15 miles of Blackbird Creek run from mouth to headwaters entirely in New Castle County, Delaware and are characterized by numerous ORVs related to the Scenery, Recreation, Geology, Fish, History, and Culture of the creek and surrounding area. The Blackbird Creek watershed drains an area of 31 square miles, has a population density of 195 people per square mile, and is 52.6% wetlands and forest.

**Broadkill River:** Runs from its headwaters in Wagamons Pond in Milton, Delaware with its headwaters in the Delaware Bay. The 10 miles of Broadkill River run from mouth to headwaters entirely in Sussex County, Delaware and are characterized by numerous ORVs related to the Scenery, Recreation, Geology, Fish, History, and Culture of the creek and surrounding area. The ORVs associated with the Broadkill River are similar to those of the Delaware River due to their proximity (See Delaware River ORV description). The Broadkill River watershed drains an area of 107.1 square miles, has a population density of 267 people per square mile, and is 44.1% wetlands and forest.

**Cedar Creek:** Cedar Creek runs through Sussex County, Delaware where it joins with Slaughter Neck Ditch. The seven miles of Cedar Creek are characterized by numerous ORVs related to the Scenery, Recreation, Geology, Fish, History, and Culture of the creek and surrounding area. The Cedar Creek watershed drains an area of 52 square miles, has a population density of 147 people per square mile, and is 38% wetlands and forest.

**Cedar Swamp:** Cedar Swamp runs through New Castle County, Delaware where it joins with the Delaware River. The five miles of Cedar Swamp are characterized by numerous ORVs related to the Scenery, Recreation, Geology, Fish, History, and Culture of the creek and surrounding area. The ORVs associated with Cedar Swamp are similar to those of the Delaware River due to their confluence (see Delaware River ORV description). The swamp is located in the Delaware Bay watershed which drains an area of 9.6 square miles, has a population density of 39 people per square mile, and is 67.4% wetlands and forest.

**Little River:** The Little River runs through Dover in Kent County, Delaware where it joins with the Delaware River. The five miles of the Little River are characterized by numerous ORVs related to the Scenery, Recreation, Geology, Fish, History, and Culture of the river and surrounding area. The ORVs associated with Little River are similar to those of the Delaware River due to their proximity (see Delaware River ORV description). The river is located in the Little Creek watershed which drains an area of 23.2 square miles, has a population density of 381 people per square mile, and is 33.3% wetlands and forest. Portions of the Little River are included in the floodplain/drainage ordinances of Dover, DE (see Table 10).



**Mispillion River:** The Mispillion River runs through Sussex County from its mouth to its headwaters at Silver Lake in Milford, Delaware. The nine miles of the Mispillion River in Sussex County, Delaware are characterized by numerous ORVs related to the Scenery, Recreation, Geology, Fish, History, and Culture of the river and surrounding area. The ORVs associated with the Mispillion River are similar to those of the Delaware River due to their proximity (see Delaware River ORV description). The Mispillion River watershed drains an area of 76.4 square miles, has a population density of 264 people per square mile, and is 39.5% wetlands and forest. Portions of the Fishing Branch of the Mispillion River are included in the floodplain/drainage ordinances of Milford, DE (see Table 10).

**Murderkill River:** The Murderkill River runs from its headwaters just west of Felton in Kent County, Delaware to the Delaware Bay. The 21 miles of the Murderkill River are characterized by numerous ORVs related to the Scenery, Recreation, Geology, Fish, History, and Culture of the river and surrounding area. The Murderkill River watershed drains an area of 106.7 square miles, has a population density of 261 people per square mile, and is 31.5% wetlands and forest. The Fan Branch of the Murderkill River is included in the floodplain/drainage ordinances in Felton, DE (see Table 10).

**Smyrna River:** The Smyrna River runs from its headwaters at Duck Creek Pond to the Delaware Bay covering area in both Kent and New Castle Counties of Delaware. The 11 miles of the Smyrna River are characterized by numerous ORVs related to the Scenery, Recreation, Geology, Fish, History, and Culture of the river and surrounding area. The Smyrna River watershed drains an area of 63.9 square miles, has a population density of 362 people per square mile, and is 31.5% wetlands and forest. Portions of the Smyrna River are included in the floodplain/drainage ordinances of Smyrna, DE (see Table 10).

**St. Georges Creek:** The St. Georges Creek runs from Thousand Acre Marsh to its confluence with the Delaware River in New Castle County, Delaware. The three miles of St. Georges Creek are characterized by numerous ORVs related to the Scenery, Recreation, Geology, Fish, History, and Culture of the creek and surrounding area. The creek is located in the C & D Canal East watershed which drains an area of 44 square miles, has a population density of 368 people per square mile, and is 36.6% wetlands and forest.

**St. Jones River:** The St. Jones River runs through Kent County, Delaware from the Route 13 bridge in Dover to the Delaware Bay. The 13 miles of the St. Jones River are characterized by numerous ORVs related to the Scenery, Recreation, Geology, Fish, History, and Culture of the river and surrounding area. The St. Jones River watershed drains an area of 90 square miles, has a population density of 837 people per square mile, and is 28% wetlands and forest. Some segments of the St. Jones River are included in the floodplain/drainage ordinances of Dover, DE (see Table 10).

**Leipsic River:** The Leipsic River runs from DuPont Boulevard to the Delaware Bay in Kent County, Delaware. The 19 miles of the Leipsic River are characterized by historic and other ORVs as it contains an almost completely undeveloped section of tidal marsh, a National Wildlife Refuge proposed Wilderness area, and has a nationally recognized sanctuary for migratory waterfowl, birds of prey, and passerine species. The Leipsic River watershed drains an area of 104.7 square miles, has a population density of 186 people per square mile, and is 48.2% wetlands and forest. Portions of the Alshon Branch of the Leipsic River are included in the floodplain/drainage ordinances of Cheswold, DE (see Table 10).

**Herr Branch:** Herr Branch runs from its headwaters above Route 9 to its confluence with the Simons River in Kent County, Delaware. The three miles of Herr Branch are characterized by Historic and Other ORVs similar to the Leipsic River due to their proximity (see Leipsic River ORV description). Herr Branch is located in the Leipsic River watershed which drains an area of 104.7 square miles, has a population density of 186 people per square mile, and is 48.2% wetlands and forest.

**Duck Creek:** Duck Creek runs from the Woodland Beach Area to the Leipsic River in Kent County, Delaware. The 12 miles of Duck Creek are characterized by Historic and Other ORVs, similar to the Leipsic River due to their



confluence (see Leipsic River ORV description). Duck Creek is located in the Leipsic River watershed which drains 104.7 square miles, has a population density of 186 people per square mile, and is 48.2% wetlands and forest.

**Mahon River:** The Mahon River runs from its confluence with the Delaware Bay to its confluence with Herr Branch in Kent County, Delaware. The three miles of the Mahon River are characterized by Historic and Other ORVs, similar to the Leipsic River due to their proximity. The Mahon River is in the Leipsic River watershed which drains an area of 104 square miles, has a population density of 186 people per square mile, and is 48.2% wetlands and forest.

**Muddy Branch:** Muddy Branch runs from its headwaters above Delaware Route 9 to its confluence with the Leipsic River in Kent County, Delaware. The four miles of Muddy Branch are characterized by Historic and Other ORVs, similar to the Leipsic River due to their confluence (see Leipsic River ORV description). Muddy Branch is located in the Leipsic River watershed which drains an area of 104.7 square miles, has a population density of 186 people per square mile, and is 48.2% wetlands and forest.

**Simons River and Green Creek:** The Simons River and Green Creek run from the Delaware Bay to Boat Gut Bay in Kent County, Delaware. The five miles of the Simons River and Green Creek are characterized by Historic and Other ORVs, similar to the Leipsic River due to their proximity (see Leipsic River ORV description). The Simons River and Green Creek are in the Leipsic River watershed which drains an area of 104.7 square miles, has a population density of 186 people per square mile, and is 48.2% wetlands and forest.

**Nanticoke River (Section A):** This section of the Nanticoke River (Section A) runs from the Tangier Sound to Seaford in Sussex County, Delaware and Dorchester County, Maryland. The 35 miles of the Nanticoke River (Section A) are characterized by Historic and Other ORVs as they contain a rare site featuring primarily Late Woodland Period occupation (900-1600 A.D.). The site also features the rare and endangered Box Huckleberry Shrub and one of the few existing remnants of Cypress Gum forests in this region. The Nanticoke River watershed, which drains an area of 144.2 square miles, has a population density of 230 people per square mile, and is 30.7% wetlands and forest. Portions of the Nanticoke River and its Cart Branch are included in the floodplain/drainage ordinances of Greenwood, DE (see Table 11).

**Nanticoke River (Section B):** This section of the Nanticoke River (Section B) runs from Route 113 to Bridgeville in Sussex County, Delaware. The ten miles of the Nanticoke River (Section B) are characterized by Historic and Other ORVs as they feature a rare site featuring primarily Late Woodland Period occupation (900-1600 A.D.). The site also features the rare and endangered Box Huckleberry Shrub and one of the few existing remnants of Cypress Gum forests in this region. The Nanticoke River watershed drains an area of 144.2 square miles, has a population density of 230 people per square mile, and is 30.7% wetlands and forest. Portions of this section of the Nanticoke River are included in the floodplain/drainage ordinances of Blades and Bridgeville, DE (see Table 11).

**Baker Mill Branch:** Baker Mill Branch runs from Concord Pond to Black Savannah Ditch in Sussex County, Delaware. The two miles of Baker Mill Branch are characterized by Historic and Other ORVs, similar to the Nanticoke River due to their proximity (see Nanticoke River ORV description). Baker Mill Branch is located in the Deep Creek watershed which drains an area of 63.4 square miles, has a population density of 176 people per square mile, and is 51.7% wetlands and forest.

**Broad Creek:** Broad Creek runs from its confluence with the Nanticoke River to near Laurel in Sussex County, Delaware. The six miles of Broad Creek are characterized by Historic and Other ORVs, similar to the Nanticoke River due to their proximity (see Nanticoke River ORV description). The Broad Creek watershed drains an area of 119.6 square miles, has a population density of 150 people per square mile, and is 40% wetlands and forest. Portions of the Broad Creek are included in the floodplain/drainage ordinances of Laurel, DE (see Table 11).

**Deep Creek:** Deep Creek runs from its confluence with the Nanticoke River near Route 13 to its headwaters in Sussex County, Delaware. The 12 miles of Deep Creek are characterized by Historic and Other ORVs, similar to the Nanticoke due to their confluence (see Nanticoke River ORV description). Deep Creek is located in the Deep Creek watershed which drains an area of 63.4 square miles, has a population density of 176 people per square mile, and is 51.7% wetlands and forest.

**Gravelly Branch:** Gravelly Branch runs from its headwaters in Redden State Forest to its confluence with the Nanticoke River in Sussex County, Delaware. The 12 miles of Gravelly Branch are characterized by Historic and Other ORVs, similar to the Nanticoke due to their confluence (see Nanticoke River ORV description). Gravelly Branch is located in the Gravelly Branch watershed which drains an area of 38.3 square miles, has a population density of 113 people per square mile, and is 63.7% wetlands and forest.

**Gum Branch:** Gum Branch runs from its confluence with Nanticoke to Rye Hole in Sussex County, Delaware. The three miles of Gum Branch are characterized by Historic and Other ORVs, similar to the Nanticoke due to their confluence. Gum Branch drains an area of 30.2 square miles, has a population density of 91 people per square mile, and is 47.1% wetlands and forest.

**James Branch:** James Branch runs from Records Pond to Trussum Pond to Trap Pond in Sussex County, Delaware. The three miles of James Branch are characterized by Historic and Other ORVs, similar to the Nanticoke River due to their proximity (see Nanticoke River ORV description). James Branch is located in the Broad Creek watershed which drains an area of 119.6 square miles, has a population density of 150 people per square mile, and is 40% wetlands and forest.

**Layton-Vaughn Ditch:** Runs from its confluence with New Ditch to Route 28 in Sussex County, Delaware. The five miles of Layton-Vaughn Ditch are characterized by Historic and Other ORVs, similar to the Nanticoke River due to their proximity (see Nanticoke River ORV description). Layton-Vaughn Ditch is located in the Deep Creek watershed which drains an area of 63.4 square miles, has a population density of 176 people per square mile, and is 51.7% wetlands and forest.

**Marshy Hope Creek:** Runs from its confluence with the Nanticoke River to south of Federalsburg in Sussex County, Delaware. The 15 miles of Marshy Hope Creek are characterized by Historic and Other ORVs, similar to the Nanticoke River due to their confluence (see Nanticoke River ORV description). Marshy Hope Creek is located in the Nanticoke River watershed which drains an area of 144.2 square miles, has a population density of 230 people per square mile, and is 30.7% wetlands and forest.

**Mifflin Ditch:** Mifflin Ditch runs from its headwaters in Redden State Forest to its confluence with Deep Creek in Sussex County, Delaware. The five miles of Mifflin Ditch are characterized by Historic and Other ORVs, similar to the Nanticoke River due to their proximity (see Nanticoke River ORV description). Mifflin Ditch is located in the Deep Creek watershed which drains an area of 63.4 square miles, has a population density of 176 people per square mile, and is 51.7% wetlands and forest.

**New Ditch:** New Ditch runs from its confluence with Deep Creek to Route 28 in Sussex County, Delaware. The four miles of New Ditch are characterized by Historic and Other ORVs, similar to the Nanticoke River due to their proximity (see Nanticoke River ORV description). New Ditch is located in the Deep Creek watershed which drains an area of 63.4 square miles, has a population density of 176 people per square mile, and is 51.7% wetlands and forest.

**Rum Bridge Branch:** Rum Bridge Branch runs from its headwaters to its confluence with Deep Creek in Sussex County, Delaware. The three miles of Rum Bridge Branch are characterized by Historic and Other ORVs, similar to the Nanticoke River due to their proximity (see Nanticoke River ORV description). Rum Bridge Branch is located in the Deep Creek watershed which drains an area of 63.4 square miles, has a population density of 176 people per square mile, and is 51.7% wetlands and forest.

**Toms Dam Branch:** Toms Dam Branch runs from its headwaters to its confluence with Gum Branch in Sussex County, Delaware. The seven miles of Toms Dam Branch are characterized by Historic and Other ORVs, similar to the Nanticoke River due to their proximity (see Nanticoke River ORV description). Toms Dam Branch is located in the Gum Branch watershed which drains an area of 30.2 square miles, has a population density of 91 people per square mile, and is 47.1% wetlands and forest.

**Tubbs Branch:** Runs from its headwaters to its confluence with Deep Creek in Sussex County, Delaware. The four miles of Tubbs Branch are characterized by Historic and Other ORVs, similar to the Nanticoke River due to their proximity (see Nanticoke River ORV description). Tubbs Branch is located in the Deep Creek watershed which drains an area of 63.4 square miles, has a population density of 176 people per square mile, and is 51.7% wetlands and forest.

**Tyndall Branch:** Tyndall Branch runs from Fleetwood Pond to its confluence with Deep Creek in Sussex County, Delaware. The two miles of Tyndall Branch are characterized by Historic and Other ORVs, similar to the Nanticoke River due to their proximity (see Nanticoke River ORV description). Tyndall Branch is located in the Deep Creek watershed which drains an area of 63.4 square miles, has a population density of 176 people per square mile, and is 51.7% wetlands and forest.

**White Clay Creek:** White Clay Creek runs from the northern boundary of the City of Newark to its confluence with Egypt Run in New Castle County, Delaware (Figure 8). The ten miles of White Clay Creek are characterized by Historic and Other ORVs, as the area is the habitat of the rare and endangered Purple Fringeless Orchid and is recognized for its diversity of habitats and biota at the edge of suburban and urban development. Additionally, White Clay Creek is recognized for its proximity to urban populations in Wilmington and Newark, Delaware and Philadelphia, Pennsylvania. White Clay Creek is located in the White Clay Creek watershed which drains an area of 46.2 square miles, has a population density of 2,040 people per square mile, and is 34.7% wetlands and forest. Portions of the White Clay Creek are included under the floodplain/drainage ordinances of the City of Newark, DE (see Table 9) .

**Red Clay Creek:** The Red Clay Creek runs from its headwaters to its confluence with the White Clay Creek in New Castle County, Delaware. The 13 miles of the Red Clay Creek have not yet been assessed to determine any associated ORVs. The Red Clay Creek drains an area of 21.1 square miles, has a population density of 1,187 people per square mile, and is 46.1% wetlands and forest.

**Christina River:** The Christina River runs from its headwaters to its confluence with the Delaware River at Wilmington in New Castle County, Delaware. The 35 miles of the Christina River have not yet been assessed to determine any associated ORVs. The Christina River watershed drains an area of 67.2 square miles, has a population density of 2,671, and is 26.9% wetlands and forest. Segments of the Christina River are included under the floodplain/drainage ordinances of Newport and the City of Wilmington, Delaware (see Table 9).

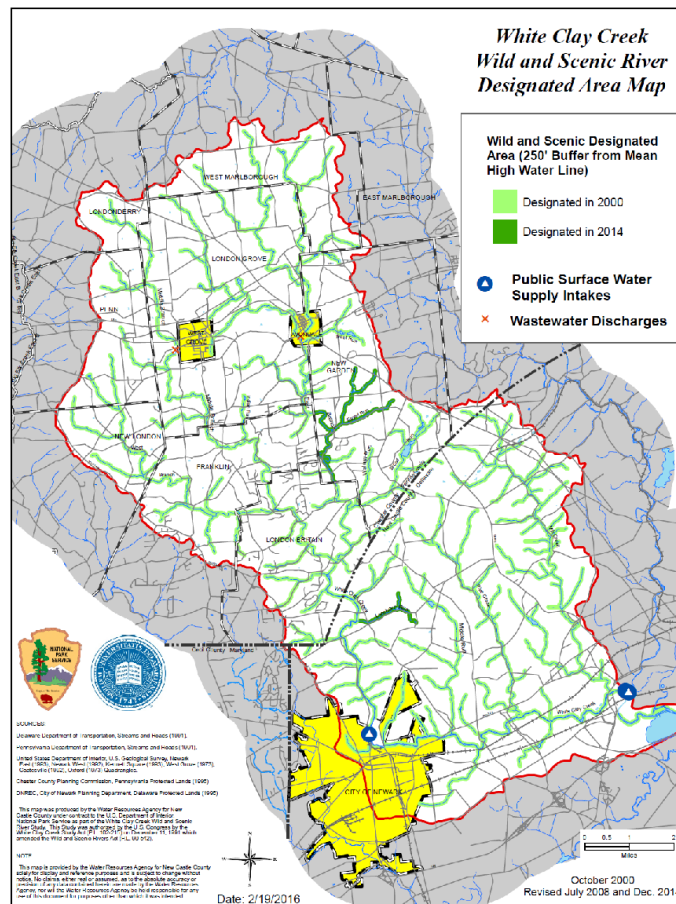


Figure 8. White Clay Creek National Wild & Scenic River watershed in Delaware and Pennsylvania

## Chapter 4 Analysis and Results

Proposing potential river segments for consideration by the National Park Service for Wild and Scenic designation involved evaluating data related to the demographics of the populations (Table 5 & Figures 15, 17 & 18), land-use (Figures 9-14 & 16, and Tables 4 & 6), and Outstandingly Remarkable Values (ORVs) (Tables 2 & 8). Watershed data was gathered utilizing Geographic Information System Mapping and used to develop maps, charts, and graphs relating the data of each river segment's surrounding watershed. The maps, charts, and figures were presented at subcommittee meetings with the National Park Service and other stakeholders in order to gain feedback regarding where more data or research was necessary in the process of developing recommendations.

Table 2. Outstandingly Remarkable Values of Nationwide Rivers Inventory segments in Delaware

River	Watershed	County	Length (Miles)	Year Listed/Updated	# of ORV Categories
Appoquinimink River	Appoquinimink River	New Castle	15	1982	8
Augustine Creek	C & D Canal East	New Castle	4	1982	8
Blackbird Creek	Blackbird Creek	New Castle	15	1982	8
Broadkill River	Broadkill River	Sussex	10	1982	8
Ceder Creek	Ceder Creek	Sussex	7	1982	8
Ceder Swamp	Delaware Bay	New Castle	5	1982	8
Little River	Little Creek	Kent	5	1982	8
Mispyllion River	Mispyllion River	Sussex	9	1982	8
Murderkill River	Murderkill River	Kent	21	1982	8
Smyrna River	Smyrna River	New Castle, Kent	11	1982	8
St. Georges Creek	C & D Canal East	New Castle	3	1982	8
St. Jones River	St. Jones River	Kent	13	1982	8
Brandywine Creek	Brandywine Creek	New Castle	6	1982	3
Leipsic River	Leipsic River	Kent	19	1982	3
Herr Branch	Leipsic River	Kent	3	1982	3

Table 3. Public Open Space in the Nationwide Rivers Inventory watersheds in Delaware

River	Watershed	County	Length (Miles)	Year Listed/Updated	% Public Open Space
Brandywine Creek	Brandywine Creek	New Castle	6	1982	67.42
Nanticoke River	Nanticoke River	Dorchester, Sussex	35	1982	52.39
Nanticoke River	Nanticoke River	Sussex	10	1982	52.39
Leipsic River	Leipsic River	Kent	19	1982	44.14
White Clay Creek	White Clay Creek	New Castle, Chester	10	1982	34.36
White Clay Creek, Middle Branch	White Clay Creek	Chester	3	1982	34.36
White Clay Creek, West Branch	White Clay Creek	Chester	10	1982	34.36
Blackbird Creek	Blackbird Creek	New Castle	15	1982	23.75
Gravelly Branch	Gravelly Branch	Sussex	12	1982	22.89
Red Clay Creek	Red Clay Creek	New Castle	13	2021	20.44
Marshy Hope Creek	Nanticoke River	Sussex	15	1982	17.85
Deep Creek	Deep Creek	Sussex	12	1982	17.35
Christina River	Christina River	New Castle	35	2021	16
Broadkill River	Broadkill River	Sussex	10	1982	15.49
Appoquinimink River	Appoquinimink River	New Castle	15	1982	15.23



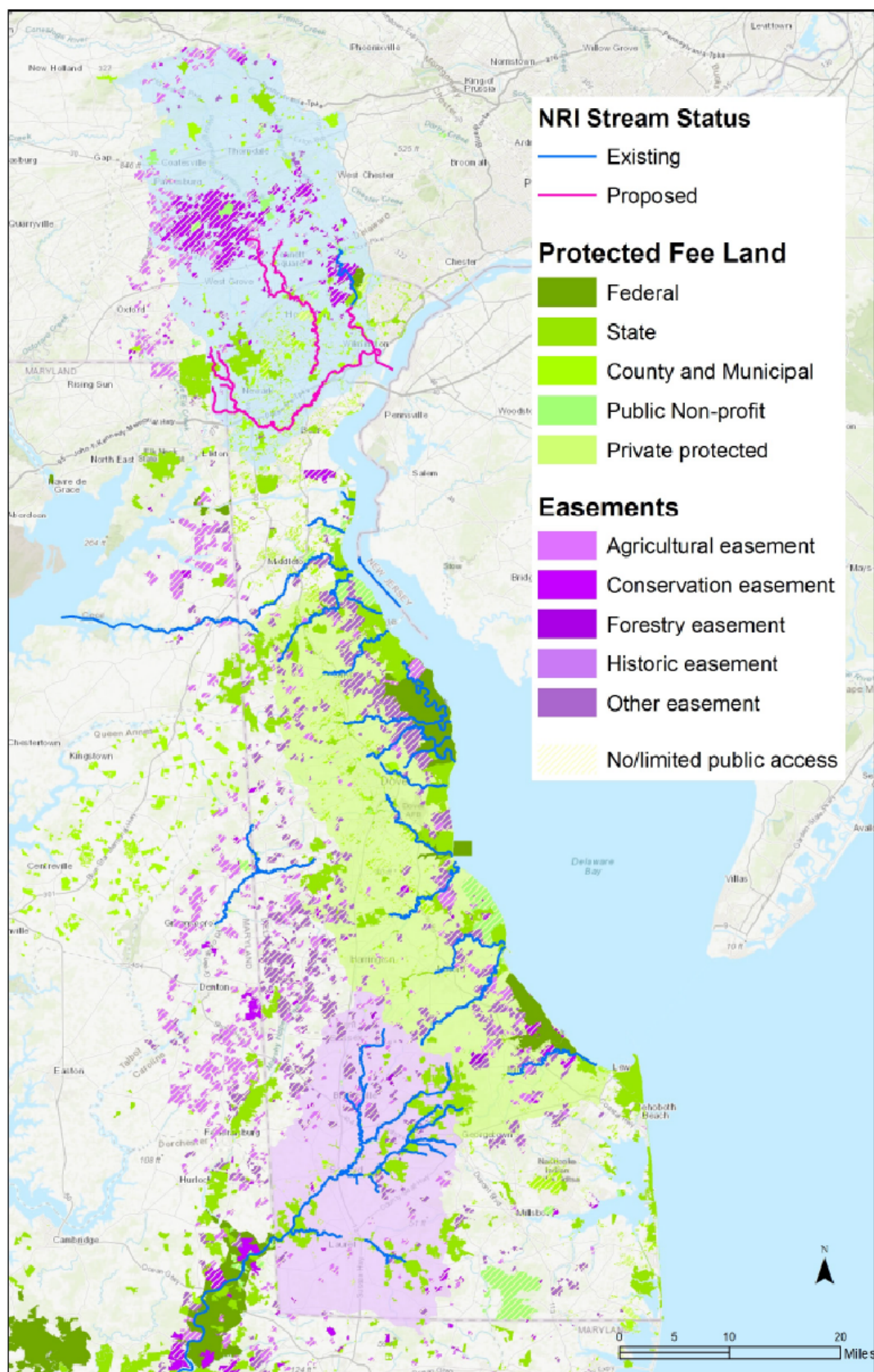


Figure 9. Protected land in the National Rivers Inventory watersheds in Delaware

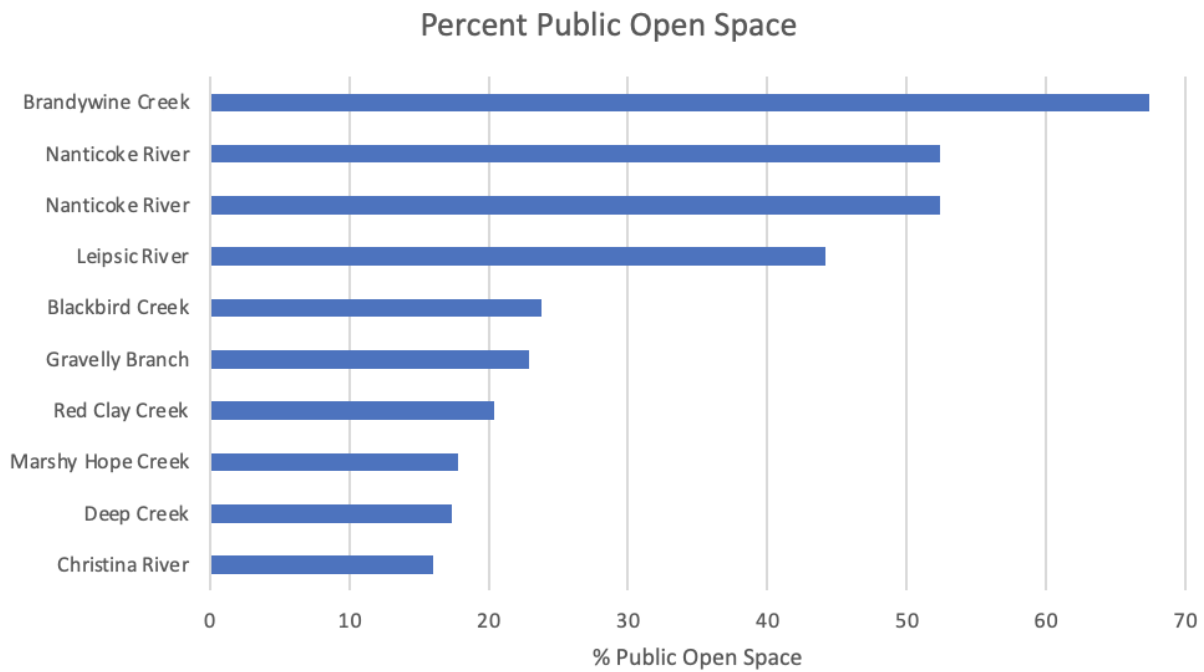


Figure 10. Public Open Space in the Nationwide Rivers Inventory watersheds in Delaware

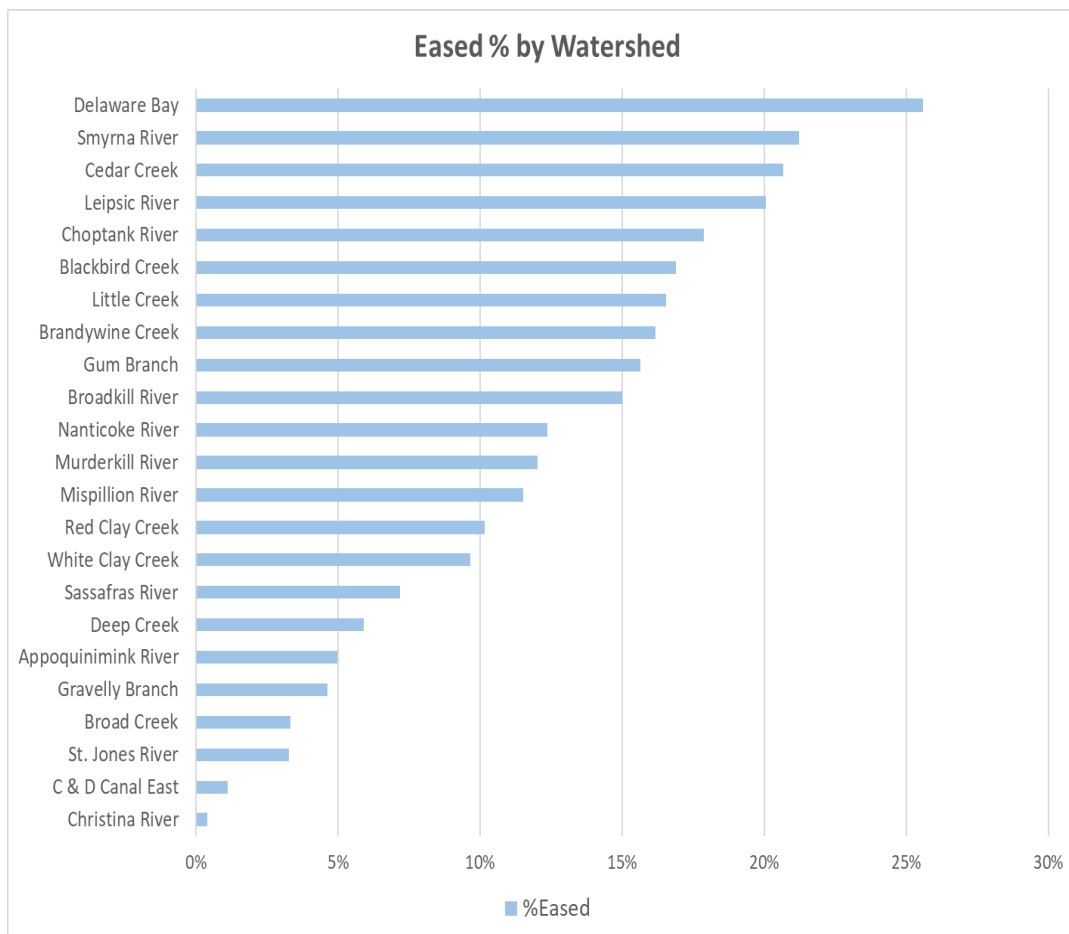


Figure 11. Protected land in the Nationwide River Inventory watersheds of Delaware

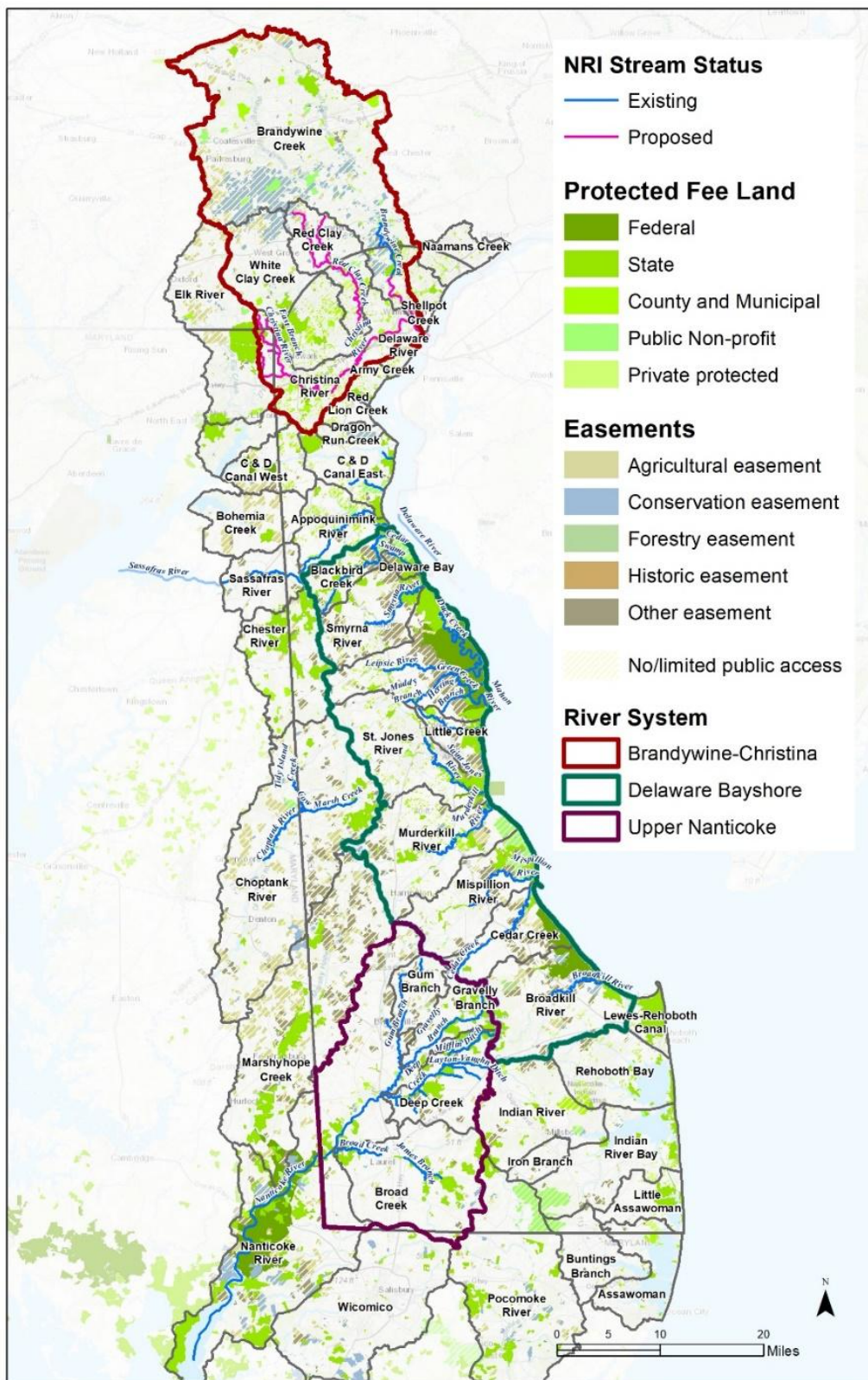


Figure 12. Protected land in the Nationwide River Inventory watersheds of Delaware



Table 4. Forest and wetlands of the Nationwide Rivers Inventory watersheds in Delaware

River	Watershed	County	Length (Miles)	Year Listed/Updated	% Forest & Wetlands
Ceder Swamp	Delaware Bay	New Castle	5	1982	67.4
Gravelly Branch	Gravelly Branch	Sussex	12	1982	63.7
Blackbird Creek	Blackbird Creek	New Castle	15	1982	52.6
Baker Mill Branch	Deep Creek	Sussex	2	1982	51.7
Deep Creek	Deep Creek	Sussex	12	1982	51.7
Layton-Vaughn Ditch	Deep Creek	Sussex	5	1982	51.7
Mifflin Ditch	Deep Creek	Sussex	5	1982	51.7
New Ditch	Deep Creek	Sussex	4	1982	51.7
Rum Bridge Branch	Deep Creek	Sussex	3	1982	51.7
Tubbs Branch	Deep Creek	Sussex	4	1982	51.7

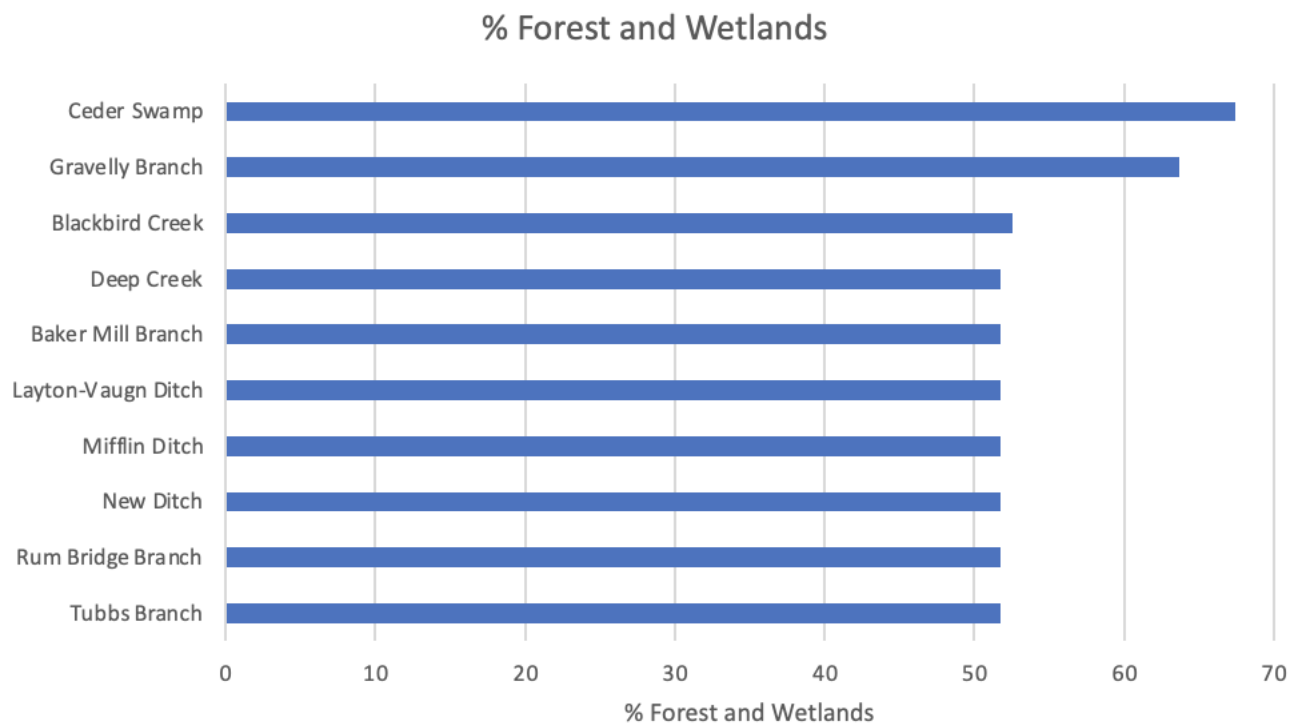


Figure 13. Forests and wetlands of the Nationwide River Inventory watersheds in Delaware

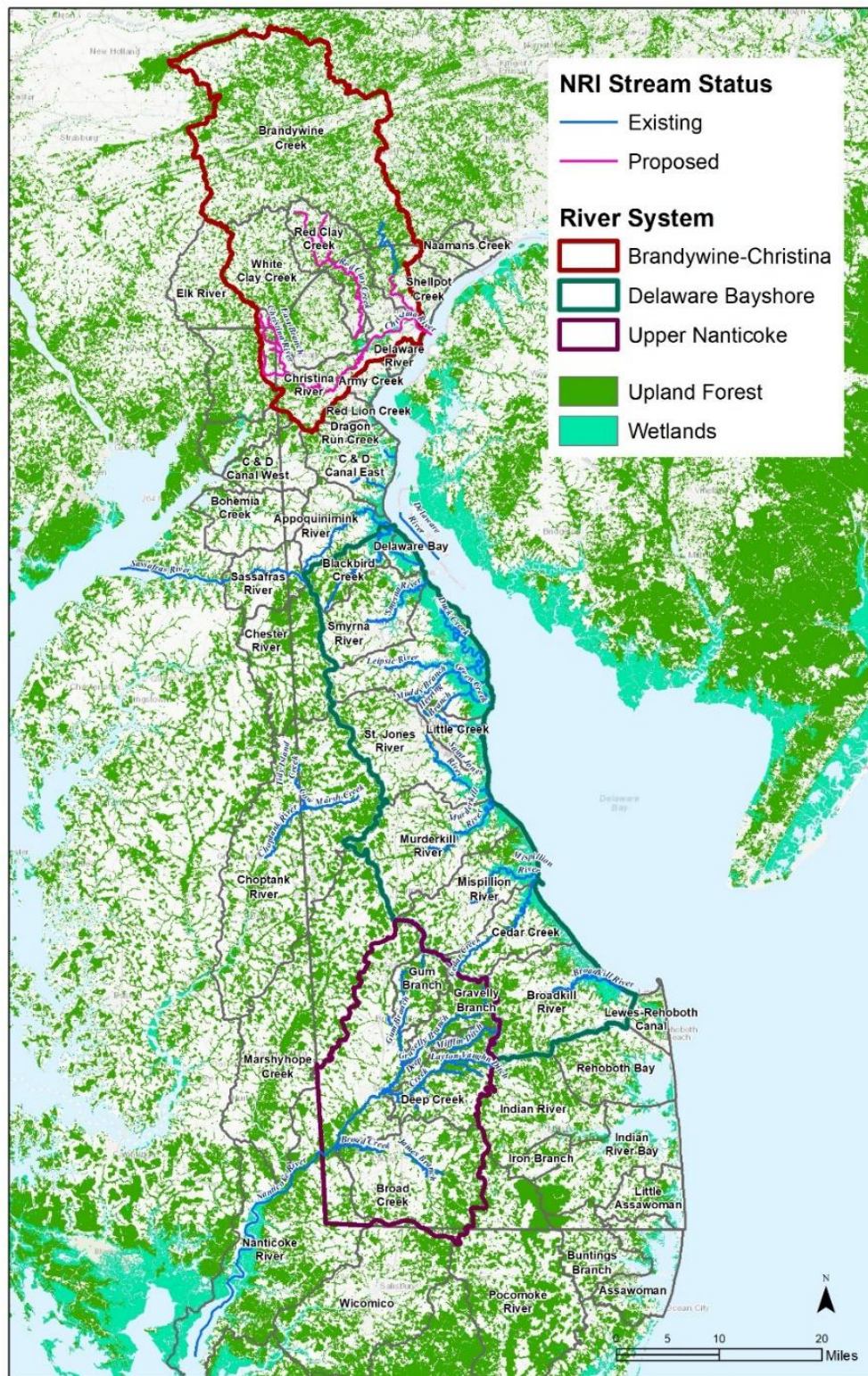


Figure 14. Forests and wetlands of the Nationwide River Inventory watersheds in Delaware

Table 5. Population Density of the Nationwide Rivers Inventory watersheds in Delaware

River	Watershed	County	Length (Miles)	Year Listed/Updated	Pop Density (p/sq mi)
Christina River	Christina River	New Castle	35	2021	2,671
Brandywine Creek	Brandywine Creek	New Castle	6	1982	2,057
White Clay Creek	White Clay Creek	New Castle, Chester	10	1982	2,040
White Clay Creek, Middle Branch	White Clay Creek	Chester	3	1982	2,040
White Clay Creek, West Branch	White Clay Creek	Chester	10	1982	2,040
Red Clay Creek	Red Clay Creek	New Castle	13	2021	1,187
St. Jones River	St. Jones River	Kent	13	1982	837
Appoquinimink River	Appoquinimink River	New Castle	15	1982	623
Little River	Little Creek	Kent	5	1982	381
Augustine Creek	C & D Canal East	New Castle	4	1982	368
St. Georges Creek	C & D Canal East	New Castle	3	1982	368
Smyrna River	Smyrna River	New Castle, Kent	11	1982	362
Broadkill River	Broadkill River	Sussex	10	1982	267
Misphillion River	Misphillion River	Sussex	9	1982	264
Murderkill River	Murderkill River	Kent	21	1982	261

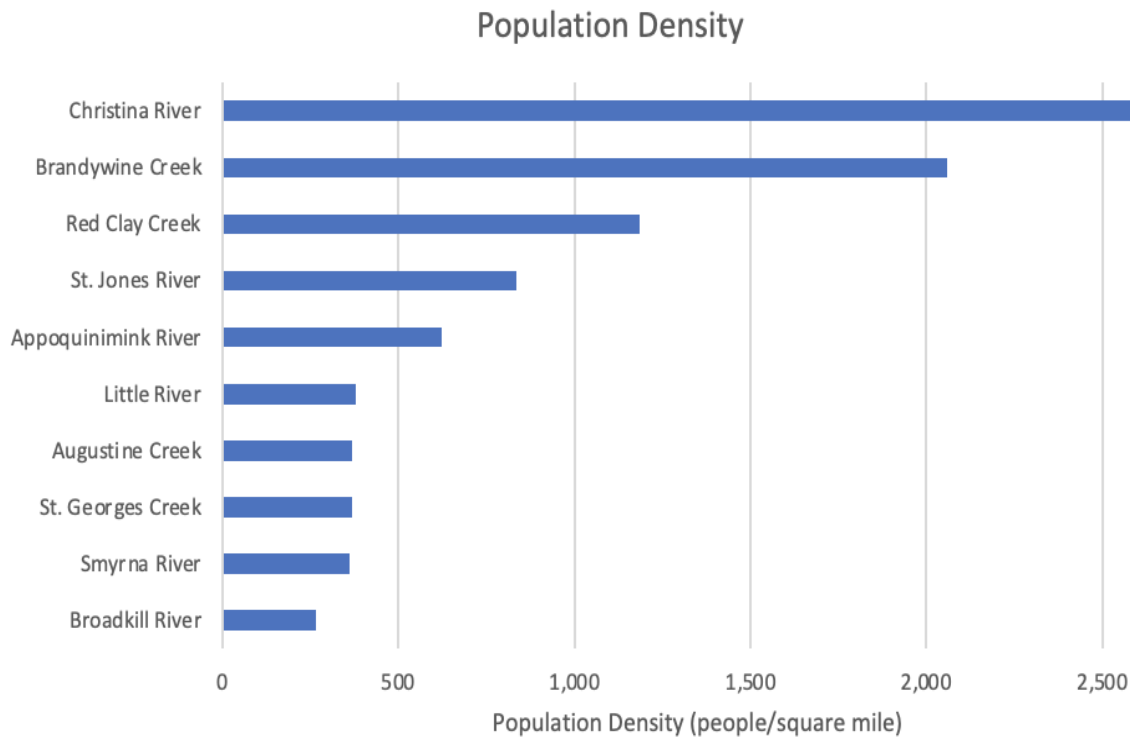


Figure 15. Population Density of the Nationwide Rivers Inventory watersheds in Delaware

Table 6. Urban/Suburban Land in Nationwide Rivers Inventory watersheds in Delaware

River	Watershed	County	Length (Miles)	Year Listed/Updated	% Urban/Suburban
Christina River	Christina River	New Castle	35	2021	67.0
White Clay Creek	White Clay Creek	New Castle, Chester	10	1982	57.6
White Clay Creek, Middle Branch	White Clay Creek	Chester	3	1982	57.6
White Clay Creek, West Branch	White Clay Creek	Chester	10	1982	57.6
Brandywine Creek	Brandywine Creek	New Castle	6	1982	46.5
Red Clay Creek	Red Clay Creek	New Castle	13	2021	39.8
St. Jones River	St. Jones River	Kent	13	1982	30.2
Appoquinimink River	Appoquinimink River	New Castle	15	1982	28.8
Little River	Little Creek	Kent	5	1982	23.5
Augustine Creek	C & D Canal East	New Castle	4	1982	20.2
St. Georges Creek	C & D Canal East	New Castle	3	1982	20.2
Smyrna River	Smyrna River	New Castle, Kent	11	1982	13.7
Broadkill River	Broadkill River	Sussex	10	1982	13.6
Mispillion River	Mispillion River	Sussex	9	1982	13.2
Murderkill River	Murderkill River	Kent	21	1982	12.1

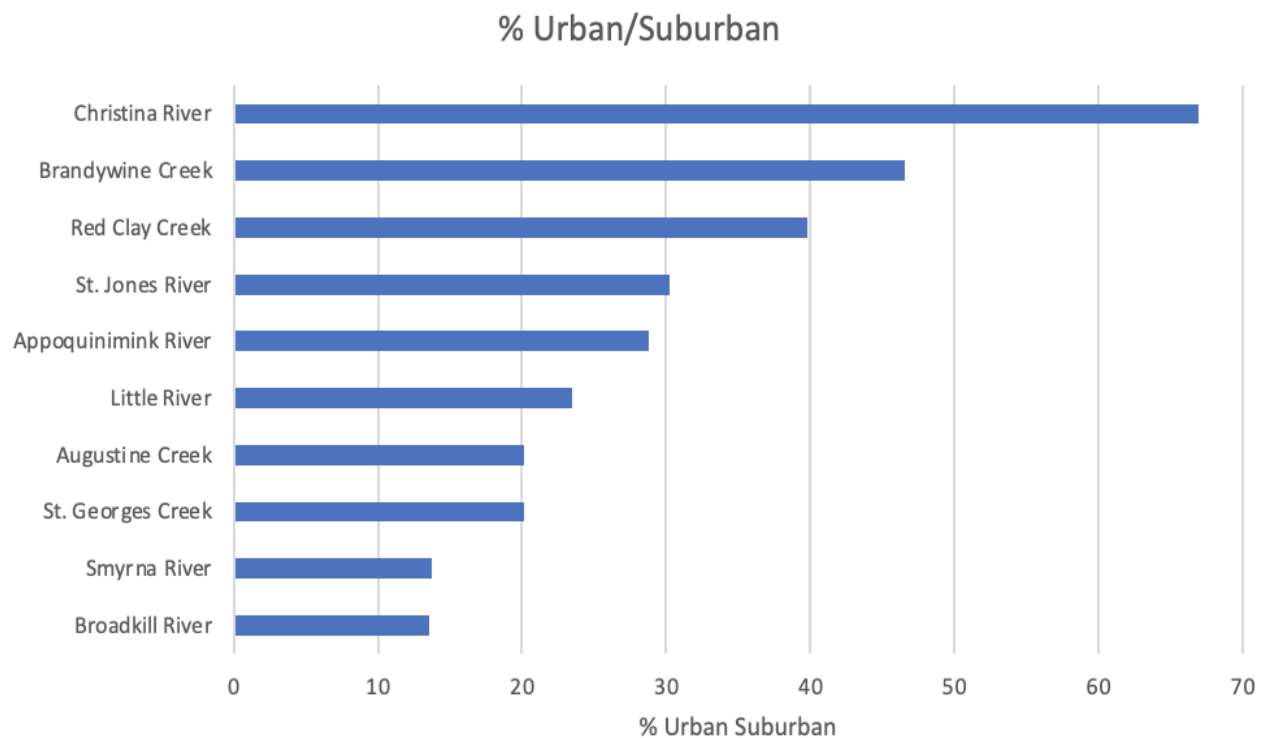


Figure 16. Urban/Suburban Land in Nationwide Rivers Inventory watersheds in Delaware





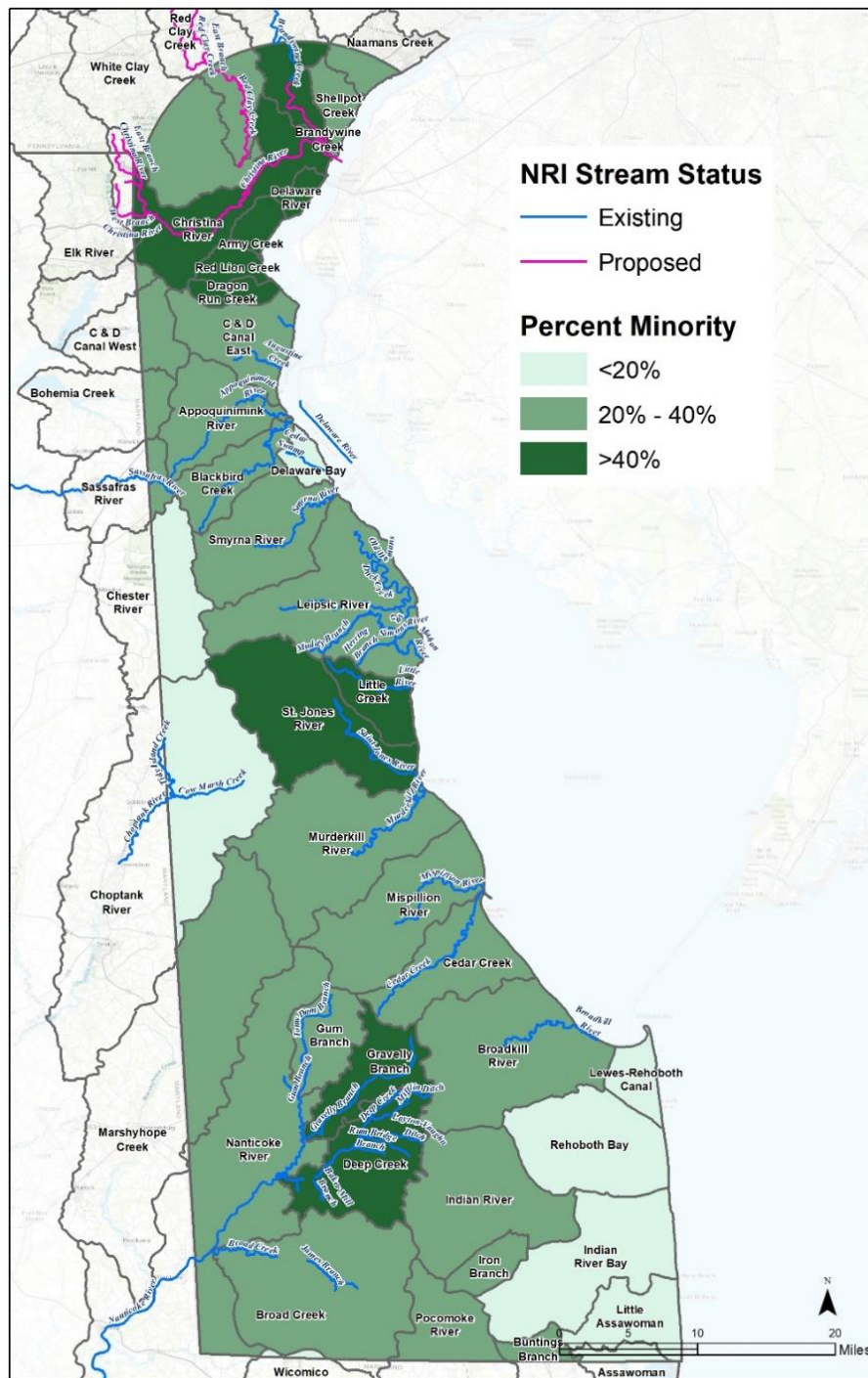


Figure 18. Minority populations in Nationwide River Inventory watersheds in Delaware

Table 7. National Rivers Inventory of Delaware

River	Watershed	County	Reach	Length (Miles)	Year Listed/Updated	ORVs	Other States	Watershed (sq)	Watershed (sq mi)	Comments
Brandywine Creek	Brandywine Creek	New Castle	Rockland to Chadds Ford Junction	6	1982	H, R, C	PA	14,699	23.0	National Historic Register District. Close proximity to Wilmington, Newark, Philly. Home area of the oldest vineyard in the United States.
Choptank River	Choptank River	Caroline	Greenboro to headwaters of Tidy Island Creek at Maryland	16	1982	H, O	MD	62,149	97.1	Extensive undeveloped freshwater swamps. Barred forest 9,10,000 yrs old with earliest example of Platanus oaks forest.
Cow Marsh Creek	Choptank River	Kent	Confluence with Choptank River to northeast of Petersburg	4	1982	H, O	MD	62,149	97.1	See Choptank comments
Delaware River	Delaware River	New Castle	Delaware Bay to Salem Nuclear Power Plant	4	1982	S, R, G, F, W, H, C, O				Highly exemplary, productive, and important river mouth estuarine system. Numerous Nat. Hist. Reg. sites. Important for nesting, feeding, migrating, and wintering waterfowl (Atlantic Flyway).
Appoquinimink River	Appoquinimink River	New Castle	Mouth to headwaters	15	1982	S, R, G, F, W, H, C, O		29,656	46.3	See Delaware River comments
Augustine Creek	C & D Canal East	New Castle	Confluence with the Delaware River to headwaters	4	1982	S, R, G, F, W, H, C, O		28,188	44.0	See Delaware River comments
Blackbird Creek	Blackbird Creek	New Castle	Mouth to headwaters	15	1982	S, R, G, F, W, H, C, O		19,811	31.0	See Delaware River comments
Broadkill River	Broadkill River	Sussex	Mouth of Milton	10	1982	S, R, G, F, W, H, C, O		68,571	107.1	See Delaware River comments
Cedar Creek	Cedar Creek	Sussex	Mouth to headwaters	7	1982	S, R, G, F, W, H, C, O		33,414	52.2	See Delaware River comments
Cedar Swamp	Delaware Bay	New Castle	Confluence with the Delaware River to headwaters	5	1982	S, R, G, F, W, H, C, O		6,152	9.6	See Delaware River comments
Little River	Little Creek	Kent	Confluence with the Delaware Bay to headwaters	5	1982	S, R, G, F, W, H, C, O		14,877	23.2	See Delaware River comments
Mispillion River	Mispillion River	Sussex	Mouth to Silver Lake in Milford	9	1982	S, R, G, F, W, H, C, O		48,875	76.4	See Delaware River comments
Murderkill River	Murderkill River	Kent	Delaware Bay to Coursey Pond	21	1982	S, R, G, F, W, H, C, O		68,309	106.7	See Delaware River comments
Smyrna River	Smyrna River	New Castle, Kent	Mouth to Duck Creek Pond	11	1982	S, R, G, F, W, H, C, O		40,913	63.9	See Delaware River comments
St. Georges Creek	C & D Canal East	New Castle	Confluence with the Delaware River to Thousand Acre Marsh	3	1982	S, R, G, F, W, H, C, O		28,188	44.0	See Delaware River comments
St. Jones River	St. Jones River	Kent	Delaware Bay to Route 13 Bridge in Dover	13	1982	S, R, G, F, W, H, C, O		57,601	90.0	See Delaware River comments
Leipic River	Leipic River	Kent	Delaware Bay to DuPont Boulevard	19	1982	W, H, O		67,011	104.7	Significant area of tidal marsh w/ proposed Wilderness area, and a nationally recognized sanctuary for migrating waterfowl.
Herr Branch	Leipic River	Kent	Confluence with the Simons River to headwaters above Rte. 9	3	1982	W, H, O		67,011	104.7	See Leipic River comments
Duck Creek	Leipic River	Kent	Leipic River to the Woodland Beach Area	12	1982	W, H, O		67,011	104.7	See Leipic River comments
Malon River	Leipic River	Kent	Confluence with the Delaware Bay to the confluence with Herr Branch	3	1982	W, H, O		67,011	104.7	See Leipic River comments
Muddy Branch	Leipic River	Kent	Confluence with the Leipic River to headwaters above DE Rte. 9	4	1982	W, H, O		67,011	104.7	See Leipic River comments
Simons River and Green Creek	Leipic River	Kent	Delaware Bay to Boat Gul Bay	5	1982	W, H, O		67,011	104.7	See Leipic River comments
Nanticoke River	Nanticoke River	Dorchester, Sussex	Tangier Sound to Seaford	35	1982	H, O	MD	92,303	144.2	Rare site of Late Woodland Period occupation (900-1600 AD). Rare/endangered Box Huckleberry shrub. Few remnants of Cypress Gum forests.
Nanticoke River	Nanticoke River	Sussex	Route 113 to Bridgeville	10	1982	H, O	MD	92,303	144.2	Rare site of Late Woodland Period occupation (900-1600 AD). Rare/endangered Box Huckleberry shrub. Few remnants of Cypress Gum forests.
Baker Mill Branch	Deep Creek	Sussex	Concord Pond to Black Savannah Ditch	2	1982	H, O		40,588	63.4	See Nanticoke River comments
Broad Creek	Broad Creek	Sussex	Confluence with the Nanticoke River to near Laurel	6	1982	H, O		76,528	119.6	See Nanticoke River comments
Deep Creek	Deep Creek	Sussex	Confluence with Nanticoke near Route 13 to headwaters	12	1982	H, O		40,588	63.4	See Nanticoke River comments
Gravelly Branch	Gravelly Branch	Sussex	Confluence with Nanticoke to headwaters in Redden State Forest	12	1982	H, O		24,506	38.3	See Nanticoke River comments
Gum Branch	Gum Branch	Sussex	Confluence with Nanticoke to Rye Hole	3	1982	H, O		19,321	30.2	See Nanticoke River comments
James Branch	Broad Creek	Sussex	Records Pond to Trussum Pond to Trap Pond	3	1982	H, O		76,528	119.6	See Nanticoke River comments
Layton-Vaughn Ditch	Deep Creek	Sussex	Confluence with New Ditch to Route 28	5	1982	H, O		40,588	63.4	See Nanticoke River comments
Marshy Hope Creek	Nanticoke River	Sussex	Confluence with the Nanticoke River to South of Federalsburg	15	1982	H, O		92,303	144.2	See Nanticoke River comments
Mifflin Ditch	Deep Creek	Sussex	Confluence with Deep Creek to headwaters in Redden State Forest	5	1982	H, O		40,588	63.4	See Nanticoke River comments
New Ditch	Deep Creek	Sussex	Confluence with Deep Creek to Route 28	4	1982	H, O		40,588	63.4	See Nanticoke River comments
Rum Bridge Branch	Deep Creek	Sussex	Confluence with Deep Creek to headwaters	3	1982	H, O		40,588	63.4	See Nanticoke River comments
Toms Dam Branch	Gum Branch	Sussex	Confluence with Gum Branch to headwaters	7	1982	H, O		19,321	30.2	See Nanticoke River comments
Tube Branch	Deep Creek	Sussex	Confluence with Deep Creek to headwaters	4	1982	H, O		40,588	63.4	See Nanticoke River comments
Tyndall Branch	Deep Creek	Sussex	Confluence/Deep Creek to Fleetwood Pond	2	1982	H, O		40,588	63.4	See Nanticoke River comments
White Clay Creek	White Clay Creek	New Castle, Chester	Northern boundary of the City of Newark to the confluence with Egypt Run	10	1982	H, O	PA	29,550	46.2	Rare/endangered Purple Fringed Orchid. Area w/ diversity of habitats & biota. Proximity to Wilm., Newark, and Philly.
White Clay Creek, Middle Branch	White Clay Creek	Chester	Confluence with the West Branch to Rt. 841	3	1982	H, O		29,550	46.2	Rare/endangered Purple Fringed Orchid. Area w/ diversity of habitats & biota. Proximity to Wilm., Newark, and Philly.
White Clay Creek, West Branch	White Clay Creek	Chester	Confluence with the Middle Branch to the headwaters	10	1982	H, O		29,550	46.2	Rare/endangered Purple Fringed Orchid. Area w/ diversity of habitats & biota. Proximity to Wilm., Newark, and Philly.
Red Clay Creek	Red Clay Creek	New Castle	Confluence with White Clay to the headwaters	13	2021			13,501	21.1	
Christina River	Christina River	New Castle	Confluence with the Delaware River at Wilmington	35	2021		PA	42,979	67.2	



Table 8. Outstanding Resource Values in Delaware

River	Watershed	County	Reach	Length (Miles)	Year Listed/Updated	ORVs	Other States	Watershed (sq mi)	Comments
Brandywine Creek	Brandywine Creek	New Castle	Rockland to Chadds Ford Junction	6	1982	H, R, C	PA	14,699	National Historic Register District. Close proximity to Wilmington, Newark, Philly. Home area of Wyeth Family artists.
Choptank River	Choptank River	Caroline	Greenboro to headwaters of Tidy Island Creek. Choptank River to confluence with Chesapeake Bay to northeast of Pritersburg.	16	1982	H, O	MD	62,149	Extensive undeveloped freshwater swamp, buried forest 9-10,000 yrs old with earliest example of Pleistocene oak forest.
Cow Marsh Creek	Choptank River	Kent		4	1982	H, O	MD	62,149	See Choptank comments
Delaware River	Delaware River	New Castle	Delaware Bay to Salem Nuclear Power Plant	4	1982	S, R, G, F, W, H, C, O			Highly exemplary, productive, and important river mouth estuarine system. Numerous Nat. Hist. Reg. sites. Important for nesting, feeding, migrating, and wintering waterfowl (Atlantic Flyway).
Appoquinimink River	Appoquinimink River	New Castle	Mouth to headwaters	15	1982	S, R, G, F, W, H, C, O		29,656	See Delaware River comments
Augustine Creek	C & D Canal East	New Castle	Confluence with the Delaware River to headwaters	4	1982	S, R, G, F, W, H, C, O		28,188	See Delaware River comments
Blackbird Creek	Blackbird Creek	New Castle	Mouth to headwaters	15	1982	S, R, G, F, W, H, C, O		19,811	See Delaware River comments
Broadkill River	Broadkill River	Sussex	Mouth of Milton	10	1982	S, R, G, F, W, H, C, O		68,571	See Delaware River comments
Cedar Creek	Cedar Creek	Sussex	Mouth to headwaters	7	1982	S, R, G, F, W, H, C, O		33,414	See Delaware River comments
Cedar Swamp	Delaware Bay	New Castle	Confluence with the Delaware River to headwaters	5	1982	S, R, G, F, W, H, C, O		6,152	See Delaware River comments
Little River	Little Creek	Kent	Confluence with the Delaware Bay to headwaters	5	1982	S, R, G, F, W, H, C, O		14,877	See Delaware River comments
Mispillion River	Mispillion River	Sussex	Mouth to Silver Lake in Millford	9	1982	S, R, G, F, W, H, C, O		48,875	See Delaware River comments
Murderkill River	Murderkill River	Kent	Delaware Bay to Coursey Pond	21	1982	S, R, G, F, W, H, C, O		68,309	See Delaware River comments
Smyrna River	Smyrna River	New Castle, Kent	Mouth to Duck Creek Pond	11	1982	S, R, G, F, W, H, C, O		40,913	See Delaware River comments
St. Georges Creek	C & D Canal East	New Castle	Confluence with the Delaware River to Thousand Acres Marsh	3	1982	S, R, G, F, W, H, C, O		28,188	See Delaware River comments
St. Jones River	St. Jones River	Kent	Delaware Bay to Route 13 Bridge in Dover	13	1982	S, R, G, F, W, H, C, O		57,601	See Delaware River comments
Leipic River	Leipic River	Kent	Delaware Bay to DuPont Boulevard	19	1982	W, H, O		67,011	Significant area of tidal marsh w/ proposed Wilderness area, and a nationally recognized sanctuary for migrating waterfowl.
Herr Branch	Leipic River	Kent	Confluence with the Simons River to headwaters above Rte. 9	3	1982	W, H, O		67,011	See Leipic River comments
Duck Creek	Leipic River	Kent	Leipic River to the Woodland Beach Area	12	1982	W, H, O		67,011	See Leipic River comments
Mahon River	Leipic River	Kent	Confluence with the Delaware Bay to the confluence with Herr Branch	3	1982	W, H, O		67,011	See Leipic River comments
Muddy Branch	Leipic River	Kent	Confluence with the Leipic River to headwaters above DE Rte. 9	4	1982	W, H, O		67,011	See Leipic River comments
Simons River and Green Creek	Leipic River	Kent	Delaware Bay to Boat Gut Bay	5	1982	W, H, O		67,011	See Leipic River comments
Nanticoke River	Nanticoke River	Dorchester, Sussex	Tangier Sound to Seaford	35	1982	H, O	MD	92,303	Rare site of Late Woodland Period occupation (900-1600 AD). Rare/endangered Box Huckleberry shrub remnants of gum forests.
Nanticoke River	Nanticoke River	Sussex	Route 113 to Bridgeville	10	1982	H, O	MD	92,303	Rare site of Late Woodland Period occupation (900-1600 AD). Rare/endangered Box Huckleberry shrub. Few remnants of Cypress gum forests.
Baker Mill Branch	Deep Creek	Sussex	Concord Pond to Black Savannah Ditch	2	1982	H, O		40,588	See Nanticoke River comments
Broad Creek	Broad Creek	Sussex	Confluence with the Nanticoke River to near Laurel	6	1982	H, O		76,528	See Nanticoke River comments
Deep Creek	Deep Creek	Sussex	Confluence with Nanticoke near Route 13 to headwaters	12	1982	H, O		40,588	See Nanticoke River comments
Gravelly Branch	Gravelly Branch	Sussex	Confluence with Nanticoke to headwaters in Redden State Forest	12	1982	H, O		24,506	See Nanticoke River comments
Gum Branch	Gum Branch	Sussex	Confluence with Nanticoke to Rye Hole	3	1982	H, O		19,321	See Nanticoke River comments
James Branch	Broad Creek	Sussex	Records Pond to Trussum Pond to Trap Pond	3	1982	H, O		76,528	See Nanticoke River comments
Layton-Vaugh Ditch	Deep Creek	Sussex	Confluence with New Ditch to Route 28	5	1982	H, O		40,588	See Nanticoke River comments
Marshy Hope Creek	Nanticoke River	Sussex	Confluence with the Nanticoke River to South of Federalburg	15	1982	H, O		92,303	See Nanticoke River comments
Millfin Ditch	Deep Creek	Sussex	Confluence with Deep Creek to headwaters in Redden State Forest	5	1982	H, O		40,588	See Nanticoke River comments
New Ditch	Deep Creek	Sussex	Confluence with Deep Creek to Route 28	4	1982	H, O		40,588	See Nanticoke River comments
Rum Bridge Branch	Deep Creek	Sussex	Confluence with Deep Creek to headwaters	3	1982	H, O		40,588	See Nanticoke River comments
Toms Dam Branch	Gum Branch	Sussex	Confluence with Gum Branch to headwaters	7	1982	H, O		19,321	See Nanticoke River comments
Tubbs Branch	Deep Creek	Sussex	Confluence with Deep Creek to headwaters	4	1982	H, O		40,588	See Nanticoke River comments
Tyndall Branch	Deep Creek	Sussex	Confluence/Deep Creek to Fleetwood Pond	2	1982	H, O		40,588	See Nanticoke River comments
White Clay Creek	White Clay Creek	New Castle, Chester	Northern boundary of the City of Newark to the confluence with EMU Run	10	1982	H, O	PA	29,550	Rare/endangered Purple Fringedless Orchid. Area w/ diversity of habitats & biota. Proximity to Wilm., Newark, and Philly.
White Clay Creek, Middle Branch	White Clay Creek	Chester	Confluence with the West Branch to Rt. 841	3	1982	H, O		29,550	Rare/endangered Purple Fringedless Orchid. Area w/ diversity of habitats & biota. Proximity to Wilm., Newark, and Philly.
White Clay Creek, West Branch	White Clay Creek	Chester	Confluence with the main branch to the headwaters	10	1982	H, O		29,550	Rare/endangered Purple Fringedless Orchid. Area w/ diversity of habitats & biota. Proximity to Wilm., Newark, and Philly.
Red Clay Creek	Red Clay Creek	New Castle	Confluence with White Clay to the headwaters	13	2021			13,501	
Christina River	Christina River	New Castle	Confluence with the Delaware River at Wilmington	35	2021		PA	42,979	



ORV	Site Type	River Segment	County	Description					
Dill Farm Site	National Register of Historic Places	Cow Marsh Creek	Kent	Prehistoric archaeological site					
Duck Creek Village	National Register of Historic Places	Duck Creek	Kent	National Historic District known now as Salisbury					
Fennimore Store	National Register of Historic Places	Leipsic River	Kent	Historic commercial building constructed between 1840-60					
Golden Mine	National Register of Historic Places	Mispillion River	Kent	Historic home built in about 1763					
Island Field Site	National Register of Historic Places	Murderkill River	Kent	An archaeological site where there is a museum.					
Alexander Laws House	National Register of Historic Places	Leipsic River	Kent	Historic home					
McClary House	National Register of Historic Places	Leipsic River	Kent	Home built in the 19th century					
Mifflin-Martin Agricultural Complex	National Register of Historic Places	Leipsic River	Kent	Historic home and associated buildings constructed in the 18th century style					
Rawley House	National Register of Historic Places	Leipsic River	Kent	Historic home built in the 19th century					
Raymond Neck Historic District	National Register of Historic Places	Leipsic River	Kent	Historic district encompassing several buildings built between 1820-1867					
Reed House	National Register of Historic Places	Leipsic River	Kent	Historic home built in the first quarter of the 19th century					
Ruth Manson House	National Register of Historic Places	Leipsic River	Kent	Historic house of William Ruth, trustee of the first free school in Delaware					
Saxton United Methodist Church	National Register of Historic Places	Murderkill River	Kent	Historic church built in 1879					
Short's Landing Hotel Complex	National Register of Historic Places	Smyrna River	Kent	Historic hotel and farm complex - hotel built in 1780					
Slipple House	National Register of Historic Places	Leipsic Rive	Kent	Historic home built in 1885					
Shoeward	National Register of Historic Places	Leipsic River	Kent	Historic home built in 1790					
Wheel of Fortune (House)	National Register of Historic Places	Muddy Branch	Kent	Historic home built in the 18th century owned by Congressman John Nicholson (1827-1908) and US Sen. Hughes (1867-1953)					
J.H. Wilkerson & Son Brickworks	National Register of Historic Places	Mispillion River	Kent	Historic brickworks and district					
Jonathan Woodley House	National Register of Historic Places	Little River	Kent	Historic home built in the mid-19th century					
Augustine Paper Mill	National Register of Historic Places	Brandywine Creek	New Castle	Historic paper mill from the 19th century					
Bancraft and Sons Cotton Mills	National Register of Historic Places	Brandywine Creek	New Castle	Mill complex - site of some of the earliest and most famous mills near Wilmington					
Bellevue Range Rear Light Station	National Register of Historic Places	Christina River	New Castle	Light tower built in 1909 - operated by lightkeepers until 1943					
Brandywine Park	National Register of Historic Places	Brandywine Creek	New Castle	First city park established in Wilmington in 1886 - designed by Frederick Law Olmstead					
Brandywine Village Historic District	National Register of Historic Places	Brandywine Creek	New Castle	Historic district, Brandywine village developed as area with mills, millers, and artisans in the late 18th century					
Church Street Historic District	National Register of Historic Places	Brandywine/Christina	New Castle	Historic district developed between 1880-1920					
Continental Army Encampment Site	National Register of Historic Places	Brandywine Creek	New Castle	Location where troops from the Continental army camped before the Battle of Brandywine in 1777					
Delaware Academy of Medicine	National Register of Historic Places	Brandywine Creek	New Castle	Historic building originally built in 1815					
East Brandywine Historic District	National Register of Historic Places	Brandywine Creek	New Castle	Historic district developed between the late 18th and early 20th century					
Fort Christina	National Register of Historic Places	Christina River	New Castle	One of the first permanent European settlements in DE					
Harlan and Hollingsworth Office Building	National Register of Historic Places	Christina River	New Castle	Historic building constructed in 1912					
Howard High School	National Register of Historic Places	Brandywine Creek	New Castle	Named for General Oliver Otis Howard, who founded Howard University, opened in 1867					
Jackson-Wilson House	National Register of Historic Places	Brandywine Creek	New Castle	Historic home constructed in 1914					
Lower Market Street Historic District	National Register of Historic Places	Christina River	New Castle	Historic district developed between the mid-18th century and early 20th century					
Main Office of the New Castle Leather Company	National Register of Historic Places	Brandywine Creek	New Castle	Office building constructed in 1917					
New Castle Leather Raw Stock Warehouse	National Register of Historic Places	Brandywine Creek	New Castle	Historic warehouse built in 1917, originally used to store goatskins for a Wilmington kid leather manufacturer					
Old Asbury Methodist Church	National Register of Historic Places	Christina River	New Castle	Historic church originally built in 1789 - first Methodist church constructed in Wilmington					
Old First Presbyterian Church of Wilmington	National Register of Historic Places	Brandywine Creek	New Castle	Historic church built in 1740, used by British troops as a prison and hospital after the Battle of Brandywine					
Rockford Park	National Register of Historic Places	Brandywine Creek	New Castle	Historic park - one of the oldest in Wilmington, site of several notable memorials					
Frank E. Schoonover Studios	National Register of Historic Places	Brandywine Creek	New Castle	Historic building constructed in 1905 - used by students of illustrator Howard Pyle					
Starr House	National Register of Historic Places	Brandywine Creek	New Castle	Historic home built between 1801-1806 - last example of colonial architecture in the city of Wilmington					
Torbert Street Livery Stables	National Register of Historic Places	Brandywine Creek	New Castle	Historic livery stable built in 1887					
Wilmington Amtrak Station	National Register of Historic Places	Christina River	New Castle	Railroad station built in 1907, originally called Pennsylvania Station					
Wilmington Rail Viaduct	National Register of Historic Places	Christina River	New Castle	Rail line originally constructed in 1837					
Augustine Beach Hotel	National Register of Historic Places	Delaware River	New Castle	Historic hotel constructed in 1814, named for early DE resident Augustine Hermann					
Corbit-Sharp House	National Register of Historic Places	Appoquinimink River	New Castle	Historic house museum built in 1772-4, one of the best examples of brick Georgian style houses in the Mid-Atlantic					
Fleming House	National Register of Historic Places	Smyrna River	New Castle	Historic home built in 1830					
Hill Island Farm	National Register of Historic Places	Appoquinimink River	New Castle	Historic home built in 1790					
Huguenot House	National Register of Historic Places	Blackbird Creek	New Castle	Historic home near Taylors Bridge built in 1711					
Lisbon Range Front Lighthouse	National Register of Historic Places	Delaware River	New Castle	Lighthouse built in 1906 in the Delaware River					
Noxontown	National Register of Historic Places	Appoquinimink River	New Castle	Country mill site and village important trading and milling center throughout the Colonial period					
Odessa Historic District	National Register of Historic Places	Appoquinimink River	New Castle	Area in the shipping and trading center of Odessa, primarily developed through the 18th and 19th centuries					
Old Brick Store	National Register of Historic Places	Smyrna River	New Castle	Also known as Old Brick Hotel and the Granary, historic commercial building constructed in 1764					
Old St. Anne's Church	National Register of Historic Places	Deep Creek	New Castle	Historic church built in 1768 on the site of an earlier wooden church built in 1705					
Port Penn Historic District	National Register of Historic Places	Delaware River	New Castle	Historic district with various buildings, the oldest dating back to 1755					
Amstel House	National Register of Historic Places	Delaware River	New Castle	Historic building constructed in the 1730s					
Armstrong Lodge No. 26, A.F. & A.M.	National Register of Historic Places	Christina River	New Castle	Historic building constructed in 1913 in the restrained Colonial Revival style					
Ashland Bridge	National Register of Historic Places	Red Clay Creek	New Castle	Covered bridge over Red Clay Creek built about 1860					
Auburn Mills Historic District	National Register of Historic Places	Red Clay Creek	New Castle	Historic district mostly developed between 1890 and 1910					
Brandywine Manufacturers Sunday School	National Register of Historic Places	Brandywine Creek	New Castle	Historic school constructed in 1817					
Breck's Mill Area	National Register of Historic Places	Brandywine Creek	New Castle	Historic district, mill built in 1813 then rebuilt in 1846 after a fire					
John Carney Agricultural Complex	National Register of Historic Places	Brandywine Creek	New Castle	Historic farm complex					
Chambers House	National Register of Historic Places	White Clay Creek	New Castle	Historic home built in 1890					
Christiana Historic District	National Register of Historic Places	Christina River	New Castle	National Historic district with structures dating from the mid-18th century to the mid-19th century					
Clyde Farm Site	National Register of Historic Places	White Clay Creek	New Castle	Prehistoric archaeological site w/ items dated to 1000 BCE					
Cooch's Bridge	National Register of Historic Places	Christina River	New Castle	Battle of Cooch's Bridge on September 3, 1777 won by the British; only battle of the Revolutionary War fought on DE soil					
Cooch's Bridge Historic District	National Register of Historic Places	Christina River	New Castle	Historic district the site of the 1777 Battle of Cooch's Bridge, the original bridge did not survive the American Revolution					
Curtis Paper Mill Workers Houses	National Register of Historic Places	White Clay Creek	New Castle	Historic family dwellings built in 1888, built to house workers at Curtis Paper Mill					
Joseph Dean & Son Woolen Mill	National Register of Historic Places	White Clay Creek	New Castle	Historic woollen mill					
S P Dixon Farm	National Register of Historic Places	Red Clay Creek	New Castle	Historic farm dating back to the late 18th or early 19th century					
Eleutherian Mills	National Register of Historic Places	Brandywine Creek	New Castle	Gunpowder mill site used for explosives manufacturing between 1802 and 1921					

ORV	Site Type	River Segment	County	Description					
Andrew Fisher House	National Register of Historic Places	Christina River	New Castle	Historic home built in 1777					
Fort Delaware on Pea Patch Island	National Register of Historic Places	Delaware River	New Castle	Used as a prison during the Civil War					
Fort DuPont Historic District	National Register of Historic Places	Delaware River	New Castle	Defended the Delaware River from 1900 to 1942, originally called Fort Reynolds built in 1863					
Gateway-Walker House	National Register of Historic Places	Christina River	New Castle	Historic home constructed in the 18th century					
Glebe House	National Register of Historic Places	Delaware River	New Castle	Historic house built between 1821-1823					
John Lewden House	National Register of Historic Places	Christina River	New Castle	Historic home built around 1770					
Louiers	National Register of Historic Places	Brandywine Creek	New Castle	Historic home built in 1833					
Lower Louiers and Chicken Alley	National Register of Historic Places	Brandywine Creek	New Castle	Historic home built in 1811 originally owned by the Du Pont family					
Meeser Store House	National Register of Historic Places	White Clay Creek	New Castle	Historic home built between 1822 and 1828, built by prominent milling family					
Mount Cuba	National Register of Historic Places	Red Clay Creek	New Castle	Historic home of Lamont du Pont Copeland built in 1937					
Mount Cuba Historic District	National Register of Historic Places	Red Clay Creek	New Castle	Historic district with buildings in mid to late 19th century style					
New Castle County Court House	National Register of Historic Places	Delaware River	New Castle	One of the oldest courthouses in the US, built in 1730					
New Castle Historic District	National Register of Historic Places	Delaware River	New Castle	Historic area with ~500 historic buildings dating from 1700 to 1940.					
New Castle Ice Piers	National Register of Historic Places	Delaware River	New Castle	Historic ice breaks constructed between 1803 and 1882					
Newport National Bank	National Register of Historic Places	Christina River	New Castle	Historic bank constructed in 1864.					
Thomas Phillips Mill Complex	National Register of Historic Places	Christina River	New Castle	Historic mill complex with 18th century mill owners home and grist mill constructed in 1795.					
George Read II House	National Register of Historic Places	Delaware River	New Castle	Historic house museum built in 1797-1804					
Rockland Historic District	National Register of Historic Places	Brandywine Creek	New Castle	Historic district encompassing 6 buildings constructed in the late 18th to late 19th century					
Rotherham Mill House	National Register of Historic Places	Red Clay Creek	New Castle	Historic home constructed in 1740.					
Springer-Cranston House	National Register of Historic Places	Red Clay Creek	New Castle	Historic home constructed in the late-18th century and constructed of local Brandywine granite.					
Strand Millas and Rock Spring	National Register of Historic Places	Brandywine Creek	New Castle	Historic home built in 1701 with springhouse.					
Joseph Tinnall House	National Register of Historic Places	Christina River	New Castle	Historic home constructed in the mid 18th century.					
Walker's Mill and Walker's Bank	National Register of Historic Places	Brandywine Creek	New Castle	Historic spinning cotton mill built between 1813 and 1815.					
Lewis Weldin House	National Register of Historic Places	Christina River	New Castle	Historic home constructed in the late 18th century. (Demolished between 2007 and 2009)					
Welsh Tract Baptist Church	National Register of Historic Places	Christina River	New Castle	Historic Primitive Baptist church built by Welsh settlers in 1746.					
Wooddale Bridge	National Register of Historic Places	Red Clay Creek	New Castle	Covered bridge over Red Clay Creek, marked on map from 1868.					
Wooddale Historic District	National Register of Historic Places	Red Clay Creek	New Castle	Historic district encompassing 6 buildings including a mill site - part of Delaware Iron works which operated from 1826-1870.					
Building at 200-202A High Street	National Register of Historic Places	Nanticoke	Sussex	Historic store built in 1910.					
Building at 218 High Street	National Register of Historic Places	Nanticoke	Sussex	Historic store built in 1885.					
Burton Hardware Store	National Register of Historic Places	Nanticoke	Sussex	Historic commercial built in 1900.					
Cannon's Ferry	National Register of Historic Places	Nanticoke	Sussex	Cable ferry, on eef the oldest ferries in continuous operation in the US, across the Nanticoke since 1740s.					
Carlisle House	National Register of Historic Places	Mispillion River	Sussex	Historic home constructed in 1794.					
J. W. Cox Dry Goods Store	National Register of Historic Places	Nanticoke River	Sussex	Historic commercial building constructed in 1885.					
Dr. Dawson House	National Register of Historic Places	Mispillion River	Sussex	Historic home built in the mid-19th century.					
First National Bank of Seaford	National Register of Historic Places	Nanticoke River	Sussex	Historic building constructed in 1868.					
Laurel Historic District	National Register of Historic Places	Broad Creek	Sussex	Historic district including 701 buildings dating from the late-18th century to the 1930s.					
Milford Railroad Station	National Register of Historic Places	Mispillion River	Sussex	Historic rail station built in the 1860s.					
Milford Shipyard Area Historic District	National Register of Historic Places	Mispillion River	Sussex	Historic district including 18 buildings including the original shipyard and buildings dating from the late 19th century.					
Mispillion Lighthouse and Beacon Tower	National Register of Historic Places	Cedar Creek	Sussex	Original lighthouse built in 1831.					
Portville Lighthouse	National Register of Historic Places	Broad Creek	Sussex	Historic house/wharf, not functioning lighthouse.					
Jesse Robinson House	National Register of Historic Places	Nanticoke River	Sussex	Historic home built in 1820.					
Edgar and Rachel Ross House	National Register of Historic Places	Nanticoke River	Sussex	Historic home built between 1894 and 1897.					
St. Luke's Protestant Episcopal Church	National Register of Historic Places	Nanticoke River	Sussex	Historic church built in 1843.					
Seaford Station Complex	National Register of Historic Places	Nanticoke River	Sussex	Railway station complex built in 1905.					
Sussex National Bank of Seaford	National Register of Historic Places	Nanticoke River	Sussex	Historic bank built in 1888.					
Dravo Plaza Shipbuilding	Historic	Christina River	New Castle	Main shipbuilding hub during WWII.					
Old Brandywine Village	Historic	Brandywine	New Castle	Built around mills that used the end of the Brandywine to generate renowned quality flour.					
Dupont Church	Historic	Christina	New Castle	Dates back to 1638, when Swedish and Finnish settlers arrived and established Fort Christina in what is now Wilmington, Delaware					
Dupont Mills	Historic	Brandywine	New Castle	Made most of the gunpowder used by American troops in the War of 1812. Union troops during the Civil War and by U.S. soldiers in WWI.					
Tubman Garrett Riverfront Park and Statue	Historic	Brandywine	New Castle	Named for abolitionists Thomas Garrett and Harriet Tubman.					
Captain John Smith Chesapeake National Historic Trail	Historic	Nanticoke	Sussex	A series of water routes following the routes of the voyages of Capt. John Smith between 1607-1609.					
Bombay Hook National Wildlife Refuge	Wildlife	Lepisc River	Kent	A refuge that protects one of the largest remaining expanses of tidal salt marsh in the mid-Atlantic region established in 1937.					
Prime Hook National Wildlife Refuge	Wildlife	Delaware Bay	Sussex	A 10,144 acre refuge officially established in 1963 which is an important stopover site for migratory birds as they travel up and down the Atlantic Flyway.					
Russell W. Peterson Urban Wildlife Refuge	Wildlife	Christina River	New Castle	Dynamic wetland preserve of flora and fauna.					
Blackbird Creek Reserve	Wildlife	Blackbird Creek	New Castle	The Reserve is part of the Delaware National Estuarine Research Reserve (DNERR), which is one of 29 National Estuarine Research Reserves across the country.					
Gov. Peterson Marsh Coastal Zone Protection	Wildlife	Christina	New Castle	Area where the outh of the Christina meets the Delaware at Port of Wilmington is protected by Gov. Peterson as part of the DE Coastal Zone.					
Atlantic Sturgeon Habitat	Wildlife	Christina	New Castle	Part of the "critical" designation for Atlantic Sturgeon habitat-aimed to help support recovery of the population.					
Red Clay Creek Scenic Byway	Wildlife	Red Clay	New Castle	28 mile system that is the first in the US to be based on the watershed model.					
DE Coastal Zone	Wildlife	Delaware River	All	Passed by then-Governor Russel Peterson in 1971; regulations associated with the Act were specified under then-governor Tom Carper in 1999.					
Dupont Environmental Education Center	Education	Christina River	New Castle	In association with Delaware Nature Society public education and recreational destination on the Christina.					
Native Lenape Land	Indigenous	Christina, Red Clay, Brandyw	New Castle, Kent	Northern DE was part of the original lands of the Lenape Native Americans.					
Native Nanticoke Land	Indigenous	Nanticoke	Sussex	Southern DE was part of the original lands of the Nanticoke Native Americans.					

## Chapter 5 Conclusions and Recommendations

### Conclusions

The University of Delaware Water Resources Center (UDWRC) evaluated 43 streams in Delaware with 41 streams listed on the National Park Service (NPS) National River Inventory (NRI) (Table 7). Given their inclusion in the NRI, the streams qualify for potential suitability and eligibility for the National Wild and Scenic River System (W&S). These evaluations present the following relevant conclusions and findings:

1. **White Clay Creek W&S:** Since the induction by President Clinton and Congress in 2000, 200 miles of the White Clay Creek and its tributaries in New Castle County, Delaware and Chester County, Pennsylvania have been designated in the National Wild and Scenic River System.
2. **National Rivers Inventory:** During the 1970s and '80s, the NPS listed 41 streams in Delaware on the National Rivers Inventory. As a result, these waterways are potentially eligible for W&S River status. More recently, the UDWRC played a role in two new additions to the NRI: Red Clay Creek (a tributary of the White Clay Creek) and Christina River. These additions bring the list of streams evaluated to 43 total.
3. **Piedmont NRIs:** Three Piedmont streams in northern Delaware--the Brandywine River, Red Clay Creek, and Christina River--feature high proportions of forest and protected land, as well as many historic sites in their watersheds. These watersheds simultaneously flow through some of Delaware's largest urban areas, such as the City of Wilmington, that are home to disadvantaged and low socioeconomic neighborhoods. Focus given to the Piedmont streams presents a great opportunity to address issues of diversity, inclusion, and environmental justice (DEIJ) that have constantly prevailed, and continue to do so, in these areas for generations.

When considered together as an interconnected system in Northern Delaware, their crucial resources, histories, and unique characteristics can be highlighted in unison. From a research standpoint, the three streams present a practical focus for study given their proximity to each other, proximity to Delaware's only current Wild and Scenic River White Clay Creek, and the connectivity of their tributaries. By viewing them as a unit, the National Park Service will find the process streamlined and the outcome valuable. These three streams rank top three in population density per capita (Brandywine 2,057, Red Clay 1,187, and Christina 2,671), top three in public open space (Brandywine 67%, Red Clay 20%, and Christina 16.0%), and high density of ORVs such as Brandywine (Historic, Recreational, Cultural; National Historic Registry District, Rockland and habitat 37.6% wetlands plus forest), Red Clay (each branch of White Clay Creek Wild and Scenic River; 46.1% wetlands plus forests), and Christina (26.9% wetlands and forests).

If not studied as part of the larger Northern Delaware trio, the Brandywine Creek alone would be recommended. The Brandywine is rich in ORVs, supportive organizations, and would be a manageable focus for the National Park Service to carry out. There is ample support for the Brandywine Creek given the relative population density and heightened level of historic, recreation, and conservation interests that lie in connection with this system with 46.5% suburban/urban land cover, 67.4% public open space, 2,057 per capita population density, and high amounts of ORVs.

4. **Delaware Bay NRIs:** The collection of Coastal Plain tidal tributaries that flow east to the Delaware Bay along Routes 9 and ,1 from Blackbird Creek in New Castle County, to Leipsic Creek and Little River in Kent County, to Broadkill River in Sussex County are protected by State wildlife land and USFWS National Wildlife Refuges. Beyond officially protected segments, this area features high percentages of forest and wetlands.
5. **Nanticoke River:** As the largest watershed in Delaware, the Nanticoke flows west to the Chesapeake Bay in southwestern Sussex County Delaware near Seaford. Recognized as a John Smith National Historic Trail, the Nanticoke holds over half of the watershed's forest and wetlands.

## Recommendations

The National Park Service should consider the following options for further study of the eligibility and suitability of the Nationwide Inventory Rivers in Delaware for designation in the National Wild and Scenic Rivers System.

**Option 1 (Study all streams).** Conduct a reconnaissance study of all 43 NRI streams in Delaware for potential Wild and Scenic River status.

**Option 2. (Study watershed system).** Conduct a reconnaissance study of the Piedmont streams (Brandywine, Red Clay, Christina) collectively for Wild and Scenic River eligibility. In future years, study the Nanticoke watershed and then the Delaware Bay stream system for additional W&S eligibility consideration. The Brandywine, Red Clay Creek, and Kennett Pike in Delaware are National Scenic Byways administered by the National Park Service

**Option 3 (Study single river).** Conduct a reconnaissance study of the Brandywine River stretching from the confluence of the east and west branches above Chadds Ford, Pennsylvania down to the mouth of the river in downtown Wilmington, Delaware for W&S river eligibility. The Brandywine is currently a Pennsylvania State Scenic River and becomes part of a reviewed floodplain/drainage code system in Wilmington (see Appendix B).

**Option 4 (Study single river).** Conduct a reconnaissance study of the Red Clay Creek as the east branch hydrologically connected to the White Clay Creek National Wild & Scenic River watershed.

## Implementation

1. **Congressional Staff.** Schedule meetings with Delaware Congressional staff to discuss legislation to conduct a wild and scenic river eligibility study for the recommended rivers in Delaware. Coordinate with Delaware and Pennsylvania congressional offices including the office of PA Congressman (retired) Joe Pitts who co-sponsored the White Clay W&S river study and legislation
2. **Watershed Organizations:** Schedule meetings with watershed organizations such as the Brandywine Conservancy, Brandywine Red Clay Alliance, and Brandywine Shad 2020 and others.
3. **Legislation:** Draft a congressional bill for the National Park Service to study the Brandywine River for wild & scenic eligibility and suitability (see Appendix A) which could bring the National Park Service three years of funding.

## **Chapter 6 References**

Fosburgh, J., J. DiBello, and F. Akers, 2008. Partnership Wild and Scenic Rivers. *The George Wright Forum*, 25(2).

Molfetta, K. A., 2016. Governance of Federally Protected Rivers: An Institutional Analysis of the Partnership Approach to Wild and Scenic River Management in the White Clay Creek.

National Park Service, 1994. America's National Park System: The Critical Documents.

National Park Service, 2016. Nationwide Rivers Inventory Eligibility.

National Park Service, 2021a. Partnership Wild and Scenic Rivers.

National Park Service, 2021b. Wild and Scenic Rivers Program Eligible and Suitable.

National Wild and Scenic Rivers System, undated. Map of White Clay Creek River System.

National Wild and Scenic Rivers System, 2007. Technical Report of the Interagency Wild and Scenic Rivers Coordinating Council.



**Appendix A**  
**Wild and Scenic Rivers Act Amendment**  
110TH CONGRESS  
1ST SESSION  
**H. R. 3667**

To amend the Wild and Scenic Rivers Act to designate a segment of the  
Missisquoi and Trout Rivers in the State of Vermont for study for  
potential addition to the National Wild and Scenic Rivers System.

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IN THE HOUSE OF REPRESENTATIVES

SEPTEMBER 25, 2007

Mr. WELCH of Vermont introduced the following bill; which was referred to  
the Committee on Natural Resources

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**A BILL**

To amend the Wild and Scenic Rivers Act to designate  
a segment of the Missisquoi and Trout Rivers in the  
State of Vermont for study for potential addition to  
the National Wild and Scenic Rivers System.

1 *Be it enacted by the Senate and House of Representa-*  
2 *tives of the United States of America in Congress assembled,*  
3 **SECTION 1. SHORT TITLE.**

4 This Act may be cited as the “Missisquoi and Trout  
5 Rivers Wild and Scenic River Study Act of 2007”.

1 **SEC. 2. DESIGNATION FOR STUDY.**

2 Section 5(a) of the Wild and Scenic Rivers Act (16  
3 U.S.C. 1276(a)) is amended by adding at the end the fol-  
4 lowing:

5 “( ) MISSISQUOI AND TROUT RIVERS,  
6 VERMONT.—The segment from the headwaters of  
7 the rivers downstream to the confluence of that seg-  
8 ment with the Missisquoi Bay of Lake Champlain.”.

9 **SEC. 3. STUDY AND REPORT.**

10 Section 5(b) of the Wild and Scenic Rivers Act (16  
11 U.S.C. 1276(b)) is amended by adding at the end the fol-  
12 lowing:

13 “(19) MISSISQUOI AND TROUT RIVERS,  
14 VERMONT.—Not later than 3 years after the date of  
15 enactment of this paragraph, the Secretary of the  
16 Interior shall—

17 “(A) complete the study of the Missisquoi  
18 and Trout Rivers, Vermont, described in sub-  
19 section (a)(140); and

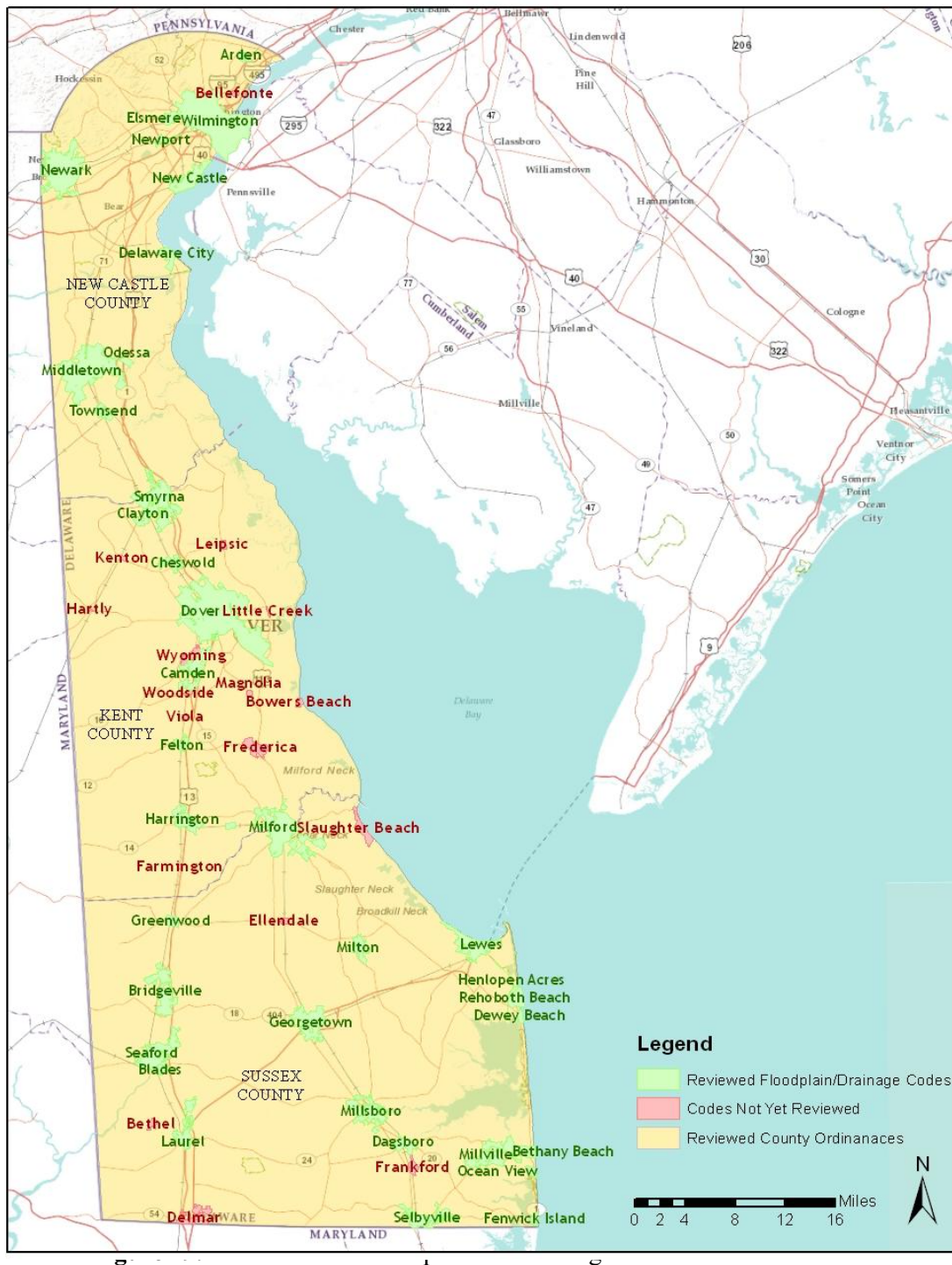
20 “(B) submit a report describing the results  
21 of that study to the appropriate committees of  
22 Congress.”.

1 **SEC. 4. AUTHORIZATION OF APPROPRIATIONS.**

2 There are authorized to be appropriated such sums  
3 as are necessary to carry out this Act and the amendments  
4 made by this Act.

## Appendix B

### Delaware Local Stormwater/Floodplain Ordinances



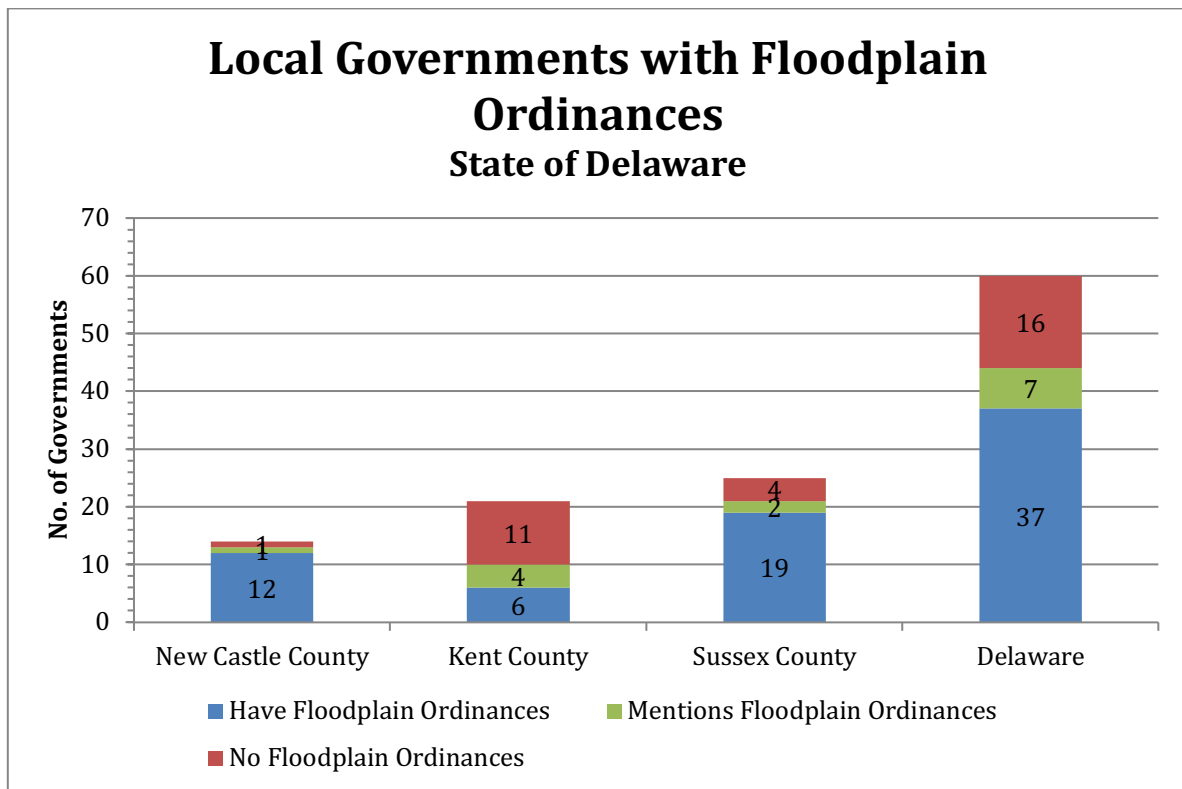


Figure 19. Local governments with floodplain ordinances in Delaware

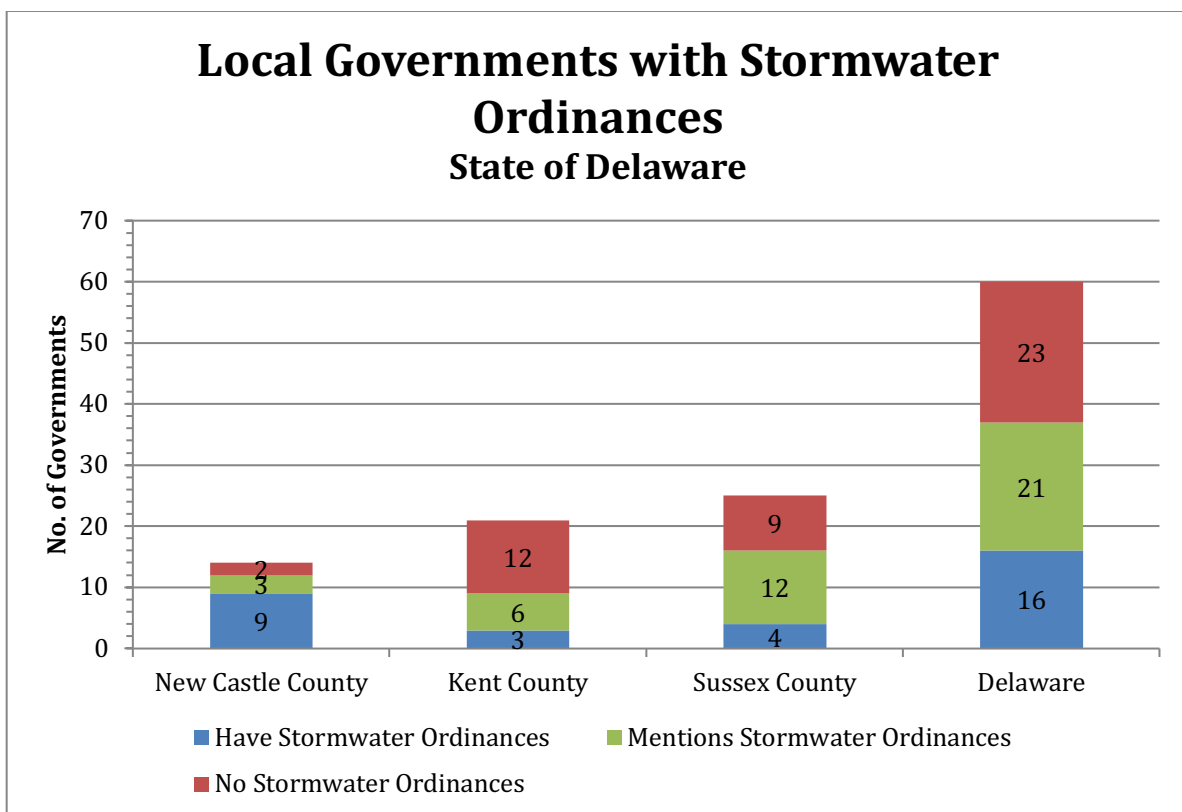


Figure 20. Local governments with stormwater ordinances in Delaware

Table 9. Review of floodplain and drainage standards in New Castle County

Government	Floodplain Standards															Drainage Standards						
	1	2	3	4	5	6	7	7a	8	9	10	11	12	13	14	15	1	2	3	4	5	6
New Castle Co.	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y			Y			Y		Y	Y	Y	Y
Arden	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y			Y			Y		Y	Y	Y	Y
Ardencroft	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y			Y			Y		Y	Y	Y	Y
Ardentown	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y			Y			Y		Y	Y	Y	Y
Bellefonte <sup>A</sup>																						
Delaware City					Y	Y				Y	Y											
Elsmere						Y					Y				Y							
Middletown										Y	Y				Y							
New Castle								Y	Y	Y					Y							
Newark <sup>B</sup>																						
Newport										Y	Y				Y						Y	
Odessa <sup>A</sup>																						
Townsend		Y								Y				Y								
Wilmington								Y		Y					Y							
Total	4	5	4	4	5	6	4	2	5	10	8	0	0	5	5	0	4	0	4	4	5	4

A. Bellefonte and Odessa not yet reviewed. B. Newark reviewed by the City with assistance by UDWRA.

#### Floodplain:

1. Flood study required in unmapped floodplains.
2. Flood study required in Zone A (no BFE) FEMA mapped floodplains.
3. Only FEMA approved and BFE data on record plans and development documents.
4. Use accepted base flood elevations in building permit application documents.
5. Floodplain information included on permitting documentation.
6. Require use of elevation and flood proofing certificates.
7. Require 18 inches of freeboard. 7a. Requires one foot of freeboard.
8. Require 18 inches of freeboard for manufactured homes.
9. Shallow fill above BFE will not exempt a structure from floodplain regulations.
10. Hydrostatic vents required.
11. Prohibit below-grade crawl spaces or enclosures.
12. Newly subdivided floodplain shall remain deed restricted open space.
13. Prohibit new non-water dependent structures in floodplains on new lots.
14. Prohibit encroachments that would cause more than 0.1 foot of rise without compensation.
15. Incorporate FEMA technical bulletins in local floodplain regulations.

#### Drainage:

1. Adequate easements required.
2. Obstruction prohibited.
3. Conveyance systems meet 10-year storm events.
4. Lot grading away from buildings.
5. Topographic plan submittal.
6. As-built submittal.

Table 10. Review of floodplain and drainage standards in Kent County

Government	Floodplain Standards															Drainage Standards						
	1	2	3	4	5	6	7	7a	8	9	10	11	12	13	14	15	1	2	3	4	5	6
Kent County		Y	Y	Y	Y			Y			Y		Y		Y		Y			Y	Y	
Bowers Beach																						
Camden			Y	Y	Y	Y					Y		Y	Y	Y		Y			Y	Y	Y
Cheswold			Y	Y	Y						Y		Y	Y			Y	Y		Y	Y	Y
Clayton																	Y				Y	Y
Dover				Y		Y					Y				Y							
Farmington																						
Felton			Y	Y	Y									Y	Y		Y	Y		Y	Y	Y
Frederica																						
Harrington		Y	Y	Y		Y		Y			Y				Y			Y			Y	Y
Hartly																						
Houston																					Y	
Kenton																						
Leipsic																						
Little Creek																						
Magnolia																						
Milford			Y	Y	Y	Y		Y			Y		Y		Y		Y	Y				
Smyrna					Y												Y		Y		Y	Y
Woodside																						
Wyoming																						
Total	0	2	6	7	6	4	0	3	0	0	6	0	4	3	6	0	7	4	1	4	8	6

Table 11. Review of floodplain and drainage standards in Sussex County

Government	Floodplain Standards															Drainage Standards						
	1	2	3	4	5	6	7	7a	8	9	10	11	12	13	14	15	1	2	3	4	5	6
Sussex Co.	Y				Y						Y				Y		Y				Y	
Bethany Bch.			Y	Y	Y	Y											Y	Y		Y	Y	Y
Bethel																						
Blades			Y	Y	Y						Y						Y				Y	
Bridgeville			Y	Y	Y						Y				Y		Y				Y	Y
Dagsboro			Y	Y	Y												Y			Y	Y	
Delmar																						
Dewey Beach			Y	Y	Y			Y			Y									Y		
Fenwick Island			Y	Y	Y		Y				Y											
Georgetown			Y	Y	Y						Y										Y	Y
Greenwood					Y						Y				Y							Y
Henlopen Acres			Y	Y	Y		Y	Y			Y				Y							
Laurel			Y	Y	Y						Y				Y							
Lewes			Y	Y	Y						Y											Y
Millsboro			Y	Y	Y						Y				Y					Y	Y	
Millville			Y	Y	Y			Y							Y		Y				Y	Y
Milton			Y	Y	Y		Y	Y	Y		Y				Y						Y	Y
Ocean View			Y	Y													Y			Y	Y	Y
Rehoboth Bch									Y		Y										Y	
Seaford			Y	Y	Y						Y							Y				
Selbyville			Y	Y	Y						Y				Y						Y	
S. Bethany			Y	Y	Y						Y						Y			Y	Y	Y
Total	1	0	17	17	18	1	3	4	2	0	16	0	0	0	9	0	8	2	0	6	13	9



### Senate Bill 64 Floodplain and Drainage Standards Checklist (DE)

Community: New Castle County County: New Castle State: DE CID:     

State Reviewer: UDWRA Date: 1/11/13 State Determination:                     

**Flood Zones:**    ☐A    ☐AE    ☐AE (w/o FW)    ☐AO    ☐VE

Item Description	State Review	Revised
<b>Senate Bill 64 Floodplain Standards</b>		
1. For all new development activities which exceed 50 lots or 5 acres in locations contiguous to streams without a FEMA-delineated floodplain, a flood study shall be conducted.	Meets Standard	
2. For all new development which exceed 50 lots or 5 acres in Zone A FEMA floodplains, a flood study shall be submitted to FEMA for approval prior to record plan approval.	Sec. 40.10.312	
3. Only FEMA approved floodplain and BFE data shall be shown on record plans and development documents.	Sec. 40.10.312	
4. Only base flood elevation approved by county, municipality or FEMA may be used in building permit application.	Unsure if meets std. Sec. 40.10.313	
5. Floodplain information must be included on permitting documentation.	Unsure if meets std. Sec. 40.10.313	
6. Require use of FEMA elevation certificate and flood-proofing certificate.	Sec. 40.10.316 No floodproofing certificate	
7. Require 18 inches of freeboard for all new construction and substantial improvements.	Sec. 40.10.316 does not contain dry-floodproofing in lieu of freeboard	
7a. Require 12 inches of freeboard for all new construction and substantial improvements.	NA	
8. Require 18 inches of freeboard for manufactures homes.	Sec. 40.10.317 not specified to include basement or new/substantially improved	
9. Fill placed in the floodplain which results in land having an elevation less than 18 inches above base flood elevation will not result in a relaxation of floodplain standards.	Yes because doesn't mention exemptions	
10. Hydrostatic vents shall be required within 1 foot grade.	Sec. 40.10.316 specifically for parking, building access or storage in other than the basement	



2. For all new development which exceed 50 lots or 5 acres in Zone A FEMA floodplains, a flood study shall be submitted to FEMA for approval prior to record plan approval.		
3. Only FEMA approved floodplain and BFE data shall be shown on record plans and development documents.		
4. Only base flood elevation approved by county, municipality or FEMA may be used in building permit application.		
5. Floodplain information must be included on permitting documentation.		
6. Require use of FEMA elevation certificate and flood-proofing certificate.		
7. Require 18 inches of freeboard for all new construction and substantial improvements.		
7a. Require 12 inches of freeboard for all new construction and substantial improvements.	48-436	
8. Require 18 inches of freeboard for manufactures homes.		
9. Fill placed in the floodplain which results in land having an elevation less than 18 inches above base flood elevation will not result in a relaxation of floodplain standards.	Within floodway	
10. Hydrostatic vents shall be required within 1 foot grade.		
11. Elevation of the lowest floor beneath an elevated building, must be above lowest adjacent grade at least one side.		
12. Prohibit subdividing land in floodplain. Newly subdivided floodplain shall remain deed restricted open space.		
13. Prohibit new non-water dependent structures dependent structures in floodplains in newly subdivided lands.		
14. Prohibit encroachments that would cause more than 0.1 foot of rise without compensation.		
15. Incorporate FEMA technical bulletins in local floodplain regulations.		

## Senate Bill 64 Drainage Standards

1. Easements of an adequate width shall be required over drainage conveyance systems within any proposed subdivision.		
2. The willful or negligent obstruction of any drainage conveyance shall be prohibited.		
3. Drainage conveyance systems within proposed subdivisions shall meet the minimum 10-year storm event.		
4. Lot grading shall ensure adequate drainage away from buildings and accessory structures without creating an adverse impact to adjacent structures or lands.		
5. A topographic plan submittal shall be required for all construction activity greater than 5,000 square feet.		
6. An as-built submittal shall be required for any construction with an approved topographic plan.		

## **Appendix C**

### **Brandywine River**

#### **The Watershed**

The Brandywine River watershed is the largest watershed in the Christina Basin and drains 324 square miles, with headwaters flowing south from Chester County, Pennsylvania down to Wilmington, Delaware, where the creek empties into the Christina River (Figure 1). Over 90 percent of the watershed is in Pennsylvania. Agriculture is the dominant land use, followed by forest/wetland, and urban areas. The watershed also provides drinking water to communities in both states as water is sourced by surface and ground water intakes, in addition to four reservoirs. It serves as the sole source of drinking water for Wilmington, Delaware's largest city. In addition, there is significant environmental value associated with the watershed, including:

- Habitat for rare and endangered species (according to the Pennsylvania Natural Diversity Index)
- Designation as a Pennsylvania Scenic River
- Headwaters that have been designated as High-Quality Waters
- Designation of the Broad Run subbasin as a Watershed of Exceptional Value

The Brandywine Creek watershed is one of four major watersheds in the Christina Basin. The Brandywine Creek is a tributary of the Christina River and flows southward out of Pennsylvania and into Delaware near Wilmington. The creek flows through Wilmington and enters the Christina River just before the Delaware River. The majority of the watershed is located in Chester County, Pennsylvania. Lower portions of the Brandywine Creek are tidal.

Major land use areas in the Brandywine include agriculture followed by forest/wetland, and urban uses. Collectively the White Clay, Red Clay, and Brandywine creeks and Christina River are used to supply drinking water to more than 60% of New Castle County's population. The Brandywine Creek has six surface water intakes and numerous public water supply wells located within the watershed for public water supplies. The Brandywine Creek serves as a major source of drinking water supplies with four reservoirs (Chambers Lake, Marsh Creek, Rock Run, and Hoopes) supplying water to central Chester and northern New Castle Counties. All together there are 48 municipalities in the two states that are either fully or partially within the Brandywine watershed.

#### **History**

The Brandywine Creek watershed, otherwise known as the Brandywine Valley, has long been a cultural and economic hub. The earliest inhabitants of the watershed were the Lenni Lenape, a tribe who knew their waterway as *Wawassan*. Over time, these "Delaware Indians," were displaced and forced north- and west-wards by European settlers. The last of the Lenape, Indian Hanna, was buried in 1802 at Embreeville at the forks of the Brandywine.

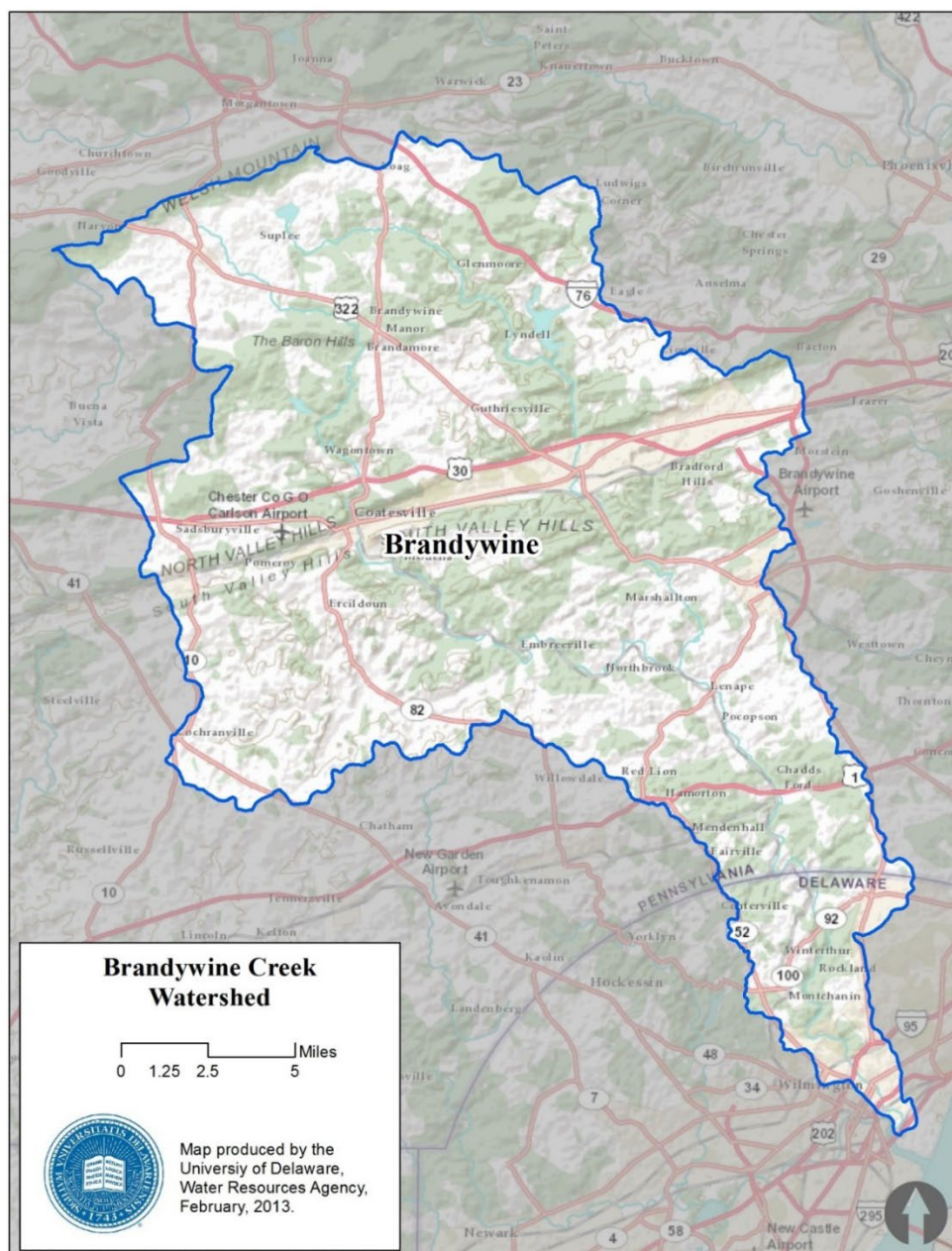
The economic importance of the Brandywine was evident early on during colonial rule. The Swedes, who arrived on the *Kalmar Nyckel*, founded the first permanent European settlement in the Delaware Valley at the mouth of Brandywine Creek along the Christina River in 1638. The Quakers later established large farms for grain and cattle, with mill dams along the waterways of the Brandywine for the grinding of meal and flour. Downstream towards Wilmington, the navigable tidewater waterways boosted the growing agricultural industry as small ships could directly dock at mills to deliver goods to other ports, both in the colonies and overseas.

Along the Brandywine at Chadds Ford, the British defeated the Americans at the largest battle of the American Revolution on September 11, 1777. Traveling from the Chesapeake, British troops sought to take Philadelphia and planned to do so through Kennett Square. General George Washington fought to hold ground at Chadds Ford without realizing until it was too late that the British General William Howe had outmaneuvered the American troops by crossing the Brandywine further north near Wistar's Ford. General Washington and his units retreated to Chester as General Howe marched on to and took Philadelphia.



After the founding of the nation, the economy of the Brandywine Valley continued to flourish as an important source of mill power. The Du Pont company traces its roots back to black powder mills established in what is now known as the Hagley Museum. Chemist Eleuthere Irenee du Pont and his family fled from the French Revolution's "Reign of Terror" and created E.I. du Pont de Nemours & Company, now a chemical and manufacturing company. Du Pont also built the Hagley mills to produce American black powder, an operation that continued through the early 1900s. Though the mill is no longer active, it serves as an historic landmark for Delaware and is a reminder of the multibillion-dollar company's humble beginnings.

Today, the Brandywine River is a natural treasure in Pennsylvania and Delaware as 32,000 acres (15% of the watershed's total area) are protected through land conservation efforts by the Brandywine Conservancy and Brandywine Valley Association and the Natural Lands Trust. The Brandywine is the home of such historic towns as Chadds Ford, Downingtown, and West Chester in Pennsylvania and Wilmington and Centreville in Delaware.



**Figure 1.** Brandywine Creek watershed

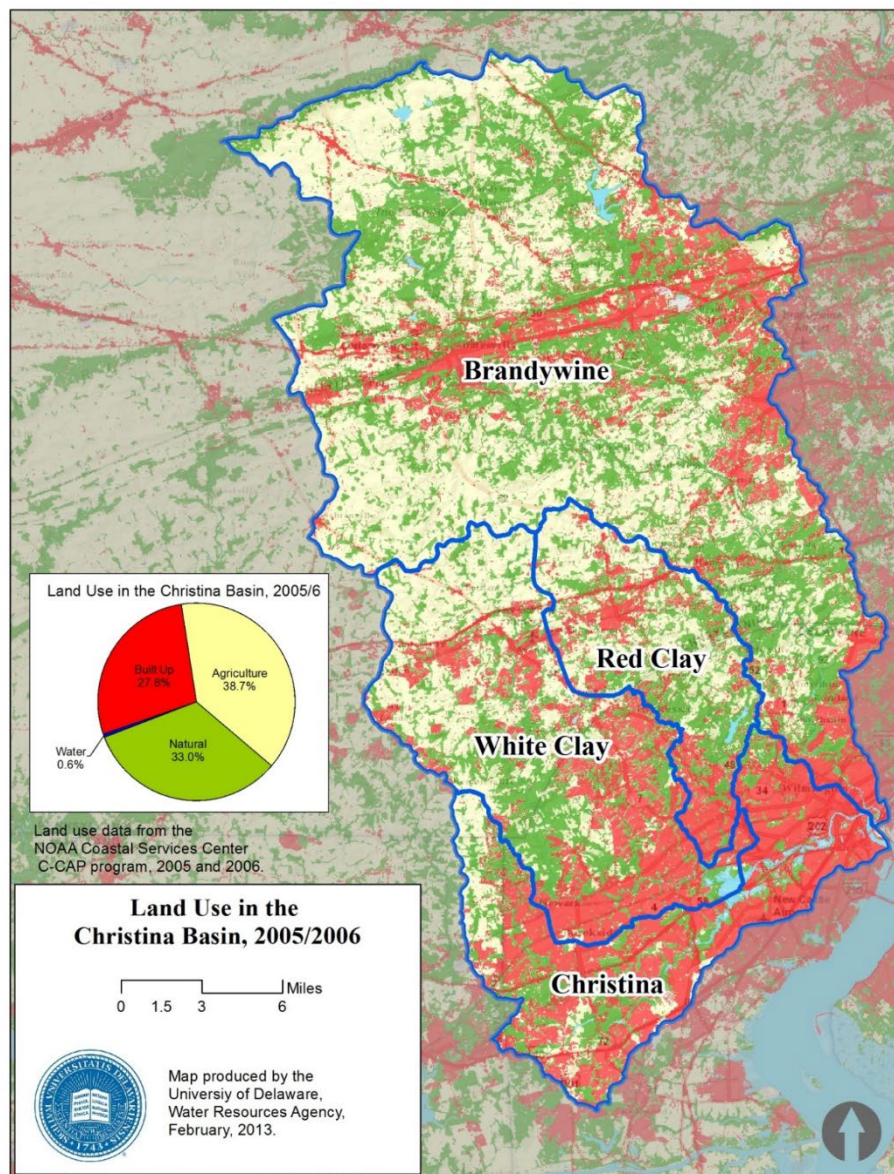
## Land Use

The most dominant land uses in the Brandywine Creek watershed are agriculture and forest, which account for 37% and 42% of the watershed area, respectively. About one quarter of the subbasin (19%) is developed land. The remainder of the watershed is covered by wetlands, barren land, and open water (2%) (Table 1 and Figure 2).

**Table 1.** Land use in Brandywine Creek watershed

Ecosystem	Area (mi <sup>2</sup> )	% Area
Urban	60	19%
Farmland	120	37%
Forest land	135	42%
Freshwater wetlands	8	2%
<b>Total</b>	<b>324</b>	<b>100%</b>

(NOAA CSC 2006)



**Figure 2.** Land cover in the Brandywine Creek watershed (NOAA CSC 2006)

## Population

Between 2000 and 2010, the population in the Brandywine Creek watershed grew by 24,170 (10.9%) from 221,413 to 245,583 (Table 2). The majority of the watershed is within Pennsylvania (301 mi<sup>2</sup>, or 93%), as is the highest population of people (201,496). Some 44,087 people reside in the smaller Delaware portion of the watershed.

**Table 2.** Population of Brandywine Creek watershed by state

State	Area (mi <sup>2</sup> ) <sup>1</sup>	2010 pop. <sup>2</sup>	2010 (p./mi <sup>2</sup> )
Pennsylvania	301	201,496	669
Delaware	23	44,087	1,917
<b>Total</b>	<b>324</b>	<b>245,583</b>	<b>2,586</b>

1. U.S. Census 2. NOAA CSC 2006

## Employment

In 2010, 120,983 people were employed within the Brandywine Creek watershed, with 100,777 employees in Chester County and 21,412 in New Castle County (Table 3).

**Table 3.** Employment in the Brandywine Creek watershed in 2010

County	County <sup>1</sup> Population	Watershed <sup>1</sup> Population	County <sup>2</sup> Employment	Watershed <sup>3</sup> Employment
Chester County, Pa.	498,886	201,496	249,515	100,777
New Castle County, Del.	538,479	44,087	261,530	21,412
<b>Total</b>	<b>1,037,365</b>	<b>245,583</b>	<b>511,045</b>	<b>120,983</b>

1. US Census 2010. 2. U.S. Bureau of Labor Statistics 2011.

## Cultural and Recreational Resources

The Brandywine-Christina watershed provides numerous ecological and natural functions while also serving as a recreation destination. It is the site of two Revolutionary War battlefields: Brandywine near Chadds Ford, PA, and Cooches Bridge near Newark, DE. The old water-powered mills along the Brandywine Creek (such as the Hagley Museum in Wilmington and the Brandywine River Museum of Art in Chadds Ford) are popular tourist destinations. The Brandywine Valley is the inspiration for and home of the Brandywine School and Wyeth family artists. The watershed has a robust and growing ecotourism industry and is an important attraction for a variety of popular tourism and recreational activities in the mid-Atlantic region, such as fishing, hiking, cycling and bird watching while the streams of the watershed provide a variety of primary and secondary recreational opportunities. The First State National Historical Park is a 1,100- acre property along the banks of the Brandywine. Several state parks and preserves are also located in the watershed, including the Brandywine Creek State Park and numerous municipal and county parks provide hiking and biking trails, fishing, water sports and camping for the community and visitors. The Brandywine Creek and its lakes host many canoe and kayak enthusiasts at public boat landings and commercial liveries. Delaware mariners own 8,400 registered boats that may cruise the tidal waters of the Christina River and lower Brandywine Creek. The Brandywine Creek is truly a unique stream from an angling perspective with three distinct fisheries and over 14 target species available along its 60-mile length. The upper reaches of the Brandywine are a cold-water fishery providing good habitat for freshwater trout; the middle and largest section is a warm water fishery with small mouth bass as a targeted species. The watershed also functions as protected- species habitat for the bald eagle, brook trout (the state fish of Pennsylvania), cerulean warbler and bog turtle.

## Economic Value

The water, natural resources and ecosystems in the Brandywine-Christina watershed contribute an estimated economic value of \$900 million to \$4.9 billion annually to the Delaware and Pennsylvania economies (Table 4).

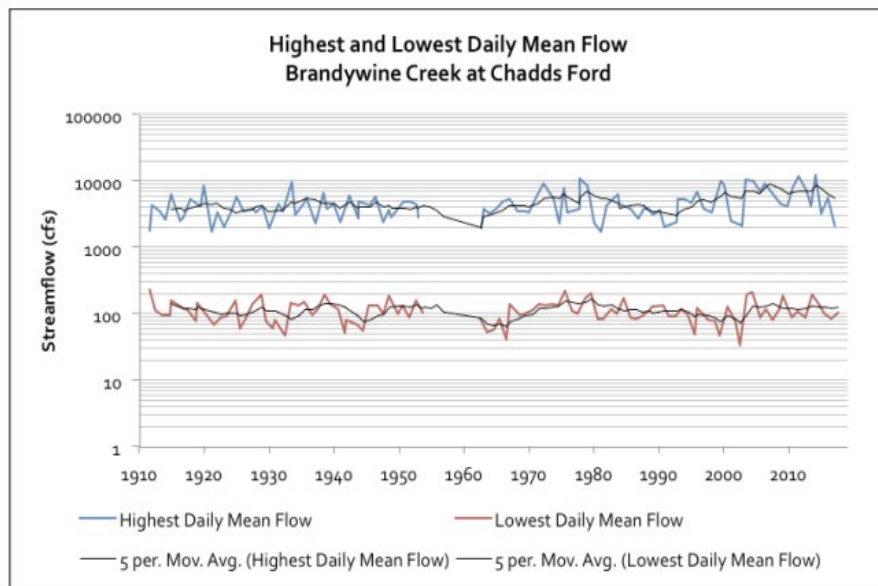


**Table 4.** Annual economic value of the Brandywine-Christina watershed

Watershed	Economic Activity (\$ million)	Ecosystem Services (\$ million)	Jobs	Wages (\$ million)
Brandywine Creek	890	560	50,000	2,000
Red Clay Creek	145	84	10,000	425
White Clay Creek	420	165	25,000	1,000
Christina River <sup>1</sup>	190	99	40,000	1,500
<b>Brandywine-Christina</b>	<b>1,645</b>	<b>908</b>	<b>125,000</b>	<b>4,925</b>

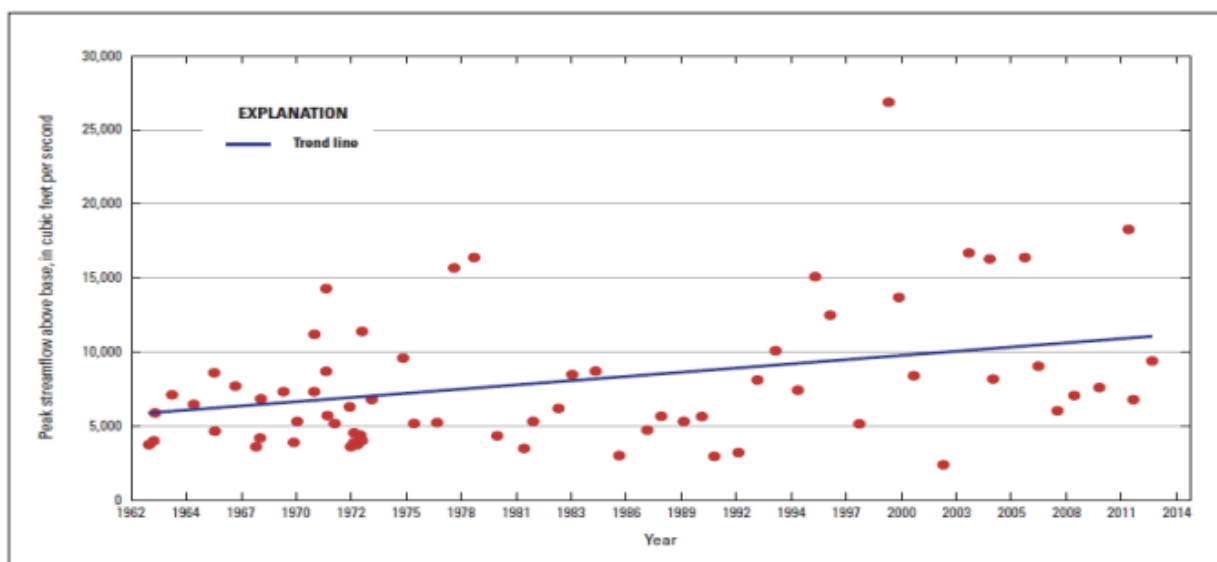
### Streamflow

With the onset of watershed urbanization and warming air temperatures, peak streamflow events have increased since the 1960s along the Brandywine Creek at Chadds Ford, PA. Drinking water streams have declined since the wet 1970s, bottoming out during the droughts of 1995-2002, and have since recovered over the last 15 years since the last drought (Figure 3).



**Figure 3.** Peak and low streamflow at Brandywine Creek at Chadds Ford, PA since 1913

There are 19 USGS continuous stream gage stations located in the Brandywine-Christina watershed, 13 in Pennsylvania operated under the cooperative USGS/Chester County/ CCWRA program, and 6 in Delaware. USGS monitors and collects peak flow data for these gages, and the data are published online by the National Water Information System (NWIS). The peak streamflow data published by USGS is the highest median daily flow for each water year, and therefore is not the highest instantaneous flow for that date. Thus, the instantaneous peak flow will be higher than the median flow for these events (Figure 4).



**Figure 4.** Peak streamflow at Brandywine Creek at Chadds Ford, PA, 1962-2012

There are 11 USGS continuous stream gage stations in the Brandywine Creek watershed. The highest storms of record at the gage stations were Hurricane Floyd and Agnes. The Brandywine at Chadds Ford, PA station, based on 44 years of record, records Hurricane Floyd as the highest storm of record in September 1999 at 26,900 cfs. For the same period of record, 44 years, the Brandywine Creek at Wilmington, DE station records Hurricane Agnes (June 1972) as the highest peak discharge at 29,000 cfs. Table 5 lists the top 10 peak discharge events at two USGS gages in the lower Brandywine Creek watershed.

**Table 5.** Mean daily peak discharge at USGS Gage 01481000 Brandywine Creek at Chadds Ford, PA

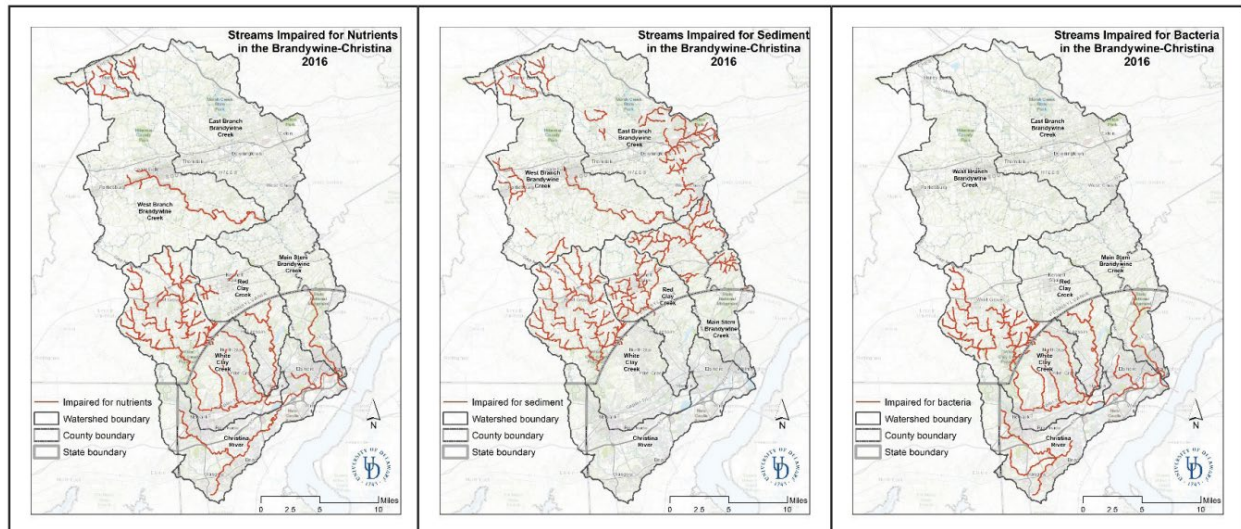
BRANDYWINE CREEK AT CHADDS FORD, PA			
Date	Peak Discharge (cfs)	Named Storm	Flood Frequency
9/17/99	26,900	Floyd	>50-yr
6/22/72	23,800	Agnes	>50-yr
5/1/14	22,200	Unnamed	>10-yr
8/28/11	18,300	Irene	>10-yr
3/5/20	17,200	Unnamed	>10-yr
8/9/42	16,800	Unnamed	>10-yr
9/15/03	16,700	Henri	>10-yr
8/4/15	16,500	Unnamed	>10-yr
8/19/55	16,400	Unnamed	>10-yr
1/25/79	16,400	Unnamed	>10-yr

## Impaired Streams

As pollutants enter the streams from all sources (wastewater discharges, wildlife, stormwater runoff from various land cover types, etc.), its levels can become high enough to have negative impacts. When pollutant levels in streams become too high the streams can no longer support certain uses that they normally could support, such as aquatic species and habitat, recreation, or water supply. The states of Pennsylvania and Delaware, under the federal Clean Water Act, are required to assess, inventory and report all stream segments and bodies of water that do not meet their water quality standards for specific uses. This reporting serves as a basis for regulations aimed at restoring the water quality of the waterways and watershed health. TMDLs are one mechanism used by USEPA and the states to set target pollution loads to achieve healthy waters.

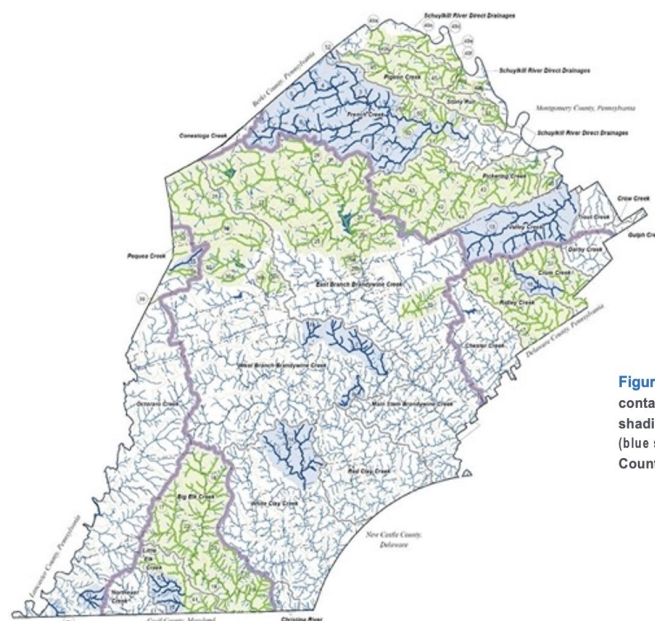


Every two years Pennsylvania and Delaware update and report their inventories of impacted water bodies to USEPA, identifying waters that, based on testing protocols, do not meet the minimum standards. The states must identify the cause of the impairment, such as nutrients, sediment, bacteria, PCBs, metals, etc. When pollution reduction efforts result in water bodies meeting their water quality standards, they may be removed from the impaired list. The latest year for which data have been approved by USEPA for stream impairments in the Brandywine-Christina watershed is 2016. The maps indicate impaired streams for three pollutants, nutrients (nitrogen and phosphorous), pathogens (bacteria), and sediment (for Pennsylvania only) (Figure 5).



**Figure 5.** Impaired streams in the Brandywine-Christina watershed (DNREC and PADEP).

Both the states of Pennsylvania and Delaware have designated certain waters that merit special protections due to their intrinsic importance based on water quality, habitat, ecological significance, sensitivity or recreational value. In Pennsylvania these waters have the designation of High Quality (HQ) or Exceptional Value (EV) waters, and receive special protections as specified in the Pennsylvania Code (§ 93.4b of the Pennsylvania Code: “Qualifying as High Quality or Exceptional Value Waters”). Watersheds whose waters are designated High Quality must meet certain criteria for water quality and support of aquatic biota (Table 6 and Figure 6).



**Figure 3-24** Watersheds containing High Quality (green shading) and Exceptional Value (blue shading) waters in Chester County, PA. (CCWRA, 2005)

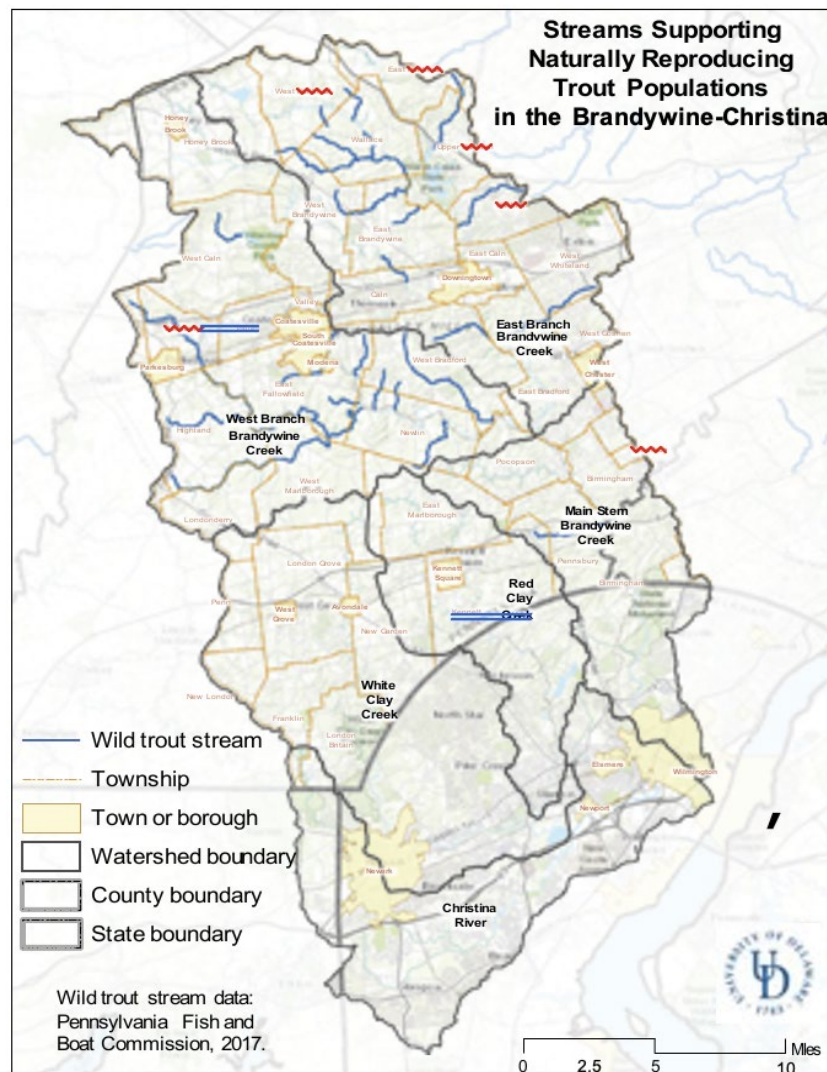
**Figure 6.** Watersheds with high quality (green) and exceptional value (blue) waters in Chester County, PA

**Table 6.** Special water protection in the Delaware portion of the Brandywine-Christina watershed

Stream	Public Water Supply	Primary Contact Recreation	Secondary Contact Recreation	Fish, Aquatic Life, and Wildlife	Cold Water Fish	ERES Waters
Brandywine Creek	(a)	x	x	x	(b)	(h)
Red Clay Creek	x	x	x	x	(e)	(q)
White Clay Creek	(a)	x	x	x	(f)	(g)

## Trout Streams

Pennsylvania is host to many streams with naturally reproducing trout. In the Brandywine-Christina watershed these fall mainly above the confluence of the east and west branches of the Brandywine River. Trout is a species sensitive to water quality conditions in streams, and therefore the presence of naturally replicating populations is a potential indicator of a healthy watershed (Figure 7).



**Figure 7.** Naturally reproducing trout streams in the Brandywine-Christina watershed. (PAFBC 2017)

## Macroinvertebrates

Benthic macroinvertebrates are aquatic organisms that live on the stream bottom. These serve as a useful tool to assess stream health at a specific site because they are directly impacted by water quality and physical conditions.

Macroinvertebrate data is available for the Pennsylvania portion of the watershed through the biological monitoring network, established by the USGS and CCWRA. Macroinvertebrate data in Delaware is provided by the Delaware Nature Society.

Since 1969, the USGS and CCWRA have had an established biological monitoring network in Chester County. Samples are taken at 27-30 sites annually, with 18 fixed-location sites (long-term monitoring of trends) and 9 -12 flexible location sites (spatial coverage-local determination of water quality conditions). The sampling measures baseflow conditions for water chemistry, instream habitat, and benthic macroinvertebrates (Reif, 2009). The network has nine fixed sampling sites located in the Brandywine-Christina watershed, five of which are located on the Brandywine, which include:

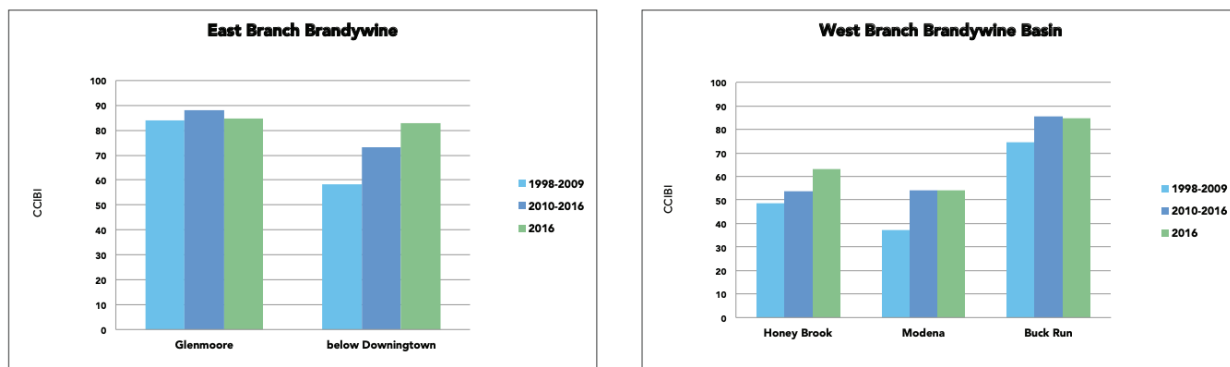
1. Glenmoore (East Branch Brandywine)
2. Below Downingtown (East Branch Brandywine)
3. Honey Brook (West Branch Brandywine)
4. Modena (West Branch Brandywine)
5. Buck Run (West Branch Brandywine)

Samples are collected October-December. The Chester County Index of Biotic Integrity (IBI) uses six individual metrics to provide a single IBI score 0-100 scale. IBI score is scaled to local conditions found in Chester County and are based on the same IBI metrics used by PADEP. The following data was collected 1998-2016 (Figure 8) at the nine sites in the Brandywine-Christina watershed. In general, the higher the score the better the site and fluctuations are normal in invertebrate data. The scoring can be generally interpreted in three categories:

1. 80–100 (good water quality)
2. 60–79 (fair water quality)
3. below 60 (poor water quality)

The 2016 sampling provided the following results:

- Three sites in the Brandywine watershed, had an IBI score above 80:
  - Glenmoore (East Branch Brandywine)
  - Below Downingtown (East Branch Brandywine)
  - Buck Run (West Branch Brandywine)
- Two sites in the Brandywine Creek had a score between 52 and 79:
  - Modena (West Branch Brandywine)
  - Honey Brook (West Branch Brandywine)



**Figure 8.** Brandywine River macroinvertebrate sampling data, 1998-2016 (USGS, Reif, 2017)

## Mussels

PDE conducted research in the northern portion of the Brandywine-Christina watershed in five freshwater ponds and streams on or adjacent to the property of Longwood Gardens in southeast Pennsylvania. Longwood Gardens is

situated partly in the Brandywine Creek watershed and partly in the Red Clay Creek watershed and historical data suggests that these streams once held robust populations of freshwater mussels. Of the five ponds selected, two of the ponds are hydrologically connected to the Brandywine and Red Clay creeks. Qualitative surveys did not yield evidence of or historical mussel presence within any of the study ponds (PDE, 2015). Three of the five ponds were determined to have suitable freshwater mussel habitat. Based on the suitability for freshwater mussels, PDE has identified several potential tactics that can be used in the future to restore freshwater mussels in the identified ponds at the study site.

## Fish

In April, May and June 2016, the Delaware Division of Fish and Wildlife sampled the Brandywine Creek and counted three American shad, two Hickory shad, and 28 striped bass below Dam No. 1 on Market Street in Wilmington and six American shad, zero hickory shad, and zero striped bass above Dam No. 1 up to Dam No. 2 (Table 7). The Market Street Dam No. 1 is slated to be removed by the City of Wilmington in fall 2018.

**Table 7.** Fish abundance along Brandywine Creek above/below Dam No. 1 at Market Street. (DNREC DFW)

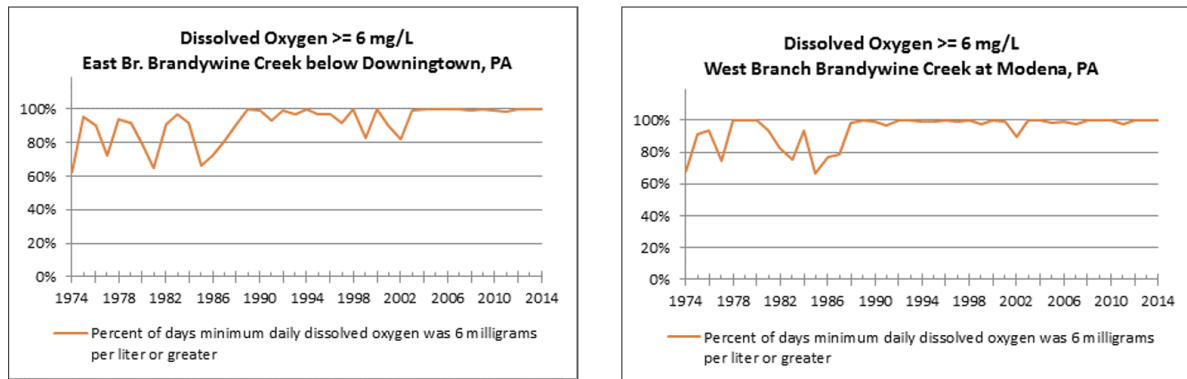
Fish Species	Fish Count	
	Below Dam No. 1 (Apr-May 2016)	Above Dam No. 1 (Jun 1, 2016)
Alewife	1	0
American Eel	4	15
American Shad	3	6
Blueback Herring	5	0
Bluegill	9	8
Channel Catfish	10	2
Common Carp	36	5
Gizzard Shad	76	0
Hickory Shad	2	0
Largemouth Bass	1	0
Menhaden	1	0
Needlefish	1	0
Smallmouth Bass	6	2
Striped Bass	28	0
Tiger Muskie	6	2
Rock Bass	0	5
White Perch	18	0
White Sucker	18	17
Yellow Perch	18	0

## Dissolved Oxygen

As part of the USGS/Chester County/CCWRA cooperative program, USGS has monitoring dissolved oxygen (DO) at three stations in the Chester County portion of the Brandywine Creek watershed since 1974 (Modena, Below Downingtown and Chadds Ford) and water quality monitors are operated continuously in non-winter months



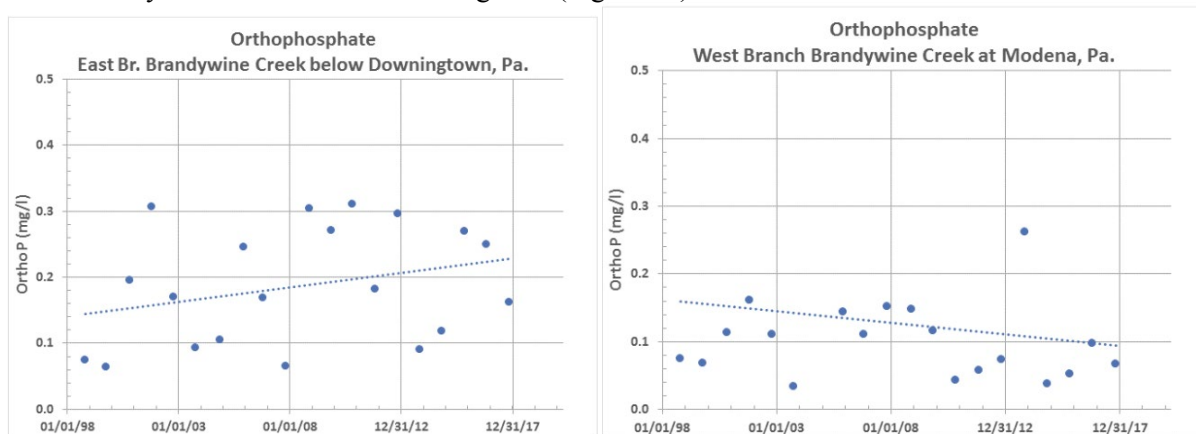
(March through November). According to the USGS report, the number of days per year since 1974 when the minimum daily DO concentration was less than 6 mg/L was evaluated. Low DO concentrations have a detrimental effect on aquatic life. Prior to 1988, it was common in the summer months for minimum daily DO concentrations at East Branch Brandywine Creek below Downingtown, PA (01480870) and West Branch Brandywine Creek at Modena, PA (01480617) to be less than 6 mg/L (Figure 9).



**Figure 9.** Dissolved oxygen at East Branch and West Branch Brandywine Creek

## Orthophosphates

Orthophosphate levels have decreased since 1998 at 3 water quality monitoring stations operated by the USGS and CCWRA along the Brandywine in Chester County, Pennsylvania. Orthophosphate levels have increased along the East Branch Brandywine Creek below Downingtown (Figure 10).

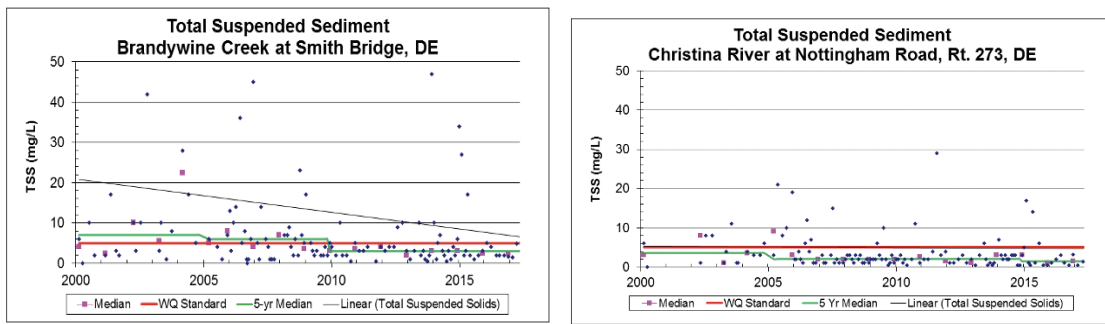


**Figure 10.** Orthophosphate levels measured along the Brandywine Creek, PA. (USGS)

## Turbidity

As part of the USGS/Chester County/CCWRA cooperative programs, the USGS has deployed turbidity sensors and conducted sediment sampling along the Brandywine Creek at Honey Brook, Modena and below Downingtown stations. Annual suspended sediment yields (tons/mi<sup>2</sup>/yr) are generally highest at Honey Brook and lowest at below Downingtown, among the Brandywine Creek stations. The maximum daily TSS load occurred on February 25, 2016 at all stations along the Brandywine Creek (Figure 11).

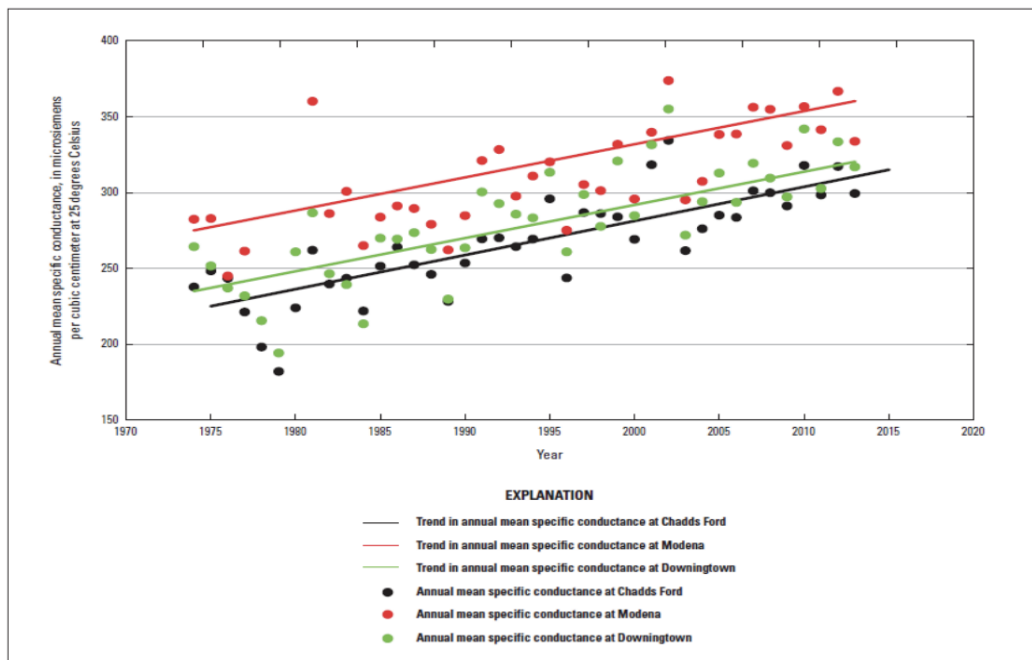




**Figure 11.** Total Suspended Sediment (TSS) on the Brandywine Creek

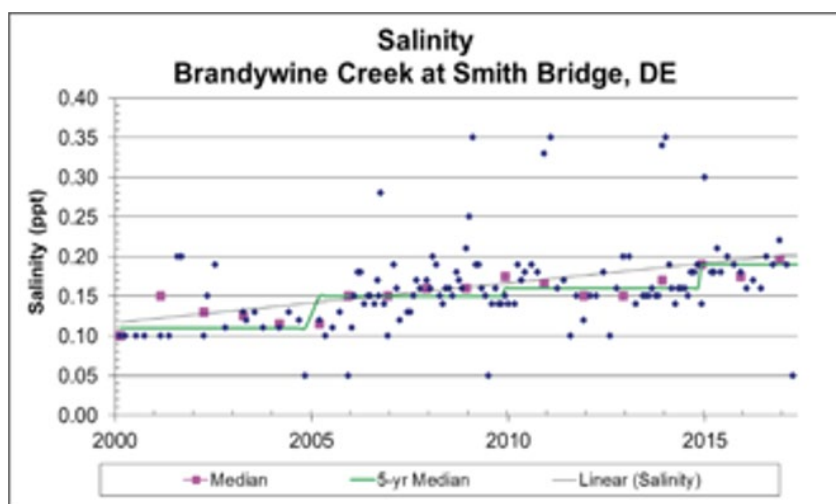
## Chloride/Salinity

Chloride and salinity levels in the Brandywine-Christina watershed are rising due to road salt. The EPA, PADEP and DNREC have set the secondary chloride drinking water standard at 200 mg/l. An upward trend in chloride concentrations was determined for Brandywine Creek at Chadds Ford, PA (01481000) for 1948–2013 where chloride levels have doubled over the past 20 years. Annual mean specific conductance (SC), which may be used to estimate chloride levels by the equation  $Cl = (SC - 310)(0.28)$ , has increased since the 1970s along the Brandywine Creek at Chadds Ford, Modena and Downingtown, PA (Figure 12).



**Figure 12.** Specific conductance along Brandywine Creek in Chester County, PA. (Sloto and Reif 2017)

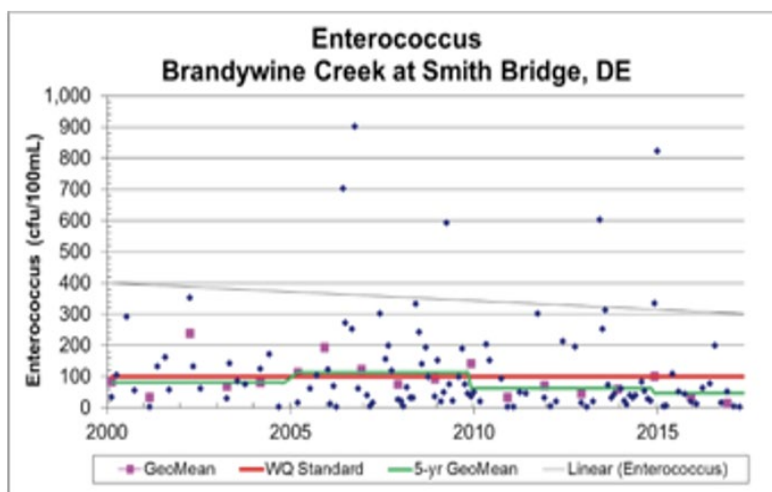
DNREC defines fresh water as water which contains natural levels of salinity at or below five parts per thousand (ppt). At water quality monitoring stations operated by DNREC, salinity levels have increased since 2000 along the Brandywine Creek in Delaware (Figure 13).



**Figure 13.** Salinity along the Brandywine Creek, DE. (DNREC)

## Bacteria

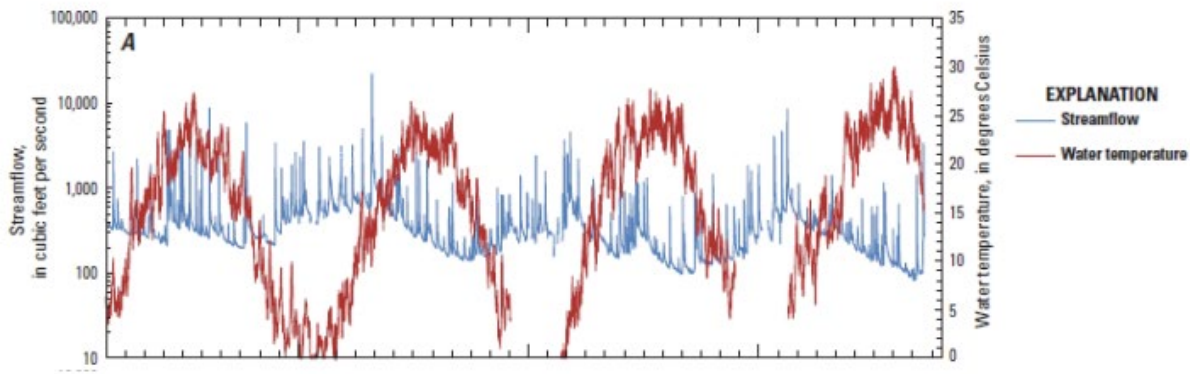
The USGS estimated from streamflow and turbidity measurements that fecal coliform levels typically decline below the 200 coliform forming units (CFU)/100 ml swimming recreation standard set by PADEP from September through April and then exceed the standard during the warmer months of June through September (Figure 14). Bacteria levels along the Brandywine Creek are typically lower than along the White Clay Creek. Delaware uses *Enterococcus* bacteria levels as the indicator to determine impacts of pathogens in streams. Bacteria in streams can come from a wide variety of sources, including human and livestock waste and wildlife. Delaware's geometric mean bacteria standard for swimming is at 100 colony forming units per 100 mL (cfu/100mL).



**Figure 14.** Enterococcus bacteria along the Brandywine Creek, DE (DNREC).

## Water Temperature

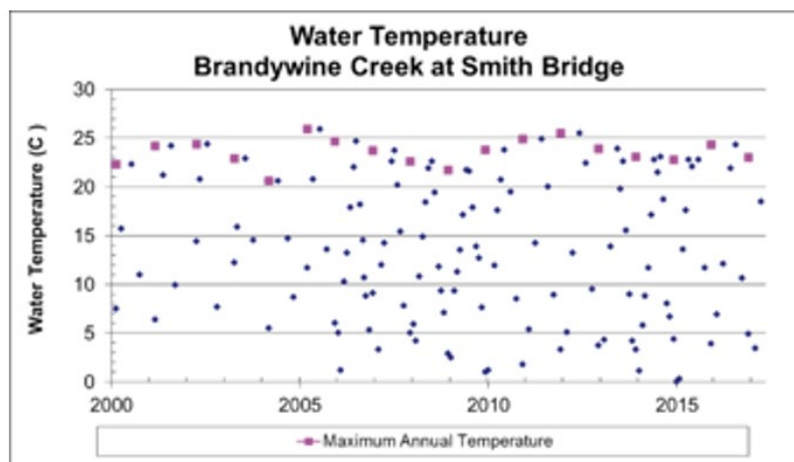
Statistically significant upward trends in stream temperature were observed at the Brandywine Creek at Chadds Ford, PA (Figure 15).



**Figure 15.** Stream temperature and streamflow for Brandywine Creek at Chadds Ford, PA. (Senior 2017)

The increase in stream temperature 0.6°C (1°F) per decade at Brandywine Creek at Chadds Ford, PA (01481000). The warming may be caused by climatic changes, warming of the earth's surface caused by urbanization, and (or) increasing quantities of warm effluent discharged to the Brandywine Creek (Sloto and Reif, 2017).

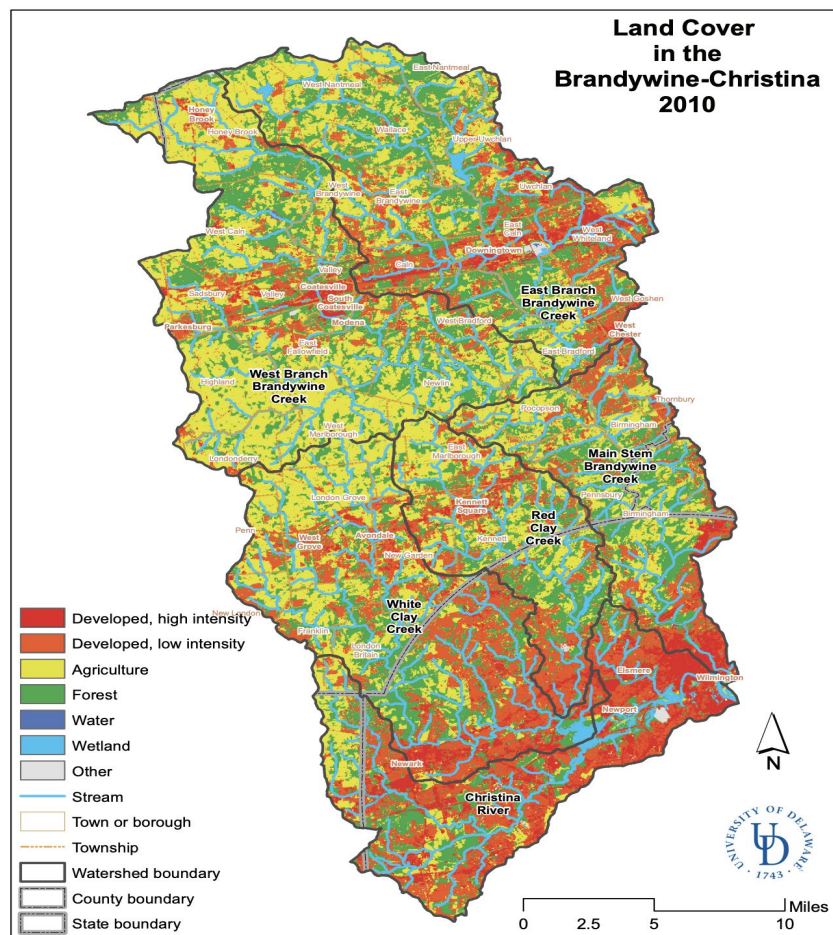
At water quality monitoring stations operated by the Delaware DNREC, there does not seem to be a noticeable rise or fall in stream water temperature since 2000 along the Brandywine Creek in Delaware (Figure 16).



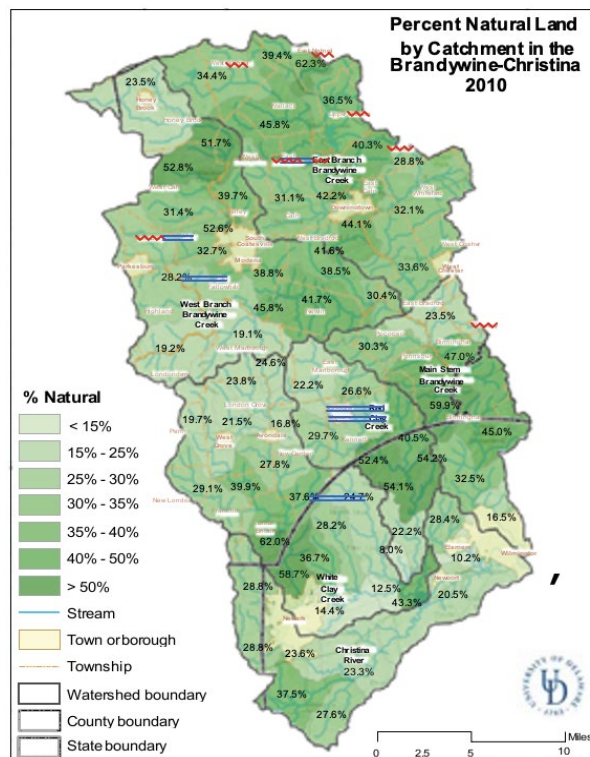
**Figure 16.** Water temperature along the Brandywine Creek, DE (DNREC).

## Land Use and Conservation

The watersheds in Delaware near Wilmington and along the I-95 corridor are the most heavily developed, along with those in the Great Valley. Agriculture predominates in the upper West and East Branches of the Brandywine, while natural areas occur most prominently in the northern watersheds in Delaware and in the upper East Branch of the Brandywine in Pennsylvania (Figures 17 and 18).



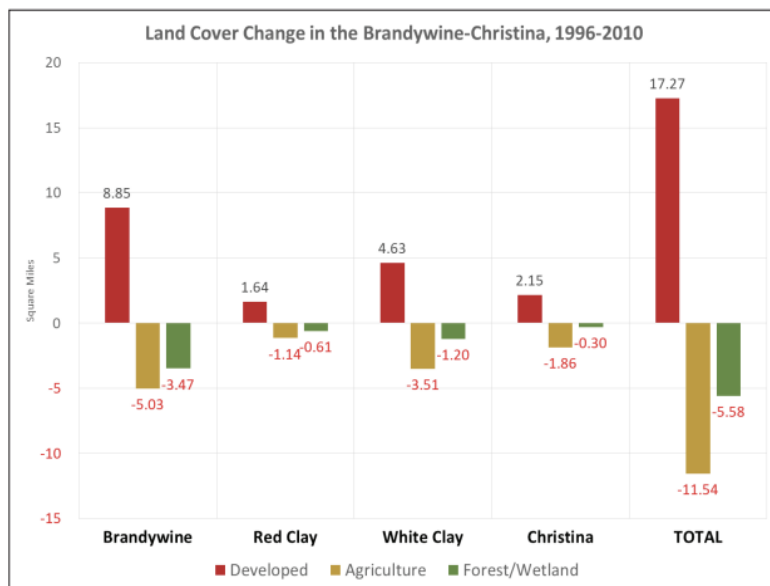
**Figure 17.** Land cover in the Brandywine-Christina watershed in 2010



**Figure 18.** Natural land in the sub-watersheds of the Brandywine-Christina watershed, 2010. (NOAA C-CAP)



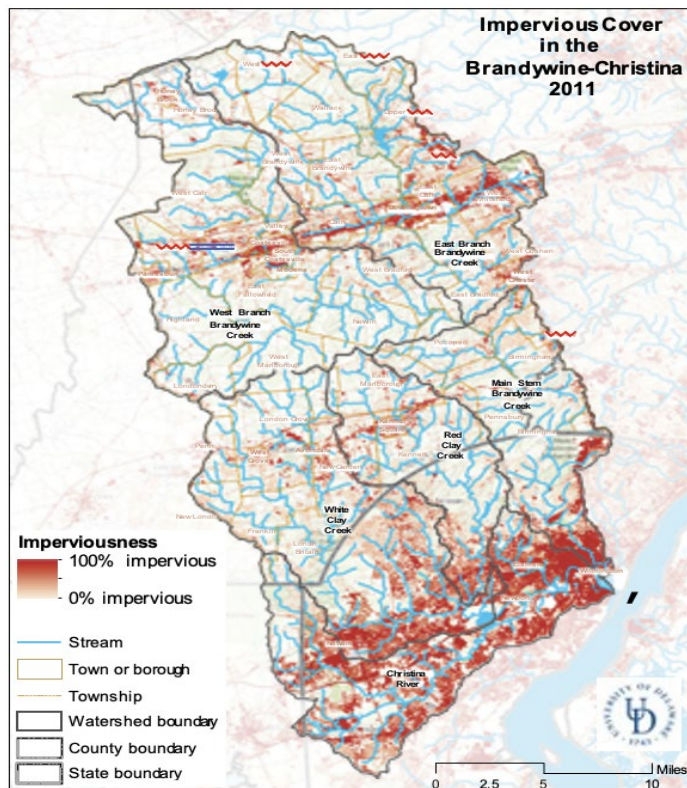
Overall, the Brandywine-Christina watershed, as well as each watershed within, between 1996 and 2010 have seen an increase in developed land, and over the same period a corresponding decrease in agriculture and natural areas (Figure 19).



**Figure 19.** Change in land cover in the Brandywine-Christina watershed, 1996-2010. (NOAA C-CAP)

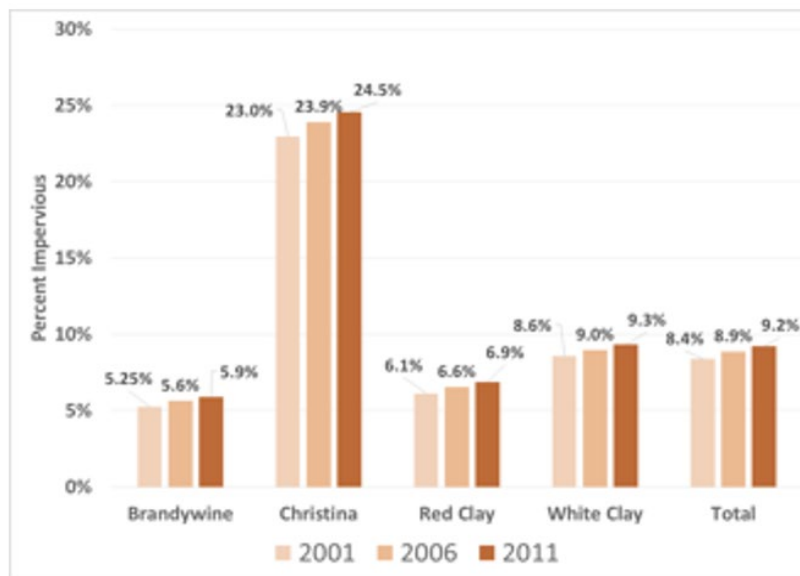
## Impervious Cover

Impervious cover in the Brandywine watershed increased from 5.2% in 2001 to 5.9% by 2011 (Figure 20 and 21).



**Figure 20.** Impervious cover in the Brandywine-Christina watershed, 2011 (USGS NLCD).





**Figure 21.** Imperviousness by year and watershed from 2006 - 2011 (USGS NLCD).

## Protected Lands

Aside from federal, state, county and municipal expenditures acquiring public park land, until the 1990s most of the lands protected in the watershed were done so through voluntary charitable donations. But as development pressure increasingly consumed more open space, citizens in Chester County clamored for funds to preserve land. In 1989, the county raised \$50 million through the issuance of a bond to fund the preservation of farmland and natural areas and help municipalities acquire parks. Chester County has ever since continued its financial commitment to protecting open space. Since that initial bond, the county has spent over \$202,089,390 to preserve open space (Source: Chester County Open Space Preservation). By the early 2000s, local townships felt the need to create and fund their own open space preservation programs, albeit on a more modest scale than the county.

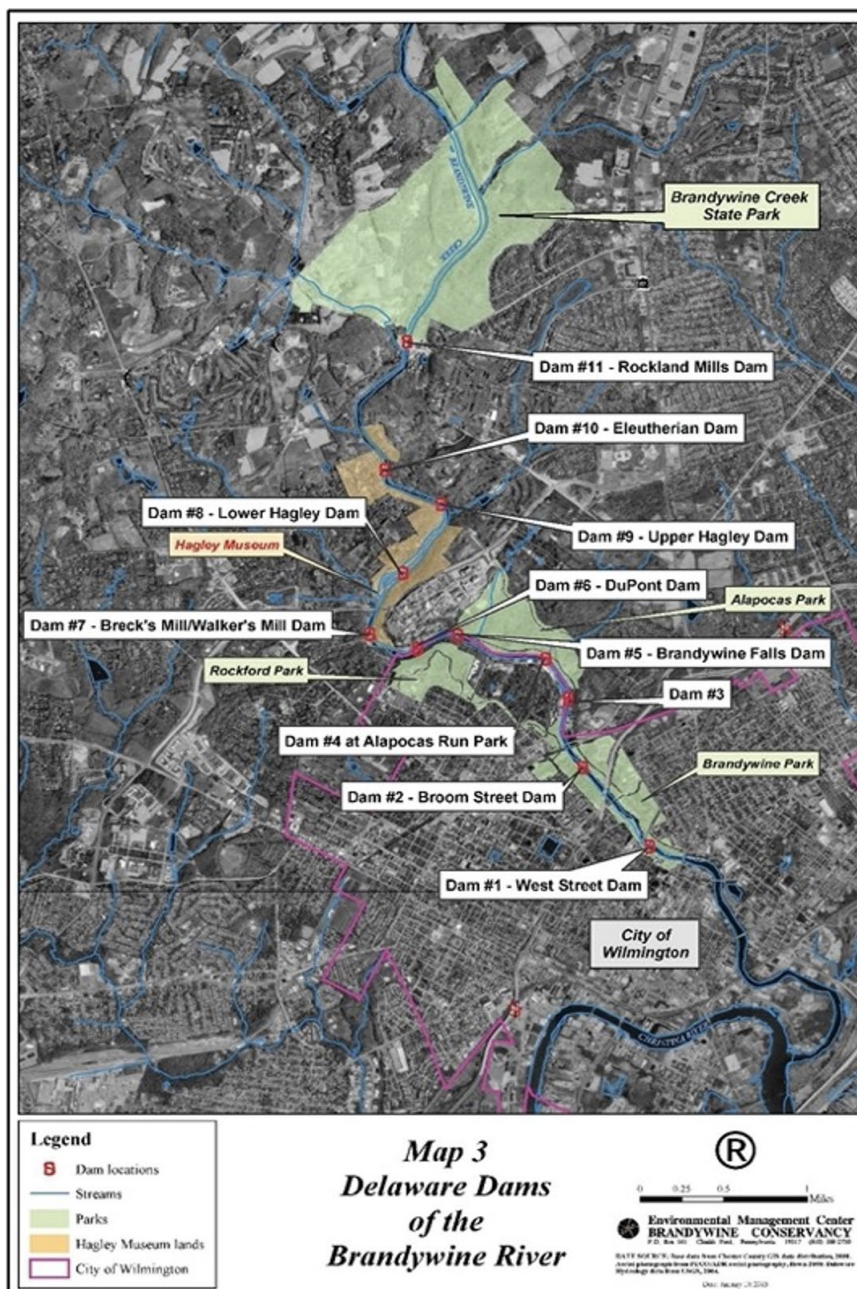
Today, 17 municipalities within the watershed have adopted and are funding open space preservation programs, spending millions of dollars toward the effort. Many of the nonprofits are using additional funds from their organizations and other funding sources (including grants from the state and private foundations) to leverage county and municipal funding, or for independent non-county funded preservation projects. The Brandywine-Christina watershed contains extensive amounts of protected open spaces. These protected lands include: (1) land trusts and other nonprofit organizations, (2) agricultural or conservation easements held by land trusts, (3) agricultural easements held by the county and/or state, (4) public lands, and (5) other protected lands (Homeowner Association (HOAs) properties and known deed restricted lands). The Brandywine Creek watershed has 31% of its land protected (Table 8).

**Table 8.** Protected lands in the Brandywine-Christina watershed

Protected Type	Brandywine (acres)	Percentage of Watershed	White Clay (acres)	Percentage of Watershed	Red Clay (acres)	Percentage of Watershed	Christina (acres)	Percentage of Watershed
Eased/fee-owned to land trusts	32,322	16%	4,802	7%	4,980	14%	349	1%
County/state ag. Easements	11,879	6%	3,261	5%	1,036	3%	9	0%
Public lands	12,303	6%	9,154	13%	1,521	4%	4,292	9%
Other protected (HOA, etc.)	7,882	4%	2,241	3%	1,775	5%	2,595	5%
Total Protected Lands	64,386	31%	19,458	28%	9,312	27%	7,245	15%

## Fish Passage

Fish passage research, focused on the Delaware portion of the Brandywine and White Clay creeks, with an effort to restore American shad migration, has been undertaken by the Brandywine Conservancy and the University of Delaware Water Resources Center. These groups, in partnership with numerous stakeholders, have compiled key information on the dam land- scape in the Delaware portion of the Brandywine and White Clay creeks. In 2005 the Brandywine Conservancy, funded through a grant by the National Fish and Wildlife Foundation (NFWF), undertook an analysis of the feasibility of restoring American shad to the Brandywine River, *The Restoration of American Shad to the Brandywine River: A Feasibility Study* (2005). The initial focus of this work was on the 11 dams located in Delaware (Figure 22). This feasibility report identified partner organizations for the restoration efforts, identified dam owners and key stakeholders, dam function and fish passage options and identified technical and legal requirements including costs and sources of funding for fish passage. This report indicated there are technically feasible options for providing fish passage at all of the dams (Brandywine Conservancy, 2009).



**Figure 22.** Delaware dams along the Brandywine River (Brandywine Conservancy, 2005).

## Wastewater Dischargers

NPDES wastewater dischargers in the Brandywine Christina watershed possess Federal and state water quality permits to treat and discharge a permitted maximum 17.64 million gallons per day (mgd) by 26 permittees. The majority of the 26 dischargers are located in Pennsylvania with only two in Delaware and two in Maryland. Federal and state water quality permits allow a maximum 15.5 mgd to be treated and discharged to Brandywine Creek watershed (Table 9).

**Table 9.** Wastewater dischargers in the Brandywine-Christina watershed (DNREC and PADEP)

NPDES ID	SEWAGE TREATMENT PLANT	DISCHARGE (MGD)
<b>BRANDYWINE</b>		<b>15.47</b>
<b>Main Stem</b>		
DE0021768	Winterthur	0.025
PA0055476	Birmingham TSA/Ridings at Chadds Ford TB Harvey Creek Municipal Small STP	0.04
PA0244031	Chadds Ford Township Harvey Run	0.15
PA0030848	Unionville-Chadds Ford Elem. School Ring Run Municipal Small STP	0.01
PA0031097	Radley Run C.C. Radley Run Municipal Small STP	0.02
PA0053449	Birmingham Twp. STP Radley Run Municipal Small STP	0.15
PA0036200	Radley Run Mews Plum Run Municipal Small STP	0.03
<b>East Branch</b>		
PA0026018	West Chester Borough MUA/Taylor Run Taylor Run Municipal Large STP	1.8
PA0043982	Broad Run Sew Co. EB Brandywine Creek Municipal Large STP	0.4
PA0026531	Downingtown Area Regional Authority EB Brandywine Creek Municipal Large STP	7.5
PA0054917	Uwchlan Twp. Municipal Authority Shamona Creek Municipal Eagleview CC STP	0.48
PA0027987	Eaglepoint Dev. Assoc. TB Marsh Creek Municipal Small STP	0.02
PA0050458	Little Washington Drainage Co. Culbertson Run Municipal Small STP	0.05
PA0050547	Indian Run Village MHP Indian Run Municipal Small STP	0.04
<b>West Branch</b>		
PA0036897	South Coatesville Borough WB Brandywine Creek Municipal Large STP	0.39
PA0026859	Coatesville City Authority WB Brandywine Creek Municipal Large STP	3.85
PA0036412	Tel Hai Retirement Community TB-WB Brandywine Creek Municipal Small STP	0.06
PA0044776	NW Chester Co. Municipal Authority WB Brandywine Creek Municipal Large STP	0.6

## **Appendix D**

### **Red Clay Creek**

#### **Background**

The Red Clay Creek watershed is one of four major watersheds in the Christina Basin and is located in southern Chester County (PA) and northern New Castle County (DE). It flows into the White Clay Creek (near Stanton, DE) and the combined flow empties into the tidal Christina River near Churchmans Marsh. Except for the very lower reaches, which are tidal, the Red Clay Creek is a free-flowing stream.

Land use within the Red Clay Creek watershed is split among three major land use categories: agriculture, forest/wetland, and urban/suburban. Collectively the White Clay and Red Clay creeks and Brandywine and Christina River supply drinking water to more than  $\frac{3}{4}$  of New Castle County's population. The Red Clay Creek watershed serves as a source of drinking water supplies with one reservoir (Hoopes) and several public water supply wells that provide water supply to parts of Chester and New Castle counties. Four surface water intakes and numerous wells are located within the watershed for commercial and community water supplies. Six municipalities in Pennsylvania and unincorporated New Castle County, Delaware are within the watershed.

As the smallest watershed in the Christina Basin, the Red Clay Creek also holds the smallest population with just under 48,000 people (U.S. Census 2010). Watershed residents reside in six Pennsylvania municipalities, including Kennett Township, Kennett Borough, New Garden Township, and East Marlborough Township as well as unincorporated areas of northern Delaware. Red Clay Creek contributes as a drinking source for Delaware, containing surface water intakes and wells for community and commercial water supplies, supporting two community public water-supply systems. Veolia Delaware also uses water from the Red Clay Creek watershed as drinking water for its customers, taking water from the Red Clay and White Clay Creeks' confluence.

#### **History**

A number of historic and cultural resources are in the Red Clay Creek watershed including Longwood Gardens, the Delaware Nature Society, and Mt. Cuba Center. Kennett Square was a known stop for the Underground Railroad with many of the conductors, people who aided fleeing slaves, of Quaker descent. The Red Clay Valley is also the site of the historic Wilmington and Western Railroad originally chartered in 1867 that runs along the Red Clay Creek, transporting passengers, freight, and industrial materials to and from mills and ports throughout its lifespan. After many changes of hands and uses throughout the past century, about 10 miles of the track remain and is owned and operated by the Historic Red Clay Valley, Inc. Because of the rich natural and American history, the National Park Service designated the Red Clay Valley Scenic Byway in 2005.

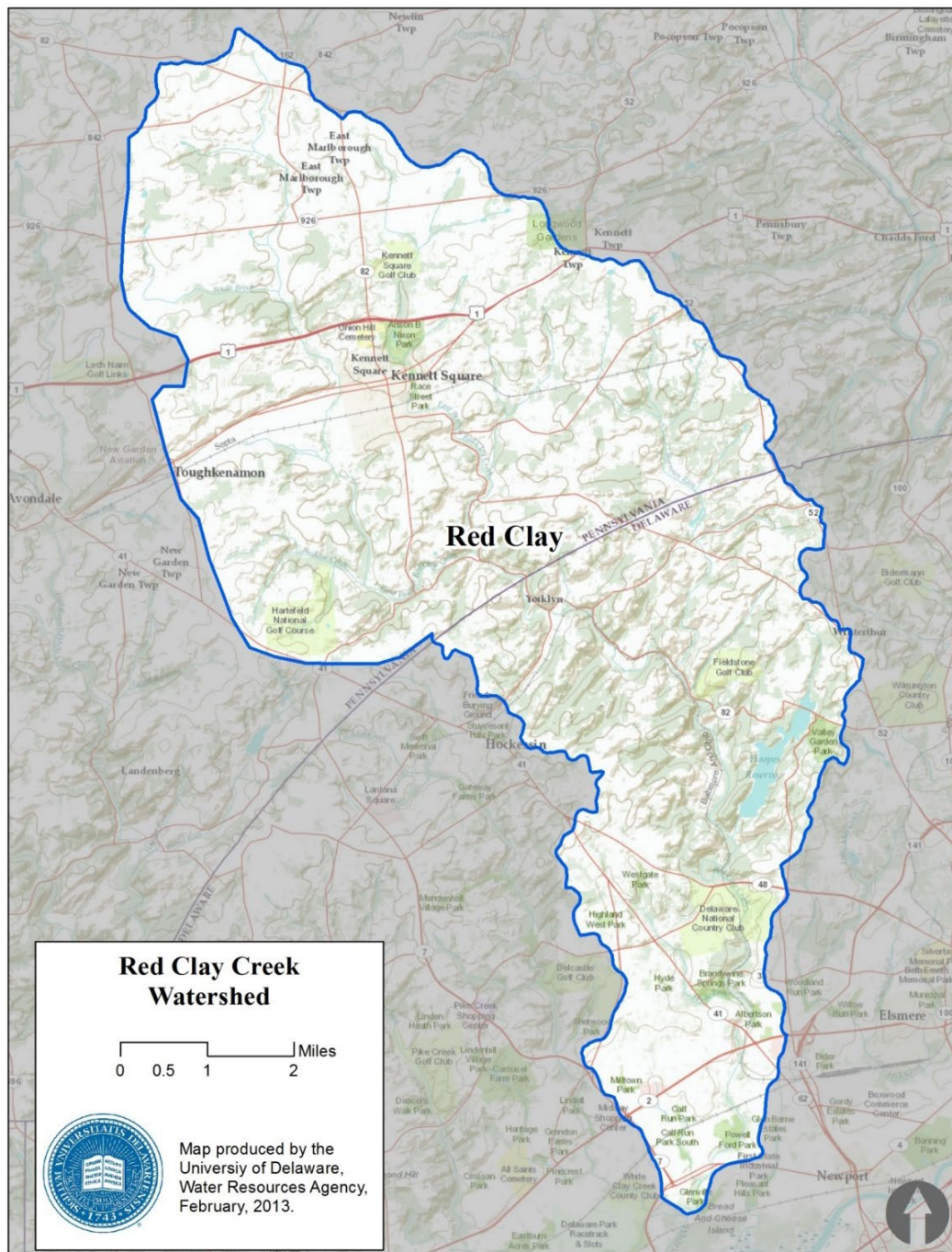
The Red Clay Valley is also partly the home of the world-renowned Longwood Gardens. Before the colonies, the Longwood area was inhabited by the Lenni Lenape, who used its forest and wild resources for survival. In 1700, the land was purchased from William Penn by the Peirce family and became a Quaker farm. In 1798, the family established an arboretum within the farm which became known as one of the nation's best collections of trees. The farm even became one of the nation's first public parks. A little over 100 years later, upon threat of the destruction of these trees, Pierre du Pont (great-grandson of Eleuthère Irénée du Pont the founder of E.I. du Pont de Nemours & Company) purchased the farm to save the arboretum and pursue his conservation and horticulture interests.

#### **The Watershed**

Spanning about 56 square miles, the Red Clay Creek watershed is the smallest of the four watersheds in the Christina Basin (Figure 1). Located in southern Chester County, PA and northern New Castle County, DE, the Red Clay Creek watershed consists of five subwatersheds: Burrows Run, Lower Red Clay Creek, Upper Red Clay Creek, West Branch Red Clay Creek, and East Branch Red Clay Creek. Within the watershed is Hoopes Reservoir found near Wilmington, Del., which is used by the City of Wilmington for drinking water storage. The source of the reservoir water is pumped from the Brandywine Creek rather than the Red Clay Creek. Red Clay Creek a free-



flowing stream although its lower reaches in Delaware are tidal at the confluence with White Clay Creek near Stanton, DE. The Burrows Run is designated as a coldwater fishery. Red Clay Creek is listed in the 303d list of impaired waters the Federal Clean Water Act with bacteria, nutrients (nitrogen, phosphorous), zinc and polychlorinated benzenes (PCBs), chlorinated pesticides, and dioxin which have led to fish consumption advisories.

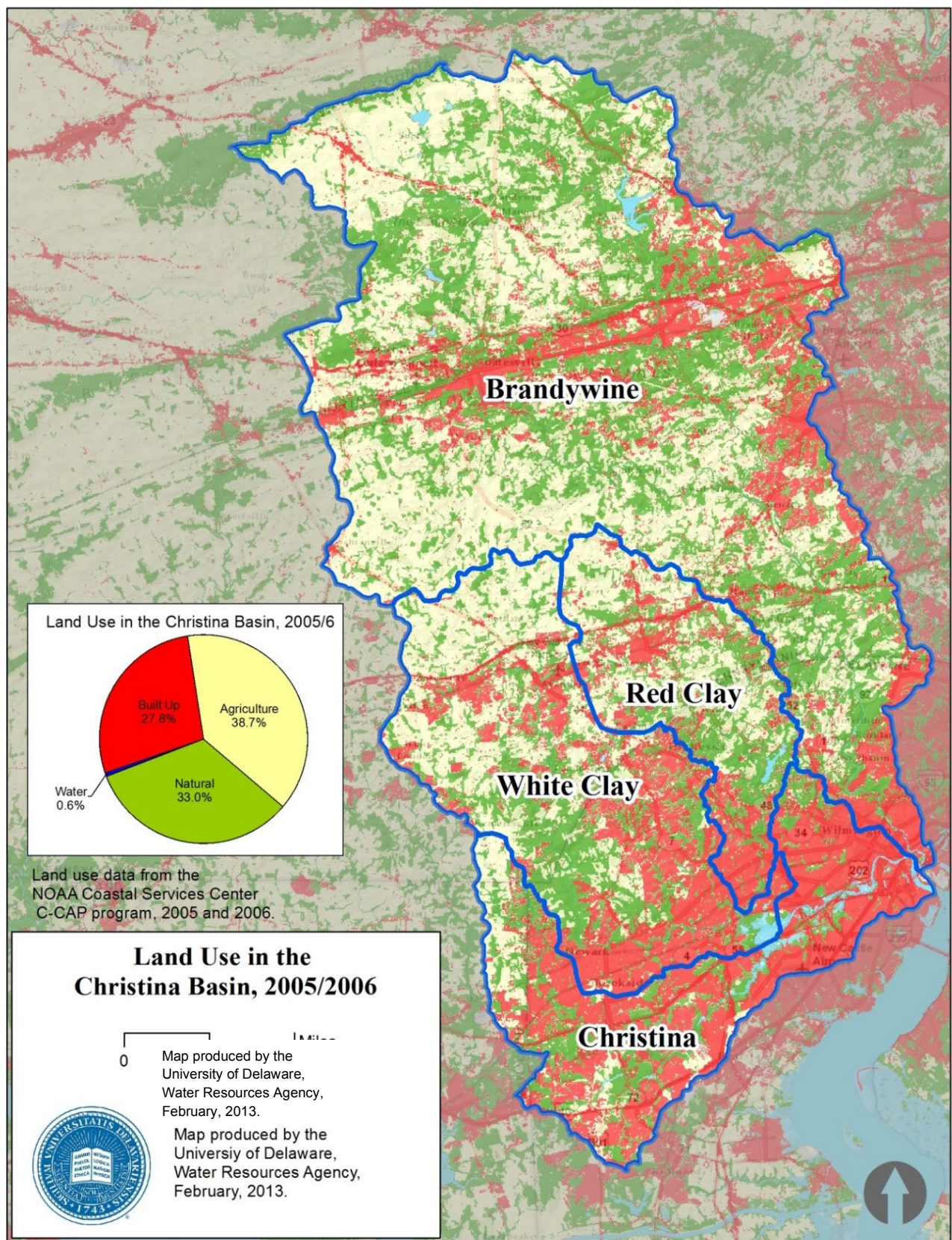


**Figure 1. Red Clay Creek watershed**

## Land Use

The largest land cover in the Red Clay Creek is forest land at 39%. Farmland is the second largest land use at 31% followed by urban land cover at 27%. Freshwater wetlands and open freshwater have the smallest cover at 2% and 0.6%, respectively (Table 1, Figure 2 and 3).

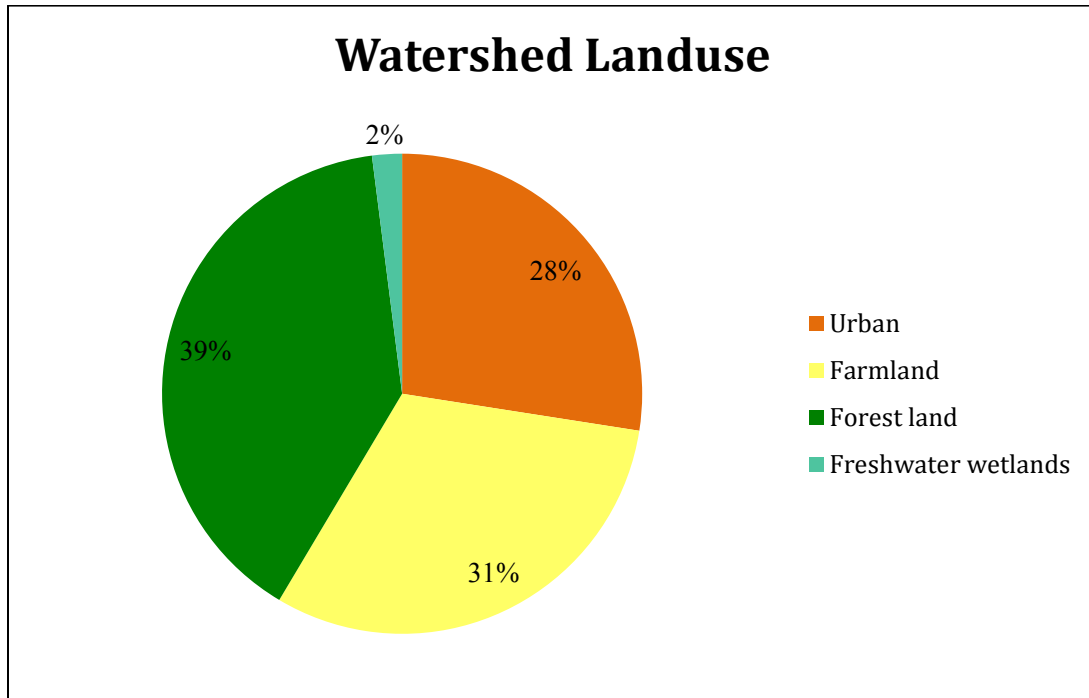




**Figure 2.** Land cover in the Red Clay Creek watershed (NOAA CSC 2006)

**Table 1.** Land use in the Red Clay Creek watershed

Ecosystem	Area (mi <sup>2</sup> )	% Area
Urban	15	27.3%
Farmland	17	30.9%
Forest land	21	39.2%
Freshwater wetlands	1	2.0%
<b>Total</b>	<b>54</b>	<b>100.0%</b>

**Figure 3.** Land use in the Red Clay Creek watershed (NOAA CSC 2006)

## Population

Between 2000 and 2010, the population in the Red Clay Creek watershed grew by 5,032 (11.8%) from 42,630 to 47,662 (Table 2). The watershed is most populated in its Delaware portion, which is also the portion with the greatest land area, at 24,083 people. The smaller Pennsylvania portion of the watershed houses the remaining 23,579 people (Table 3).

**Table 2.** Population change in the Red Clay Creek watershed, 2000-2010

Area (mi <sup>2</sup> )	2000 pop.	2010 pop.	Change	2000 (pop/ mi <sup>2</sup> )	2010 (pop/ mi <sup>2</sup> )
54	42,630	47,662	5,032	789	883

**Table 3.** Population of Red Clay Creek watershed by state

State	Area <sup>1</sup>	2010 pop. <sup>2</sup>	2010 (pop/mi <sup>2</sup> )
Pennsylvania	33	23,579	715
Delaware	21	24,083	1,147
<b>Total</b>	<b>54</b>	<b>47,662</b>	<b>1,862</b>

1. U.S. Census 2. NOAA CSC 2006



## Employment

In 2010, employment in the Red Clay Creek watershed was 23,490, compared to 498,886 in Chester County, PA and 538,479 in New Castle County, PA (Table 4).

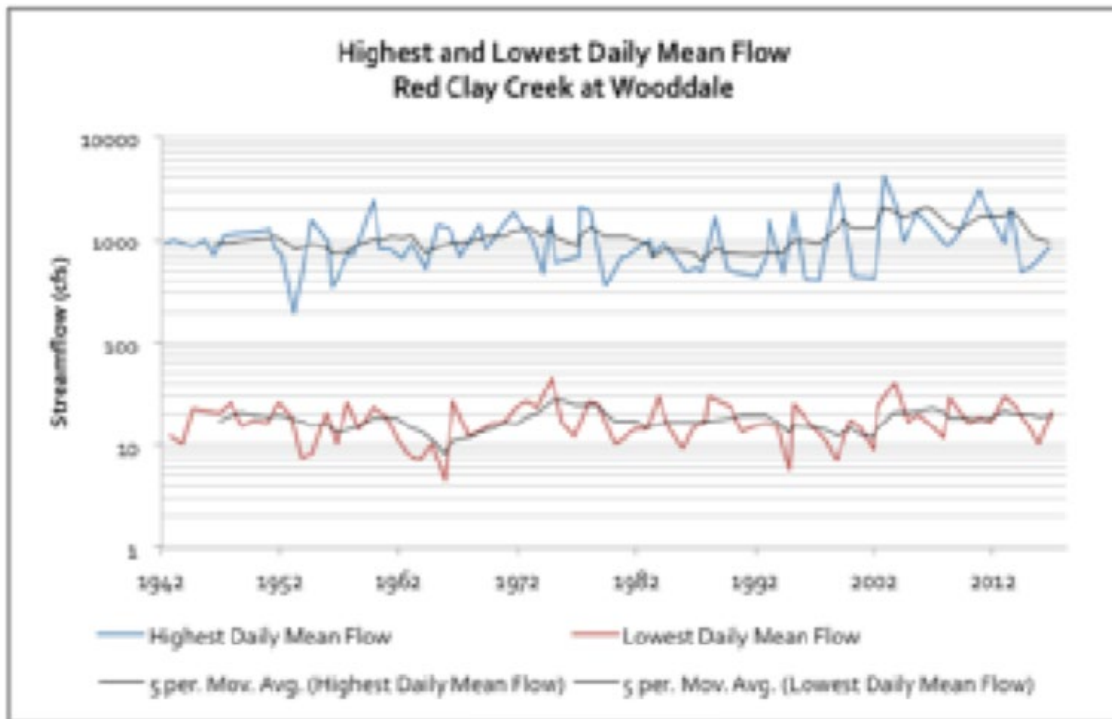
**Table 4.** Employment in the Red Clay Creek watershed in 2010

County	County <sup>1</sup> Population	Watershed <sup>1</sup> Population	County <sup>2</sup> Employment	Watershed <sup>3</sup> Employment
Chester County	498,886	23,579	249,515	11,793
New Castle County	538,479	24,083	261,530	11,697
<b>Total</b>	<b>1,037,365</b>	<b>47,662</b>	<b>511,045</b>	<b>23,490</b>

1. US Census 2010. 2. U.S. Bureau of Labor Statistics 2011.

## Hydrology

With the onset of watershed urbanization and warming air temperatures, peak streamflows (floods) have increased since the 1960s along the Brandywine Creek at Chadds Ford, PA and Red Clay Creek at Wooddale and White Clay Creek near Newark, DE. Low flows, or droughts, at all three drinking water streams declined since the wet 1970s, bottomed out during the droughts of 1995-2002 and have since recovered over the last 15 years since the last drought. As part of the USGS/Chester County/ CCWRA cooperative program, the USGS evaluated flow data to determine if any statistically significant trends of change were evident over the entire period of record. For this evaluation, USGS reviewed data from one station in the Red Clay Creek watershed with respect to the bank full discharge (also referred to as the two-year recurrence for their entire periods of record). The USGS concluded that there were not statistically significant trends of change for the magnitude of peak streamflow equal to or greater than the two-year recurrence interval or the number of annual peak streamflows equal to or greater than the two-year recurrence interval (Sloto and Reif, 2017).



**Figure 4.** Peak and low streamflow at Red Clay Creek at Wooddale, DE since 1946. (USGS)

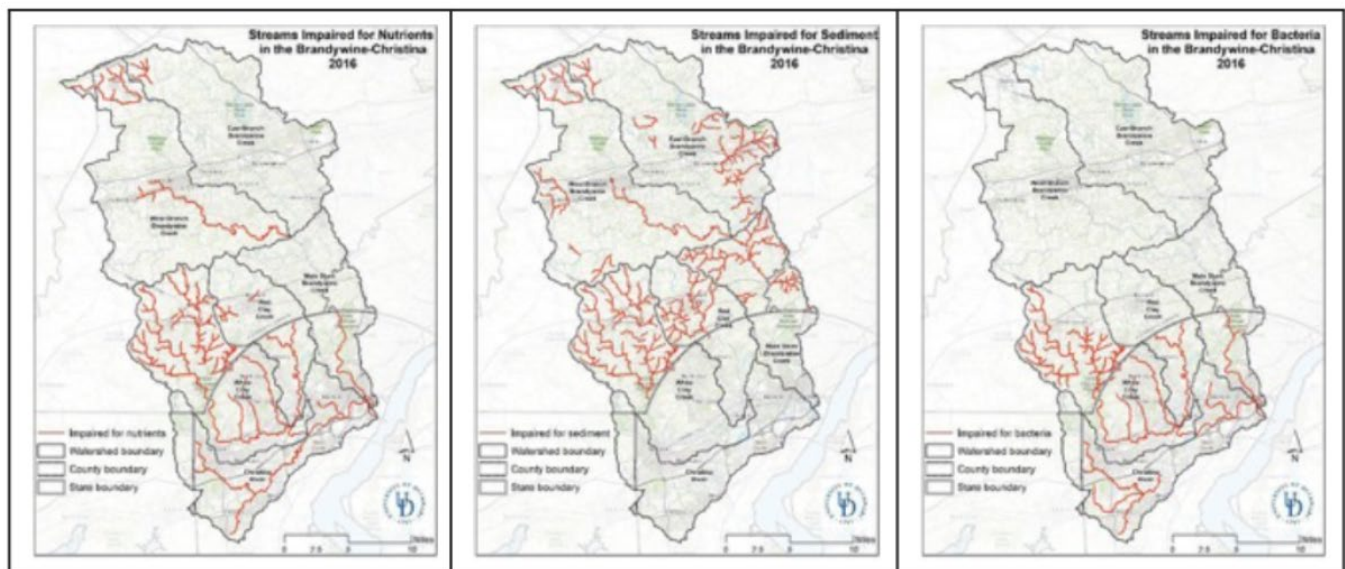
In the Red Clay Creek, Tropical Storms Henri (2003), Jeanne (2004) and Irene (2011) were the most significant storms for this period of record with the first, second, and third highest discharges respectively (Table 5).

**Table 5.** Peaks floods along Red Clay Creek at Wooddale.

RED CLAY CREEK AT WOODDALE, DE			
Date	Peak Discharge (cfs)	Named Storm	Flood Frequency
9/15/03	16,000	Henri	>100-yr
9/28/04	8,280	Jeanne	>50-yr
8/28/11	7,690	Irene	50-yr
9/16/99	7,650	Floyd	50-yr
4/30/14	5,830	Unnamed	>10-yr
10/1/10	5,530	Unnamed	>10-yr
6/28/06	5,490	Unnamed	>10-yr
7/21/75	5,010	Unnamed	>10-yr
6/20/03	4,820	Unnamed	>10-yr
9/12/60	4,780	Donna	>10-yr

## Impaired Streams

As pollutants enter the streams from all sources (wastewater discharges, wildlife, stormwater runoff from various land cover types, etc.), its levels can become high enough to have negative impacts. When pollutant levels in streams become too high the streams can no longer support certain uses that they normally could support, such as aquatic species and habitat, recreation, or water supply. The states of Pennsylvania and Delaware, under the federal Clean Water Act, are required to assess, inventory and report all stream segments and water bodies that do not meet their water quality standards for specific uses. This reporting serves as a basis for regulations aimed at restoring the water quality of the waterways and watershed health. TMDLs are one mechanism used by USEPA and the states to set target pollution loads to achieve healthy waters. Every two years Pennsylvania and Delaware update and report their inventories of impacted water bodies to USEPA, identifying waters that, based on testing protocols, do not meet the minimum standards. The states must identify the cause of the impairment, such as nutrients, sediment, bacteria, PCBs, metals, etc. When pollution reduction efforts result in water bodies meeting their water quality standards, they may be removed from the impaired list. Figure 5 below shows the impaired streams and their respective impairment categories. The Red Clay Creek Watershed has stream segments included in all three categories: nutrients, sediments, and bacteria.



**Figure 5.** Impaired streams in the Brandywine-Christina watershed for nutrients, sediment, and bacteria.

## Special Protection Waters

Both Pennsylvania and Delaware have designated certain waters that merit special protections due to their intrinsic importance based on water quality, habitat, ecological significance, sensitivity or recreational value. In Pennsylvania these waters have the designation of High Quality (HQ) or Exceptional Value (EV) waters, and receive special protections as specified in the Pennsylvania Code. Watersheds whose waters are designated High Quality must meet certain criteria for water quality and support of aquatic biota.

Pennsylvania is host to many streams with naturally reproducing trout. In the Brandywine-Christina watershed these fall mainly above the confluence of the East and West Branches of the Brandywine Creek. Trout is a species sensitive to water quality conditions in streams, and therefore the presence of naturally replicating populations is a potential indicator of a healthy watershed. Table 6 lists the Delaware-specific special protections, showing that the Red Clay Creek watershed includes designated use year-round for cold water fish (put and take), as well as ERES designation for Burrows Run, a stream segment running from the Pennsylvania line to the confluence with the Red Clay Creek.

**Table 6.** Special protection waters in the Delaware portion of the Brandywine-Christina watershed.

STREAM	PUBLIC WATER SUPPLY SOURCE	PRIMARY CONTACT RECREATION	SECONDARY CONTACT RECREATION	FISH, AQUATIC LIFE & WILDLIFE	COLD WATER FISH (PUT-AND-TAKE)	ERES WATERS*
<i>Brandywine Creek</i>	(a)	x	x	x	(b)	(h)
<i>Red Clay Creek</i>	x	x	x	x	(e)	(q)
<i>White Clay Creek</i>	(a)	x	x	x	(f)	(g)

(a) Designated use for freshwater segments only.

(b) Designated use from March 15 to June 30 on: 1. Beaver Run from PA/DE line to Brandywine, 2. Wilson Run Route 92 through Brandywine Creek State Park,

(c) Designated use from March 15 to June 30 on: 1. Christina River from MD/DE line through Rittenhouse Park.

(e) Designated use year round on: 1. Red Clay Creek from PA/DE line to the concrete bridge above Yorklyn

(f) Designated use year round on: 1. White Clay Creek from the PA/DE line to the dam at Curtis Paper. Designated use from March 15 to June 30 on: 2. Mill Creek from Brackenville Road to Route 7, 3. Pike Creek from Route 72 to Henderson Road.

(g) Designated use from PA/DE line to the dam at Curtis Paper.

(h) Designated use from PA/DE line to Wilmington city line.

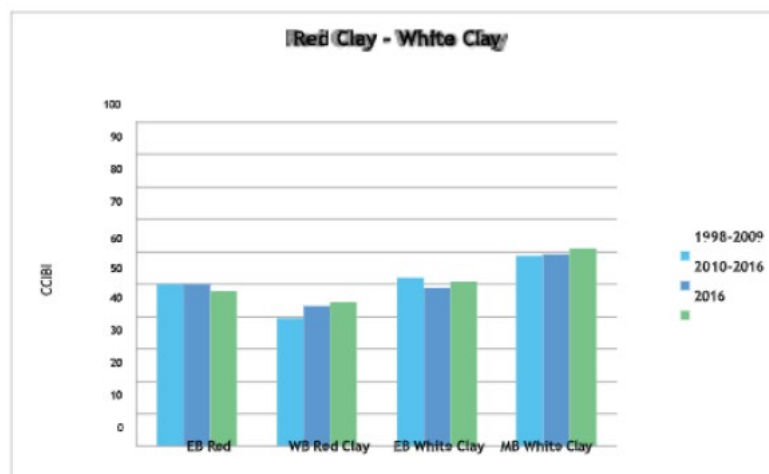
(q) ERES designation is for Burrows Run from the Pennsylvania Line to the confluence with Red Clay Creek

## Fish and Wildlife Resources

Benthic macroinvertebrates are aquatic organisms that live on the stream bottom. These serve as a useful tool to assess stream health at a specific site because they are directly impacted by water quality and physical conditions. Macroinvertebrate data is available for the Pennsylvania portion of the watershed through the biological monitoring network, established by the USGS and CCWRA. Macroinvertebrate data in Delaware is provided by the Delaware Nature Society.

Samples are collected October-December. The Chester County Index of Biotic Integrity (IBI) uses six individual metrics to provide a single IBI score 0-100 scale. IBI score is scaled to local conditions found in Chester County and are based on the same IBI metrics used by PADEP. The following data was collected 1998-2016 at the nine sites in the Brandywine-Christina watershed. In general, the higher the score the better the site and fluctuations are normal in invertebrate data. The scoring can be generally interpreted in three categories: 1. 80–100 (good water quality), 2. 60–79 (fair water quality), and 3. below 60 (poor water quality). In 2016, one site in the Red Clay had a score below 51: East Branch Red Clay. Figure 6 shows macroinvertebrate sampling data from 1998 to 2016 for both White and Red Clay Creek watersheds.

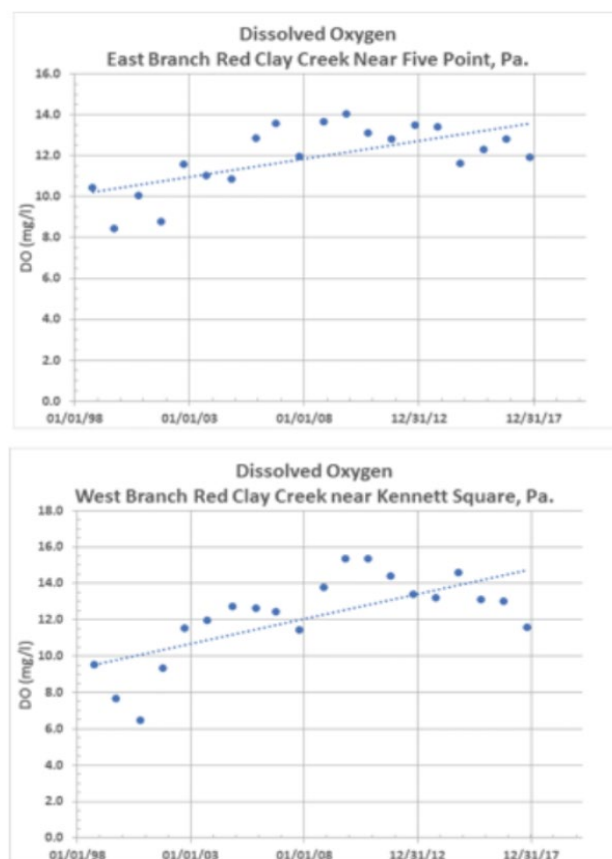




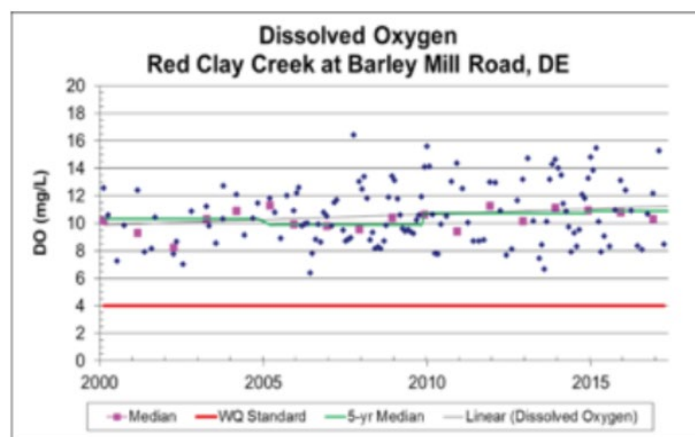
**Figure 6.** Macroinvertebrate sampling in the Red Clay Creek watershed. (USGS)

## Dissolved Oxygen

The USGS/Chester County/CCWRA cooperative program monitors dissolved oxygen (DO) levels. Figure 8 (right) shows DO data in the East and West branches of the Red Clay Creek over a 19-year period from 1998 to 2017. DO levels have increased since 1996 at all six water quality monitoring stations on the Brandywine, Red Clay, and White Clay creeks in Chester County, Pennsylvania. At water quality monitoring stations operated by DE DNREC, DO levels have increased since 2000 along the Red Clay (Figure 7).



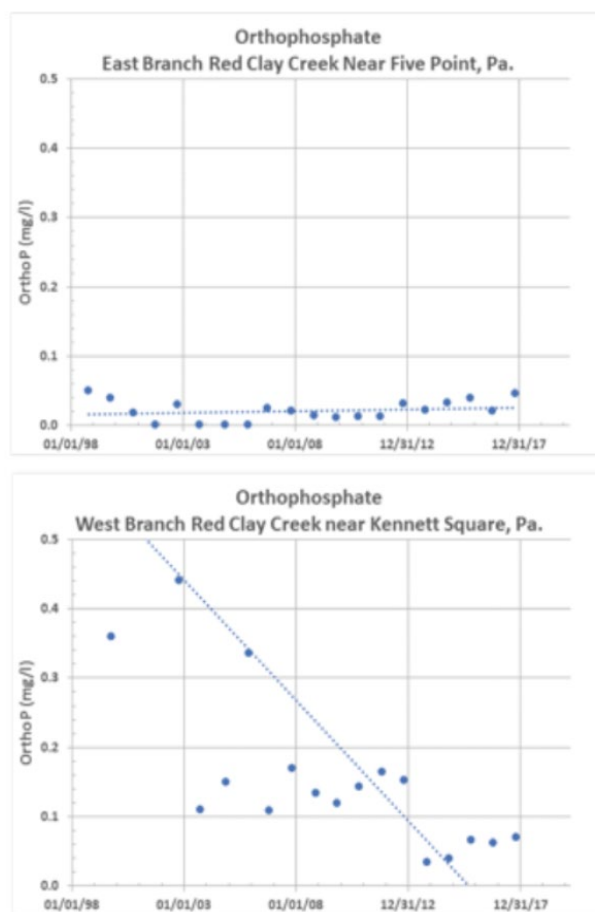
**Figure 7.** Dissolved Oxygen in the Red Clay Creek



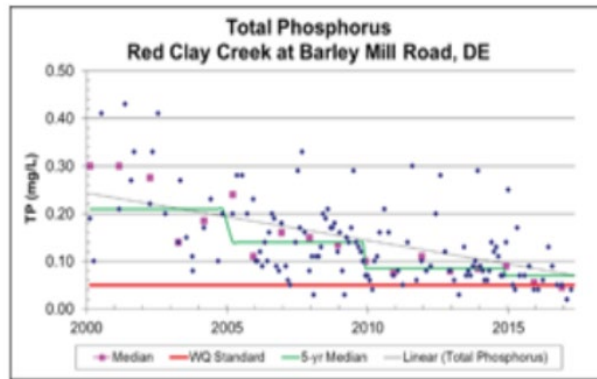
**Figure 8.** Dissolved oxygen in the Red Clay Creek from 2000 to 2015.

## Phosphorus

Orthophosphate levels have decreased since 1998 at three water quality monitoring stations operated by USGS and CCWRA along Red Clay in Chester County, PA. Orthophosphate levels remain low and constant along the East Branch Red Clay Creek (Figure 9). At water quality monitoring stations operated by DNREC, total phosphorus levels have decreased since 2000 along the Red Clay in Delaware (Figure 10).



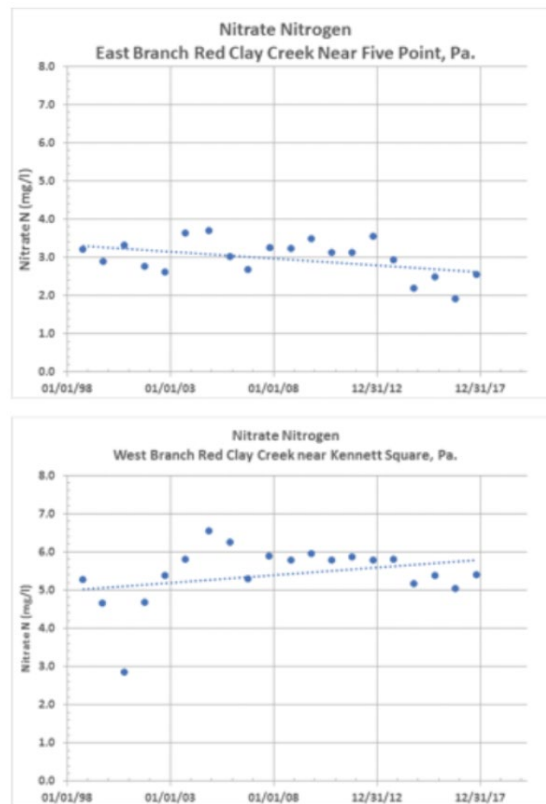
**Figure 9.** Orthophosphate along the Red Clay Creek



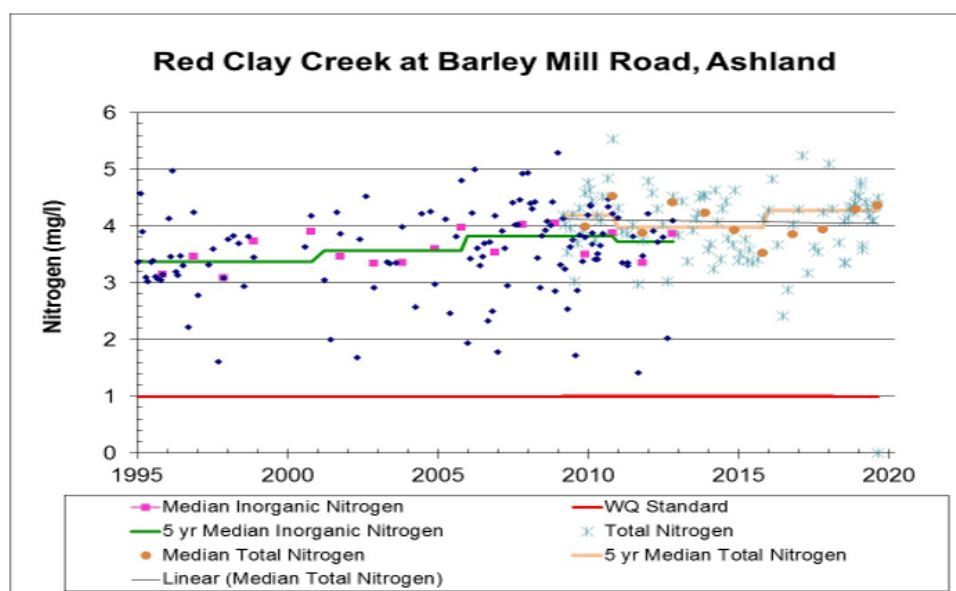
**Figure 10.** Total phosphorus along the Red Clay Creek

## Nitrogen

Nitrate nitrogen levels have increased since 1998 at water quality monitoring stations operated by the USGS and CCWRA along the West Branch of Red Clay Creek. Conversely, Nitrate levels have decreased along the East Branch Red Clay Creek. These trends can be observed in Figure 11.



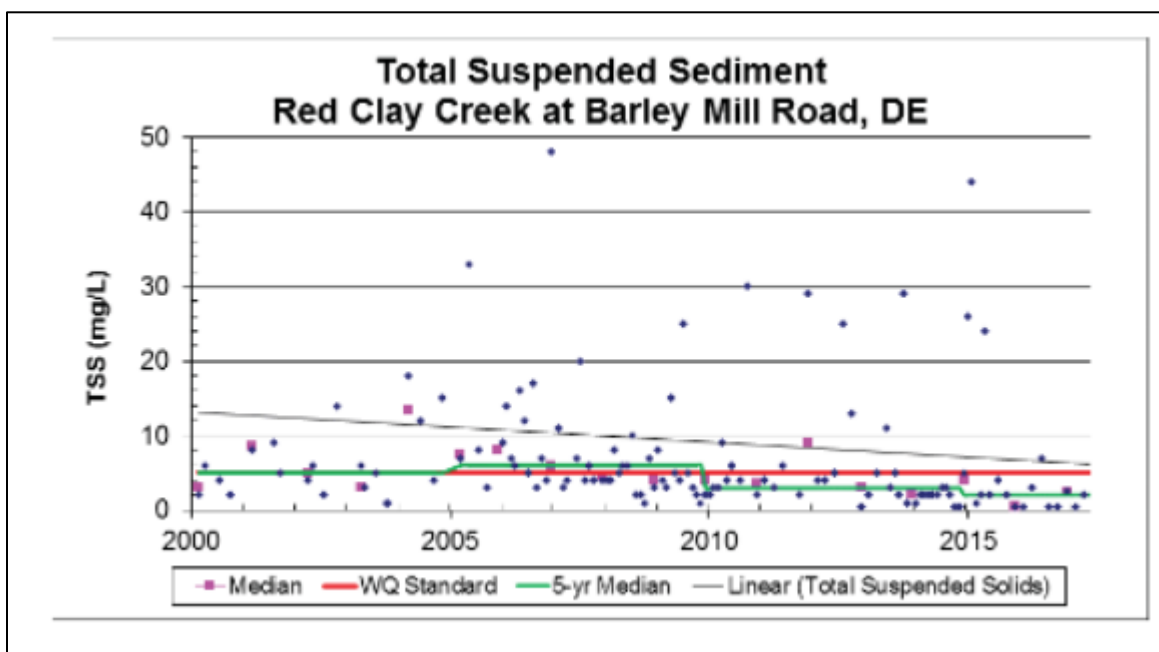
**Figure 11.** Nitrate nitrogen along the Red Clay Creek



**Figure 12.** Total nitrogen along Red Clay Creek

### Total Suspended Sediment

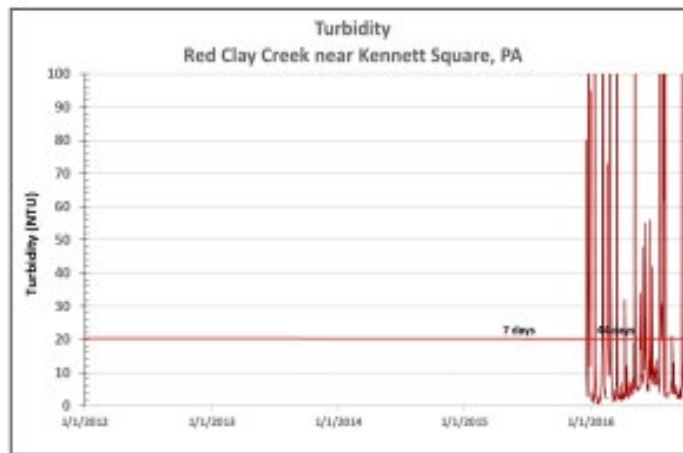
At water quality monitoring stations operated by DNREC, total suspended sediment (TSS) levels have decreased since 2000 and have approached the 40 mg/l target level along the Red Clay in Delaware (Figure 13).



**Figure 13.** Total suspended sediment along Red Clay Creek

### Turbidity

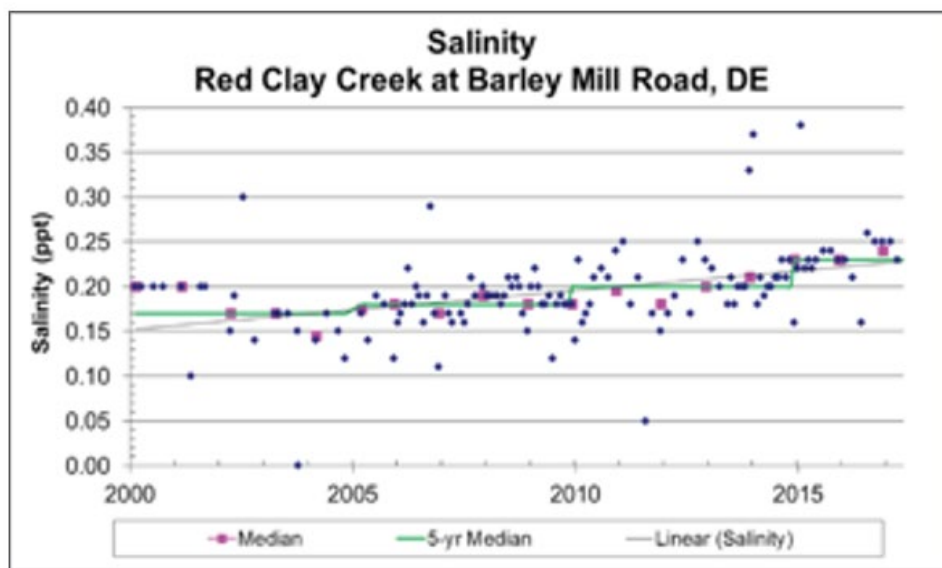
Water purveyors operate water supply intakes that curtail withdrawals turbidity exceeds 20 NTU. Between 2012 and 2016, water purveyors would have curtailed withdrawals when turbidity exceeded 20 NTU for 44 days along the Red Clay Creek (Figure 14).



**Figure 14.** Turbidity in the Red Clay Creek.

### Chloride/Salinity

Chloride and salinity levels in the Red Clay Creek are rising due to road salt. At water quality monitoring stations operated by DNREC, salinity levels have increased since 2000 along the Red Clay Creek watershed (Figure 15).

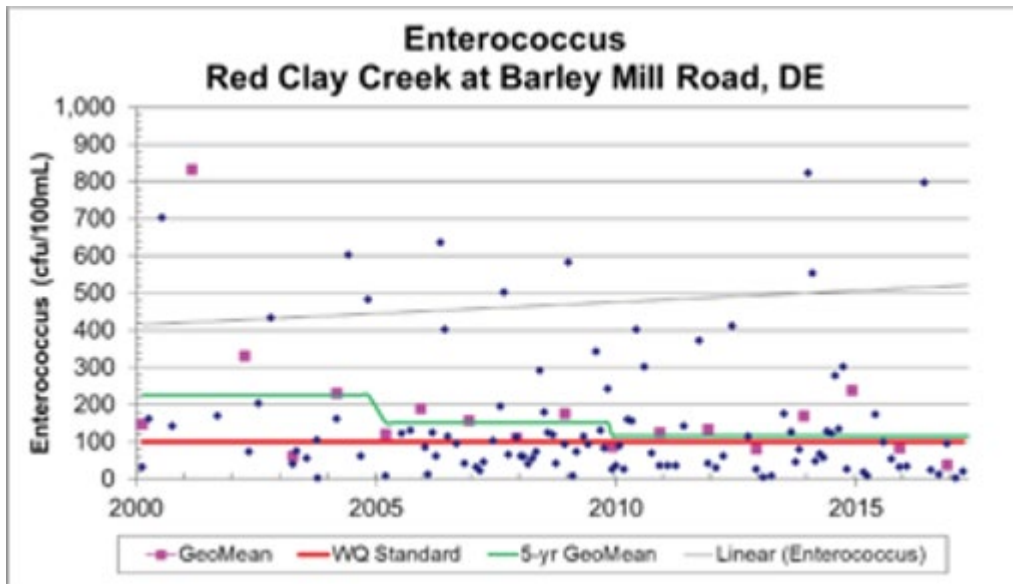


**Figure 15.** Salinity levels in the Red Clay Creek at Barley Mill Road.

### Bacteria

The USGS found that coliform levels typically decline below the 200 coliform forming units (CFU)/100 ml swimming recreation standard set by PADEP from September through April and then exceed the standard during the warmer months of June through September. Delaware uses *Enterococcus* bacteria levels as the indicator to determine impacts of pathogens in streams. Bacteria in streams can come from a wide variety of sources, including human and livestock waste and wildlife. Delaware's geometric mean bacteria standard for swimming is at 100 colony forming units per 100 mL (cfu/100mL). Five-year averages in the Red Clay Creek watershed have remained relatively stable and have exhibited yearly geometric means of less than the Delaware standard and, along with the other sites, contains bacteria levels much greater than 100 cfu/100mL (Figure 16).

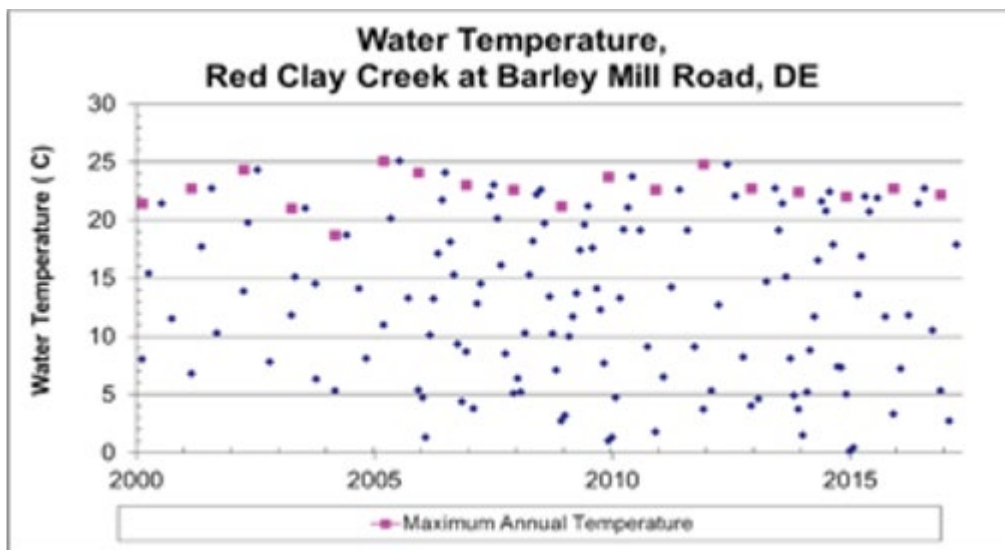




**Figure 16.** *Enterococcus* levels in the Red Clay over a 15-year period

### Water Temperature

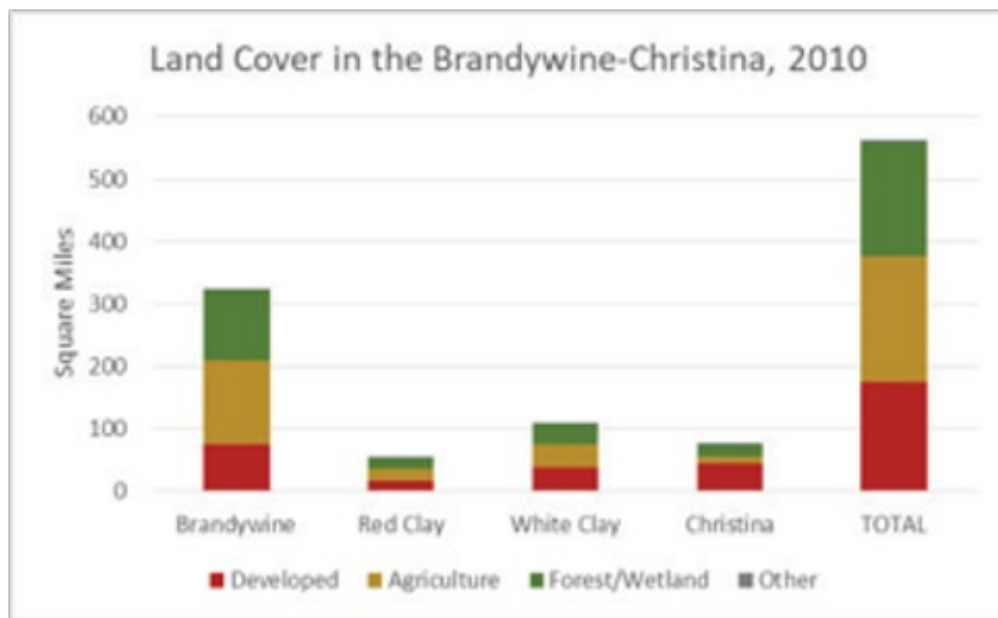
At water quality monitoring stations operated by the Delaware DNREC, there does not seem to be a noticeable rise or fall in stream water temperature since 2000 along the Red Clay Creek, as seen in Figure 17.



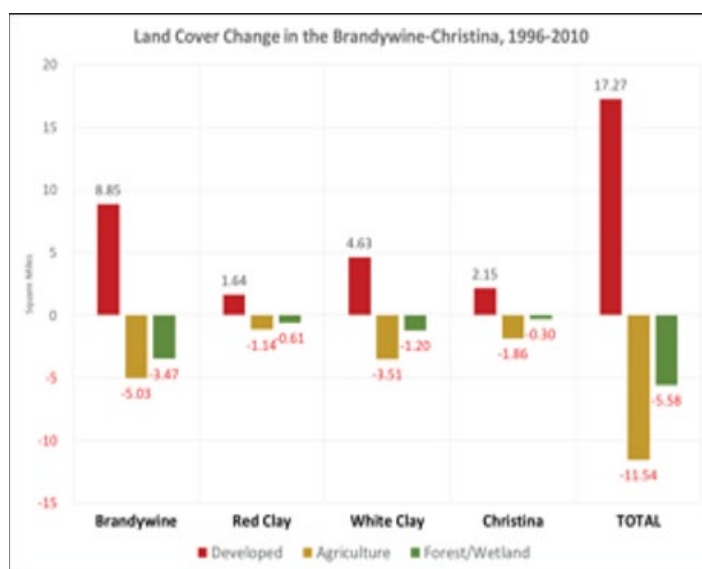
**Figure 17.** Maximum annual water temperature in the Red Clay Creek

### Land Use

The Red Clay Creek watershed extends into rural and suburbanized areas of Chester County and are experiencing increased growth. They also include areas of livestock and dairy farming, cultivated land and many mushroom farms. The Red Clay Creek watershed includes developed, agriculture, and forest/wetland land cover (Figure 18). Areas in the lower Red Clay Creek watershed have experienced increases in development and concurrent loss of agricultural land (Figure 19).



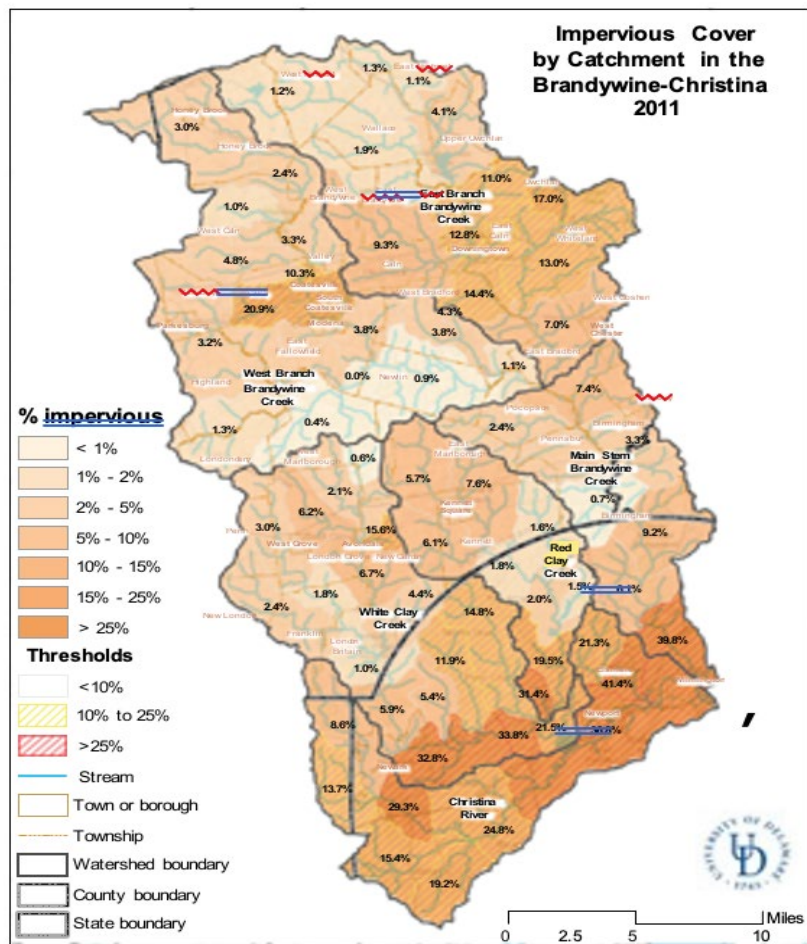
**Figure 18.** Land cover distribution in the various sub-watersheds.



**Figure 19.** Land cover change in the Red Clay Creek watershed

### Impervious Cover

Impervious cover is any land cover type that prevents rain water from percolating into the ground, such as roads, parking lots, sidewalks and rooftops. As water runs off hard surfaces it can pick up contaminants such as dirt, gravel and other solid debris, motor oil, nutrients, pesticides and other pollutants. Figure 20 shows high levels of impervious surfaces towards the lower end of the watershed in Delaware, the highest level reaching greater than 25% impervious.



**Figure 20.** Impervious cover in the Red Clay Creek watershed

## Protected Lands and Best Management Practices

The Red Clay Creek watershed is covered by 27% protected land with the most protected acreage in the “eased/fee-owned to land trust” category (Table 7).

**Table 7.** Protected land in the Red Clay Creek watershed

Protected Type	Brandywine (acres)	Percentage of Watershed	White Clay (acres)	Percentage of Watershed	Red Clay (acres)	Percentage of Watershed	Christina (acres)	Percentage of Watershed
Eased/fee-owned to land trusts	32,322	16%	4,802	7%	4,980	14%	349	1%
County/state ag. Easements	11,879	6%	3,261	5%	1,036	3%	9	0%
Public lands	12,303	6%	9,154	13%	1,521	4%	4,292	9%
Other protected (HOA, etc.)	7,882	4%	2,241	3%	1,775	5%	2,595	5%
<b>Total Protected Lands</b>	<b>64,386</b>	<b>31%</b>	<b>19,458</b>	<b>28%</b>	<b>9,312</b>	<b>27%</b>	<b>7,245</b>	<b>15%</b>

## Best management practices (BMPs)

The Red Clay Creek watershed is protected by 7.9 miles of riparian forest buffer, 1.6 miles of buffer fencing, and 77.9 acres of farm conservation plans (Table 8).

**Table 8.** Best management practices in the Red Clay Creek watershed

RED CLAY CREEK BMP DATA				
Riparian Forest Buffer	2,175 trees		20.4 acres	7.9 miles
Buffer Protection Fencing	1.6 miles			
Ag BMP highlights:	Practice Type		Metrics	
	Stream Crossings		2	
	Misc BMPs—Animal Trail, Grassed Waterway		18	
	Conservation Planning—including Grazing and Nutrient Mgmt		1	
				77.9

## Stream Restoration

Within the Brandywine and Red Clay watersheds eight sub-watersheds have been identified for restoration plans. These plans then indicate those stretches of stream which, when restored, can have the largest impact on water quality. Stream restoration has the goal of stabilizing streams so that bank erosion is minimized, habitat improved and aquatic life enhanced. To accomplish this goal the steep, eroding banks are graded to a lower slope and planted with native grasses and wildflowers. Instream structures such as cross vanes, J-hooks and root wads are used to maintain the stream channel, further protect the banks and to improve water quality and fish habitat.

## Fish Consumption Advisories

In the Red Clay Creek, from the mouth to the Delaware-Pennsylvania state line border, all finfish are deemed edible (Table 9). Consumption amounts have changed over a short period of time, dropping from six in 2015-2016 to only three suggested meals per year in 2018. Contaminants of concern in the Red Clay include: PCBs, dioxins, furans, dieldrin, DDT, DDD, and DDE. The segments of the Red Clay Creek in Chester County, Pennsylvania have some different advisory details. Eels in all segments except the East Branch are approved for 12 meals per year, and this suggestion did not change over time. The only listed contaminant of concern in this section is PCBs. Table 1 below shows the consumption advisory details in full.

**Table 9.** Fish consumption advisories

WATER BODY	GEOGRAPHICAL EXTENT	SPECIES	CONTAMINANT OF CONCERN	MEALS/YR <sub>1</sub>	
				2015/16 <sub>2</sub>	2018 <sub>3,4</sub>
DELAWARE					
Red Clay Creek	Creek Mouth to DE/PA Line	All finfish	PCBs, dioxins, furans, dieldrin, DDT, DDD and DDE	6	3
Red Clay Creek (Chester County)	Entire Basin (except East Branch Red Clay Creek)	American eel	PCB	12	12

## Wastewater Discharges

Two permitted surface discharge sewage treatment plants are in the Red Clay Creek watershed in Pennsylvania and are permitted to discharge 1.12 mgd (Table 10). In the Red Clay Creek watershed three dischargers moved to land application in 2001-2002 and two larger dischargers closed in 2007-2009.

**Table 10.** Wastewater discharges in the Red Clay Creek watershed

NPDES Permit facility	Flow (mgd)	Level 1 and 2 (% Reduction)		
		CBOD5	NH3-N	TP
<b>West Branch Red Clay Creek</b>				
PA0024058 – Kennett Square	1.1	34%	34%	83%
PA0057720 – Sunny Dell Foods	0.072	5%	5%	5%

## Dams

Currently the Red Clay Creek watershed has 11 dams that block fish passage and prevent fish migration throughout the 54 square mile watershed (Figure 21 and Table 11). Delaware Sea Grant and the UD Water Resources Center are cooperating with a National Fish and Wildlife Foundation (NFWF) supported research project that will identify the extent where fish passage is blocked and identify options to restore shad and diadromous fish migration so that the Red Clay Creek is restoring historic numbers of fish and meeting the intent of the Delaware Basin Fish and Wildlife Management Cooperative with the following objectives:

- Reopen 50 square miles of Red Clay Creek watershed to diadromous fish migration for first time in a century.
- Increase the number of diadromous and resident fish species.
- Create a self-sustaining population of fish resilient to recreational fishing pressure.
- Make the Red Clay Creek watershed free flowing again.
- Examine restored shad runs as a resurgence in stream water quality after decades of legacy pollution.

**Table 11.** Dams along the Delaware portion of Red Clay Creek.

Dam No.	Dam Name	River Station (ft)	Function	Height (ft.) / Width (ft.)
1	Kiamensi	9,500	None	13/100
2	CSX RR	13,470	None	8/100
3	W&W RR	17,030	None	5/105
4	Lancaster Pike	26,600	USGS stream gage	4/80
5	Covered Bridge Rd	35,000	None	7/50
6	Hoopers Res.	43,850	None	8/60
7	Sharpless Rd	56,300	Breached	8/70
8	Dam #8	58,750	Breached	8/90
9	Yorklyn Rd	62,150	None	4/80
10	DE/PA line	67,300	Mill Race	8/120



Figure 21. Dams along the Delaware portion of Red Clay Creek.

