Economic Value of the White Clay Creek Watershed

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Prepared for

The Christina Basin Task Force

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Executive Summary

The water, natural resources, and ecosystems in the White Clay Creek watershed contribute an economic value of $55 to $500 million annually to the economies of Pennsylvania, Delaware, and Maryland. This report examines that economic value in three different ways:

1. **Economic value directly related to the White Clay Creek watershed water resources and habitats.** The White Clay Creek watershed contributes over $500 million in annual economic activity from water quality, water supply, fish/wildlife, recreation, agriculture, forests, and public parks benefits.

2. **Value of goods and services provided by White Clay Creek watershed ecosystems.** Using natural capital as a measure of value, habitat in the White Clay Creek watershed provides $165 million annually in ecosystem goods and services in 2010 dollars, with a net present value (NPV) of $5.4 billion calculated over a 100-year period.

3. **Employment related to White Clay Creek watershed resources and habitats.** Using employment as a measure of value, natural resources within the White Clay Creek watershed directly and indirectly supports over 25,000 jobs with over $55 million in annual wages.

The purpose of these estimates is to demonstrate that the White Clay Creek watershed provides real and significant economic benefits to Pennsylvania and Delaware and is worthy of investment to keep these natural resources healthy and productive. Estimates were made by taking values from existing literature and studies and applying them to the White Clay Creek watershed using ecological economics and benefits-transfer techniques described in this report. Values are converted to 2010 dollars based on the change in the Northeast Region Consumer Price Index except where noted.

Note that the values in the three categories are not summed because there is some overlap between certain values within each category that could result in double counting. For example, the jobs of fishermen that contribute to employment and wages are also a factor in the economic activity generated from fishing, and the ecosystem values of forests for water-quality benefits may be at least partially captured in the economic value of water supply. Accurately determining (and eliminating) this overlap is difficult within the scope of this analysis.

The estimates presented in this report are as inclusive as possible due to a lack of data for some economic sectors. Additionally, they are not meant to be used to compare and contrast uses of the White Clay Creek's water resources for their value. Some values were not included in these estimates because the data to assess them either are not readily available or do not exist. For example, the full amount of economic activity and jobs associated with the industries that rely on the White Clay Creek watershed for their processes is not included here, because identifying those companies and gathering information on their economic activity is beyond the scope of this analysis.

1. Introduction

Objectives

This report summarizes the economic value of water, natural resources, and ecosystems of the White Clay Creek watershed in Chester County, Pennsylvania, New Castle County, Delaware, and Cecil County, Maryland estimated as:

1. Economic activity including market and non-market value of water quality, water supply, fish/wildlife, recreation, agriculture, forests, and public parks benefits.
2. Ecosystem goods and services (natural capital) value provided by habitat such as wetlands, beaches, open water, forests, and farms.
3. Jobs and wages directly and indirectly associated with the White Clay Creek watershed.

These estimates demonstrate that the White Clay Creek watershed provides significant economic benefits to the regional economy and are worthy of investment to keep them healthy and productive. Value-transfer techniques were applied by selecting data from published literature and applying them to the White Clay Creek watershed using ecological economics techniques.

Values in the three categories above are not summed because there may be overlap and double-counting. For example, the jobs of fishermen are also a factor in economic activity from fishing. The ecosystem values of forests for water-quality benefits are at least partially captured in the economic value of water supply. Accounting for this overlap is difficult. However, each of the above estimates clearly indicates that the White Clay Creek watershed is an economic engine that contributes between $55 million and $500 million annually to the Pennsylvania, Delaware, and Maryland economies.

The estimates presented in this report can be considered in the low range because the data to assess economic value are not readily available in some categories. For example, the full amount of economic activity and jobs associated with the companies and industries that rely on the watershed for their processes is not included here, because identifying those companies and gathering information on their economic activity is complicated and beyond the scope of this analysis. Since some estimates were made by taking values from existing literature, the values for various activities differ greatly in how they were determined and applied to the creek's water resources, making it difficult to accurately compare values across uses.

History

The White Clay Creek watershed is a historically significant area within the region. It was inhabited by the Lenni Lenape Native Americans for centuries before the arrival of European settlers in the 17th century. The first of these settlers were the Dutch and the Swedish, but they were soon followed by the English after William Penn acquired the land. The American and British troops marched through it during the Revolutionary War, and the Mason Dixon Line runs through it as well. Over the years, the watershed was developed into farms and small mills. Large tracts of land were owned by the DuPont family, and much of that land has since been converted into state park and preserve lands for the public to enjoy. Seven low dams that were once used for milling or rudimentary hydropower dot the creek, some dating back to before the nation's founding. Today, the area is still predominantly rural, but there has been significant suburbanization in the Delaware portion of the watershed.

Though relatively small, this area of land was highly valuable to the states, even in colonial times. A portion of the White Clay Creek watershed lies within what is commonly known as "the Wedge." This tiny piece of land at the intersection of Pennsylvania, Maryland, and Delaware was a hotly disputed region for many years. The Wedge's ownership was ambiguous because of faulty surveying completed in the 18th century, although Pennsylvania and Delaware both lay claim to it. Because of this ambiguity, the Wedge developed a reputation as a lawless area, and provided a haven for criminals, gamblers, and prize fighters. Eventually, the area was resurveyed in the late 1800's and Pennsylvania ceded its claim to the land. It was officially annexed by the State of Delaware in 1921.

In 2000, Congress passed a bill that designated the White Clay Creek as a Wild and Scenic River. The White Clay Creek is the only National Wild and Scenic River protected in its entirety. This designation seeks to promote watershed sensitive development and the preservation of natural and cultural resources.

The Watershed

The White Clay Creek watershed spans Delaware, Pennsylvania, and Maryland and drains 108 mi^2 (Figure 6). Approximately 55% of the White Clay Creek watershed lies in Pennsylvania, 45% lies in Delaware, and less than 1% lies in Maryland. The northern portion of the watershed in Chester County, Pennsylvania, includes the East, Middle, and West Branches of the White Clay Creek. The White Clay Creek flows southeast into New Castle County, Delaware, and is joined by Middle Run and Pike and Mill Creeks before emptying into the Christina River. Towns within the White Clay Creek watershed include Newark, Delaware, and Avondale and West Grove, Pennsylvania. Table 5 summarizes the drainage areas of the seven streams that make up the White Clay Creek watershed.

In 2000, the President signed a law adding 190 miles of the White Clay Creek and its tributaries to the National Wild and Scenic Rivers System. The White Clay Creek is the first wild and scenic river in the United States designated on a watershed basis rather than a river corridor.

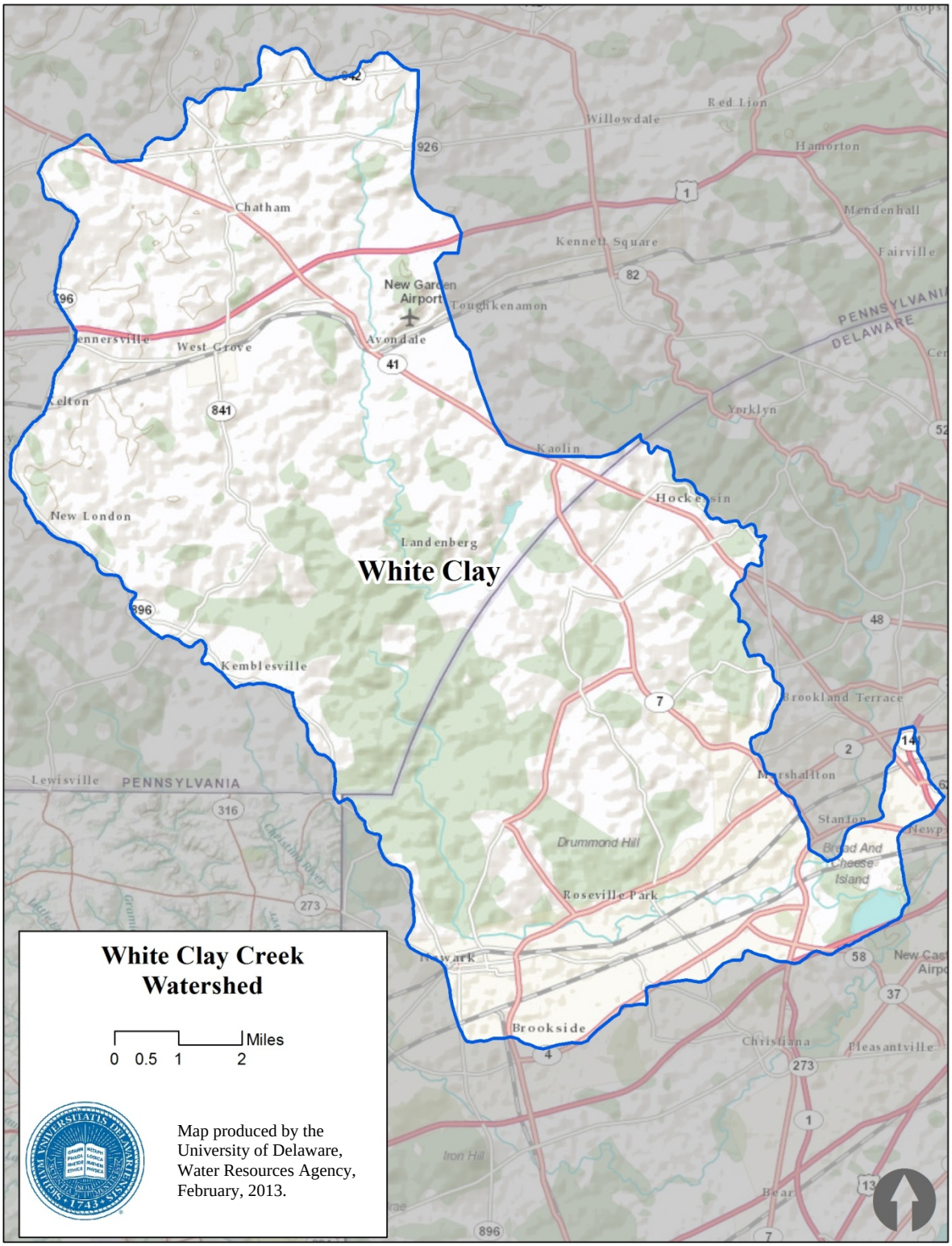

Figure 1. The White Clay Creek watershed

Land Use

Land use in the White Clay Creek watershed is more or less equally distributed among the three dominant land use categories. The exact distributions are as follows: urban (34%), farmland (30%), and forest (33%). (Table 1, Figure 2, and Figure 3).

Table 1. Land use in White Clay Creek watershed

Ecosystem	Area (sq. mi.)	Percent Area
Urban	37	34.2%
Farmland	32	29.8%
Forest land	35	32.6%
Freshwater wetlands	3	2.8%
Total	**107**	**100%**

Source: NOAA CSC, 2006

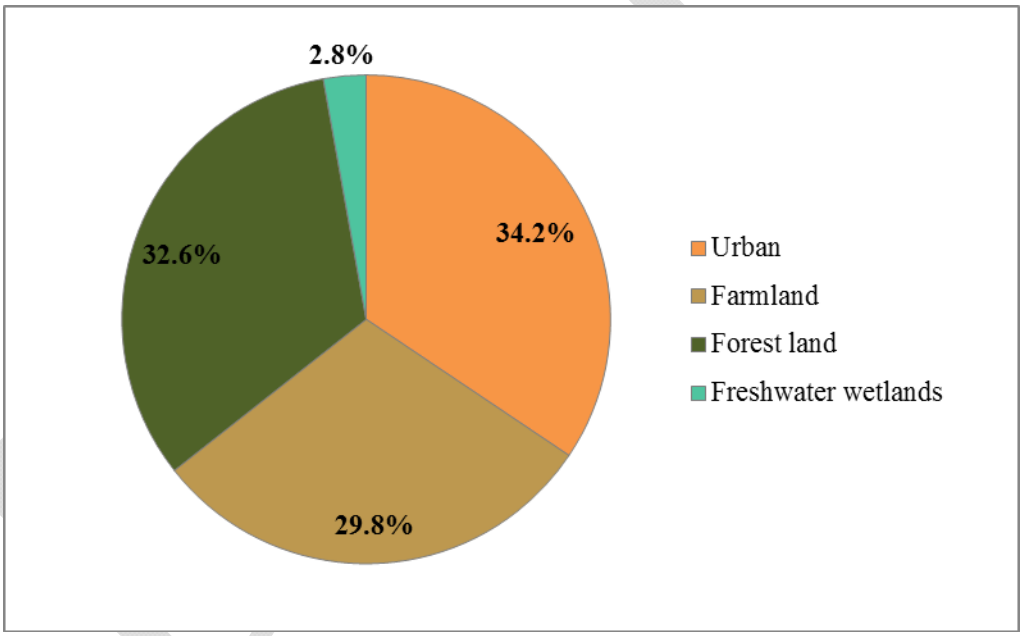

Figure 2. Percentage of land use in the White Clay Creek watershed

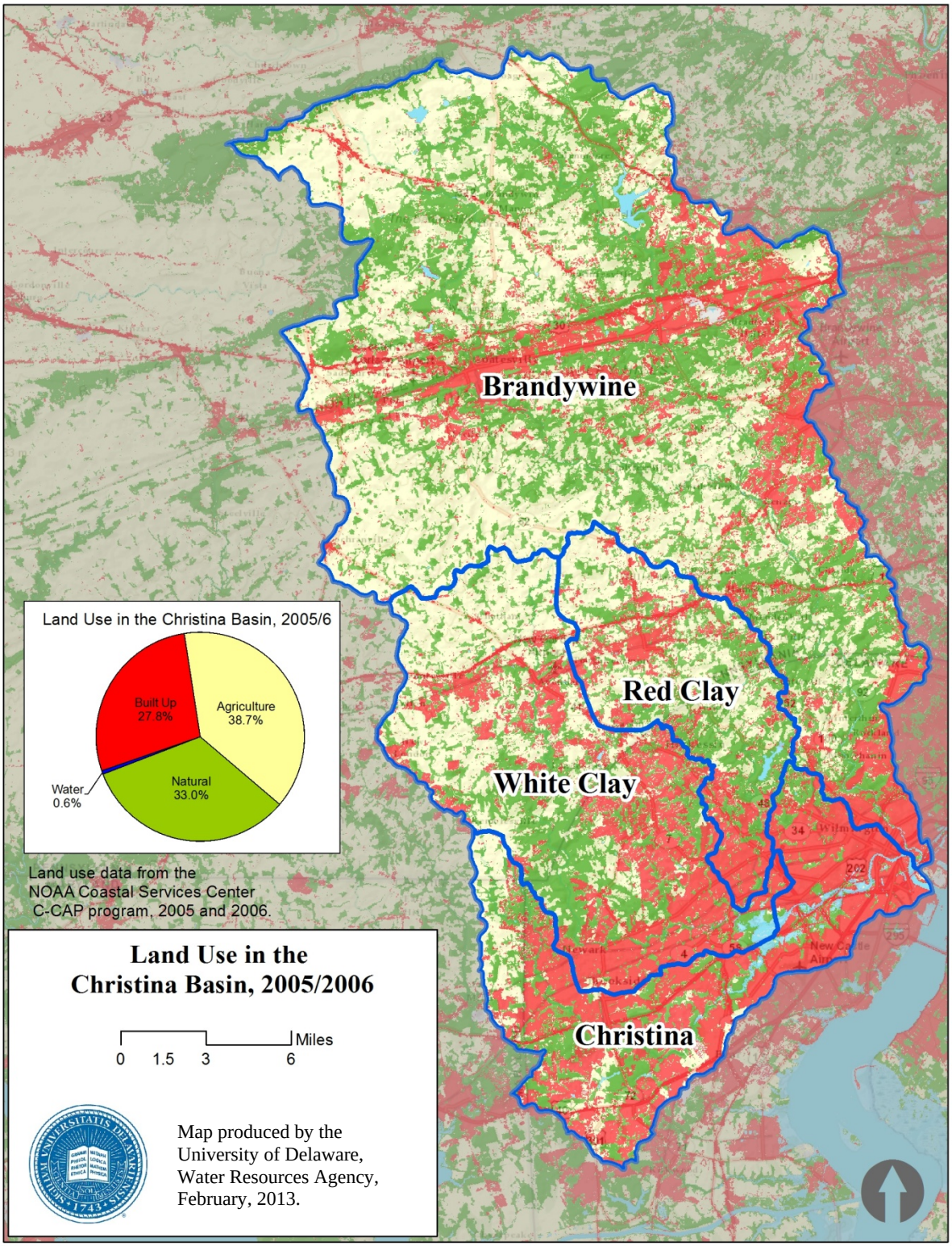

Figure 3. Land cover in the White Clay Creek watershed in 2006

Population

Between 2000 and 2010, the population in the White Clay Creek watershed grew by 6,266 (5.3%) from 118,579 to 124,845 (Table 3). The watershed is most populated in its Delaware portion, despite being smaller in land area than the Pennsylvania portion. The smallest portion of the watershed, both in population and land area, lies in Maryland. (Table 2).

Table 2. Population of White Clay Creek Watershed by state

State	Area[1]	2010 pop.[2]	2010 (people/sq. mi.)
Pennsylvania	61	27,638	453
Delaware	46	97,204	2,113
Maryland	0	3	-
Total	**107**	**124,845**	**1,167**

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

Table 3. Population change in the White Clay Creek Watershed, 2000-2010

Watershed	Area (sq. mi.)	2000 pop.	2010 pop.	Change	2000 (people/sq. mi.)	2010 (people/sq. mi.)
White Clay Creek	107	118,579	124,845	6,266	1,108	1,167

U.S. Census, 2010

Employment

In 2010, the total employment in the White Clay Creek watershed was 58,626. Employment in Chester and New Castle counties was 249,515 and 261,530, respectively (Table 4).

Table 4. Total Employment in the White Clay Creek Watershed

County	County[1] Population	Watershed[1] Population	County[2] Employment	Watershed[3] Employment
Chester County	498,886	27,638	249,515	13,823
New Castle County	538,479	97,204	261,530	47,210
Cecil County	101,108	3	23,573	1
Total	**1,138,473**	**124,845**	**534,618**	**58,626**

1. U.S. Census 2010. 2. U.S. Bureau of Labor Statistics 2011.
3. Scaled by ratio of watershed population to county population, and multiplied by county employment.

2. Methods

Valuation Techniques

The University of Delaware derived the economic value of the White Clay Creek watershed from published studies that employed the following valuation techniques:

Avoided Cost: Society sustains costs if certain ecosystems are not present or are lost. For instance, the loss of wetlands may increase economic costs from flood damage.

Replacement Cost: Natural services are lost and replaced by more expensive human systems. For instance, forests provide water-filtration benefits that would be replaced by costly water-filtration plants.

Net Factor Income by Enhancement of Income: Improved water quality is known to enhance fishing productivity and boost fishing jobs/wages.

Travel Cost: Visitors are willing to pay to travel and purchase food and lodging to visit ecosystems and natural resources for tourism, boating, hunting, fishing, and birding.

Hedonic Pricing: Residents may be willing to pay more for higher property values along scenic river coastlines with improved water quality.

Contingent Valuation: Valuation by survey of individual preferences to preserve ecosystems. People may be willing to pay more in fees or water rates to preserve river water quality.

Scope of Work

The University of Delaware established the economic value of the White Clay Creek watershed according to the following scope of work.

1. Area of Interest: The area of interest is defined as the White Clay Creek watershed in Chester County, Pennsylvania and New Castle County, Delaware. The University of Delaware developed ArcGIS map layers of watersheds, population, ecosystems, habitat, and land use/land cover to perform the analysis.

2. Literature Review: Gather published literature and socioeconomic data relevant to the White Clay Creek watershed including databases from the U.S. Census Bureau, U.S. Bureau of Labor Statistics, U.S. Department of Agriculture, U.S. Forest Service, and U.S. Fish and Wildlife Service.

3. Annual Economic Value: Estimate the direct (market) and indirect (non-market) economic value of agriculture, water quality, water supply, fishing, hunting, recreation, boating,

ecotourism, and navigation by utilizing population, employment, industrial activity, and land-use data. Total economic activity is the sum of direct and indirect uses, option demand, and non-use values (Ingraham and Foster 2008). Direct-use (market) values are derived from the sale or purchase of natural goods such as drinking water, boating, recreation, and commercial fishing. Indirect (non-market) values are benefits from ecosystems such as water filtration by forests and flood control/habitat protection from wetlands. Option demand is public willingness to pay for benefits from water quality or scenic value of the water resources. Non-use (existence) values are treasured by a public who may never visit the resource but are willing to pay to preserve the existence of the resource. Values are converted to 2010 dollars based on the change in the Consumer Price Index (CPI) in the Northeast Region as reported by the Bureau of Labor Statistics.

4. Ecosystem Services: Tabulate the market value of natural resources (ecosystem services value) in the White Clay Creek watershed for habitat such as wetlands, forests, farmland, and open water. Ecosystem services (ecological services) are economic benefits provided to society by nature such as water filtration, flood reduction, and drinking water supply. Using ArcGIS, map and tabulate ecosystem areas (acres) using land cover data in the following classifications: (a) freshwater wetlands, (b) marine, (c) farmland, (d), forest, (e) barren, (f) saltwater wetland, (g) urban, (h) beach/dune, and (i) open freshwater. Review published research studies and gather economic value ($/acre) data for these ecosystem goods and services: (a) carbon sequestration, (b) flood control, (c) drinking water supply, (d) water-quality filtration, (e) waste treatment and assimilation, (f) nutrient regulation, (g) fish and wildlife habitat, (h) recreation and aesthetics. Compute ecosystem services value by multiplying land-use area (acres) by ecosystem value ($/acre).

Ecosystem services are estimated using value (benefits) transfer where published data and literature from similar watersheds are reviewed and applied to the resource in question. Value-transfer techniques include selecting data from published literature from another watershed or study area and applying the dollars-per-acre values to White Clay Creek watershed land-use areas. While primary research data from the area in question is preferable and is used in many cases in this report, value transfer is the next best practical way to value ecosystems, especially when, in the absence of such data, the worth of ecosystems have previously been deemed zero.

5. Jobs and wages: Obtain employment and wage data from the U.S. Department of Labor, U.S. Census Bureau, National Ocean Economics Program, and other sources. Estimate direct/indirect jobs by North American Industry Classification System (NAICS) codes such as shipbuilding, marine transportation/ports, fisheries, recreation, minerals, trade, agriculture, and others. NAICS data were supplemented with farm jobs data from the USDA Agricultural Statistics Bureau, U.S. Fish and Wildlife Service ecotourism jobs data, and jobs provided by water purveyors and watershed organizations.

6. Report: Prepare a report and GIS mapping that summarizes (1) annual economic value of activities related to the White Clay Creek watershed, (2) ecosystem goods and services (natural capital), and (3) jobs and wages directly and indirectly related to the watershed in 2010 dollars.

3. Economic Value

Hodge and Dunn (1992) illustrated the total economic value of water resources based on use and non-use values (Figure 4). Use values include direct values, such as market goods from sales of crops, fish, and timber; unpriced benefits from recreation and aesthetic view sheds; and ecological-function values (ecosystem services) from flood control, water storage, and waste-assimilation services of wetland and forest habitat. Non-use values include future-option values such as future drug discoveries from wetland plants and future recreation, existence values from satisfaction that a water resource exists but may never be visited, and bequest values such as preserving water quality for future generations.

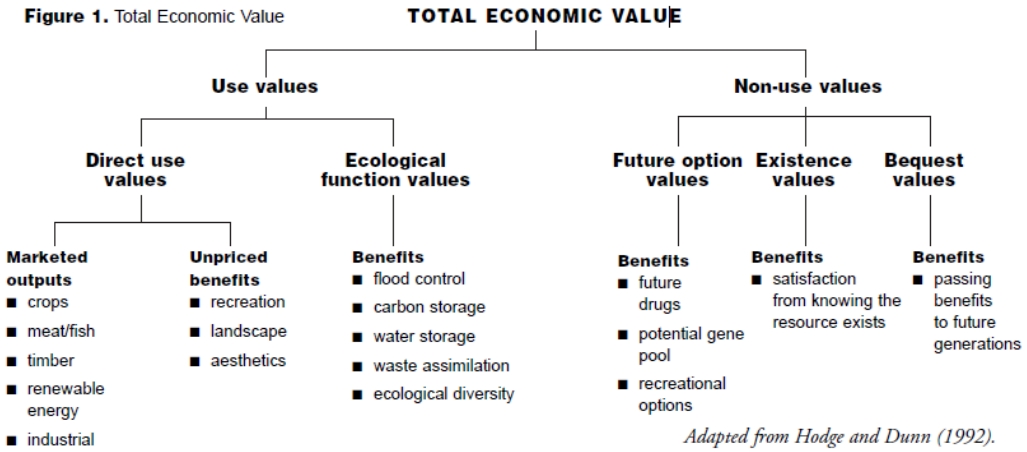

Figure 4. Economic value of water resources (Hodge and Dunn, 1992)

The economic value of the White Clay Creek watershed from water quality, water supply, fish/wildlife, recreation, agriculture, forests and public parks benefits exceeds $500 million (Figure 5 and Table 5).

Water Quality	$164 million
Water Supply	$94 million
Fish/Wildlife	$12 million
Recreation	$59 million
Agriculture	$62 million
Forests	$27 million
Public Parks	$103 million
Total	**> $500 million**

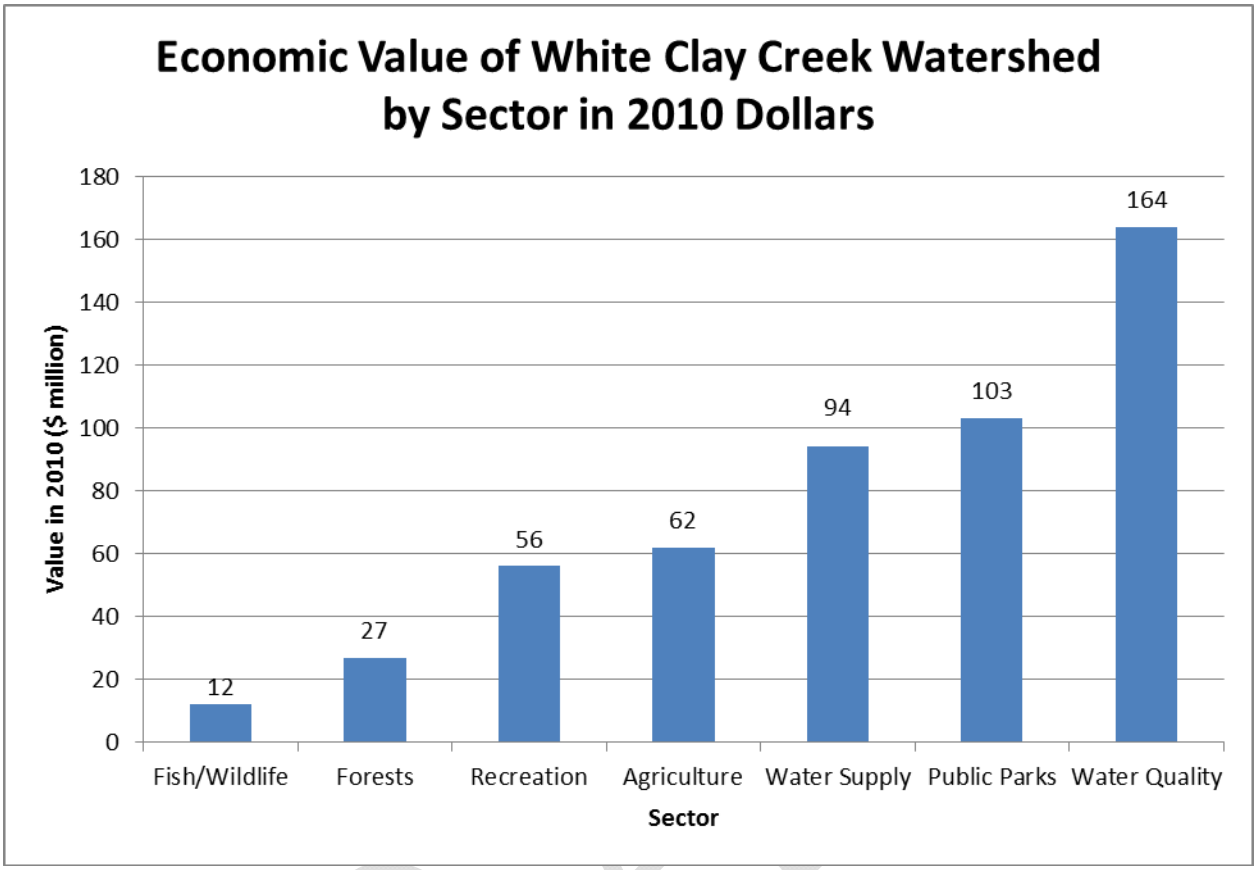

Figure 5. Annual economic value of the White Clay Creek watershed by sector

Table 5. Annual economic value of the White Clay Creek watershed

Sector	Activity	2010 ($ million)	Source
Water Quality	Boatable (WTP=$13.20)	2	University of Delaware (2003)
	Fishable (WTP=$13.22)	2	University of Delaware (2003)
	Swimmable (WTP=$112.75)	14	University of Delaware (2003)
	Increased Property Value (+8% over 20 years)	144	EPA (1973), Brookings Institute (2010)
	Water Treatment by Forest ($76/mgd)	0.8	Trust for Public Land, AWWA (2004)
	Wastewater Treatment	0.8	DNREC (2010), WRA
Water Supply	Drinking Water Supply ($7.85/1,000 gallons)	93	WRA, Chester County Conservation District, & Chester Water Resources Authority (1998)
	Irrigation Water Supply ($300/acre-foot)	0.5	Resources for the Future (1996), USDA (2007)
	Industrial Water Supply ($200/acre-foot)	0	Resources for the Future (1996), USGS (2005)
Fish/Wildlife	Fishing	4	U.S. Fish and Wildlife Service (2008)
	Hunting	3	U.S. Fish and Wildlife Service (2008)
	Wildlife/Bird-watching	5	U.S. Fish and Wildlife Service (2008)
Recreation	Outdoor Recreation (49,859 participants)	56	Outdoor Idustry Foundation (2006)
	State Parks ($53/visit, 5,714 acres)	3	PA DEP and Penn State
Agriculture	Crop, poultry, livestock value ($3,482/acre)	62	USDA Census of Agriculture 2007 (2009)
Forests	Carbon Storage ($827/acre)	19	U.S. Forest Service, Del Ctr. Hort. (2008)
	Carbon Sequestration ($29/acre)	0.6	U.S. Forest Service, Del Ctr. Hort. (2008)
	Air Pollution Removal ($266/acre)	6	U.S. Forest Service, Del Ctr. Hort. (2008)
	Building Energy Savings ($56/acre)	1	U.S. Forest Service, Del Ctr. Hort. (2008)
	Avoided Carbon Emissions ($3/acre)	0.7	U.S. Forest Service, Del Ctr. Hort. (2008)
Public Parks	Health Benefits ($9,734/acre)	76	Trust for Public Land
	Community Cohesion ($2,383/acre)	19	Trust for Public Land
	Stormwater Benefit ($921/acre)	7	Trust for Public Land
	Air Pollution Control ($88/acre)	0.7	Trust for Public Land
Total for Watershed		**520**	

Note: Total economic value is rounded down to avoid double-counting.

Water Quality

Improved Water Quality

Helm, Parsons, and Bondelid (2003) measured the economic benefits of water-quality improvements to recreational users in the New England states of Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, and Connecticut and found per person willingness to pay (WTP) for good water quality ranged from $8.25 for boating, $8.26 for fishing, and $70.47 for swimming use support in 1994 dollars. Adjusting to 2010 dollars based on the change in the Consumer Price Index (CPI) in the Northeast Region as reported by the Bureau of Labor Statistics, per person WTP is estimated at $13.20 for boating, $13.22 for fishing, and $112.75 for swimming uses (Table 6).

In 2010, the White Clay Creek watershed population reached 124,845 (U.S. Census, 2010). Based on value transfer data from the study in six New England states, WTP for improved water quality in the White Clay Creek boasts over $17 million in monetary value. The greatest WTP value comes from a swimmable quality level at $14,076,274, followed by fishable quality and boatable quality at $1,650,451 and $1,647,954, respectively (Table 6).

Table 6. Annual willingness to pay for water quality benefits in New England

WQ Use Support	WTP per person[1] ($1994)	WTP per person[2] ($2010)	Watershed Population	WTP ($2010)
Boatable	8.25	13.20	124,845	1,647,954
Fishable	8.26	13.22	124,845	1,650,451
Swimmable	70.47	112.75	124,845	14,076,274
Total	**86.98**	**139.17**	**124,845**	**17,374,679**

1. Helm, Parsons, and Bondelid (2003).
2. Adjusted to 2010 based on change in Northeast Region CPI (BLS).

Increased Property Value

Studies along rivers and bays in the U.S. indicate that improved water quality can increase shoreline property values by 4% to 18% (Table 7). The EPA (1973) estimated improved water quality can raise property values by up to 18% next to the water, 8% at 1,000 feet from the water, and 4% at 2,000 feet from the water. Leggett et al. (2000) estimated improving bacteria levels to meet water quality standards along the western shore of the Chesapeake Bay in Maryland could raise property values by 6%. Poor et al. (2007) studied 1,377 residential property sales in the St. Mary's River watershed on the western shore of the Chesapeake Bay and concluded that a 1 mg/l increase in dissolved inorganic nitrogen reduced the average selling price. For example, a given property worth $200,936 would experience an 8.8% decline in value, a decrease equal to $17,642 . Austin et al. (2007) from the Brookings Institute projected that investing $26 billion to restore the Great Lakes would increase shore property values by 10%.

Table 7. Increased property value resulting from improved water quality

Study	Watershed	Increased Property Value
EPA (1973)	San Diego Bay, Calif.	
- Next to water	Kanawha, Ohio	18%
- 1000 ft from water	Willamette River, Ore.	8%
- 2000 ft from water		4%
Leggett et al. (2000)	Chesapeake Bay	6%
Poor et al. (2007)	Chesapeake Bay	9%
Brookings Institute (2007)	Great Lakes	10%

With improved water quality, property values within 2,000 feet of the White Clay Creek and its tributaries are estimated to increase by 8%, which is the adjusted midpoint between 18% next to the water and 4% at 2000 ft from the water. The White Clay Creek has 253 stream miles. If the median household property value in the White Clay Creek is $293,550/acre, based on housing data from the U.S. Census, then properties within 2,000 feet of the creek have an estimated value of $36 billion. Property values within 2,000 feet of the water would increase by 8% or $2.9 billion due to improved water quality (Table 8). Since increased property value is a one-time benefit, the annual value over a 20-year period is estimated at $144 million.

Table 8. Added property value due to improved water quality in White Clay watershed

Stream Length (miles)	Stream Length (ft)	Area within 2,000 ft of Stream (ac)	Property Value @ $293,550/ac ($)	Increased Value @ 8% ($)	Annual Value 20 years ($)
253	1,335,840	122,667	36,008,800,000	2,880,704,000	144,035,200

Water Treatment by Forests

Forests provide significant water-quality and water-treatment benefits. The Trust for Public Land and American Water Works Association (2004) found for every 10% increase in forested watershed land, drinking water treatment and chemical costs are reduced by approximately 20% (Table 11). If the public drinking water supply is 33 mgd and forests cover 22,400 acres (35 mi^2 or 33%) of the White Clay Creek watershed, then loss of these forests would increase drinking water treatment costs by $70 per mgd ($139/mgd @ 0% forested minus $69/mgd @ 33% forested) or $2,310/day or $843,150 /year (Table 9).

Table 9. Drinking water treatment costs based on percent of forested watershed

Watershed Forested	Treatment Costs ($/mg)	Change in Costs
0%	139	21%
10%	115	19%
20%	93	20%
30%	73	21%
40%	58	21%
50%	46	21%
60%	37	19%

Trust for Public Land and AWWA 2004

Wastewater Treatment

According to DNREC's Surface Water Discharges Section and the U.S. EPA's High Flow TMDL report, there are a total of 4 permitted surface-discharge-sewage-treatment plants in the White Clay Creek watershed, only one of which is located in the Delaware portion of the watershed.

The NPDES wastewater dischargers in Pennsylvania and Delaware possess Federal and state water-quality permits to treat and discharge 0.6 million gallons per day to the waters of the White Clay Creek watershed. An analysis of wastewater utilities conducted by WRA computes that the average wastewater rate in the watershed is $4.00 per 1,000 gallons, which, for an average residence of four people (at 50 gpcd), is a fee of $290 per year. The total market value based on treated-wastewater rates in the White Clay Creek watershed is $2,241 per day or $817,892 per year (Table 10).

Table 10. Value of NPDES Surface Discharge Sewage-Treatment Plants in the White Clay Creek Watershed

NPDES ID	Sewage Treatment Plant	Discharge (mgd)	$/day ($4.00/1,000gal)	$/Year
Main Stem				
PA0024066	West Grove Borough Authority STP MB White Clay Creek Municipal Large STP	0.25	$1,000	$365,000
East Branch				
PA0052451	Frances L. Hamilton Oates STP EB White Clay Creek Municipal Small STP	0.0012	$5	$1,752
PA0025488	Avondale Borough Sewer Authority Indian Run Municipal Large STP	0.3	$1,200	$438,000
PA0040436	Chadds Ford Investment Co./Red Fox GC TB-EB White Clay Creek Municipal Small STP	0.01	$36	$13,140
Total		**0.56**	**2,241**	**817,892**

Water Supply

Drinking Water Supply

The streams and wells of the White Clay Creek watershed provide 38.8 million gallons per day (mgd) of public drinking water. The annual value of public water supplies in the White Clay Creek is more than $93 million per year, or $75 million from surface water and $18 million from groundwater.

The surface water of the White Clay Creek watershed provides local citizens with 33 mgd of drinking water. The rivers and streams in the watershed serve as a major drinking water source for portions of Chester County, PA and northern Delaware. Drinking water purveyors in the White Clay Creek include:

- City of Newark, Delaware
- United Water Delaware

Table 11 provides a list of the public surface water suppliers and the associated pump capacity withdrawals (mgd) in the White Clay Creek watershed. The annual value of 33 mgd of treated surface water in the White Clay Creek watershed is approximately $75 million, over $200,000 per day.

Table 11. Public surface water withdrawals

State	County	Purveyor	Capacity (mgd)[1]	Actual Rate ($/1,000 gal)[2]	Value/day treated (Actual Rate/1,000 gal)	Value/year treated (Actual Rate/1,000 gal)
Delaware	New Castle	City of Newark	White Clay	3.0	$5.92	$17,760
Delaware	New Castle	United Water DE	White Clay	30.0	$6.28	$188,400
Total for watershed			**33.0**		**$206,160**	**$75,248,400**

1. Phase I & II Report Christina River Basin, Water Quality Management Strategy, May 1998
2. Water Rates based on 2011 and 2012 Water Rate Study, UD WRA

The community public water supply wells in the White Clay Creek watershed provide approximately 5.8 mgd of drinking water to the region. These wells serve as drinking water sources for northern Delaware and southeastern Pennsylvania. The value per year of treated water supply from 5.8 mgd community public water supply wells is $18.2 million. Table 12 provides a list of the suppliers, their capacity, and the value of the treated water for the community public water supply wells in the White Clay Creek watershed.

Table 12. Community Public Water Supply Well in the White Clay Creek watershed

Owner	Capacity (mgd)	Rate ($/1,000 gal)	Value/day treated (Actual Rate/1,000 gal)	Value/year treated (Actual Rate/1,000 gal)
Avondale Boro. Water Dept.	0.232	$7.85	$1,821	$664,738
Avonwheel Estates MHP	0.005	$7.85	$39	$14,326
Chatham Acres Nursing Co.	0.01	$7.85	$79	$28,653
PSW Franklin Water Co.	0.019	$7.85	$149	$54,440
London Grove MHP	0.004	$7.85	$31	$11,461
Landenburg Water Co.	0.008	$7.85	$63	$22,922
Shangri La Water Co.	0.017	$7.85	$133	$48,709
West Grove Borough Water Co.	0.276	$7.85	$2,167	$790,809
Artesian Water Co.	3.24	$10.34	$33,502	$12,228,084
Newark Water Dept.	2.002	$5.92	$11,852	$4,325,922
Total	**5.813**		**$49,836**	**$18,190,063**

*Wells use the $7.85 average.

Reservoir Storage

The Newark Reservoir stores 317 million gallons of water for public supply in the White Clay Creek watershed. The New Jersey Water Supply Authority delivers untreated water to public water purveyors from the Raritan River reservoir system at an estimated market price of $0.394/1,000 gallons (NJWSA 2011). Given the raw water storage value of $0.394/1,000 gallons, the annual value of reservoir storage in the White Clay Creek is $124,898.

Table 13. Economic value of reservoir storage in the White Clay Creek watershed

Reservoir	Storage (MG)	Value ($0.394/1000 gal)
Newark Reservoir	317	124,898
Total	**317**	**124,898**

Irrigation Water Supply

In a study of the economic value of freshwater in the United States, Resources for the Future (Frederick et al. 1996) estimated the median value of irrigation water withdrawals was $198/ac-ft in 1996 dollars or $300/ac-ft ($0.92/1,000 gal) in 2010 dollars, adjusting for change in the CPI (Table 14). In 2007, 20,480 acres of cropland (30% of the White Clay Creek watershed) were cultivated and 529 acres were irrigated (USDA 2009). Annual irrigation-water needs from June through September are 9 inches for corn, soybeans, and grain (2,600 gpd/ac for 1,090 irrigated acres or 2.4 mgd). In the White Clay Creek watershed, the annual value of water needed to irrigate 9 inches of water over 529 acres at a use value of $0.92/1,000 gal is $462,200/yr.

Table 14. Freshwater-use values in the United States

Use	1996 Median[1] ($/ac-ft)	2010 Median[2] ($/ac-ft)	2010 Median ($/1,000 gal)
Navigation	10	15	0.02
Irrigation	198	300	0.92
Industrial Process	132	200	0.61
Thermoelectric Power	29	44	0.14

1. Frederick et al. 1996.
2. Adjusted to $2010 based on change in Northeast Region CPI (BLS).

Table 15. Value of agriculture irrigation in the White Clay Creek watershed

County	Farmland by County[1] (ac)	Irrigation by County[1] (ac)	Farmland in Watershed (ac)	Irrigation in Watershed (ac)	Irrigation @ 2,600 gpd/ac (gpd)	Value of Irrigation @ $0.92/1,000 gal ($/day)	Value of Irrigation ($/yr)
Chester	117,145	1,659					
New Castle	51,913	2,711					
Total	**169,058**	**4,370**	**20,480**	**529**	**1,376,414**	**1,266**	**462,200**

1. Census of Agriculture, 2007, (USDA, 2009)
2. Frederick et al., 1996

Using data from the USDA and USGS, the annual value of water used to irrigate cropland in the White Clay Creek watershed ranges from $245,250 to $1.4 million.

Industrial Water Supply

In 2005, the USGS estimated that industrial-water withdrawals totaled 0.03 mgd in the White Clay Creek watershed. The median market value of industrial withdrawals is $132/ac-ft in 1996 dollars (Frederick et al. 1996) or $200/ac-ft. ($0.61/1,000 gal) in 2010 dollars based on the change in CPI. The value of industrial-water withdrawals (0.03mgd) in the White Clay Creek watershed is $20 per day or $7,125 per year.

Table 16. Industrial Water Supply-Use in the White Clay Creek

Industry	Industrial Water Supply (mgd)[1]	Use Value[2] ($/1,000 gal)	2010 value ($/day)	2010 value ($/year)
Laurel Valley Farms	0.032	0.61	20	7,125

1. USGS, 2003. 2. Frederick et al. 1996, converted to 2010 dollars based on the change in CPI.

Fish/Wildlife

Fishing, Hunting, and Bird/Wildlife Watching

The U.S. Fish and Wildlife Service (2008) conducted a survey of the 2006 annual economic value of recreational fishing, hunting, birding and wildlife-associated activities in the U.S. The annual economic value of these activities was $4,343 million in Pennsylvania, $269 million in Delaware, and $1,411 million in Maryland. Using these statewide totals and adjusting for the percentage of the state within the White Clay Creek watershed, the annual economic value of the recreational fishing, hunting, birding and wildlife-associated activities for the watershed was $12.5 million.

Table 17. Value of fishing, hunting, wildlife/birding recreation in White Clay Creek watershed

Recreation Activity	PA[1] ($2006)	PA in watershed[2] ($2006)	DE[1] ($2006)	DE in watershed[2] ($2006)	MD[1] ($2006)	MD in watershed[2] ($2006)	White Clay Watershed[3] ($2006)
Fishing	1,291,211,000	1,807,695	96,775,000	2,293,568	568,211,000	1,136	4,102,399
Hunting	1,609,045,000	2,252,663	41,381,000	980,730	210,087,000	420	3,233,813
Wildlife/Birding	1,442,582,000	2,019,615	130,832,000	3,100,718	633,699,000	1,267	5,121,601
Total	**4,342,838,000**	**6,079,973**	**268,988,000**	**6,375,016**	**1,411,997,000**	**2,823**	**12,457,813**

1. USFWS, Survey conducted in 2006, report issued 2008.
2. Scaled by the percentage of each state that is in the Christina Basin (0.0089 PA, 0.08 DE).
3. Sum of scaled values.

Recreation

Outdoor Recreation

The Outdoor Industry Foundation (2006) concluded there were 16.3 million participants in recreation activities such as bicycling, camping, fishing, hunting, paddling, hiking, and wildlife viewing in the mid-Atlantic region (NJ, NY, PA) who contributed $18.3 billion ($15.6 billion in gear/trip sales) and 216,396 jobs to the regional economy. Given that the population of the 3 states totals 40.9 million (NJ: 8.8 million, NY: 19.4 million, and PA: 12.7 million), then by proportion outdoor recreation activity in the White Clay Creek watershed (pop. 124,845) contributes $56 million and 661 jobs to the economy (Table 21).

Table 18. Outdoor recreation activity in the Brandywine Creek watershed

Recreation	Activity	Mid-Atlantic Region[1]	White Clay Creek[2]
Bicycling	Gear Trip/Sales/Contributions	$3,372,000,000	$10,292,844
	Participants	2,496,000	7,619
	Jobs	40,121	122
Camping	Gear Trip/Sales/Contributions	$7,513,000,000	$22,933,019
	Participants	1,874,000	5,720
	Jobs	89,384	273
Fishing	Gear Trip/Sales/Contributions	$1,768,000,000	$5,396,723
	Participants	1,890,000	5,769
	Jobs	17,195	52
Hunting	Gear Trip/Sales/Contributions	$731,000,000	$2,231,337
	Participants	450,000	1,374
	Jobs	7,234	22
Paddling	Gear Trip/Sales/Contributions	$784,000,000	$2,393,117
	Participants	1,586,000	4,841
	Jobs	9,331	28
Hiking	Gear Trip/Sales/Contributions	$2,411,000,000	$7,359,445
	Participants	3,048,000	9,304
	Jobs	28,686	88
Wildlife Viewing	Gear Trip/Sales/Contributions	$1,756,000,000	$5,360,093
	Participants	4,990,000	15,232
	Jobs	24,445	75
Total	**Gear Trip/Sales**	**$18,335,000,000**	**$55,966,579**
	Participants	**16,334,000**	**49,859**
	Jobs	**216,396**	**661**

1. Outdoor Industry Foundation 2006.
2. Scaled by population of the White Clay Creek (124,845) to mid-Atlantic region population.

State Parks

The White Clay Creek watershed has 2 state parks that cover 5,714 acres (8.9 mi^2). In 2012 the Pennsylvania Department of Conservation and Natural Resources and Penn State reported that there were 30,374 visitors to the White Clay Creek Preserve in Pennsylvania in 2010, and those visitors spent $1,623,000 on their trips. For the purposes of this report, it is presumed that the same number of people visited the White Clay Creek State Park in Delaware in 2010. Based upon these numbers, $53.44 per visitor is spent at each park. Using the $53 multipliers from the PA data, the White Clay Creek State Park and the White Clay Creek Preserve provide an economic benefit of 3.2 million (Table 19).

Table 19. State Park Usage in the White Clay Creek Watershed

State	Park	Acreage	Total visitors (per year)[1,2,3]	Spending/visitor ($)4	Estimated $ spent per year (2010)[1]
PA	White Clay Creek Preserve	2,072	30,374	$53.44	$1,623,187
DE	White Clay Creek State Park	3,642	30,374	$53.44	$1,623,187
Total					**$3,246,373**

1. PADCN and Penn State (2012)
2. Values for Brandywine Creek from staff at the Brandywine Creek State Park
3. Estimated using the report: Summary of Economic Significant for White Clay Creek and Marsh Creek, individual reports
4. White Clay Creek values estimated using PA spending /visitor (at $53/visit)

Agriculture

In 2007, the USDA National Agricultural Statistics Service (2009) estimated the annual market value of agricultural products sold in Chester, Cecil, and New Castle Counties was $695 million. Scaling by the area of farmland in the White Clay Creek watershed, the value of crops in the watershed is $62 million (Table 20).

Table 20. Value of Cropland and Agriculture in the White Clay Creek

County	Farmland by County[1] (ac)	2007 Value by County[1] ($ million)	Farmland in Watershed (ac)[2]	Crop Value in Watershed in 2007 dollars ($ million)
Chester	117,145	553.3		
Cecil	60,147	95.8		
New Castle	51,913	45.7		
Total	**229,205**	**695**	**20,480**	**62**

1. Census of Agriculture, 2007, (USDA, 2009)
2. NOAA CSC, 2006

Forests

The U.S. Forest Service (Nowak et al. 2008) estimated that forests provide environmental benefits such as carbon storage of $5.9 million ($827/acre) and air-pollution removal of $1.9 million ($266/acre/year). Applying these multipliers, 22,400 acres (35 mi^2) of forests in the White Clay Creek watershed provide the benefits of carbon storage ($18.5 million), carbon sequestration ($650,000), air-pollution removal ($6 million), and building-energy savings ($1.3 million). Forests in the White Clay Creek watershed provide these environmental benefits by regulating climate change, cooling, and air-emissions control including 896,000 tons of carbon-storage capacity, 31,360 tons of carbon sequestration, 896 tons of air-pollution removal, and 3,136 tons of avoided carbon-emissions capacity (Table 21).

Table 21. Economic and environmental benefits of forests in the White Clay Creek

Forest Benefits	Forests New Castle County[1]		Forests White Clay Creek[2]	
	Environmental (tons/acre)	Economic ($/acre)	Environmental (tons)	Economic ($)
Carbon Storage	40	$827	896,000	18,524,800
Carbon Sequestration	1.4	$29	31,360	649,600
Air Pollution Control	0.04	$266	896	5,958,400
Energy Savings		$56	0	1,254,400
Avoided Carbon Emissions	0.14	$3	3,136	67,200
Total				**26,454,400**

1. Nowak et al. (2008).
2. Computed for 22,400 acres of forest in the White Clay Creek watershed.

Public Parks

The Trust for Public Land (2009) found the 444-acre City of Wilmington park system provides annual economic value and savings to the public from:

- Health benefits from exercise in the parks ($4,322,000 or $9,734/ac).
- Community-cohesion benefits as people socialize in the parks ($1,058,000 or $2,383/ac).
- Water pollution–mitigation benefits in treating stormwater ($409,000 or $921/ac).
- Air pollution–mitigation value from tree and shrub absorption ($39,000 or $88/ac).

Presuming that the data from the City of Wilmington study are appropriate for benefits-transfer, the 7,829 acres of public parks within the White Clay Creek watershed provide health benefits ($76 million), community cohesion benefits ($18.7 million), clean-water benefits ($7 million), and air pollution mitigation benefits ($688,952). The total value of benefits provided by the public parks in the White Clay Creek watershed is $102.8 million.

Table 22. Value of public parks in the White Clay Creek watershed

State	Parks in Watershed (acres)	Health Benefits (at $9,734/acre)	Community Cohesion (at $2,383/acre)	Stormwater Benefit (at $921/acre)	Air Pollution (at $88/acre)	Total
PA	2,377	23,137,718	5,664,391	2,189,217	209,176	31,202,879
DE	5,452	53,069,768	12,992,116	5,021,292	479,776	71,568,404
Total	**7,829**	**76,207,486**	**18,656,507**	**7,210,509**	**688,952**	**102,771,283**

4. Ecosystem Services

Ecosystem services (natural capital) are the sum of goods (commodities like water, crops, and timber that can be sold) and services (functions like flood control, water filtration, and fisheries habitat) provided by watershed habitat such as wetlands, forests, farms, and open water. The following studies were examined to estimate ecosystem-services values for the White Clay Creek watershed:

- Cecil County green infrastructure study by the Conservation Fund, Annapolis, Md. (2007)
- New Jersey Department of Environmental Protection with the University of Vermont (2007)
- Ecosystem services value of forests by the Wilderness Society (2001)
- Ecosystem services value of Peconic Estuary watershed by University of Rhode Island (2002)
- U.S. National Wildlife Refuges by University of Maryland and Nature Conservancy (2008)
- Economic value of ecosystem services in Massachusetts by the Audubon Society (2003).

Related Research

Ecosystem services include air filtration, water filtration, recycling nutrients, soil conservation, pollinating crops and plants, climate regulation, carbon sequestration, flood/stormwater control, and hydrologic-cycle regulation. Ecological resources provide marketable goods and services such as timber, fish and wildlife recreation, hiking, and boating/kayaking.

The N.J. Department of Environmental Protection (2007) partnered with the University of Vermont and estimated the value of New Jersey's natural capital at $20 billion/year in 2004 dollars with a net present value (NPV) of $681 billion. NPV takes the value of a dollar today and projects it into the future summed annually over a lifetime (say 100 years) given the annual value is discounted by a rate (3%) due to inflation based on the Consumer Price Index.

Others have calculated the value of natural capital in ecosystems along the Atlantic seaboard and across the United States. Weber (2007) from the Conservation Fund found the largest ecosystem services values in Cecil County, Maryland are from stormwater/flood control, water supply, and clean water functions (Table 29). The Wilderness Society (Krieger 2001) concluded that forest ecosystem services for climate regulation, water supply, water quality, and recreation benefits totaled $392/ac in 1994 dollars or $631/ac in 2010 dollars based on change in the Northeast Region CPI (Table 30). A contingent value study by University of Rhode Island economists found that natural resources values in the Peconic Estuary watershed in Suffolk County on Long Island New York ranged from $6,560/ac for wetlands to $9,979/ac for farmland in 1995 dollars (Johnston et al. 2002). The University of Maryland studied the U.S. National Wildlife Refuge System and determined that ecosystem values of freshwater wetlands and forests are $6,268/ac and $845/ac, respectively (Ingraham and Foster 2008). The Audubon Society found the economic value of ecosystems in Massachusetts ranged from $984/ac for forests to $15,452/ac for saltwater wetlands (Breunig 2003). According to the 2007 USDA Census of Agriculture (2009) the market value of agricultural crops, poultry, and livestock sold from 166,891 acres of

farmland in Chester County was $553 million, or $3,315/ac. The market value of agriculture from 66,891 acres of farmland in New Castle County was $46 million, or $682/ac.

Table 23 compares ecosystem services values from other watersheds. Data from the NJDEP study and crop value of Ocean County agriculture are used for value transfer to the White Clay Creek watershed as the study area shares similar ecosystems (forests/wetlands), climate (humid continental at 40°N latitude), and physiographic provinces. NJDEP ecosystem-services values are lower than Cecil County's for wetlands and forests and MassAudubon's for wetlands. NJDEP estimates are higher than the Wilderness Society's for forests and U.S. Wildlife Refuge values for freshwater wetlands and forests.

Table 23. Comparison of ecosystem goods and services values from various studies

Ecosystem	Cecil Co. Md. 2006 ($/ac/yr)	NJDEP 2007 ($/ac/yr)	Wilderness Society 2001 ($/ac/yr)	Peconic Estuary 1995 ($/ac/yr)	U.S. Wildlife 2008 ($/ac/yr)	Mass. Audubon 2003 ($/ac/yr)	USDA Census [1] 2007 ($/ac/yr)
Freshwater wetland	43,685	11,802			6,268	15,452	
Marine		8,670					
Farmland		6,229		9,979		1,387	3,315[1]
Forest land	12,033	1,714	641		845	984	
Saltwater wetland	28,146	6,269		6,560		12,580	
Undeveloped				2,080			
Urban		296					
Beach/dune		42,149					
Open freshwater		1,686			217	983	
Riparian buffer	52,765	3,500					
Shellfish areas				4,555			

1. Value of natural goods only measured by crops, livestock, and poultry sold in Chester County (USDA 2009).

Watershed Ecosystem Services

Ecosystem goods and services in the White Clay Creek watershed using the NJDEP and USDA farm-good values are worth $165 million (2010 dollars) or $5.4 billion (NPV), which are conservatively in the lower end of the range. If lower per-acre estimates of ecosystem services from other studies were used instead of the NJDEP values, ecosystem services in the White Clay Creek watershed would be $64 million or NPV = $2.1 billion. If higher per-acre estimates from other studies were used, the value of ecosystems in the White Clay Creek watershed would be $566 million or NPV = $18.4 billion.

Estimate	PV ($mil)	NPV ($mil)
Low	64	2,083
NJDEP	165	5,363
High	566	18,389

Ecosystem-services areas within the White Clay Creek watershed are comprised of forests (33%), farmland (30%), and freshwater wetlands (3%). Roughly 34% of the land in the White Clay Creek watershed is urban (Figure 6).

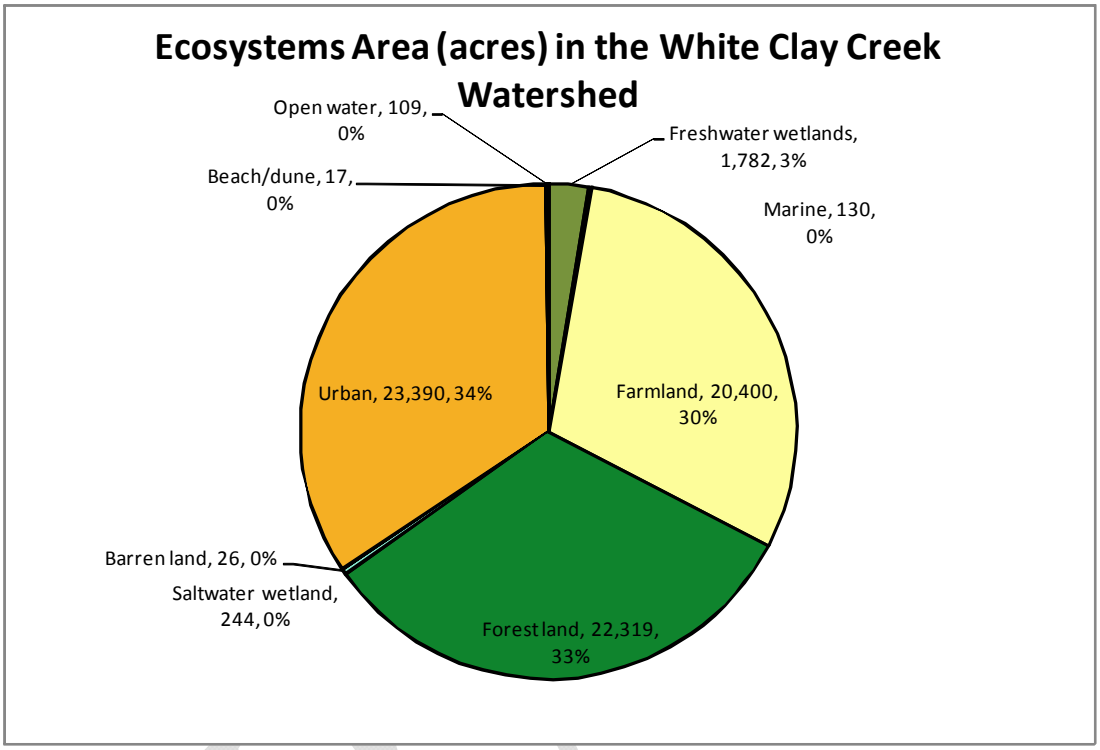

Figure 6. Ecosystem Service Areas in the White Clay Creek watershed

Table 24. Value of Ecosystem Goods and Services in the White Clay Creek watershed

Ecosystem	Area (acres)	$/acre/yr	PV $	NPV $
Freshwater wetlands	1,782	13,621	24,271,250	788,815,610
Marine	130	10,006	1,300,344	42,261,189
Farmland	20,400	4,124	84,506,869	2,746,473,248
Forest land	22,319	1,978	44,149,832	1,434,869,532
Saltwater wetland	244	7,235	1,764,403	57,343,106
Barren land	26	0	0	0
Urban	23,390	342	7,990,391	259,687,703
Beach/dune	17	48,644	833,283	27,081,702
Open water	109	1,946	212,602	6,909,563
Total	**68,418**	**2,412**	**165,028,974**	**5,363,441,652**

Table 25. Low range of ecosystem services in the White Clay Creek watershed

Ecosystem	Area (acres)	$/acre/year	PV ($)	NPV ($)
Freshwater wetlands	1,782	6,268	11,169,219	362,999,632
Marine	130	8,670	1,126,719	36,618,371
Farmland	20,400	1,387	28,294,836	919,582,181
Forest land	22,319	641	14,306,506	464,961,440
Saltwater wetland	244	6,269	1,528,816	49,686,514
Barren land	26	0	0	0
Urban	23,390	296	6,923,494	225,013,563
Beach/dune	17	42,149	722,021	23,465,686
Open water	109	217	23,710	770,566
Total	**68,418**	**937**	**64,095,322**	**2,083,097,954**

Table 26. High range of ecosystem services in the White Clay Creek watershed

Ecosystem	Area (acres)	$/acre/year	PV ($)	NPV ($)
Freshwater wetlands	1,782	43,685	77,844,185	2,529,936,015
Marine	130	8,670	1,126,719	36,618,371
Farmland	20,400	9,979	203,571,861	6,616,085,498
Forest land	22,319	12,033	268,565,031	8,728,363,501
Saltwater wetland	244	28,146	6,863,942	223,078,102
Barren land	26	0	0	0
Urban	23,390	296	6,923,494	225,013,563
Beach/dune	17	42,149	722,021	23,465,686
Open water	109	1,686	184,215	5,986,981
Total	**68,418**	**8,270**	**565,801,468**	**18,388,547,717**

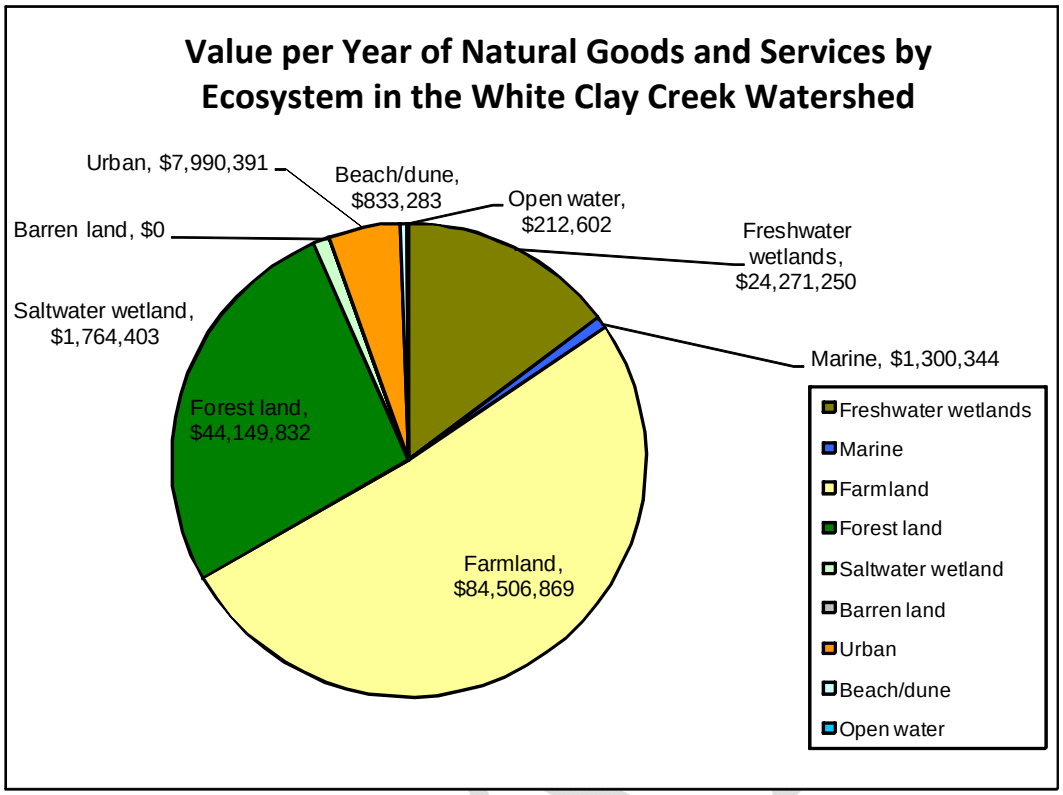

Figure 7. Value of Natural Goods and Services by Ecosystem in the White Clay

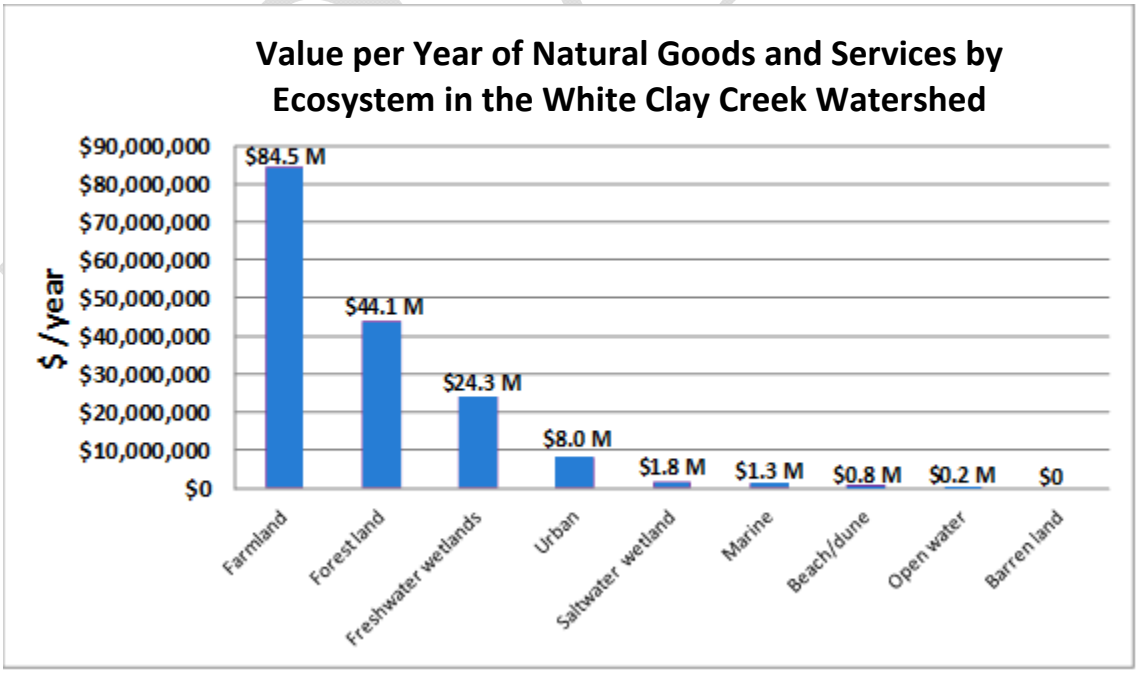

Figure 8. Ecosystem Service Value (2010 dollars) in the White Clay

5. Jobs and Wages

The White Clay Creek watershed contains habitats and water resources that support more than 25,000 jobs and provides over $55 million in annual wages in the coastal, agriculture, fishing/hunting/birding, tourism, recreation, and water supply sectors (Table 27).

Table 27. Jobs and wages directly and indirectly related to the White Clay Creek watershed

Sector	Jobs	Wages ($)	Data Source
Direct Watershed-Related	11,399	548,742	U.S. Census Bureau (2010)
Indirect Watershed-Related	13,679	438,994	U.S. Census Bureau (2010)
Coastal	1,639	32,780,227	National Coastal Econ. Program (2009)
Farm	846	726,266	U.S. Dept. of Agriculture., (2007)
Fishing/Hunting/Birding	427	14,021,378	U.S. Fish and Wildlife Service (2008)
Watershed Organizations	117	5,616,000	WRA and DRBC (2010)
Water Supply Utilities	99	5,485,293	Delaware Tourism Office (2008)
Public Wells	24	1,314,586	WRA and DRBC (2010)
Wastewater Utilities	4	160,000	WRA and DRBC (2010)
	> 25,000	**> $55 million**	

1. The total values of jobs and wages have been rounded down to avoid double counting.

Direct and indirect jobs and wages data in the White Clay Creek watershed were obtained from U.S. Bureau of Labor Statistics (2010) and U.S. Census Bureau (2010) databases. Note the NAICS database does not include jobs for certain known water-related industries, such as commercial fishing and boat building; therefore the columns are left blank. Hence, watershed-related jobs are likely undercounted. White Clay Creek watershed-related jobs are tabulated for three categories: (1) total jobs in the White Clay Creek, (2) direct White Clay Creek watershed jobs, and (3) indirect watershed jobs.

The U.S. Census Bureau (2010) indicates that there were 58,626 nonfarm jobs in the White Clay Creek watershed (Table 28).

Table 28. Total Employment in the White Clay Creek Watershed

County	County[1] Population	Watershed[1] Population	County[2] Employment	Watershed[3] Employment
Chester County	498,886	27,638	249,515	13,823
New Castle County	538,479	97,204	261,530	47,210
Cecil County	101,108	3	23,573	1
Total	**1,138,473**	**124,845**	**534,618**	**58,626**

1. U.S. Census 2010. 2. U.S. Bureau of Labor Statistics 2011.
3. Scaled by ratio of watershed population to county population, and multiplied by county employment.

Direct White Clay Creek watershed-related jobs such as water/sewer construction, living resources, maritime, tourism/recreation, ports, environmental services, and water/wastewater

management determined for each NAICS code in the watershed. Industries directly associated with the White Clay Creek (such as water/sewer construction, water utilities, fishing, recreation, tourism, and ports) employed 11,399 people with $548.7 million in wages (Table 29).

Indirect jobs and wages funded by purchases of goods/services by direct jobs earners are estimated by a multiplier of 2.2 for direct jobs and 1.8 for direct wages (Latham and Stapleford, 1990). The United Nations Environment Programme (2011) estimates each tourism job generates 1.5 indirect jobs. For this report, it is assumed that each direct watershed job funds 1.2 indirect jobs and a dollar in direct wages funds $0.80 in indirect wages. Indirect jobs in the watershed (based on multipliers of 2.2 for jobs and 1.8 for salaries) employed 13,679 people with $439 million in wages (Table 29).

Table 29. Direct and indirect watershed-related jobs in the White Clay Creek watershed, 2009

Sector	North American Industry Classification System (NAICS)	NAICS code	Direct Jobs[1]	Direct Wages[1] (x$1000)	Indirect Jobs[2]	Indirect Wages[2] (x$1000)
Construction	Water and sewer construction	23711	43	2,575	52	2,060
Living Resources	Agriculture and forestry	115	33	1,152	39	922
	Wineries	31213				
	Fish and seafood wholesalers	42446				
	Nursery, garden center, and farm supply stores	44422	53	1,744	64	1,395
	Fish and seafood markets	44522	5	95	6	76
	Fruit and vegetable markets	44523	4	77	4	61
Minerals	Mining, quarrying, extraction	21	6	578	7	462
	Electric power generation and distribution	2211		0		
Tourism/ Recreation	Sporting/recreational goods	42391	4	254	5	203
	Sporting goods stores	45111	96	1,852	115	1,481
	Recreational goods rental	532292				
	Commercial air/rail/water transport	532411				
	Recreational vehicle dealers	44121				
	Boat dealers	441222	17	665	20	532
	Museums/historical sites/similar institutions	712	126	3,700	151	2,960
	Amusement parks and arcades	7131	9	101	11	81
	Amusement arcades	71312	5	47	6	38
	Other amusement/recreation	7139	699	12,088	839	9,670
	Golf courses/country clubs	71391	175	5,360	210	4,288
	Marinas	71393		116		93
	Fitness/recreational centers	71394	454	5,318	545	4,254
	All other amusement/recreation industries	71399	23	841	28	672
	Accommodation	721	350	7,185	420	5,748
	Hotels (except casino hotels) and motels	72111	329	6,701	395	5,360
	Bed-and-breakfast inns	721191				
	RV (recreational vehicle) parks, camps	7212	3	120	4	96
	Full-service restaurants	7221	2,024	30,952	2,429	24,762
	Limited-service restaurants	722211	1,174	14,635	1,409	11,708
	Snack and nonalcoholic beverage bars	722213	181	2,504	217	2,003
	Food service contractors	72231	331	8,104	397	6,483
	Caterers	722320	65	1,314	78	1,051
Transportation	Water transportation	483		3,194		2,555
	Inland water transportation	4832		0		
	Scenic and sightseeing transportation	487	3	140	3	112
	Scenic and sightseeing transportation, water	4872	3	140	3	112
	Support activities for water transportation	4883	87	3,593	105	2,874
	Marine cargo handling	488320	75	2,927	91	2,341
Environmental	Professional/scientific/technical services	541	4,737	413,032	5,684	330,426
	Grantmaking foundations	813211	10	1,634	12	1,307
	Civic and social organizations	8134	36	2,799	43	2,239
Water/ Wastewater	Water, sewage and other systems	2213	58	4,007	69	3,205
	Waste management/remediation services	562	182	9,202	219	7,362
SUM OF ALL INDUSTRIES			**11,399**	**548,742**	**13,679**	**438,994**

1. Direct jobs/wages are those directly related to the Brandywine Creek watershed.
2. Indirect jobs/wages are derived from purchases of goods and services by direct jobs earners by multipliers of 2.2 for jobs and 1.8 for wages.

National Coastal Economy

The National Ocean Economics Program (NOEP, 2009) published a report that summarized the coastal and ocean economy in the United States for the following industrial sectors: Marine Transportation, Tourism and Recreation, Living Marine Resources, Marine Construction, Ship and Boat Building, Mineral Extraction. According to NOEP, the coastal economy in the Delaware portion of the White Clay Creek contributed 1,639 jobs, representing $32.8 million in annual wages and $63 million toward the state GDP (Table 30).

Table 30. Coastal employment in the White Clay Creek watershed

Economic Sector	Establishments	Employment	Wages	GDP
Construction	3	19	958,424	1,561,800
Living Resources	3	20	668,454	1,524,045
Minerals	D	D	D	D
Ship & Boat Building	D	D	D	D
Tourism & Recreation	84	1,407	22,494,585	46,828,878
Transportation	4	187	8,373,407	12,125,329
All Ocean Sectors	**95**	**1,639**	**32,780,227**	**62,989,508**

Source: NOEP, 2009
Based on 2010 Delaware and New Castle County, DE population estimates
D = Disclosure issues prevent this data from being presented.

Farm Jobs

The USDA 2007 Census of Agriculture indicates that the agricultural industry contributes about 1,045 jobs in the White Clay Creek watershed with $726,265 in wages.

Table 31. Jobs from farms in the White Clay Creek Watershed

Region	Farmland (ac)	Farm Jobs	Wages
PENNSYLVANIA			
Chester County	166,891	7,708	5,047,000
White Clay Creek Portion	17,845	824	539,655
DELAWARE			
New Castle County	66,981	565	4,892,000
White Clay Creek Portion	2,555	22	186,611
Watershed Total	**20,400**	**846**	**726,265**

Fishing/Hunting/Bird and Wildlife Recreation Jobs

A study by the NJDEP estimated that the average annual salary per ecotourism job is $32,843, based on figures from the 2001 U.S. Fish and Wildlife Service report on fishing, hunting, and wildlife-associated recreation. Using this wage multiplier, fishing, hunting, and bird/wildlife-associated recreation accounts for 427 jobs in the White Clay Creek watershed. This annual activity is valued at $14 million in 2010 dollars (Table 42). While this estimate of ecotourism jobs is not exact, it provides a reasonable estimate of the jobs provided by fishing, hunting, and bird/wildlife-associated recreation in the White Clay Creek watershed.

Table 32. Jobs from fishing, hunting, and wildlife/birding recreation in the White Clay Creek watershed

Recreation Activity	Recreation Value[1] ($2010)	Jobs[2] in 2010 Dollars
Fishing	**4,617,287**	**141**
Trip Related	1,765,859	54
Equipment	2,851,428	87
Hunting	**3,639,685**	**111**
Trip Related	795,922	24
Equipment	2,843,763	87
Wildlife/Birding	**5,764,407**	**176**
Trip Related	862,433	26
Equipment	4,901,974	149
Total	**14,021,378**	**427**

1. USFWS (2007) in $2006
2. Scaled by the percentage of each state that is in the White Clay Creek watershed.
3. Jobs estimated at $32,843 average salary.

Outdoor Recreation

The Outdoor Industry Foundation (2006) concluded that 16.3 million participants in watershed-based recreation activities such as bicycling, camping, fishing, hunting, paddling, hiking, and wildlife viewing in the mid-Atlantic region (New Jersey, New York, and Pennsylvania) and contributed 216,396 jobs. Given that the population of the three states totals 40.9 million (NJ: 8.8 million, NY: 19.4 million, and PA: 12.7 million), by proportion outdoor recreation activity in the White Clay Creek watershed (pop. 124,845) contributes 661 jobs (Table 33).

Table 33. Outdoor recreation jobs in the White Clay Creek watershed

Activity	Mid-Atlantic Region[1]	White Clay Creek[2]	Total Earned Wages
Bicycling	40,121	122	10,292,844
Camping	89,384	273	22,933,019
Fishing	17,195	52	5,396,723
Hunting	7,234	22	2,231,337
Paddling	9,331	28	2,393,117
Hiking	28,686	88	7,359,445
Wildlife Viewing	24,445	75	5,360,093
Total	**216,396**	**661**	**55,966,579**

1. Outdoor Recreation Foundation 2006.
2. Scaled by population of watershed to Mid-Atlantic region population. White Clay Creek: 124,845

Watershed Organization Jobs

Twenty nonprofit watershed and environmental organizations employ at least 117 staff to work on programs to protect the White Clay Creek watershed (Table 34). Assuming that the average salary of an environmental scientist/specialist is $61,700 (Bureau of Labor Statistics), these watershed organization jobs account for $5.62 million in annual wages.

Table 34. Watershed organization jobs in the White Clay Creek watershed

Watershed Organization	Town	Jobs	Salaries ($)
PENNSYLVANIA			
Delaware Nature Society	Hockessin	20	960,000
Stroud Water Research Center	Avondale	45	2,160,000
White Clay Flyfishers	Landenburg	-	-
Total for Pennsylvania		65	3,120,000
DELAWARE			
Coalition for Natural Stream Valleys	Newark	0	$0
Delaware Audobon Society	Wilmington	1	48,000
Delaware Center for Horticulture	Wilmington	18	864,000
Delaware Chapter of the Sierra Club	Wilmington	0	0
Delaware Greenways	Wilmington	6	288,000
Fairfield Watershed Association	Newark	0	0
Friends of Lums Pond	Bear	0	0
Friends of White Clay Creek State Park	Newark	1	48,000
Green Delaware	Wilmington	-	-
League of Women Voters of Delaware	Wilmington	5	240,000
Nature Conservancy - Delaware Chapter	Wilmington	2	96,000
Partnership for the Delaware Estuary	Wilmington	16	768,000
Sierra Club	Wilmington	0	0
Urban Environmental Center	Wilmington	1	48,000
White Clay Creek Watershed Association	Newark	0	0
White Clay Creek Watershed Management Committee	Newark	1	48,000
Widener Environmental and Natural Resources Law Clinic[2]	Wilmington	1	48,000
Total for Delaware		52	2,496,000
Total for Watershed		**117**	**5,616,000**

Water Supply Jobs

Public and private water utilities withdraw over 33 mgd of drinking water from surface-water and groundwater supplies in the White Clay Creek watershed. According to the American Water Works Association, the average salary of a water-system employee is $55,407. Water supply utilities in the White Clay Creek watershed employ at least 99 jobs with annual wages of $5.5 million (Table 35).

Table 35. Jobs from public water utilities in the White Clay Creek watershed

Water Purveyor	State	Withdrawal (mgd)	Jobs	Salaries ($)
City of Newark	DE	3	9	498,663
United Water DE	DE	30	90	4,986,630
Total for watershed		**33**	**99**	**5,485,293**

Wastewater Utility Jobs

Four wastewater utilities discharge more than half a million gallons per day of treated wastewater to the White Clay Creek watershed. The wage information is computed using the assumption that the average wastewater utility salary is $40,000 per year. These wastewater utilities employ 4 staff members who earn roughly $160,000 in annual wages.

Table 36. Public water supply jobs in the White Clay Creek watershed

NPDES ID	Sewage Treatment Plant	Discharge (mgd)	Jobs	Salaries
Main Stem				
PA0024066	West Grove Borough Authority STP MB White Clay Creek Municipal Large STP	0.25	1	$40,000
East Branch				
PA0052451	Frances L. Hamilton Oates STP EB White Clay Creek Municipal Small STP	0.0012	1	$40,000
PA0025488	Avondale Borough Sewer Authority Indian Run Municipal Large STP	0.3	1	$40,000
PA0040436	Chadds Ford Investment Co./Red Fox GC TB-EB White Clay Creek Municipal Small STP	0.01	1	$40,000
Total for watershed		**0.56**	**4**	**$160,000**

Appendix - Employment Codes by Industry, 2009

(U. S. Bureau of Labor Statistics)

Industry	NAICS Code
Agriculture, Forestry, Fishing and Hunting	11
Crop Production	111
Animal Production	112
Aquaculture	1125
Forestry and Logging	113
Fishing, Hunting and Trapping	114
Fishing	1141
Support Activities for Agriculture and Forestry	115
Mining, Quarrying, and Oil and Gas Extraction	21
Oil and Gas Extraction	211
Mining (except Oil and Gas)	212
Nonmetallic Mineral Mining and Quarrying	2123
Support Activities for Mining	213
Utilities	22
Utilities	221
Electric Power Generation, Transmission and Distribution	2211
Natural Gas Distribution	2212
Water, Sewage and Other Systems	2213
Construction	23
Construction of Buildings	236
Residential Building Construction	2361
Nonresidential Building Construction	2362
Heavy and Civil Engineering Construction	237
Land Subdivision	2372
Highway, Street, and Bridge Construction	2373
Other Heavy and Civil Engineering Construction	2379
Specialty Trade Contractors	238
Manufacturing	31
Food Manufacturing	311
Seafood Product Preparation and Packaging	3117
Beverage and Tobacco Product Manufacturing	312
Textile Mills	313
Textile Product Mills	314
Apparel Manufacturing	315
Apparel Knitting Mills	3151
Leather and Allied Product Manufacturing	316
Wood Product Manufacturing	321
Paper Manufacturing	322
Petroleum and Coal Products Manufacturing	324
Chemical Manufacturing	325
Basic Chemical Manufacturing	3251
Resin, Synthetic Rubber, and Artificial Synthetic Fibers and Filaments Manufacturing	3252
Pesticide, Fertilizer, and Other Agricultural Chemical Manufacturing	3253

		Pharmaceutical and Medicine Manufacturing	3254
		Paint, Coating, and Adhesive Manufacturing	3255
		Soap, Cleaning Compound, and Toilet Preparation Manufacturing	3256
		Other Chemical Product and Preparation Manufacturing	3259
	Plastics and Rubber Products Manufacturing		326
	Nonmetallic Mineral Product Manufacturing		327
		Cement and Concrete Product Manufacturing	3273
		Lime and Gypsum Product Manufacturing	3274
		Other Nonmetallic Mineral Product Manufacturing	3279
	Primary Metal Manufacturing		331
	Fabricated Metal Product Manufacturing		332
	Machinery Manufacturing		333
	Computer and Electronic Product Manufacturing		334
		Computer and Peripheral Equipment Manufacturing	3341
		Communications Equipment Manufacturing	3342
		Audio and Video Equipment Manufacturing	3343
		Semiconductor and Other Electronic Component Manufacturing	3344
		Navigational, Measuring, Electromedical, and Control Instruments Manufacturing	3345
		Manufacturing and Reproducing Magnetic and Optical Media	3346
	Electrical Equipment, Appliance, and Component Manufacturing		335
	Transportation Equipment Manufacturing		336
		Motor Vehicle Manufacturing	3361
		Motor Vehicle Body and Trailer Manufacturing	3362
		Motor Vehicle Parts Manufacturing	3363
		Aerospace Product and Parts Manufacturing	3364
		Railroad Rolling Stock Manufacturing	3365
		Ship and Boat Building	3366
		Other Transportation Equipment Manufacturing	3369
	Furniture and Related Product Manufacturing		337
	Miscellaneous Manufacturing		339
Wholesale Trade			42
	Merchant Wholesalers, Durable Goods		423
	Merchant Wholesalers, Nondurable Goods		424
	Wholesale Electronic Markets and Agents and Brokers		425
Retail Trade			44
	Motor Vehicle and Parts Dealers		441
	Furniture and Home Furnishings Stores		442
	Electronics and Appliance Stores		443
		Electronics and Appliance Stores	4431
	Building Material and Garden Equipment and Supplies Dealers		444
	Food and Beverage Stores		445
	Health and Personal Care Stores		446
	Gasoline Stations		447
	Clothing and Clothing Accessories Stores		448
	Sporting Goods, Hobby, Book, and Music Stores		451
	General Merchandise Stores		452
	Miscellaneous Store Retailers		453
	Nonstore Retailers		454
Transportation and Warehousing			48

	Air Transportation		481
		Scheduled Air Transportation	4811
		Nonscheduled Air Transportation	4812
	Rail Transportation		482
		Rail Transportation	4821
	Water Transportation		483
		Deep Sea, Coastal, and Great Lakes Water Transportation	4831
		Inland Water Transportation	4832
		Support Activities for Water Transportation	4883
	Truck Transportation		484
		General Freight Trucking	4841
		Specialized Freight Trucking	4842
	Transit and Ground Passenger Transportation		485
		Urban Transit Systems	4851
		Interurban and Rural Bus Transportation	4852
		Taxi and Limousine Service	4853
		School and Employee Bus Transportation	4854
		Charter Bus Industry	4855
		Other Transit and Ground Passenger Transportation	4859
	Pipeline Transportation		486
		Pipeline Transportation of Crude Oil	4861
Information			51
	Publishing Industries (except Internet)		511
	Motion Picture and Sound Recording Industries		512
	Broadcasting (except Internet)		515
	Telecommunications		517
	Data Processing, Hosting, and Related Services		518
	Other Information Services		519
Finance and Insurance			52
	Monetary Authorities-Central Bank		521
	Credit Intermediation and Related Activities		522
	Securities, Commodity Contracts, and Other Financial Investments and Related Activities		523
	Insurance Carriers and Related Activities		524
	Funds, Trusts, and Other Financial Vehicles		525
Real Estate and Rental and Leasing			53
	Real Estate		531
	Rental and Leasing Services		532
	Lessors of Nonfinancial Intangible Assets (except Copyrighted Works)		533
Professional, Scientific, and Technical Services			54
	Professional, Scientific, and Technical Services		541
		Management, Scientific, and Technical Consulting Services	5416
		Scientific Research and Development Services	5417
Management of Companies and Enterprises			55
	Management of Companies and Enterprises		551
Administrative and Support and Waste Management and Remediation Services			56
	Administrative and Support Services		561
		Travel Arrangement and Reservation Services	5615
	Waste Management and Remediation Services		562
Educational Services			61

	Educational Services		611
		Colleges, Universities, and Professional Schools	6113
		Technical and Trade Schools	6115
		Educational Support Services	6117
Health Care and Social Assistance			62
	Ambulatory Health Care Services		621
	Hospitals		622
	Nursing and Residential Care Facilities		623
	Social Assistance		624
Arts, Entertainment, and Recreation			71
	Performing Arts, Spectator Sports, and Related Industries		711
	Museums, Historical Sites, and Similar Institutions		712
	Amusement, Gambling, and Recreation Industries		713
		Other Amusement and Recreation Industries	7139
Accommodation and Food Services			72
	Accommodation		721
		Traveler Accommodation	7211
		RV (Recreational Vehicle) Parks and Recreational Camps	7212
		Rooming and Boarding Houses	7213
	Food Services and Drinking Places		722
Other Services (except Public Administration)			81
	Repair and Maintenance		811
	Personal and Laundry Services		812
	Religious, Grantmaking, Civic, Professional, and Similar Organizations		813
		Social Advocacy Organizations	8133
		Business, Professional, Labor, Political, and Similar Organizations	8139
	Private Households		814
Public Administration			92
	Executive, Legislative, and Other General Government Support		921
	Justice, Public Order, and Safety Activities		922
	Administration of Human Resource Programs		923
	Administration of Environmental Quality Programs		924
	Administration of Housing Programs, Urban Planning, Community Development		925
	Administration of Economic Programs		926
	Space Research and Technology		927
	National Security and International Affairs		928

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