Upper East Branch White Clay Creek Watershed Restoration Plan

West Marlborough Township, New Garden Township, London Grove Township, and Avondale Borough, Chester County, White Clay Watershed, Pennsylvania

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1.0 INTRODUCTION

Since the instatement of the White Clay Creek as a National Wild and Scenic River in 2000, the White Clay Watershed Association has been working with local leaders, community groups, and project partners to restore and preserve the stream and its watershed. Since 2013, key watershed partners have been teaming up within the headwaters areas of this sub-watershed to collaborate on restoration projects organized and funded through William Penn Foundation's Delaware River Watershed Initiative (DRWI). White Clay Watershed Association desires to build upon that work and extend the restoration focus to better protect downstream at-risk communities and water quality concerns through a holistic restoration plan that focuses on the underserved lower portion of the sub-watershed. To aid in identifying the areas within the watershed where restoration work would be most effective, White Clay Wild and Scenic partnered with Clauser Environmental LLC to complete a detailed watershed assessment (Clauser and Clauser, 2023). With the scientific background knowledge from the watershed assessment serving as a foundation, this detailed restoration plan for the Upper East Branch White Clay Creek Watershed was prepared to address the specific areas of impairment. As the solutions outlined within this restoration plan are implemented, substantial progress will continue to be made in restoring this sub-watershed of the Brandywine Christina Basin.

The majority of the Upper East Branch White Clay Creek Watershed has a Pennsylvania Code, Title 25, Chapter 93 water quality designation of Exceptional Value. During the watershed assessment phase, only one tributary within the watershed was found to have the diverse macroinvertebrate community that meets the Department of Environmental Protection's criteria for an exceptional value stream. The remainder of the watershed has impaired water quality (Clauser and Clauser, 2023, DEP, 2020). The portion of the mainstem of the Upper East Branch White Clay Creek below Avondale is listed as a Cold-Water Fishery, Migratory Fishery (CWF, MF). The Upper East Branch White Clay Creek and its tributaries are not listed by the Pennsylvania Fish and Boat Commission as streams that support the natural reproduction of trout (PFBC, 2022).

Land usage within the Upper East Branch White Clay Creek Watershed is distributed between agricultural areas, residential developments, commercial areas, open spaces, and forested corridors. Located within the watershed is a former golf course that is being converted to a passive recreation park and other small public parks. The Upper East Branch White Clay Creek passes through many fields and mowed areas such as yards and horse pastures. In the upper section of the watershed, rolling pastures and equine operations dominate the landscape. Near the bottom of the watershed, the stream passes through Avondale, which is a more urban area. Within Avondale, repeated flood events have strained the lives of those who live and work closest to the stream.

Here, a restoration plan for the Upper East Branch White Clay Creek Watershed is presented to address specific areas of water quality impairment and threats to the local community and environment. The plan focuses on passive, long-term projects that will help to manage stormwater during heavy rain events, reduce the impacts of flooding, improve water quality, and improve habitat conditions within the watershed. Projects

such as this will both help protect crucial habitat for species living in the watershed and protect the homes and businesses of community members from flooding. Finally, this plan will operate as a base plan for multiple communities throughout the White Clay Watershed so they may better collaborate on projects which help to address shared climate resiliency issues and inequity.

2.0 METHODOLOGY

To determine the areas within Upper East Branch White Clay Creek Watershed in need of the most attention, Shane Morgan of the White Clay Valley Association and Kora Clauser and Aaron Clauser, Ph.D. of Clauser Environmental, LLC conducted a stream walk on July 19th, 2022 within the lower reaches of the watershed (downstream of the Kennett Oxford Bypass). Photographs, field notes, and GPS coordinates were collected at areas identified as points of interest. Within the upper reaches of the watershed, restoration opportunities were identified and prioritized by reviewing recent and historical aerial photography, conducting windshield surveys from roadways, studying the watershed geology, meeting with stakeholders, and reviewing the water quality data collected and presented in the Upper East Branch White Clay Creek Watershed Assessment Report that was prepared as part of this project (Clauser and Clauser, 2023). Sources of impairment were identified at the parcel level.

Clauser Environmental, LLC located the points of interest within the watershed using a Trimble Geo7X Global Positioning System (GPS) receiver with H-Star and Floodlight enabled decimeter accuracy configuration during the site visits (Appendix C). The instrument smart settings were used per manufacturer's recommendation. Logging interval was set at 1 second with typically a minimum of 30 readings collected at each point. Data collected in the field was downloaded to a personal computer for differential correction using GPS Pathfinder Office software (Version 5.6). Correction files were obtained from dedicated base stations located in Schuylkill Haven and Philadelphia, Pennsylvania and Wilmington, Delaware. Mission planning, parameter settings, and post processing typically allow an accuracy of 10 centimeters (Trimble Navigation 2014). The precision of GPS collected data is subject to variation caused by canopy cover, atmospheric interference, time of day, and satellite geometry. Cost estimates were prepared based on recent projects completed by Clauser Environmental, LLC. The included cost estimates provide an order of magnitude idea of the potential costs to implement the various watershed solutions that are proposed.

3.0 WATERSHED PROBLEMS AND SOLUTIONS

This section focuses on the sources and causes of impairment within the Upper East Branch White Clay Creek Watershed and potential restoration practices that can be completed to address the noted impacts for high and medium priority areas. Low priority restoration projects are included in Appendix B. Each impacted segment identification number can be cross-referenced with its approximate location on the map in Appendix A.

3.1 High Priority Projects:

Impacted Stream Segment #1:
Invasive species including stilt grass (*Microstegium vimineum*), poison hemlock (*Conium maculatum*), Japanese knotweed (*Reynoutria japonica*), multiflora rose (*Rosa multiflora*), Japanese hops (*Humulus japonicus*), reed canary grass (*Phalaris arundinacea*), porcelain berry (*Ampelopsis brevipedunculata*), mugwort (*Artemisia vulgaris*), Asiatic bittersweet (*Celastrus orbiculatus*), and others dominate this section of the watershed and many others. Invasive species outcompete native plant species and often provide less desirable habitat conditions for other species within the watershed. This high priority project includes the entire watershed.

Solution:
Restoration of the watershed should include the removal of invasive species. For each area where the invasives are removed, the need for planting of native species as replacements should be considered. Typically, removal of the invasive species within this watershed will include selective herbicide application on multiple occasions. Within the watershed as a whole, restoration projects should include a longterm maintenance plan that includes managing invasive species with an integrated pest management plan approach.

Impacted Stream Segment #2-4:

Within this section of stream, the streambanks are actively eroding and are between 4 and 5 feet high. This height disconnects the stream from the active floodplain. Some areas are mowed to the top of the streambank. Large pieces of flood debris and litter are within the channel and on the floodplain. Throughout this stream section and the older areas within the Borough of Avondale, there is a lack of control of stormwater discharging to the stream from impervious areas within commercial areas, roadways, and residences.

Solution:

Restoration of this stream segment should focus on restoring the floodplain by removing legacy sediments on the eastern side of the stream to create an active floodplain that is more closely tied to the stream channel. The new floodplain should include wetland pockets to improve the habitat diversity and flood water retention of the site. Creating a more gradual slope for the streambanks on both sides of the channel and then stabilizing them with native vegetation will allow for this section of the watershed to filter pollutants and absorb some of the flooding flows. The incorporation of natural stream design structures such as j-hooks, rock vanes, root wads, and deflectors in the project plan will aid in stabilizing the streambanks during vegetation establishment and creating diverse habitat areas. Ongoing maintenance of this area should incorporate litter cleanups and invasive species removal.

Impacted Stream Segment #6-8:

Within this section of the stream, businesses and residences along the northwestern streambank are routinely flooded. Stormwater from the surrounding area discharges into the stream without control, and the streambanks are mowed to the edge in some areas. Directly upstream of this point is park property, a section of which has stable banks and a well-connected floodplain.

Solution:

After careful consideration and communication with watershed stakeholders, Clauser Environmental proposes that the best long-term solution to the impacts of the flooding in this part of Avondale is likely a FEMA buyout of the impacted properties. Even with all of the recommendations from this watershed restoration plan implemented, it is unlikely that the properties within the floodplain of this stream segment will be spared from future flooding. It is a matter of when, not if, the properties will flood again. With global climate change increasing the frequency and magnitude of flood events, the impacts to this area will likely increase in the foreseable future. This buyout is recommended as being contingent on the establishment of additional low-income housing options within or near the Borough of Avondale and the provision of necessary assistance to help current residents with relocation. The area could be converted into a passive public park that could be a centerpiece for outdoor recreation within the community. By limiting infrastructure within the floodplain, future risks to residents and property will be limited. As the area is naturalized, the streambanks and riparian zone should be planted with native vegetation.

Impacted Stream Segment #11:

Within the lower section of the Upper East Branch White Clay Creek watershed, substantial flooding has repeatedly occurred. Residents, business owners, public officials, and first responders lack a reliable notification system for flooding within the watershed. When flooding occurs, there is an immediate need to rescue residents from the floodwaters, sometimes with boats. During the flooding and while work is done to repair the damaged areas, approximately 140 residents need to be housed in temporary shelters.

Solution:

This high priority project focuses on protection of life and property from future flooding events within the watershed. The USGS stream gauge at this location could be coupled with long-term data from flow measurements Stroud Water Research Center and others have taken in the headwaters to develop a flow model for flooding in the watershed. By linking the stream gauges with precipitation data and forecasts, it is possible to develop an early warning system for flooding that could allow residents and business owners the opportunity to escape the floodplain before floodwaters put their lives and those that work to protect them at risk.

Impacted Stream Segment #12-13:

This high priority stream segment includes a pasture where livestock have direct access to the Upper East Branch White Clay Creek. Approximately 30% of the streambanks in this section of the stream are actively eroding and average four feet high. Where livestock routinely cross the stream, the banks are raw and eroding. At the downstream end of this section, the stream drains under the Third Street bridge.

Solution:

Restoration of this area should focus on floodplain restoration, streambank stabilization, streambank fencing, and riparian buffer enhancement. Stable ford crossings should be installed at appropriate locations for the livestock to cross the stream without further degrading the steam channel. Native trees and shrubs should be planted within the riparian zone to help the buffer become established. When the Third Street bridge is replaced at some point in the future, the design process should include investigating ways to expand the waterway opening and eliminate piers that contribute to potential channel blockages.

Impacted Stream Segment 35-37:
Within this stream section, the riparian zone is mowed to the edge of the stream. In large sections of the reach, the streambanks are 2-3' high and actively eroding. In a portion of the stream segment, livestock have access to the stream. When livestock are allowed uncontrolled access to a steam channel, they typically contribute to erosion of the streambanks, increase the nutrient loading of the channel, and can directly increase the amount of fecal coliform bacteria in the water making it unsafe for downstream users.

Solution:
Restoration of this stream segment should include grading the streambanks to a 4:1 or flatter slope and stabilizing the streambanks with a combination of native plantings and instream log or rock habitat structures. Grading the banks to a stable slope will improve the filtering of pollutants in the riparian zone by increasing the surface area of the contact zone between riparian vegetation and pollutants being transported by the stream during high flow events. In areas where livestock have access to the creek, streambank fencing, stable livestock ford crossings, rotational grazing, and other agricultural best management practices should be implemented. After the streambank fencing is installed, the riparian buffer should be planted with native trees and shrubs.

Impacted Stream Segment #43:

The unnamed, headwaters stream (Tributary 00455) that flows through this point is primarily forested with mostly stable streambanks. During the watershed assessment phase, the sample point in the headwaters of this unnamed tributary had the highest macroinvertebrate score in the watershed. While many of the parcels in this section of the watershed already are covered under conservation stewardship agreements, additional work to seek easements and protect the water quality of this section of the watershed remains as there are several unprotected parcels that contribute stormwater and pollutants to the stream channel and threaten the continued integrity of the riparian buffer.

Solution:

Natural Lands, Brandywine Conervancy, and Stroud Water Research Center have been leaders in reaching out to landowners, identifying shared goals, and securing lasting conservation stewardship agreements throughout the watershed. This study reaffirms the importance of these conservation stewardship agreements and adds a particular focus to the sub-watershed that drains to Tributary 00455 as it provides the highest water quality in the Upper East Branch Red Clay Creek Watershed and is a refuge for sensitive aquatic life within this exceptional value watershed. For those conservation stewardship agreements that are already in place, it is important to complete routine site visits to ensure the goals and conditions of the easements are being upheld.

3.2 Medium Priority Projects:

Impacted Stream Segment #5:
At this location, the Gap Newport Pike crosses the East Branch White Clay Creek. The existing bridge has a center pier that catches debris and contributes to the formation of a gravel bar just downstream of the bridge. The pier and gravel bar increase the potential for channel blockage during high water events and increase the risk of flooding for the upstream community.

Solution:
The gravel bar and any debris on the central pier of the bridge should be removed as part of routine maintenance by PennDOT. Avondale Borough should monitor the bridge for blockages and notify PennDOT if maintenance is required. When the bridge is replaced at the end of its service lifetime, the replacement structure should be a single span bridge if feasible as that would greatly reduce the risk of blockage.

Impacted Stream Segment #15-17:
Within this section of stream, active agricultural fields extend to within ten feet of the top of the streambanks. Legacy sediment from farming before conservation practices were standard has buried the pre-colonial floodplain and stream system so that the current channel is steeply incised. The streambanks are 4-5' high and are actively eroding in portions of the steam segment.

Solution:
Floodplain restoration is key to repairing this impacted stream segment. The removal of legacy sediment could allow for construction of an active floodplain with wetland pockets to aid in attenuating flooding and pollutants moving through the watershed. Streambank stabilization, instream structures, and riparian buffer plantings could aid in creating a more resilient stream and riparian zone.

Impacted Stream Segment #27-28:
Within this section of stream, the streambanks are actively eroding and are 3-4' high. The riparian zone is mowed to the streambank on the western side and dominated by the invasive Japanese knotweed (*Reynoutria japonica*) on the eastern streambank.

Solution:
Restoration of this area should include floodplain restoration that focuses on removal of legacy sediments and reconnecting the floodplain, streambank stabilization, installation of instream habitat structures, invasive species removal, and riparian buffer enhancements.

Impacted Stream Section 47-49:
This stream section flows through the former Loch Nairn Golf Club. The club was recently acquired as a passive recreation park by New Garden Township. A legacy of impacts from the golf club remain on the property. The legacy impacts include mowed riparian zones, residual fertilizers and pesticides, and many areas dominated by non-native species.

Solution:
The site is being converted from a traditional golf course to a naturalized, passive recreation area. The restoration of this stream segment should include retentive grading and wetland cells to decrease flooding flows to downstream areas, native riparian buffer and upland plantings, and implementation and retrofits of stormwater management areas. Natural Lands and Stroud Water Research Center are working with New Garden Township to develop the park under the guidance of a site master plan.

2018 PEMA Aerial Photo

Impacted Stream Section 49-50:
This stream section runs through a field with minimal cover along the stream. The riparian zone is mowed to the edge of the stream channel.

Solution:
The restoration of this stream segment should focus on installing a forested riparian buffer. For a more aggressive and beneficial restoration approach, constructed wetlands could be installed to aid in absorbing floodwaters, filtering contaminants, and recharging the groundwater.

4.0 RESTORATION IMPLEMENTATION

Restoration of the Upper East Branch White Clay Creek Watershed will require a combination of best management practices (BMPs) that are especially tailored to improving the aquatic conditions of streams flowing through agricultural communities. Appendix D provides information related to the implementation of each of the proposed restoration BMPs. The format is such that each of the individual BMP sheets may be selected as needed for a particular property/project and provided to the individual landowner.

5.0 COST ESTIMATES

As the restoration of the Upper East Branch White Clay Creek Watershed moves from the assessment and planning stages into the funding and implementation stages, it is imperative that an understanding of both the benefits and costs of completing each project is held by the partnering agencies and landowners. In the previous sections, the benefits of stream restoration are described. In this section, the design and implementation costs for each high and medium priority restoration project are estimated.

Clauser Environmental, LLC prepared a preliminary construction cost opinion based upon experience in the field and costs for various best management practices to serve as a general guideline for the approximate project costs. For each project, a maximum and minimum estimated cost is presented (Appendix E).

Costs associated with stream restoration practices are quite variable depending upon the overall restoration goals, landowner objectives, project funding requirements, availability of building materials, site conditions, volunteer hours, level of detail required for survey and design, and permitting costs.

The total estimated cost to implement all of the high and medium priority projects within the watershed is $7,890,000 to $12,250,000. These costs include construction, demolition, and professional services.

To set each project in motion, the project partners will need to seek out interested landowners and funding opportunities. As the identified projects are located on a mix of public and private parcels, landowner support and objectives will need to be at the forefront of every decision during the design, permitting, and construction stages of the projects. After reviewing the project on the ground with the landowner, a more refined cost opinion should be developed and utilized as a guide to seek funding for the project. Important considerations should include access to the project site, locations of resources of special concern (wetlands, etc.), funding limitations, volunteer matches available, and permitting requirements. With the exceptional value designation of many areas of the Upper East Branch White Clay Creek, permitting requirements are particularly rigorous for projects that will impact the streams and wetlands within the watershed. Pre-application meetings and open communication with regulatory offices will be essential for the efficient implementation of the identified projects.

After each project is funded and design and permitting are complete, a set of bid documents should be prepared. The bidding process should be conducted in accordance with accepted practices and at least three bids should be sought. The selection of a contractor should be based upon experience with the type of project being conducted, a check of references, capacity to complete the project within the desired timeline, and cost.

6.0 OBTAINING SUPPORT AND MONITORING PROGRESS

Community outreach and attaining landowner support is often the most challenging step in restoring a watershed. Developing a positive relationship with landowners is critical. The White Clay Watershed Association has already taken the first steps in this direction by spending the time up-front to visit many of the landowners whose properties adjoin the stream. Many of the landowners and project partners found the stream assessment phase of the project to be of interest and have indicated that they would be interested in learning the results of the study. An important next step is to provide a forum to disseminate information to the community. Possible outreach activities include an open forum type presentation at the Avondale Borough Hall or a watershed science fair festival where families may attend and not only hear about the results from the study, but become engaged through activities and exhibits targeting the watershed.

Within the Upper East Branch White Clay Creek Watershed, many of the landowners have existing relationships with conservation organizations. It is essential for the White Clay Watershed Association to nurture and support these relationships as a collaborative partner. On the ground projects have been completed by Brandywine Conservancy, Stroud Water Research Center, Chester County Conservation District, and others. Some of the key teaming partners for the watershed include:

- Avondale Borough, London Grove Township, West Marlborough Township, New Garden Township, and the Chester County Planning Commission (Project implementation and regulation)
- Stroud Water Research Center (Project development, research, and monitoring)
- Brandywine Conservancy (Project leadership, land preservation, and implementation)
- Natural Lands (Land preservation and conservation)
- New Bolton Center (Agricultural research and design)
- Chester County Agricultural Preservation Board (Farmland preservation)
- Chester County Conservation District (Agricultural BMP design, soil conservation, nutrient management, and watershed consultation)
- Chester County Water Resources Authority (Leadership and management)
- Chester County Solid Waste Authority (Funding assistance)
- Chester County Emergency Services (Flooding assistance and emergency planning)
- Natural Resources Conservation Service (Conservation plans for individual farms and agricultural best management practices)
- University of Delaware (Research and monitoring)
- The Nature Conservancy (Preservation and conservation)
- Pennsylvania Department of Environmental Protection (Water quality grant opportunities and regulation)
- Pennsylvania Department of Conservation & Natural Resources (Land preservation, resource management, and recreation grant opportunities)
- Pennsylvania Fish & Boat Commission (Fisheries protection, resource management, and aquatic habitat improvement)

- Pennsylvania Game Commission (Wildlife protection and habitat improvement)
- Ducks Unlimited (Volunteers and funding assistance)
- William Penn Foundation (Grant Funding and leadership)
- National Fish and Wildlife Foundation (Grant funding)
- National Park Service (Project development, funding, and leadership)
- Trout Unlimited (Volunteers and funding assistance)
- United States Geological Survey (Research and monitoring)
- Kennett Area Community Service, United Way of Southern Chester County, and The Garage Youth Center (Flooding assistance, planning, and emergency relief)
- Local Scout and Civic Groups (Riparian buffer planting volunteers)

The effectiveness of installed restoration projects should be monitored within the watershed. The background data collected during the assessment phase of this project provides a baseline by which to compare data collected with the same standard methodologies. Monitoring will aid in not only understanding what best management practices are having the greatest impact and guiding future projects, but will provide crucial supporting data to demonstrate success and leverage funding of future projects. With continued progress in the watershed, the water quality of the White Clay Creek will continue to improve for future generations.

7.0 LITERATURE CITED

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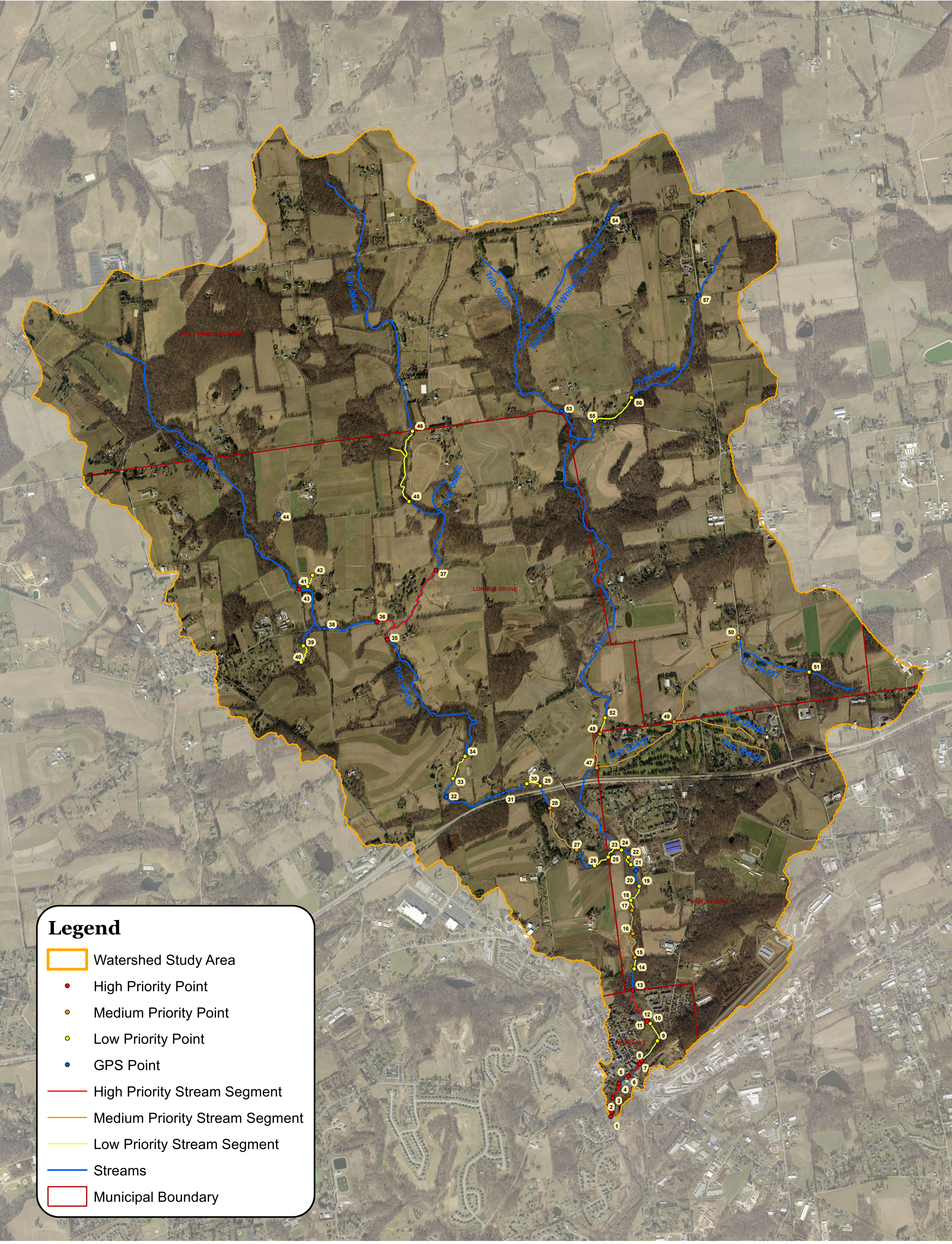
APPENDIX A
WATERSHED RESTORATION PLAN MAP



0 1,000 2,000 4,000 Feet

Data Sources:
Clauser Environmental, LLC
Chester County GIS Department
PEMA 2018 Imagery
www.pasda.psu.edu

N W E S

Upper East Branch White Clay Creek Watershed Restoration Plan Map Chester County, Pennsylvania

CLAUSER environmental llc

WHITE CLAY CREEK
National Wild & Scenic River
Ours to Enjoy. Ours to Protect.

APPENDIX B
GPS POINT DESCRIPTIONS AND ACTION ITEMS

GPS Point Descriptions and Action Items

Point #	Description	Action Item	Key Partners	Priority	Comments
1	Invasive species dominate the riparian zone throughout the watershed. Invasive species in the watershed include stilt grass (*Microstegium vimineum*), poison hemlock (*Conium maculatum*), Japanese knotweed (*Reynoutria japonica*), multiflora rose (*Rosa multiflora*), Japanese hops (*Humulus japonicus*), reed canary grass (*Phalaris arundinacea*), porcelain berry (*Ampelopsis brevipedunculata*), mugwort (*Artemisia vulgaris*), Asiatic bittersweet (*Celastrus orbiculatus*), and others.	Invasive species removal and riparian buffer enhancements	Chester County Conservation District, Stroud Water Research Center, Brandywine Conservancy, Municipalities, Landowners	High	Watershed Wide Priority Item
2	Upstream of this point, the floodplain is disconnected with actively eroding 4-5' high streambanks. Litter and large pieces of debris are in the stream channel and riparian zone.	Floodplain restoration, streambank stabilization, and litter cleanup	Chester County Conservation District, Stroud Water Research Center, Avondale Borough, Landowners	High	
3	Upstream of this point, the western streambank is mowed to the top of the streambank. The floodplain is disconnected and the streambanks are approximately 4' high and actively eroding.	Floodplain restoration, streambank stabilization, and litter cleanup	Chester County Conservation District, Stroud Water Research Center, Avondale Borough, Landowners	High	
4	Downstream of this point, the streambanks are approximately 5' high and actively eroding. Upstream, the riparian zone is 10-15' wide. Lawns and commercial areas discharge stormwater into the stream without control.	Floodplain restoration, streambank stabilization, stormwater retrofits, and litter cleanup	Chester County Conservation District, Stroud Water Research Center, Avondale Borough, Landowners	High	

GPS Point Descriptions and Action Items

Point #	Description	Action Item	Key Partners	Priority	Comments
5	Downstream of this point, the banks are relatively stable, but the streambed is heavily sedimented. Roadside drainage discharges into the the creek via an outfall without control. A gravel bar has formed downstream of the bridge pier.	Routinely remove the gravel bar, replace the bridge with a single span structure, stormwater retrofits	PennDOT, Chester County Conservation District, Avondale Borough	Medium	
6	Upstream of this point, the homes and businesses routinely flood. The banks are mowed to the edge of the stream. Stormwater from the apartments and mushroom houses discharge to this area without control.	FEMA buyout, floodplain restoration, riparian buffer enhancement, stormwater retrofits	FEMA, Avondale Borough, United Way of Southern Chester County, Kennett Area Community Service, Avondale Apartments Advocacy Group, Chester County Conservation District, Landowners	High	

GPS Point Descriptions and Action Items

Point #	Description	Action Item	Key Partners	Priority	Comments
7	Stormwater from the town discharges to the stream without control. The southwest bank of the stream is mowed to the edge, but the northeast bank has a forested buffer.	FEMA buyout, stormwater retrofits, riparian zone buffer enhancement	FEMA, Avondale Borough, United Way of Southern Chester County, Kennett Area Community Service, Avondale Apartments Advocacy Group, Chester County Conservation District, Landowners	High	
8	Downstream of this point there are buildings constructed within the floodplain. Upstream is of this point is park property with stable banks and a connected floodplain.	FEMA buyout, floodplain restoration, riparian buffer enhancement	FEMA, Avondale Borough, United Way of Southern Chester County, Kennett Area Community Service, Avondale Apartments Advocacy Group, Chester County Conservation District, Landowners	High	The upstream community park could potentially be expanded downstream to use the area with minimal infrastructure risk.

GPS Point Descriptions and Action Items

Point #	Description	Action Item	Key Partners	Priority	Comments
9	Upstream banks are 2-3' high, slightly disconnected and actively eroding. Instream structures and bank stabilization in this segment of stream are over twenty years old, are still functional, and are providing the best habitat in this stream section. Upstream and downstream of this point, there is space to expand and enhance the riparian buffer with native tree and shrub plantings.	Riparian buffer plantings, signage educating the public on stormwater and environmental issues	Chester County Conservation District, Stroud Water Research Center, Avondale Borough, Landowners	Low	
10	A sanitary sewer line is exposed on the bottom of the stream at this point.	Lower the sewer line during future utility work in the area	Avondale Borough, Landowners	Low	
11	A USGS gauging station is located at this point. This station could potentially be coupled with other stations in the watershed to create an early warning system for future flooding to aid in alerting first responders, municipal officials, and residents that live within the floodplain so they can better protect life and property.	Create an early warning system for flooding within the watershed	USGS, Stroud Water Research Center, Avondale Borough, Chester County Emergency Services	High	
12	Upstream of this point, pasture exists on both sides of the creek. This point marks the Third Street bridge, a multiple span road bridge.	Floodplain restoration, streambank fencing, streambank stabilization, riparian zone enhancement, eliminate the bridge piers when it is due for replacement	Chester County Conservation District, Brandywine Conservancy, Stroud Water Research Center, Avondale Borough, Landowners, PennDOT	High	

GPS Point Descriptions and Action Items

Point #	Description	Action Item	Key Partners	Priority	Comments
13	Downstream of this point, approximately 30% of the streambank is actively eroding and averages 4' high. Cattle have direct access to the stream. Upstream of this point, streambanks are stable and there is a healthy riparian forest.	Streambank stabilization, floodplain restoration, streambank fencing, and riparian zone enhancement	Chester County Conservation District, Brandywine Conservancy, Stroud Water Research Center, Avondale Borough, Landowners	High	
14	Downstream of this point, the streambanks are mostly forested and stable. Upstream, the streambanks are 3-4' high and actively eroding in a few locations.	Streambank stabilization, riparian zone enhancement	Chester County Conservation District, Brandywine Conservancy, Stroud Water Research Center, New Garden Township, Landowners	Low	
15	Downstream of this point, a pasture extends within five feet of the stream. There is bamboo growing along the eastern bank of the stream. Upstream of this point, there is active agriculture within 10 feet of the stream.	Floodplain restoration, riparian buffer enhancement, streambank stabilization, remove bamboo and replace with native plantings	Chester County Conservation District, Brandywine Conservancy, Stroud Water Research Center, New Garden Township, Landowners	Medium	

GPS Point Descriptions and Action Items

Point #	Description	Action Item	Key Partners	Priority	Comments
16	Upstream and downstream of this point, the stream section has 4-5' high actively eroding banks and no forested buffer on the western side of the stream.	Floodplain restoration, riparian buffer enhancement, streambank stabilization	Chester County Conservation District, Brandywine Conservancy, Stroud Water Research Center, New Garden Township, Landowners	Medium	
17	The section downstream of this point has 4-5' high actively eroding streambanks. The upstream section is mowed to the top of the streambanks with some large trees along the banks .	Floodplain restoration, riparian buffer enhancement, streambank stabilization	Chester County Conservation District, Brandywine Conservancy, Stroud Water Research Center, New Garden Township, Landowners	Medium	
18	This point marks a bridge on private property. Downstream of this point, the riparian zone has been mowed to the top of the streambanks. The streambanks are 4-5' high and actively eroding outside of the meander bends of the streambed. The area upstream of this point is forested with some sections of the understory being mowed.	Streambank stabilization, riparian zone enhancement	Chester County Conservation District, Stroud Water Research Center, New Garden Township, Landowners	Low	

GPS Point Descriptions and Action Items

Point #	Description	Action Item	Key Partners	Priority	Comments
19	Downstream of this point, the riparian zone is mowed to within 10' of the streambank. Upstream, the streambanks are stable and forested. The upstream streambanks are 3-4' high with a disconnected floodplain.	Downstream riparian zone enhancement that focuses on planting additional trees and shrubs	Chester County Conservation District, Stroud Water Research Center, New Garden Township, Landowners	Low	
20	This area has forested, 3-4' high, stable streambanks.				This area is not a target for floodplain restoration as it has stable banks and is forested.
21	Streambanks downstream of this site are 3-4' high, forested, and stable. Streambanks upstream of this point are 3-4' high and have some minor areas of active erosion.	Streambank stabilization	Chester County Conservation District, New Garden Township, Landowners	Low	
22	Downstream, the streambanks are 3-4' high and have some minor areas of active erosion. Upstream of this point, the streambanks are stable and 2-3' high.	Streambank stabilization	Chester County Conservation District, New Garden Township, Landowners	Low	
23	Downstream of this section, the streambanks are stable. Upstream of this point, the riparian zone is mowed to the edge of the eastern bank and some riparian buffer trees have been planted. Some areas of active erosion are present upstream.	Stop mowing streambank after buffer trees become established	Chester County Conservation District, Brandywine Conservancy, Stroud Water Research Center, New Garden Township, Landowners	Low	

GPS Point Descriptions and Action Items

Point #	Description	Action Item	Key Partners	Priority	Comments
24	This point marks the confluence of the Upper East Branch of White Clay Creek and Tributary 00454. Upstream of this point on Tributary 00454, the streambanks are 2-4' high and are actively eroding.	Streambank stabilization	Chester County Conservation District, New Garden Township, Landowners	Low	The impacts to the riparian forest for access likely do not justify working on the streambanks in this area.
25	Throughout this stream reach, the riparian buffer is intact. The banks are 2-4' high and actively eroding.	Streambank stabilization	Chester County Conservation District, New Garden and London Grove Townships, Landowners	Low	The impacts to the riparian forest for access likely do not justify working on the streambanks in this area.
26	Downstream of this point, the streambanks are 3-4' high and actively eroding. The riparian buffer is in good shape.	Streambank stabilization	Chester County Conservation District, London Grove Township, Landowners	Low	The impacts to the riparian forest for access likely do not justify working on the streambanks in this area.
27	Downstream of this point, the streambanks have some minor areas of 2-3' high active erosion. The riparian buffer is 15-35' wide. Upstream of this point, the western bank is 3-4' high and actively eroding. The riparian zone is mowed to the top of the western streambank. The eastern bank has invasive Japanese knotweed (*Reynoutria japonica*) growing along the streambank.	Floodplain restoration, streambank stabilization, and riparian buffer enhancement	Chester County Conservation District, Stroud Water Research Center, London Grove Township, Landowners	Medium	

GPS Point Descriptions and Action Items

Point #	Description	Action Item	Key Partners	Priority	Comments
28	Downstream of this point, the streambanks are 3-4' high and actively eroding. Some sections of this stream reach lack a riparian buffer. Upstream of this point, the streambanks are stable and have a riparian buffer.	Floodplain restoration, streambank stabilization, and riparian buffer enhancement	Chester County Conservation District, Stroud Water Research Center, London Grove Township, Landowners	Medium	
29	Downstream of this point, the streambanks are stable. There has been a recent riparian zone planting upstream of this point. The banks are 4' high and are actively eroding.	Floodplain restoration, streambank stabilization	Chester County Conservation District, Brandywine Conservancy, Stroud Water Research Center, London Grove Township, Landowners	Low	
30	Downstream of this point, the banks are 2-4' high and actively eroding in some areas. The riparian zone is planted and livestock are fenced out of the creek in this reach. A stable agricultural ford crossing is installed in this stream section.	Floodplain restoration, streambank stabilization	Chester County Conservation District, Brandywine Conservancy, Stroud Water Research Center, London Grove Township, Landowners	Low	

GPS Point Descriptions and Action Items

Point #	Description	Action Item	Key Partners	Priority	Comments
31	Banks upstream and downstream of this point are mostly stable although they are approximately 4' high and disconnected from the floodplain in many areas. Some very minor areas of erosion exist.	Maintain buffer plantings	Landowners		Points 1-31 were completed by walking the stream channel, reviewing aerial photography, and stakeholder meetings.
32	Upstream of this point, an equine farm has implemented streambank fencing, stable livestock crossings, and a planted riparian buffer. The streambanks and riparian zone appear stable.	Monitor project and control invasive species during riparian buffer establishment	Chester County Conservation District, Brandywine Conservancy, Stroud Water Research Center, London Grove Township, Landowners		Points 32 and higher were completed through windshield studies, aerial photography review, and stakeholder meetings.
33	Upstream of this point, streambank fencing has been installed along a forested buffer. The buffer width is only a few feet wide at some places and the horse pasture is close to the stream.	Expand riparian buffer	Chester County Conservation District, Brandywine Conservancy, Stroud Water Research Center, London Grove Township, Landowners	Low	

GPS Point Descriptions and Action Items

Point #	Description	Action Item	Key Partners	Priority	Comments
34	Downstream of this point, streambank fencing has been installed along a forested buffer. The buffer width is only a few feet wide at some places and the horse pasture is close to the stream.	Expand riparian buffer	Chester County Conservation District, Brandywine Conservancy, Stroud Water Research Center, London Grove Township, Landowners	Low	
35	Upstream of this point, the stream lacks a buffer and has 2-3' high eroded streambanks.	Riparian buffer enhacement, streambank stabilization	Chester County Conservation District, Brandywine Conservancy, Stroud Water Research Center, London Grove Township, Landowners	High	
36	Downstream of this point, the stream channel has some areas of active erosion where the streambanks are 2-3' high. The riparian zone is vegetated and thinly planted with trees.	Riparian buffer enhacement, streambank stabilization	Chester County Conservation District, Brandywine Conservancy, Stroud Water Research Center, London Grove Township, Landowners	High	Stroud Water Research Center indicated an interest in working with the landowners in this area for a potential buffer planting project during a stakeholder meeting.

GPS Point Descriptions and Action Items

Point #	Description	Action Item	Key Partners	Priority	Comments
37	Downstream of this point, the stream channel has some areas of active erosion where the streambanks are 2-3' high. The riparian zone is mostly herbaceous. Livestock have access to the stream in some areas downstream of this point.	Riparian buffer enhacement, streambank stabilization, streambank fencing, stable livestock crossings	Chester County Conservation District, Brandywine Conservancy, Stroud Water Research Center, London Grove Township, Landowners	High	
38	The streambanks in this section of the watershed appear mostly stable.				
39	Upstream of this point, the riparian zone is mowed to the edge of the stream on a small unnamed tributary.	Riparian buffer enhancement	Chester County Conservation District, Brandywine Conservancy, Stroud Water Research Center, London Grove Township, Landowners	Low	
40	Downstream of this point, the riparian zone is mowed to the edge of the stream on a small unnamed tributary.	Riparian buffer enhancement	Chester County Conservation District, Brandywine Conservancy, Stroud Water Research Center, London Grove Township, Landowners	Low	

GPS Point Descriptions and Action Items

Point #	Description	Action Item	Key Partners	Priority	Comments
41	Upstream of this point, the riparian zone of a small unnamed tributary is within a pasture area and lacks a riparian buffer.	Riparian buffer enhancement	Chester County Conservation District, Brandywine Conservancy, Stroud Water Research Center, London Grove Township, Landowners	Low	If livestock routinely use the area, streambank fencing and a stable crossing should be considered.
42	Downstream of this point, the riparian zone of a small unnamed tributary is within a pasture area and lacks a riparian buffer. Upstream of this point, a substantial riparian buffer planting has been implemented.	Riparian buffer enhancement, monitor and maintain the upstream riparian buffer project	Chester County Conservation District, Brandywine Conservancy, Stroud Water Research Center, London Grove Township, Landowners	Low	
43	This section of stream has forested, mostly stable streambanks. During the watershed assessment phase, the sample point in the headwaters of this unnamed tributary had the highest macroinvertebrate score in the watershed. While many of the parcels in this section of the watershed already are covered under conservation stewardship agreements, additional work to seek conservation stewardship agreements and protect the water quality of this section of the watershed remains.	Secure additional conservation stewardship agreements, monitor existing conservation stewardship agreements	Brandywine Conservancy, Stroud Water Research Center, London Grove and West Marlborough Townships, Landowners	High	
44	On this unnamed tributary, a substantial riparian buffer planting has been recently implemented.	Monitor and maintain the upstream riparian buffer project	Stroud Water Research Center, Landowners		

GPS Point Descriptions and Action Items

Point #	Description	Action Item	Key Partners	Priority	Comments
45	Upstream of this point, the riparian zone is narrow and is a potential site of additional riparian buffer plantings by Stroud Water Research Center.	Riparian buffer enhancement	Stroud Water Research Center, Landowners	Low	
46	Downstream of this point, the riparian zone is narrow and is a potential site of additional riparian buffer plantings by Stroud Water Research Center. Upstream, the riparian zone is forested with several large sections of riparian buffer plantings having already been completed.	Riparian buffer enhancement, monitor and maintain the upstream riparian buffer projects	Stroud Water Research Center, Landowners	Low	Detailed, updated stream buffer planning and implementation maps are maintained by Stroud Water Research Center
47	Upstream of this point is the former Loch Nairn Golf Club. The club was recently acquired as a passive recreation park by New Garden Township. Natural Lands is working with the township to develop the park under the guidance of a master plan. The site is being converted from a traditional golf course to a naturalized recreation area.	Riparian buffer enhacement, floodplain restoration, wetland creation, stormwater retrofits, native upland plantings, environmental recreation	New Garden Township, Natural Lands, Stroud Water Research Center	Medium	Detailed restoration planning will be completed in the park master planning process
48	Upstream limit of the former Loch Nairn Golf Club on the East Branch White Clay Creek. Upstream of this point, the riparian buffer is mowed to the edge of the stream channel.	Riparian buffer enhacement, floodplain restoration, wetland creation, stormwater retrofits, native upland plantings, environmental recreation	New Garden and London Grove Townships, Natural Lands, Stroud Water Research Center, Landowners	Medium	Detailed restoration planning will be completed in the park master planning process

GPS Point Descriptions and Action Items

Point #	Description	Action Item	Key Partners	Priority	Comments
49	Upstream limit of the former Loch Nairn Golf Club on an unnamed tributary. Upstream of this point, the riparian buffer is mowed to the top of the stream channel.	Riparian buffer enhacement, floodplain restoration, wetland creation, stormwater retrofits, native upland plantings, environmental recreation	New Garden and West Marlborough Townships, Natural Lands, Stroud Water Research Center, Landowners	Medium	Detailed restoration planning will be completed in the park master planning process
50	Downstream of this point, the riparian buffer is mowed to the top of the stream channel.	Riparian buffer enhacement, wetland creation	New Garden Township, Stroud Water Research Center, Landowners	Medium	
51	Upstream of this point is the University of Pennsylvania's New Bolton Center. Substantial opportunity exists for innovative agricultural, stormwater, and restoration practices within the tributary as it is the most degraded in the watershed. New Boloton Center has the opportunity to be a leader in improved conservation practices.	Innovative agricultural practices such as advancements in no-till farming, cover crops, riparian buffers, and animal husbandry best practices	University of Pennsylvania, West Marlborough Township, Stroud Water Research Center, Brandywine Conservancy, Natural Lands, Landowners	Low	
52	Downstream of this point, the riparian zone is mowed to the edge of the stream.	Riparian buffer enhancement	Stroud Water Research Center, London Grove Township, Landowners	Low	
53	This section of stream has an established forested buffer within existing streambank fencing.	Maintain buffer plantings and fencing	Landowners		

GPS Point Descriptions and Action Items

Point #	Description	Action Item	Key Partners	Priority	Comments
54	This section of stream has a recently planted forested buffer	Maintain buffer plantings	Landowners		
55	Downstream of this point, the stream is stable and flows through a forested area. Upstream of this point, the riparian zone is mowed to the top of the streambank.	Riparian buffer enhancement	Stroud Water Research Center, Landowners	Low	
56	Downstream of this point, the riparian zone is mowed to the top of the streambank.	Riparian buffer enhancement	Stroud Water Research Center, Landowners	Low	
57	Downstream of this point, the stream flows through a forested area. Upstream, a forested buffer has recently been planted.	Maintain buffer plantings	Landowners		

APPENDIX C
POINT LOCATION DATA

Upper East Branch White Clay Creek
Point Location Data

Point #	Latitude (°N)	Longitude (°W)
1	39.82121	75.78415
2	39.82154	75.78407
3	39.82256	75.78394
4	39.82358	75.78330
5	39.82400	75.78256
6	39.82410	75.78242
7	39.82497	75.78136
8	39.82520	75.78114
9	39.82660	75.77963
10	39.82787	75.78028
11	39.82804	75.78055
12	39.82814	75.78064
13	39.83028	75.78185
14	39.83182	75.78165
15	39.83264	75.78154
16	39.83436	75.78169
17	39.83605	75.78173
18	39.83678	75.78183
19	39.83779	75.78100
20	39.83891	75.78127
21	39.83935	75.78174
22	39.83989	75.78198
23	39.84041	75.78258
24	39.84058	75.78289
25	39.83992	75.78385
26	39.83932	75.78515
27	39.84049	75.78678
28	39.84354	75.78920
29	39.84516	75.79005
30	39.84534	75.79130

Point #	Latitude (°N)	Longitude (°W)
31	39.84473	75.79352
32	39.84451	75.79887
33	39.84584	75.79820
34	39.84742	75.79703
35	39.85596	75.80406
36	39.85724	75.80500
37	39.86088	75.79938
38	39.85685	75.80991
39	39.85564	75.81191
40	39.85447	75.81215
41	39.85992	75.81138
42	39.86070	75.81093
43	39.85973	75.81219
44	39.86516	75.81397
45	39.86588	75.80175
46	39.87095	75.80126
47	39.84637	75.78473
48	39.84882	75.78435
49	39.84958	75.77741
50	39.85555	75.77121
51	39.85294	75.76468
52	39.84995	75.78390
53	39.87215	75.78731
54	39.88602	75.78258
55	39.87141	75.78421
56	39.87304	75.78076
57	39.88030	75.77423

APPENDIX D
RESTORATION BMP HANDOUTS

Invasive Species Removal

Throughout the Upper East Branch White Clay Creek Watershed, invasive species pose a threat to the ecosystem and native species. Of particular concern in this watershed is stilt grass (*Microstegium vimineum*), poison hemlock (*Conium maculatum*), Japanese knotweed (*Reynoutria japonica*), multiflora rose (*Rosa multiflora*), Japanese hops (*Humulus japonicus*), reed canary grass (*Phalaris arundinacea*), porcelain berry (*Ampelopsis brevipedunculata*), mugwort (*Artemisia vulgaris*), Asiatic bittersweet (*Celastrus orbiculatus*), and others. Invasive species wreak havoc on ecosystems by dominating niches belonging to native plants. This results in changes in the populations of all types of creatures, changes in soil and water quality over time, and eventually a reduction in native biodiversity.

Control of most invasive plant species over large areas typically requires selective herbicide application on multiple occasions. It is crucial that soil containing invasive plant roots and seeds is appropriately managed and that tires and tracks from construction equipment is cleaned in such a way as to minimize the risk of the plants spreading to other areas.

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Streambank Fencing

Within the Upper East Branch White Clay Creek Watershed, grazing livestock in and around streams creates one of the greatest negative impacts on water quality within the watershed. Livestock trample the streambanks which contributes to accelerated erosion and produce manure that gets into the stream system. Manure that is within the stream contains bacterial pathogens that make the water unsafe for drinking and greatly increases the chances of infection for those with cuts or scrapes that come in contact with the water. The nutrients contained within the manure, while an important resource for crop fields, cause algal blooms within the streams. When the algae die, they decay and use up oxygen within the water that often leads to fish kills and a shift to less desirable insects that live within the water. With unrestricted access to streams, wetlands, and ponds, livestock are at increased risk of injury, black leg, mastitis, and other ailments.

Restricting livestock access to streams and wetlands contributes to herd health, improves wildlife habitat, improves water quality, and makes the water safer for those coming in contact with it. Streambank fencing typically consists of either single strand (adult cattle only) or double strand electric fencing. The fence is located as far back from the streambank as practical and installed parallel to the flow of the stream. Installation assistance is often available. The landowner is typically responsible for maintaining the fence. While livestock often graze the area under the fence, it is sometimes necessary to mow to control vegetation from shorting the fence. Streambank fencing is often coupled with stabilized ford crossings so livestock can access pasture areas on the opposite bank of the stream.

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Forested Stream Buffer Zone

Clearing and mowing of stream corridors to the stream edge impacts water quality and the community of creatures that live within the stream. Streams flowing through open areas are exposed to high levels of sunlight and lack a filter to minimize sediment and nutrients from discharging to the stream. As sunlight warms the water, it is able to hold less dissolved oxygen, which is essential for a healthy stream community. When combined with elevated levels of nutrients, excessive sun exposure contributes to the severity of algal blooms. As the algae dies and decays, dissolved oxygen is utilized by the bacteria that thrive on the dying algae.

Riparian buffers provide shade that helps moderate daily stream temperature changes during both winter and summer months. Pollutants can be successfully filtered and trapped by the physical structure of the vegetation itself. Carbon from the atmosphere is sequestered within forested areas, which aids in combating global climate change. In addition, healthy riparian buffers provide a home for a diversity of wildlife and function as a corridor to allow wildlife to move from one pocket of habitat to another.

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Streambank Stabilization

Within the Upper East Branch White Clay Creek Watershed, some stream segments are impaired by erosion and sedimentation within the stream itself. When streambanks erode, sediment that is discharged to the stream channel smothers the small nooks and crannies between the rocks on the streambed that provide micro-habitat areas for the instream community. Sediment discharges are often partnered with the release of soil bound nutrients. Within these areas, stream restoration and stabilization are often effective tools to improve in-stream habitat and water quality. Stream restoration within the watershed should focus on long-term stability of the stream by looking at the stream's pattern, profile, and dimension. Where streambanks are actively eroding, stabilization that focuses on establishing native vegetation is often the best long-term option. As the vegetation becomes established, a combination of log and rock structures are often implemented to aid stabilization. The use of well positioned in-stream deflectors, cross-vanes, j-hooks, and straight vanes can help to hold the streambanks in place as the vegetation becomes established. These structures, when utilized effectively, minimize streambank erosion by reducing the force of water that is scouring the bank surface and provide habitat for many types of aquatic life.

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Floodplain Restoration

In many areas of the Upper East Branch White Clay Creek Watershed, past human activities have placed fill in or caused extensive sedimentation within the riparian zone. The excess material along the edge of the stream channel has disconnected the stream from the floodplain. Floodplain restoration projects are designed to remove excess soil from the floodplain so that the stream is reconnected to an active floodplain. Active floodplains are important to not only reduce the volume and velocity of floodwaters, but also to filter nutrients and pollutants from floodwaters and to provide habitat for a diverse riparian community. The restored streambanks and floodplain area can be planted with native wildflowers, grasses, shrubs, and trees to help stabilize the riparian zone and promote use of the area by a diversity of native wildlife. Floodplain restoration projects can range from establishing a small bankfull bench to help disperse flows to large scale excavation projects that uncover the historic valley floor.

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Constructed Wetlands

Throughout the Upper East Branch White Clay Creek Watershed, many areas lack connections to wetlands. Creation of constructed wetlands in the watershed will have multiple positive impacts on the watershed. Foremost, constructed wetlands can serve to remove contaminants and pollutants caused by human activity from the water supply through the same processes of naturally occurring wetlands. These processes help to remove and break down contaminants. Constructed wetlands not only offer the benefit of water quality improvements through a natural and holistic process, but also provide a variety of niche habitats for local plants and wildlife. Wetlands are considered to be one of the most productive ecosystems on Earth, and provide habitat for birds, mammals, amphibians, and reptiles, as well as diverse plants and fungi in the area. Constructed wetlands can help to reduce the impacts caused by erosion as the complex root systems of wetland species help to anchor soils. Additionally, wetlands can mitigate the impacts of flooding and aid in groundwater recharge. This phenomenon occurs because of the ability of wetlands to hold significant amounts of water, which otherwise might pose a threat to urban areas nearby and downstream.

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Litter Cleanup

Throughout the watershed, the impact of human activity is noticeable through the litter laying along the streambanks and streambed. In the part of the watershed that runs just downstream of Avondale, larger pieces of litter (such as tires, old construction materials, and pieces of metal) line the banks of the stream. Litter can change the public perception of stream ecosystems, resulting in reduced interest in keeping the stream healthy for both wildlife and human use. Litter not only takes away from the aesthetic value of the stream but can also be detrimental to the stream ecosystems and water quality.

Volunteer litter clean ups may be used to collect litter that is small and easily carried. Large litter will require a more involved effort to remove safely.

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In-stream Restoration Structures

In-stream rock and log deflectors, cross-vanes, j-hooks, and boulder placements are effective tools for creating in-stream fish habitat and aiding in the stabilization of streambanks. The structures are typically constructed based on what materials are available on the site or are locally available. Root wads from clearing operations may be anchored into the streambanks to slow the flow of water in the stream and create habitat for fish and aquatic life. Log sections may be used to create vanes and deflectors to protect banks and create in-stream habitat. Where needed, boulders can be placed either randomly for fish habitat and to disperse flows or aligned to roll the stream flow away from the bank and into the center of the channel. In-stream structures are typically designed to manage low to moderate flow conditions and help shape and maintain a natural stream configuration. During high flow events, the structures are designed to stay in place beneath the floodwaters.

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Stormwater Management Retrofits

As the amount of developed land increases within the watershed, the landscape is altered by an increase in impervious cover. Impervious areas shed runoff and increase stormwater discharges to the streams. Increased stormwater flows contribute to flooding, degrade water quality, and accelerate in-stream erosion.

In order to decrease the impacts of stormwater on the watershed, effective best management practices should be installed with new construction. Where existing stormwater structures exist, they should be evaluated for effectiveness and retro-fitted where nescessary.

Common stormwater retrofits focus on improving the function of existing structures so that they more closely reflect the natural hydrological cycle. Within existing stormwater basins, native species may be planted or allowed to become established. Minimizing mowing and labor in this way provides for additional wildlife habitat, reduces nutrient discharges to the stream, and allows for the vegetation to return more of the stormwater to the atmosphere through evapo-transpiration. Other strategies for stormwater retrofits include installing cisterns to allow for water reuse and infiltration trenches to increase the return of stormwater to the groundwater.

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APPENDIX E
PRELIMINARY PROBABLE CONSTRUCTION COST OPINION

Upper East Branch White Clay Creek Watershed
Probable Construction Cost Opinion

Site	Priority	Min Cost	Max Cost
1	High	$475,000	$950,000
2-4	High	$280,000	$400,000
5	Medium	$1,250,000	$1,750,000
6-8	High	$3,250,000	$4,500,000
11	High	$10,000	$50,000
12-13	High	$325,000	$450,000
15-17	Medium	$250,000	$450,000
27-28	Medium	$225,000	$425,000
35-37	High	$400,000	$550,000
43	High	$425,000	$750,000
47-49	Medium	$750,000	$1,500,000
49-50	Medium	$250,000	$475,000
		$7,890,000	**$12,250,000**

Clauser Environmental, LLC is not a construction contractor and therefore probable construction cost opinions are made on the basis of Clauser Environmental, LLC's experience and qualifications as an environmental consultant and represent the consultant's best judgment as experienced and qualified design professionals generally familiar with the industry. This requires a number of assumptions as to actual conditions which will be encountered on the site; the specific decisions of other design professionals engaged; the means and methods of construction the contractor will employ; contractors' techniques in determining prices and market conditions at the time, and other factors over which Clauser Environmental, LLC has no control. Given these assumptions which must be made, Clauser Environmental, LLC states that the above probable construction cost opinion is a fair and reasonable estimate for construction costs but cannot and does not guarantee that actual construction costs will not vary from the Probable Construction Cost Opinion.

APPENDIX F
PROFESSIONAL QUALIFICATIONS

Aaron S. Clauser, PhD, CPESC
At Clauser Environmental, LLC, he serves as the technical/production lead on scientific projects. Dr. Clauser earned his bachelor's degree in Biology and Environmental Studies from East Stroudsburg University of Pennsylvania and a doctorate in Environmental Science from Lehigh University. Dr. Clauser is a Certified Professional in Erosion and Sediment Control. He served as an environmental regulator with the Berks and Schuylkill Conservation Districts where he performed at both the technician and managerial levels. Dr. Clauser consulted as a Senior Environmental Scientist and Project Manager for RETTEW Associates, Inc. He has given oral presentations at conferences held by the Ecological Society of America, American Society of Limnology and Oceanography, Coldwater Heritage Partnership, Partnership for the Delaware Estuary, Delaware Riverkeeper, Pocono Comparative Lakes Program and Schuylkill and Berks Conservation Districts and has collaborated on an article published about Pacific Northwest amphibians in a peer-reviewed journal. Dr. Clauser has completed numerous training courses including DEP sponsored NPDES, Chapter 102 and 105 technical seminars, Applied Fluvial Geomorphology for Engineers (FGE) by Wildland Hydrology, Inc., and Environmentally Sensitive Maintenance of Dirt and Gravel Roads Training. Dr. Clauser served in the PA Air National Guard where he attained the rank of Staff Sergeant. His doctoral dissertation entitled "Zooplankton to Amphibians: Sensitivity to UVR in Temporary Pools" includes quantitative optical and organismal level models that are extended to landscape level variations in pool optical properties and population level sensitivity to Ultraviolet Radiation.

Kora S. Clauser, BS
Kora works as a biologist with Clauser Environmental, LLC. She has experience with watershed studies, wetland delineation, scientific field investigations, and project delivery. She is currently working towards an M.B.A degree at Lehigh University. She completed her B.S. in Biological Science with a minor in Psychology at Rowan University.

Krista S. Clauser, MEd
As the president of Clauser Environmental, LLC, she is responsible for overall client satisfaction, quality assurance, educational outreach programs, and project management. Krista has her bachelor's degree in Special Education and Elementary Education from Kutztown University of Pennsylvania. She has her Master of Education degree from the University of Georgia, with a concentration in Learning, Leadership, and Organization Development. Krista has completed additional graduate level coursework at Kutztown University of Pennsylvania and Indiana Wesleyan University. Currently, she is a doctoral student, pursuing her EdD at Drexel University in Leadership and Management, concentrating in Creativity and Innovation. She is a certified yoga teacher, breathwork coach, reiki teacher, and qi gong teacher. She has experience as a special education teacher at Schuylkill Intermediate Unit and as a homeschool educator at the elementary, middle, and high school levels. Krista has expertise in integrating environmental/outdoor curricula into a diversity of subjects and educational settings.