

West Branch Brandywine Ag-1 Watershed Restoration Plan

Honey Brook Township and Honey Brook Borough, Chester County
Caernarvon Township, Lancaster County
Brandywine Creek Watershed, Pennsylvania


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1.0 INTRODUCTION

Brandywine Valley Association (BVA) has created the Red Streams Blue program to ensure that all streams within the Brandywine Creek Watershed meet Pennsylvania Water Quality Standards. The Red Streams Blue Program targets impaired (Red) stream reaches for restoration. The program goal is to improve water quality and habitat within each Red stream so that scientific assessments determine the stream to be unimpaired (Blue).

The West Branch Brandywine Ag-1 Watershed includes approximately 6.2 square miles and stretches from Welsh Mountain in the north to the farmland just south of US-322. The West Branch Brandywine Ag-1 Watershed is considered a Red Stream by BVA as it is listed by the Pennsylvania Department of Environmental Protection (DEP) on its 303(d) list of impaired stream reaches (DEP 2008). DEP identifies the overall watershed impairments as agricultural pathogens, nutrients (organic enrichment/ low dissolved oxygen), and siltation. In the spring and summer of 2010, BVA worked with Clauser Environmental, LLC to develop an assessment report to determine baseline conditions and targeted sources of impairment within the watershed. The watershed assessment confirmed the DEP listed impairments and determined that restoration projects should focus first on the headwater areas and then move downstream. Best Management Practices (BMPs) that are suggested for installation within the watershed include streambank fencing, riparian buffer enhancements, grassed waterways, stabilized stream crossings, and improved nutrient management.

Here, a restoration plan for the West Branch Brandywine Ag-1 Watershed is presented to address specific areas of impairment. As the solutions outlined within this restoration plan are implemented, substantial progress will be made in turning this Red Stream Blue.

2.0 METHODOLOGY

To determine the areas within West Branch Brandywine Ag-1 Watershed in need of the most attention, Kathy Bergmann and Jane Fava of Brandywine Valley Association and Aaron Clauser, Ph.D. of Clauser Environmental, LLC conducted stream walks on June 8th and 11th, 2010. Photographs, field notes, and GPS coordinates were collected at areas identified as points of interest. Where access was not permitted, impacted areas were identified by conducting windshield surveys from roadways and reviewing aerial photography provided by the Chester County GIS Department. Sources of impairment were identified at the parcel level.

Clauser Environmental, LLC located the points of interest within the watershed using a Trimble GeoXT Global Positioning System (GPS) receiver during the site visits. The instrument settings used were: a) Elevation Mask of 15 degrees to limit lowest angle of satellite acceptance to 15 degrees, b) Signal Noise Ratio Mask 6 to minimize weak signal strength, and c) PDOP Mask 6 to control the geometry of satellite constellations. Logging interval was set at 1 second with typically a minimum of 30 readings collected at each point (Trimble Navigation 2008). Data collected in the field was downloaded to

a personal computer for differential correction using GPS Pathfinder Office software (Version 4.20). Correction files were obtained from a dedicated base station located in Chester County, PA. Mission planning, parameter settings, and post processing typically allow an accuracy of less than (<) 1 meter. The precision of GPS collected data is subject to variation caused by canopy cover, atmospheric interference, time of day, and satellite geometry. GPS collected data should not be used in situations involving high property values, controversial projects, or in situations where legal questions may arise (Hook et al. 1995).

3.0 WATERSHED PROBLEMS AND SOLUTIONS

This section focuses on the sources and causes of impairment within the West Branch Brandywine Ag-1 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 #2-5:

Within this stream segment, cattle have direct access to the stream that flows through the center of an open pasture. Several iron pipes discharge to the stream from an off-line pond and a watering trough. Within the stream segment, approximately 200 feet of 3 feet high, raw, eroding streambanks are present. A small spring seep is located to the west of the stream and originates within the pasture area. Cattle have direct access to the spring.



Solution:

The restoration of this stream segment should focus on minimizing the direct access of livestock to the stream and spring. Streambank fencing should be installed on both sides of the stream and around the spring area. The installation of stabilized stream crossings would allow livestock to cross the stream without causing additional bank erosion. In the areas where the streambank is raw and actively eroding, streambank stabilization should be considered. The streambanks could be graded to a more stable angle that is no greater than 3:1 (horizontal:vertical). The watering trough should be maintained to encourage cattle to drink from that area rather than loafing in the stream. Native vegetation should be planted within the riparian zone to aid in filtering runoff, stabilize the banks, and eventually provide a forest canopy over the stream. The installation of a biofiltration area around the headwater spring should be considered to minimize the impact of contaminated runoff on the spring.

Impacted Stream Segment

#14-16:

This stream segment includes a large area of pasture on several parcels. The stream flows through an open area and is not shaded. Livestock have direct access to the stream. In addition to the mainstem of the West Branch Brandywine Creek, six ponds and several small tributary streams are located within this stream segment.



Solution:

Restoration of this stream segment should focus on reducing nutrient, sediment, and pathogen discharges to the stream by installing streambank fencing and riparian buffers. As the pastures extend to both sides of the streams, the installation of stabilized stream crossings will be necessary. Throughout the area, watering troughs should be installed to encourage livestock to drink and loaf in upland areas. Within the riparian zone, native vegetation should be planted that will eventually develop a forested canopy over the stream.





**Impacted Stream
Segment #18-19:**

Within this stream segment, livestock have direct access to the stream. This pasture is rotationally grazed by both horses and cattle. The streambanks are stable and vegetated, but the stream is not shaded.

Solution:

Restoration of this area should focus on streambank fencing and riparian buffer enhancement. Several culvert pipes are located within this reach and should be considered for use as stabilized crossing areas to minimize the amount of time livestock spend within the stream. Native trees and shrubs should be planted within the riparian zone to help the buffer become established. Restoration of the stream within this segment should aid in improving the water quality at Sample Site 5 as identified in the West Branch Ag-1 Assessment Report.



Impacted Stream Segment #21-23:

This high priority stream segment includes a pasture where livestock have direct access to two unnamed tributaries. The majority of the pasture is open without an established riparian buffer. While the streambanks are primarily stable throughout this reach, in the areas where livestock routinely cross the stream the banks are raw and eroding. Within the stream segment, two unnamed tributaries meet. The western tributary drains from a forested parcel that is under a conservation easement. The eastern tributary drains through a wetland area identified as stream segment 20-21. Downstream of this segment, riparian buffers have been established within a stream corridor that has streambank fencing.



Solution:

Restoration of this stream segment should include installation of streambank fencing and riparian buffers. Stabilized stream crossings and upland watering troughs are also important to minimize the impact that this pasture area has on water quality. To jump start the establishment of a native riparian buffer, trees and shrubs should be planted along the stream. The restoration of this segment is essential to improving the water quality of this unnamed tributary. Water quality improvements made by this project should benefit the biology of the restored area immediately downstream. Long-term monitoring before and after restoration of this segment should be completed. Data collected within this tributary could then be utilized to guide BMP selection, leverage funding, and generate support for work in other sections of the watershed.



Impacted Stream Segment #25-26:

This stream segment flows through an open pasture where livestock have direct access to the stream. The streambanks are stable throughout the majority of this segment. The pastures immediately upstream and downstream of this pasture have streambank fencing and established riparian buffers.

Solution:

Restoration of this stream segment should include installation of streambank fencing on both sides of the stream. As the pasture includes substantial areas on both sides of the valley, stabilized crossing areas should be established. Upland watering troughs should be installed to encourage livestock to drink and loaf away from the stream corridor. Native riparian buffer plantings should be installed to create a wildlife corridor that connects the downstream and upstream buffer areas, shade the stream, and filter runoff.



Impacted Stream Segment #28-29:

Within this stream segment on the mainstem of the West Branch Brandywine Creek, livestock have direct access to the stream. While the streambanks are stable, the vegetation is grazed so that it is only several inches tall. The lack of a stream buffer allows agricultural pathogens, nutrients, and sediment to discharge directly to the stream without control. The



lack of a forested canopy over the stream allows for excessive algal growth, warming of the stream, and impacts the foodchain dynamics of the stream.



Solution:

Restoration of this area should include the installation of streambank fencing along with stabilized stream crossings and upland watering troughs. The riparian zone should be planted in native vegetation so that a canopy becomes established over the stream.

Impacted Stream Segment #31-34:

This stream segment includes several pastures on adjacent properties where livestock have direct access to the stream. Throughout the segment, pastures extend to both sides of the stream and cattle often loaf within the riparian zone. The streambanks within this area range from stable with short, cropped vegetation to raw and



steeply eroded. The majority of the eroded stream banks are located along the mainstem of the West Branch Brandywine Creek. In the section of the stream segment that is upstream of Suplee Road, several areas are eroded with streambanks that are 4-6 feet high. Within the downstream portion of the stream segment, some areas have streambanks that are eroded with banks that are 3-4 feet high. The farm at the downstream portion of the site and the farm just upstream of Suplee Rd. have feedlots that drain in the direction of the stream.

Solution:

Restoration of this stream segment should focus on bank stabilization along the mainstem and streambank fencing throughout the segment. The pastures within this area extend to both sides of the stream so that the installation of stabilized stream crossings will be required. Native riparian buffers should be installed throughout the



length of the segment. During the conceptual design stage, fluvial geomorphological techniques should be considered to determine if the stream is overly wide in portions of this area and to ensure that the most appropriate best management practices are selected to stabilize the stream. The feedlots within this segment should be investigated to determine if an improved manure management system could be developed to minimize manure draining to the stream.

Impacted Stream Segment #37-38:

Within this stream segment, livestock have direct access to the stream and have grazed the vegetation so that it has very limited value as a buffer along the stream. Within the upstream portion of this segment, the streambanks are eroded approximately 2 to 3 feet high. The stream channel is incised and has become overly wide and shallow.



Solution:

In order to minimize the impacts of agriculture on this stream segment, streambank fencing and bank stabilization should be considered. The overly wide channel and eroding banks should be evaluated for restoration with a fluvial geomorphological approach. The use of in-stream structures such as deflectors, cross-vanes, and J-hooks should be considered during the design phase of the project. As this pasture extends to both sides of the stream, the use of stabilized stream crossings will be necessary. After the streambank fencing is installed, native trees and shrubs should be planted to shade the stream and provide long-term stabilization of the streambanks.



Impacted Stream Segment #49-50:

Livestock within this stream segment have direct access to the stream. The streambanks range from stable to several feet high and actively eroding throughout this reach. The stream corridor lacks riparian vegetation and is heavily grazed to the stream edge.



Solution:

Streambank fencing should be installed throughout the length of this segment to minimize the impacts of livestock on the stream. The channel should be evaluated to determine if it is overly wide and appropriately stabilized where the banks are eroding. The installation of stabilized stream crossings will be required as the pasture extends to both sides of the stream. The stream corridor should be planted with native trees and shrubs to establish an effective buffer.

3.2 Medium Priority Projects:

Impacted Stream Segment #5-8:

Livestock have direct access to the stream within this forested area. In several areas, the streambanks are unstable from repeated livestock crossings within those areas. Within one portion of this segment, streambank fencing has not been maintained.



Solution:

Install and maintain streambank fencing. Where livestock cross the stream, stable crossings should be installed. The forested nature of this area should allow a riparian buffer to quickly become established.

Impacted Stream Segment #9-10:

Within this small stream segment, livestock have direct access to a stream that cuts through the corner of a pasture. The animals are trampling the streambank and contributing to its instability.



Solution:

Restoration of this stream segment should include fencing the livestock out of the corner of the pasture where the stream crosses. An upland watering trough may be required. The area adjacent to the stream should be allowed to grow into a riparian buffer to filter stormwater discharges to the stream from the upslope pasture area.

Impacted Stream Segment #20-21:

A small unnamed tributary that flows through this stream segment flows through a wetland area that is intermittently grazed. While the livestock appear to minimize their use of the wetland portion of the pasture, they have direct access to it.



Solution:

Restoration of this area should include streambank fencing to keep the livestock out of this headwater wetland area. The wetland should quickly develop into a suitable stream buffer when grazing pressure is removed.

Impacted Stream Segment #39-40:

Within this segment, large shade trees provide canopy over much of the stream. The understory area is a pasture where livestock have direct access to the stream. The streambanks are stable. Of primary concern within this segment is the nutrient and pathogen inputs from the livestock being discharged directly into the stream.

Solution:

Restoration of this area should include streambank fencing with stabilized stream crossings. The existing large trees should be maintained to continue shading the stream. After the fencing is installed, the riparian zone should be allowed to grow into a more effective stream buffer.



Impacted Stream Segment #41:

An emergent wetland area is located within a pasture at this location. The wetland serves as the headwaters for a small unnamed tributary that flows through an area with streambank fencing.

Solution:

The streambank fencing and riparian buffer that are located downstream of this point should be extended upslope to protect this headwater wetland area.

Impacted Stream Segment #43-44:

Within this forested area, livestock have direct access to the stream. The stream within this area includes several fringe wetlands and has stable banks.



Solution:

Conservation practices within this area should focus on installation of streambank fencing to keep livestock out of the stream and wetland areas. The landowner has indicated that he intends to install streambank fencing within the next year and is actively working with the Brandywine Conservancy.

Impacted Stream Segment # 46-49:

Within this stream segment, livestock have direct access to the stream as it flows through a meadow area. Livestock stocking density and corresponding grazing appear to be light within this area and the streambanks are stable. A pond located along the western streambank was green with an algal bloom on the day of the streamwalk. Excessive nutrient and pathogen inputs likely impact the stream and pond in this area.



Solution:

Streambank fencing and installation of effective buffer areas around the stream and pond should be the top priority of restoration in this area. After the livestock are removed from the riparian zone and the immediate vicinity of the pond, ongoing monitoring should be conducted to determine if additional nutrient reductions will be necessary to improve the biology of the stream and pond.

Impacted Stream Segment #50-54:

Livestock within this stream segment have direct access to the stream. The riparian zone is forested within the upstream portion of the segment. The downstream portion of the segment is partly shaded by a small buffer where livestock are fenced out of the stream by fencing located at the top of the streambank. Livestock cross the stream and a small unnamed tributary in several areas and have made the streambanks unstable in those locations.



Solution:

Restoration of this area should include installing streambank fencing throughout the upper portion of the segment and widening the downstream fencing to include a vegetated filter strip to help filter runoff discharging to the stream. In the locations where livestock cross the stream and have contributed to the instability of the banks, stabilization and installation of livestock crossing structures should occur. Within the downstream segment, the streambank fencing should be extended to include several wetland areas located to the east of the stream.

4.0 RESTORATION IMPLEMENTATION

Restoration of the West Branch Ag-1 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 West Branch Brandywine Ag-1 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.

Clouser Environmental, LLC prepared a preliminary construction cost opinion based upon its experience in the field and costs for various best management practices based on PRedICT 2007 to serve as a general guideline for the approximate project costs (Appendix E). For each project, a maximum and minimum estimated cost is presented.

Costs associated with stream restoration in agrarian areas are quite variable depending upon the overall restoration goals, landowner objectives, project funding requirements, availability of building materials and rock, 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 \$600,150 to \$1,023,250. These costs include installing more than 14 miles of streambank fencing (along approximately 7 miles of streams, ponds, and wetlands) and approximately 87 stabilized livestock crossings. Construction costs for these two most critical items total approximately \$215,000.00 (not including design and permitting for the crossings). The balance of the estimated costs include buffer plantings, streambank restoration, installation of in-stream structures, 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 project are all located on 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.

After the 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.

5.0 OBTAINING SUPPORT AND MONITORING PROGRESS

Community outreach and attaining landowner support is often the most challenging step in restoring a watershed. As all of the high and medium priority projects within the West Branch Brandywine Ag-1 Watershed are located on private property, developing a positive relationship with landowners is particularly critical. BVA 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 found the stream assessment phase of the project to be particularly 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 Honey Brook Township building 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 West Branch Brandywine Ag-1 Watershed, many of the landowners have existing relationships with conservation organizations. It is essential for BVA to nurture and support these relationships as collaborative partners. On the ground projects have been completed by Brandywine Conservancy, Chester County Conservation District, Ducks Unlimited and others. Some of the key teaming partners for the watershed include:

- City of Wilmington, Delaware, Department of Public Works (Funding assistance and laboratory analysis)
- Chester County Solid Waste Authority (Funding assistance)
- Honey Brook Borough, Honey Brook Township, Caernarvon Township and Chester County Planning Commission (Adoption of protective municipal ordinance language to protect critical watershed resources)
- Brandywine Conservancy (Teaming partner)
- Chester County Agricultural Preservation Board (Farmland Preservation)
- Chester County Conservation District (Agricultural BMP design, soil conservation, nutrient management, and watershed consultation)
- Natural Resources Conservation Service (Conservation plans for individual farms and agricultural best management practices)
- Honey Brook Township Land Preservation Committee
- Pennsylvania Department of Environmental Protection (Water quality grant opportunities)

- Pennsylvania Department of Conservation & Natural Resources (Land preservation, resource management and 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)
- Trout Unlimited (Volunteers and funding assistance)
- Local Scout and Civic Groups (Riparian buffer planting volunteers)

The effectiveness of installed restoration projects should be monitored within the 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 Brandywine will one day be restored.



7.0 LITERATURE CITED

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APPENDIX A
FIELD INVESTIGATION MAP

APPENDIX B
GPS POINT DESCRIPTIONS AND ACTION ITEMS

GPS Point Descriptions and Action Items

Point #	Description	Action Item	Key Partners	Red-Blue Priority	Comments
1	A dam breast at this location is from the abandoned Honeybrook reservoir. The reservoir is drawn down with only minimal water and wetland vegetation present. Just below the reservoir, unnamed headwater tributaries enter from the west. A waterway discharges from the east in this location from a field currently in no-till farming. Downstream, cattle have access to the stream.	N/A	N/A	N/A	
2		Streambank fencing, Riparian buffer enhancement, Plant grass in waterway to minimize sediment and pollutant discharges	Landowner, NRCS, Conservation District	High Priority	
3	At this point, an outfall from a farm pond located east of the stream discharges from a 5 inch iron pipe.	N/A	N/A	N/A	
4	An outfall from a watering trough (5 inch iron pipe) discharges from east of the stream.	Maintain watering trough to minimize livestock accessing the stream	N/A	N/A	
5	Upstream of this point cattle have direct access to the stream with no riparian buffer. There are approximately 200 feet of 3 feet high unstable banks in this segment. An underdrain discharges from a 5 inch iron pipe that is likely connected to tile drains to the west of the stream.	Streambank fencing, Riparian buffer enhancement, Bank stabilization	Landowner, NRCS, Conservation District	High Priority	
6	An unnamed tributary discharges to the stream from the west. Cattle have direct access to the stream within this forested area.	Stabilized cattle crossing, Streambank fencing	Landowner, NRCS, Conservation District	Medium Priority	
7	An unnamed tributary discharges to the stream from the west. This section of pasture is a lightly grazed meadow with interspersed trees. Livestock have direct access to the stream.	Stabilized cattle crossing, Streambank fencing	Landowner, NRCS, Conservation District	Medium Priority	

GPS Point Descriptions and Action Items

Point #	Description	Action Item	Key Partners	Red-Blue Priority	Comments
8	Upstream of this point, the streambank fencing has not been maintained. Livestock have direct access to the stream.	Maintain buffer to keep cattle out of the stream, Maintain cattle crossings	Landowner, NRCS, Conservation District	Medium Priority	
9	An unnamed tributary discharges to the stream from the east in this location. Upstream of this point, the stream buffer is approximately 5 feet wide on each side of the stream. Downstream of this point, cattle have direct access to the stream.	Riparian buffer enhancement upstream, Streambank fencing and riparian buffer enhancement downstream	Landowner, NRCS, Conservation District	Medium Priority	
10	Upstream of this point where Poplar Road crosses the stream, cattle have direct access to the stream.	Streambank fencing, Riparian buffer enhancement upstream	Landowner, NRCS, Conservation District	Medium Priority	
11	An unnamed tributary discharges to the stream from the west in this location. The riparian zone is mowed to the top of the streambanks upstream of this point. The landowner has requested additional information on riparian zone plantings and has completed some instream stabilization.	Follow-up with landowner to provide riparian buffer literature and encourage plantings	Landowner	Low Priority	
12	An unnamed tributary discharges to the stream from the west in this location. The stream has adequate buffer on both sides.	N/A	N/A	N/A	
13	A stormwater basin in this location is currently mowed.	Basin Naturalization	Conservation District	Low Priority	
14	Downstream of this point, livestock have direct access to the stream. No riparian buffer exists and the stream is not shaded.	Streambank fencing, Riparian buffer enhancement, Stabilized stream crossings	Landowner, NRCS, Conservation District	High Priority	

GPS Point Descriptions and Action Items

Point #	Description	Action Item	Key Partners	Red-Blue Priority	Comments
15	Downstream of this point, livestock have direct access to the stream. No riparian buffer exists and the stream is not shaded.	Streambank fencing, Riparian buffer enhancement, Stabilized stream crossings	Landowner, NRCS, Conservation District	High Priority	
16	Upstream of this point, cattle have direct access to the stream without riparian buffers. Downstream of this point, adequate buffers exist on both sides of the stream. The downstream riparian zone is dominated by invasive species including multi-flora rose.	Streambank fencing, Riparian buffer enhancement, Stabilized stream crossings	Landowner, NRCS, Conservation District	High Priority	Invasive species removal is low priority in comparison with water quality and other projects in this watershed.
17	Downstream of this point, the riparian zone is mowed to the top of the streambanks on both sides of the stream.	Riparian buffer enhancement	Landowner, Tree Vitalize	Low Priority	
18	Downstream of this point livestock have direct access to the stream without a riparian buffer. Upstream of this the riparian zone is a mowed lawn.	Riparian buffer enhancement, Streambank fencing, Livestock stream crossings could utilize existing culvert pipes	Landowner, Tree Vitalize	High Priority	
19	Upstream of this point, livestock have direct access to the stream. Downstream of this point, a riparian buffer exists although in some areas it is only several feet wide.	Riparian buffer enhancement, Streambank fencing, Livestock stream crossings could utilize existing culvert pipes	Landowner, Tree Vitalize	High Priority	

GPS Point Descriptions and Action Items

Point #	Description	Action Item	Key Partners	Red-Blue Priority	Comments
20	Upstream of this point is forested. Two headwater unnamed tributaries that drain the forested area meet at this point. Downstream of this point, the tributaries enter a forested pasture that is intermittently grazed. The livestock appear to not utilize the riparian zone as much as the upland area in this section although they have direct access to it.	Streambank fencing	Landowner, NRCS, Conservation District	Medium Priority	
21	Upstream of this point, the riparian vegetation is only minimally grazed. Downstream of this point, an open pasture area has higher grazing pressure. Livestock have un-restricted access to the stream as the pasture extends to both sides of the stream.	Streambank fencing, Riparian buffer enhancement, Stabilized stream crossings	Landowner, NRCS, Conservation District	High Priority	
22	Upstream of this point, an unnamed tributary drains a forested area on a parcel that is under a conservation easement. Downstream of this point, livestock have un-restricted access to the stream.	Streambank fencing, Riparian buffer enhancement, Stabilized stream crossings	Landowner, NRCS, Conservation District	High Priority	
23	Upstream of this point, livestock have direct access to the stream. Downstream of this point, a buffer project has been implemented.	Streambank fencing, Riparian buffer enhancement	NRCS, Landowner	High Priority	
24	This point is on the centerline of White School Road's stream crossing. There is an 18 inch by 72 inch culvert pipe at this location.	N/A	N/A	N/A	
25	Upstream of this point, streambank fencing and a riparian buffer project with stabilized stream crossings have been implemented. Evidence of periodic grazing within the buffer area is present. Downstream of this point, the cattle have direct stream access although the pasture appears lightly grazed.	Streambank fencing, Riparian buffer enhancement, Stabilized stream crossings	Landowner, NRCS, Conservation District	High Priority	

GPS Point Descriptions and Action Items

Point #	Description	Action Item	Key Partners	Red-Blue Priority	Comments
26	Upstream of this point, cattle have direct access to the stream. Downstream of this point, livestock are fenced out of the riparian zone and a substantial buffer has become established.	Streambank fencing, Riparian buffer enhancement, Stabilized stream crossings	Landowner, NRCS, Conservation District	High Priority	
27	This point is at the centerline of Maple Road. Upstream and downstream are fenced buffer areas.	N/A	N/A	N/A	
28	This point is located on the downstream edge of the Walnut Road stream crossing, upstream of this point, riparian zones are well maintained. Downstream of this point, livestock have direct access to the stream.	Streambank fencing, Riparian buffer enhancement, Stabilized stream crossings	Landowner, NRCS, Conservation District, Tree Vitalize	High Priority	
29	Upstream of this point, livestock have direct access to the stream. Downstream of this point, the riparian zone is mowed to the eastern streambank.	Streambank fencing, Riparian buffer enhancement, Stabilized stream crossings	Landowner, NRCS, Conservation District, Tree Vitalize	High Priority	
30	A functioning mill is part of an on-line dam at this location.	Restore fish passage	American Rivers, Conservation District	Low Priority	
31	Downstream of this point, livestock have direct access to the stream. The streambank is eroded approximately 4 to 6 feet high on the outside of some meander bends particularly upstream of Suplee Road.	Streambank fencing, Riparian buffer enhancement, Bank stabilization	Landowner, NRCS, Conservation District, Tree Vitalize	High Priority	
32	Downstream of this point, livestock have direct access to the stream. Upstream of this point, the riparian zone is mowed to the top of the streambanks.	Streambank fencing, Riparian buffer enhancement, Bank stabilization	Landowner, NRCS, Conservation District	High Priority	Upstream of this point is a low priority riparian buffer enhancement project.

GPS Point Descriptions and Action Items

Point #	Description	Action Item	Key Partners	Red-Blue Priority	Comments
33	Upstream of this point, an unnamed tributary drains from a forested buffer. Downstream of this point, livestock have un-restricted access to the stream.	Streambank fencing, Riparian buffer enhancement, Bank stabilization	Landowner, NRCS, Conservation District, Tree Vitalize	High Priority	
34	Upstream of this point, livestock have direct access to the stream. The streambank is eroded 3 to 4 feet high in portions of this segment.	Streambank fencing, Riparian buffer enhancement, Bank stabilization	Landowner, NRCS, Conservation District, Tree Vitalize	High Priority	
35	An unnamed tributary drains from a wet area north of this point and discharges to the stream.	N/A	N/A	N/A	
36	A tile drain discharges to the stream from the north in this location.	N/A	N/A	N/A	
37	Downstream of this point, cattle have direct access to the stream without buffer. The streambanks are eroded approximately 2 to 3 feet high.	Streambank fencing, Riparian buffer enhancement, Bank stabilization	Landowner, NRCS, Conservation District, Tree Vitalize	High Priority	
38	Upstream of this point, cattle have direct access to the stream without buffer. The banks have small areas that are raw from erosion.	Streambank fencing, Riparian buffer enhancement, Bank stabilization	Landowner, NRCS, Conservation District, Tree Vitalize	High Priority	
39	A forested buffer exists on both sides of the stream above this point. Downstream, livestock have direct access to the stream. Large shade trees provide canopy over much of the stream in this segment. The streambanks are stable.	Streambank fencing, Riparian buffer enhancement	Landowner, NRCS, Conservation District, Tree Vitalize	Medium Priority	
40	Upstream of this point, the streambanks are stable and trees shade the stream. Livestock has direct access to the stream. Downstream, livestock have direct access to the stream, and the stream banks are eroded approximately 3 to 4 feet high.	Streambank fencing, Riparian buffer enhancement, Streambank Stabilization	Landowner, NRCS, Conservation District	High Priority	

GPS Point Descriptions and Action Items

Point #	Description	Action Item	Key Partners	Red-Blue Priority	Comments
41	Upstream of this point is a headwater wetland that is located within a pasture where livestock are able to graze within the wetland area. Downstream of this point, the unnamed tributary is within a riparian zone with streambank fencing.	Extend streambank fencing to protect headwater wetland area	Landowner, NRCS, Conservation District, Tree Vitalize	Medium Priority	
42	Upstream of this point, an unnamed tributary is within a riparian buffer.	N/A	N/A	N/A	
43	An adequate riparian buffer exists upstream of this point. Downstream, livestock have direct access to the stream within this forested area.	Streambank fencing, Riparian buffer enhancement	Brandywine Conservancy, Landowner, NRCS, Conservation District	Medium Priority	The landowner is currently working to install streambank fencing on this segment.
44	Upstream of this point is a forested area where livestock have direct access to the stream. A forested riparian area is located downstream of this point.	Streambank fencing, Riparian buffer enhancement	Brandywine Conservancy, Landowner, NRCS, Conservation District	Medium Priority	The landowner is currently working to install streambank fencing on this segment.
45	An unnamed tributary discharges to the stream from the west. This area is forested with stable streambanks. Silt covers most of the stream bottom.	N/A	N/A	N/A	
46	An open meadow with interspersed trees is located downstream of this point. Livestock have access to the area and evidence of light grazing is present.	Streambank fencing, Riparian buffer enhancement, Stabilized stream crossings	Landowner, NRCS, Conservation District	Medium Priority	
47	A pond located to the west of the stream is covered with a thick coat of algae. Excessive nutrient inputs likely have contributed to the algal bloom within the pond.	Nutrient reduction in drainage area	Landowner, NRCS, Conservation District	Medium Priority	

GPS Point Descriptions and Action Items

Point #	Description	Action Item	Key Partners	Red-Blue Priority	Comments
48	This point is located on an intermittent unnamed tributary that flows through a mixed meadow area. The unnamed tributary was dry on the day of the streamwalk. The unnamed tributary drains from an area where cattle have direct access.	Streambank fencing	Landowner, NRCS, Conservation District	Low Priority	
49	Livestock have access to the stream upstream of this point within a shaded area and downstream of this point within an open meadow.	Streambank fencing, Riparian buffer enhancement, Stabilized stream crossings	Landowner, NRCS, Conservation District	High Priority	
50	Livestock have direct access to the stream upstream of this point. The open pasture area has several sections with steep, eroded banks. Downstream of this point is a mature forest with a pasture understory. Livestock have direct access to the stream. A picnic grove is located along a section of stream that is boulder strewn.	Streambank fencing, Riparian buffer enhancement, Stabilized stream crossings, Streambank stabilization	Landowner, NRCS, Conservation District	High Priority	Projects in this section should minimize impacts to the aesthetics of the picnic grove area.
51	This point is located within a forested area where livestock are periodically grazed with direct access to the stream.	Streambank fencing, Stabilized stream crossings	Landowner, NRCS, Conservation District	Medium Priority	
52	The US-322 bridge is located at this point. Upstream livestock have direct access to the stream, but grazing pressure is minimal. Downstream there is streambank fencing at the top of the bank without a riparian buffer.	Riparian buffer enhancement, Stabilized stream crossings	Landowner, NRCS, Conservation District	Medium Priority	
53	The streambank fencing that is located at the top of bank upstream of this point ends here. Livestock have direct access to the stream.	Streambank fencing, Riparian buffer enhancement, Stabilized stream crossings	Landowner, NRCS, Conservation District	Medium Priority	
54	Streambank fencing within this area is knocked down. Livestock are able to cross over the fencing into the buffer area.	Maintain buffer fence	Landowner	Low Priority	

GPS Point Descriptions and Action Items

Point #	Description	Action Item	Key Partners	Red-Blue Priority	Comments
55	Upstream of this point, the streambank fencing requires maintenance. Downstream of this point, there is adequate stream buffer on both sides of the stream.	Maintain buffer fence	Landowner	Low Priority	
56	This forested area is within a pasture where livestock have access to the stream. The area is very lightly grazed. The stream bottom is covered with sediment and lacks fish habitat.	Fish habitat enhancement structures, streambank fencing	Landowner, NRCS, Conservation District	Low Priority	Projects within this area will likely have minimal impact until water quality conditions improve.

APPENDIX C
POINT LOCATION DATA

Point Location Data

Point #	Northing	Easting
1	289572.60	2478994.24
2	289492.80	2479245.77
3	289242.17	2479548.62
4	289141.42	2479696.42
5	288593.55	2480192.65
6	288489.91	2480237.99
7	288344.72	2480344.06
8	288086.56	2480595.50
9	287681.44	2481143.26
10	287658.26	2481208.15
11	287316.17	2481438.24
12	286779.23	2481979.96
13	286709.79	2480472.42
14	286786.12	2482142.42
15	290087.50	2481876.00
16	286283.50	2484016.35
17	284719.44	2482119.57
18	285008.68	2482613.77
19	285442.64	2483313.42
20	290202.91	2486339.81
21	289827.30	2486485.92
22	290063.56	2485693.46
23	288994.30	2486237.08
24	288168.77	2485846.82
25	287269.98	2485730.93
26	285741.45	2485711.97
27	285360.87	2485835.84
28	284248.67	2486161.21

Point #	Northing	Easting
29	283659.75	2486722.62
30	283432.00	2486726.75
31	283300.28	2486785.21
32	281815.86	2486186.37
33	280987.18	2486765.00
34	279956.76	2488747.79
35	279951.60	2488832.00
36	279892.80	2489254.66
37	279810.57	2489480.22
38	279479.30	2490499.43
39	279296.76	2491007.08
40	279461.94	2492254.93
41	282848.68	2493204.11
42	282549.34	2492599.87
43	282716.85	2492440.43
44	281854.04	2492523.49
45	281589.31	2492289.05
46	281505.00	2492324.31
47	280881.80	2492406.32
48	280031.08	2493112.48
49	279781.50	2492527.04
50	278707.99	2493136.12
51	278008.51	2493806.06
52	277759.76	2493953.90
53	277271.73	2493882.92
54	276974.04	2493839.41
55	276699.74	2493813.79
56	276129.08	2493975.14

Coordinate System: State Plane, PA South, NAD83 datum

APPENDIX D
RESTORATION BMP HANDOUTS

Streambank Fencing

Within the West Branch Brandywine Ag-1 Watershed, grazing livestock in and around streams has the greatest negative impact on water quality of all practices within the watershed. Livestock trample the streambanks and contribute 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.

For more information please contact:
Brandywine Valley Association
1760 Unionville-Wawaset Road
West Chester, PA 19382
Phone: (610) 793-1090



Forested Stream Buffer Zone

Mowing and grazing stream corridors to the stream edge impacts water quality and the community of creatures that live within the stream. Streams flowing through open field 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.



Forested stream buffers provide shade, helping 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 and be taken up through the root systems and stored in the tree and shrub's wood. In addition, forested 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.

For more information please contact:
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Phone: (610) 793-1090



Stabilized Livestock Stream Crossing

Where livestock have un-restricted access to streams, they typically find a few favorite crossing areas and use those sites repeatedly. The resulting crossing locations begin to erode and become slippery and unstable. In these locations, livestock are at risk of injury and the stream is subjected to high levels of sedimentation.



In combination with any streambank fencing project where quality pastureland exists on both sides of the stream, stabilized crossing areas are a necessity. Installation of the crossings typically requires a general permit registration to be sent to the Department of Environmental Protection (DEP) and conservation district. In Pennsylvania, the most common installation technique is to place concrete hog slats across the bottom of the stream and maintain slopes on the approaches that are no greater than 4:1. The crossings may easily be equipped with gates to create paddocks that aid in rotational grazing. Routine maintenance of the crossing locations should include inspection after high water events to ensure that the fencing with dropper wires utilized to guide livestock through the crossing remains serviceable.

For more information please contact:

Brandywine Valley Association

1760 Unionville-Wawaset Road

West Chester, PA 19382

Phone: (610) 793-1090



Stabilized Watering Areas

Adequate amounts of clean water are vital to successful livestock production. Dairy cattle typically require 15-30 gallons of water per head per day while each horse typically requires 10-15 gallons of water per day.

In order to minimize the time that livestock spend visiting and loafing near the stream, several watering options are typically considered as part of a streambank restoration project. The most common method is to allow the livestock to drink in areas where stabilized stream crossings are installed. If the pasture layout dictates that cattle will not need to cross the stream, a stabilized ramp may be installed with hog slats or stone so that cattle may drink directly from the stream in a stabilized area. Another option is to install watering troughs in stable upland areas. The watering troughs should be designed to refill automatically with water from a spring development, gravity or siphon line from a pond, or pressurized watering system.



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Manure Management

Manure produced on each farm is an important resource for providing nutrients to crops, but when not handled appropriately becomes a pollution risk for streams, wetlands, and ponds. Typically, manure becomes a problem when it is not managed in feedlots, pastures, and in fields where it is spread. Manure discharged from these areas carries high levels of bacteria and nutrients into the stream. The bacteria are associated with pathogens that put both humans and livestock drinking or coming in contact with the water at risk of disease.



Ammonia and nitrite that are present in fresh manure are toxic to many forms of aquatic life. Additionally, excessive nutrient enrichment in streams and ponds often leads to algal blooms that later crash and decay. The decaying algae decreases dissolved oxygen levels and sometimes leads to fish kills.

Within feedlots, manure management facilities eliminate the need to haul and apply manure daily. The collected manure is stored so that it may be applied when soil conditions are optimal and crop nutrient needs are at their highest. Within pastures, manure



management should focus on getting livestock out of the streams and installing a vegetated buffer to filter nutrients before they discharge to the stream. When manure is applied to the land, soil fertility levels, manure nutrient content, crop nutrient needs, site conditions, and weather conditions should be considered. To ensure appropriate application rates, manure spreaders should be calibrated.

For more information please contact:
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Cropland Erosion Control

Within the West Branch Brandywine Ag-1 Watershed, excessive sedimentation has occurred and impacts the majority of stream miles. Sediment impairs the stream by smothering the small spaces between the rocks and gravel where aquatic creatures make their home. Excessive sediment within the stream also clogs culverts and bridges, increasing downstream landowner, township and state expenditures for routine maintenance. Effective upland erosion and sediment control are important to minimize additional sedimentation to the stream.



Erosion and sediment control on farmlands has been the focus of extensive work completed by the conservation district and natural resources conservation service. Within the West Branch Brandywine Ag-1 Watershed, most farms have already implemented best management practices for erosion control. Some of the already installed best management practices that are effectively being implemented within the watershed include: maintaining grassed waterways to provide stable flow paths for

stormwater, filter strips to slow runoff and settle out pollutants, diversions to handle upslope flows and minimize the amount of water flowing across the surface of a field, farm terraces and contour farming to slow runoff and retain moisture, conservation tillage (no till), and utilizing cover crops to minimize the exposure of bare soils.

For more information please contact:
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1760 Unionville-Wawaset Road
West Chester, PA 19382
Phone: (610) 793-1090



In-stream Restoration Structures

Within the West Branch Brandywine Ag-1 Watershed, some stream segments are impaired by erosion and sedimentation within the stream itself. When streambanks erode within agrarian areas, the impacts from the sediment that is discharged to the stream often are 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. Analysis of these structures with a fluvial geomorphological approach is necessary in determining the best restoration methods for the stream. Restoration practices should include a combination of floodplain restoration, streambank stabilization, and in-stream structures as determined by the site conditions.

Where streambanks are actively eroding, a combination of rip-rap and vegetation is often implemented to provide stabilization. Other commonly utilized techniques include in-stream deflectors, cross-vanes, j-hooks, and boulder placements. 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.



Boulder Placements



Rock Deflector



Rock Cross Vane

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.

For more information please contact:
Brandywine Valley Association
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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 necessary.



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.

For more information please contact:
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APPENDIX E
PRELIMINARY PROBABLE CONSTRUCTION COST OPINION

West Branch Brandywine Ag-1 Watershed Probable Construction Cost Opinion

Site	Priority	Min Cost	Max Cost
2-5	High	\$25,000	\$60,000
14-16	High	\$75,000	\$125,000
18-19	High	\$6,500	\$12,500
21-23	High	\$35,000	\$60,000
25-26	High	\$25,000	\$50,000
28-29	High	\$15,000	\$35,000
31-34	High	\$180,000	\$300,000
37-38	High	\$75,000	\$100,000
49-50	High	\$75,000	\$100,000
5-8	Medium	\$10,000	\$25,000
9-10	Medium	\$150	\$750
20-21	Medium	\$500	\$2,000
39-40	Medium	\$25,000	\$40,000
41	Medium	\$1,500	\$3,000
43-44	Medium	\$3,500	\$10,000
46-49	Medium	\$25,000	\$50,000
50-54	Medium	\$25,000	\$50,000
		\$602,150	\$1,023,250

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, Ph.D., CPESC

At Clauser Environmental, LLC, he serves as Vice President and the technical/production lead on scientific projects. Dr. Clauser has 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 has experience as an environmental regulator with the Berks and Schuylkill Conservation Districts where he has served at both the technician and managerial levels. Dr. Clauser began consulting 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.

Krista S. Clauser

As the President of Clauser Environmental, LLC, she is responsible for overall client satisfaction, quality assurance, educational outreach programs, and project management. Ms. Clauser has her bachelor's degree in Special Education and Elementary Education from Kutztown University of Pennsylvania and graduate level coursework in Education from Kutztown University of Pennsylvania and Indiana Wesleyan University. She has experience as a Special Education Teacher at Schuylkill Intermediate Unit and a homeschool educator at the elementary level. Ms. Clauser has expertise in integrating environmental/outdoor curricula into a diversity of subjects and educational settings.