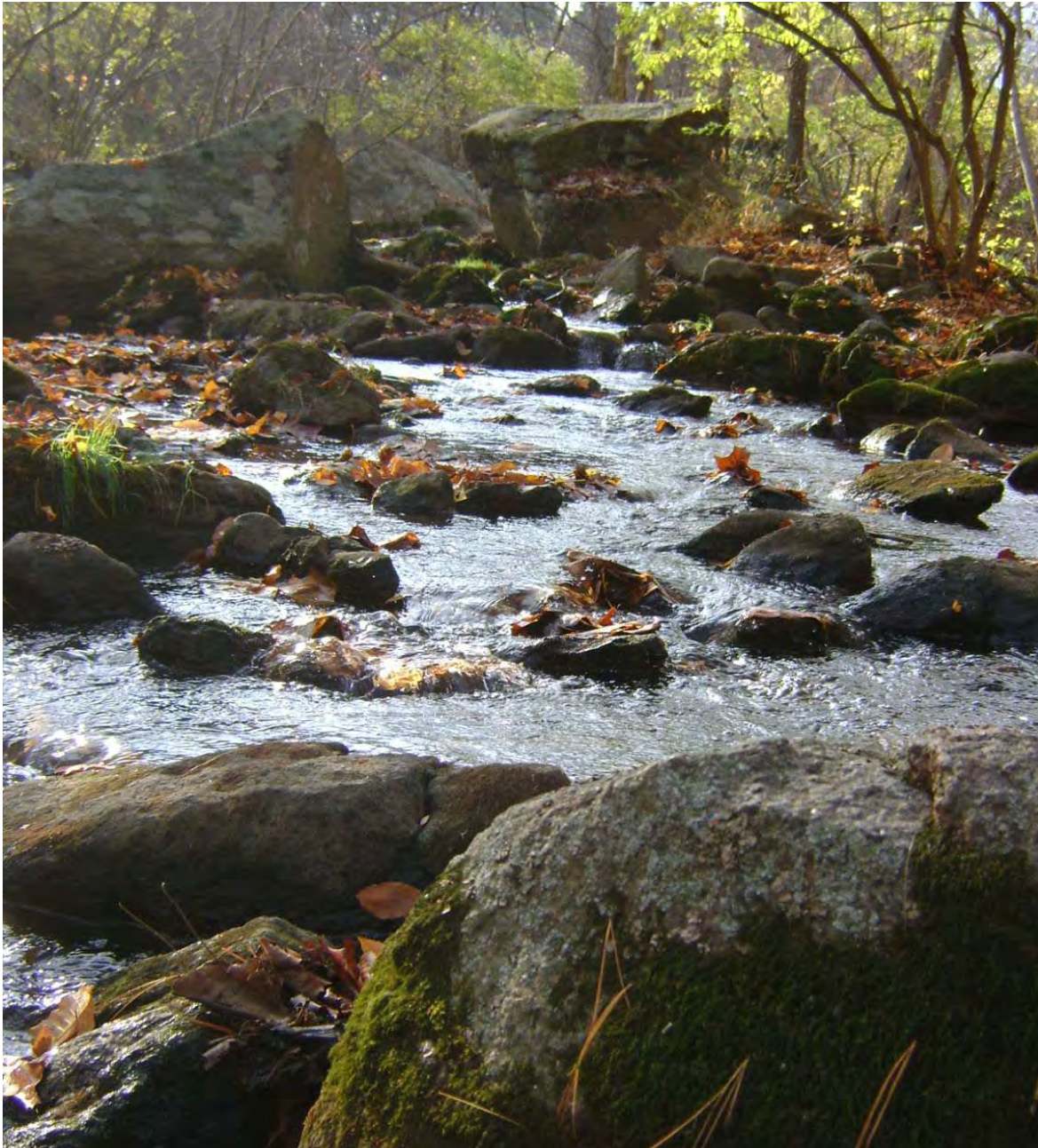


WEST BRANCH CRUM CREEK
COLDWATER CONSERVATION PLAN



CHESTER-RIDLEY-CRUM WATERSHEDS ASSOCIATION
DELAWARE RIVERKEEPER NETWORK

July 2009

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The Delaware Riverkeeper Network (DRN) is the only advocacy organization working throughout the entire Delaware River Watershed. The Delaware Riverkeeper is an individual who is the voice of the River, championing the rights of the River and its streams as members of our community. The Delaware Riverkeeper is assisted by seasoned professionals and a network of members, volunteers and supporters. Together they are the Delaware Riverkeeper Network, and together they stand as vigilant protectors and defenders of the River, its tributaries and watershed. DRN is committed to restoring the watershed's natural balance where it has been lost and ensuring its preservation where it still exists.

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Chester Ridley Crum Watersheds Association (CRC) is a 501 (c) (3) nonprofit, conservation organization whose mission is to protect, conserve, and restore the natural resources of the Chester, Ridley, and Crum Creek watersheds.

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FORWARD

The West Branch of Crum Creek and its watershed has been recognized as unique and special by the State of Pennsylvania two times – first with its determination by the Pennsylvania Fish and Boat Commission as a Cold Water Trout Fishery in 2002 along with the rest of the Upper Crum Creek, and second with its Exceptional Value protection status granted by DEP in 2003. Only 4% of Pennsylvania’s over 83,000 miles of stream rate high enough in biological diversity to be afforded Exceptional Value designation. Willistown Conservation Trust, Brandywine Conservancy, and Willistown Township have worked tirelessly over the past 25 years to preserve the open space, natural resources, and unique character of the Upper Crum watershed. The Willistown countryside, including the gem of the West Branch, would not be what it is today without their efforts.

The Coldwater Heritage Partnership awarded a grant to Chester Ridley Crum Watersheds Association (CRC) to develop a plan to preserve the coldwater species and their habitat in the Upper Crum, and in particular the West Branch. Implementation of stream enhancement, habitat improvement, and land management activities noted in this Coldwater Conservation Plan will help preserve the unique resource that is the West Branch for future generations, as well as benefit coldwater species downstream. The comparative macroinvertebrate analysis done by our project partner Delaware Riverkeeper Network and consultant Normandeau Associates reveals a decline in the superior quality of the West Branch, and indicates that land management practices are not adequate to avoid ongoing degradation of the resource. The stream survey compiled recommendations for over thirty properties. If collectively implemented by landowners these recommendations will act to reverse this trend and preserve what is a very beautiful and ecologically valuable stream. CRC is grateful for the insightful participation of its major conservation partners, Willistown Conservation Trust, Brandywine Conservancy, and Willistown Township, as well as West Branch landowners and the Delaware Riverkeeper Network for partnering with CRC to begin the process of thoughtfully implementing this plan.

Anne Murphy
CRC Executive Director

PURPOSE OF STUDY

The Coldwater Heritage Partnership (CHP) seeks to protect and improve Pennsylvania's coldwater streams, especially those containing naturally reproducing wild trout. In 2008 CHP awarded funds to Chester Ridley Crum Watersheds Association (CRC) to develop a Coldwater Conservation Plan for the Upper Crum Creek, specifically the West Branch of Crum Creek. The Upper Crum Creek was selected for funding due to its special protection water designation (Exceptional Value and High Quality-Cold Water Fishery) and the 2001 Pennsylvania Fish and Boat Commission study that documented Upper Crum Creek as supporting wild brown trout (*Salmo trutta*) production. The Upper Crum Creek is one of only a handful of streams in southeastern Pennsylvania with a naturally reproducing trout population.

This Coldwater Conservation Plan focuses on the West Branch of Crum Creek, a subbasin of the Upper Crum Creek. The West Branch was selected due to its Exceptional Value designation and the influence this headwater stream has on the downstream trout fishery of Crum Creek. This Coldwater Conservation Plan is a supplement to previous reports completed for the Crum Creek watershed and provides site-specific recommendations for streamside property owners to improve and protect this recognized important coldwater ecosystem. It is hoped that the dissemination and use of this Coldwater Conservation Plan will inspire, aid in the implementation of beneficial improvements by property owners and conservation partners, and in general increase awareness of the jewel that is the West Branch of Crum Creek.

CRUM CREEK AND THE WEST BRANCH

Overview of the Crum Creek Watershed

The Crum Creek watershed, located west of Philadelphia in southeastern Chester and central Delaware counties, is a 38-square mile basin with 62 subbasins. With its headwaters in Malvern, PA, the approximately 72 miles of stream channels flow southeasterly and empty into the Delaware River between Eddystone and Ridley Township. Crum Creek, named Crum or "crooked creek" by early Dutch settlers of the region, winds through varied landscapes including large tracts of preserved farms and woodlands in Willistown Township, a growing suburban community near Newtown Square, the Springton Reservoir which supplies drinking water for 200,000 residents of Delaware County, densely developed suburbs such as Swarthmore and Springfield, and the industrial towns of Eddystone and Ridley Township. Crum Creek

begins in the Northern Piedmont physiographic setting and flows into the narrow portion of Pennsylvania that includes the Atlantic Coastal Plain as it nears the Delaware River.

The Crum Creek watershed reflects its past as an early European settlement and its present as a suburb to Philadelphia. The watershed retains some late 17th century historic treasures and the upper reaches sustain a number of remnant natural areas and agricultural lands. In the late 20th century the Blue Route (I-476) and Route 202 were constructed leading to population and development growth and increased pollution (Chester-Ridley-Crum Watersheds Association and Natural Lands Trust, 2005). Early European settlement along with recent development resulted in wetlands being filled and stream channels being relocated or placed in culverts. Today the watershed continues to feel the pressures of development.

The lower third of Crum Creek, largely south of Baltimore Pike, is listed as impaired due to urban runoff, storm sewers, thermal modifications, siltation, and flow alterations under PA DEP's Integrated List of Impaired Waters. Under the Clean Water Act, a plan must be developed for these stream segments to restore them to their designated use of Warm Water Fishery (WWF). A key to restoring water quality is the establishment of total maximum daily loads (TMDLs) which act as watershed budgets for pollutants. Though the Upper Crum Creek is in better condition, many pollution inputs exist for these streams as well. Action is needed to preserve and restore Crum Creek.

The West Branch of Crum Creek and its tributaries were granted Exceptional Value (EV) status in 2002 by the Pennsylvania Department of Environmental Protection (PA DEP) based on outstanding biological quality. Exceptional Value streams represent only 4% of Pennsylvania's total stream miles. They are the most pristine and ecologically functioning streams in the state. By nature of their designation and requirements of the Clean Water Act, EV streams are to be protected against any degradation in water quality to preserve these resources for future generations.

The main stem of Crum Creek and its tributaries upstream of the Springton Reservoir are designated as a Cold Water Fishery (CWF). Those upstream of Route 3 and above the intersection of Edgmont, Newtown and Willistown are High Quality Cold Water Fishery (HQ-CWF). Similar to the EV designation, HQ streams are important state resources protected by anti-degradation legislation. The HQ-CWF segments of Upper Crum Creek were petitioned for EV status in 2000 along with the West Branch of Crum Creek; however, PA DEP determined water quality and biological diversity did not warrant the EV designation.

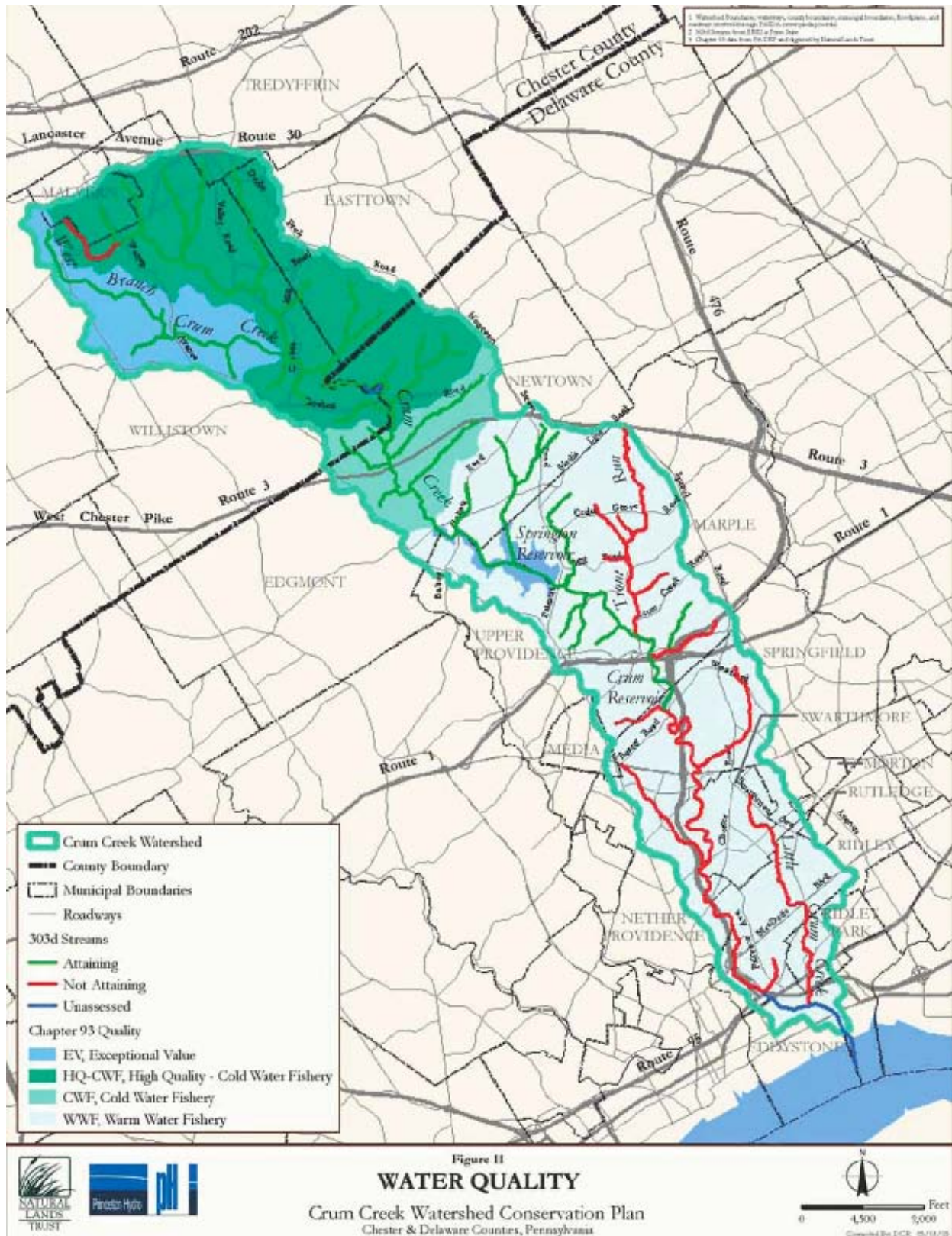


Figure 1. Designated uses for Crum Creek. (Map from the 2005 Crum Creek Watershed Conservation Plan.)

Coldwater Conservation Plan Study Area

The entire Upper Crum Creek was selected for a Coldwater Conservation Plan due to its special protection water designations (EV and HQ-CWF) and the fact that it is one of only a few streams in southeastern Pennsylvania with a naturally reproducing brown trout population (Pennsylvania Fish and Boat Commission, 2001). Brown trout (*Salmo trutta*) were introduced in the late 1800s from Eurasia and are not a native species to Pennsylvania streams; however, the Pennsylvania Fish and Boat Commission (PFBC) recognize brown trout as a naturalized species. Per fish sampling conducted by PFBC in 1999 along Crum Creek, trout biomass was highest in the Newtown section of Crum Creek upstream of the covered bridge at the intersection of Boot Road and Goshen Road (HQ stream segment) and at Mill Hollow upstream of Route 3 and the confluence with Reese's Run (CWF stream segment). For a list of findings from the 1999 fish survey, see Appendix C.

To further refine the scope of this project, this Coldwater Conservation Plan is directed specifically at the West Branch of Crum Creek. However, many of the general recommendations and prescribed management practices are certainly applicable to the rest of the Upper Crum Creek. The West Branch was selected as the plan's focus due to its EV status and the influence it has on the downstream trout fishery of Upper Crum Creek. Concentrating on this smaller sub-watershed allowed the development of a fuller, site-specific action plan which when implemented will improve and protect this recognized important coldwater ecosystem. Protecting and enhancing the water quality, stream health, and coldwater habitat of the West Branch, from its headwaters down to the confluence with the main stem of Crum Creek, will benefit the stream and the communities it supports throughout the entire Crum Creek watershed.

The West Branch

The West Branch is the western most tributary of the Crum Creek watershed and drains approximately 3.3 square miles. The basin is located almost entirely (99.8%) within Willistown Township with limited drainage from Malvern Borough. The West Branch headwaters are located in Willistown Township and a smaller section of the western portion of Malvern Borough north of Paoli Pike. The stream flows in a southeasterly direction for 5.1 miles before it empties into the main branch of Crum Creek on private property upstream of the White Horse Road Bridge.

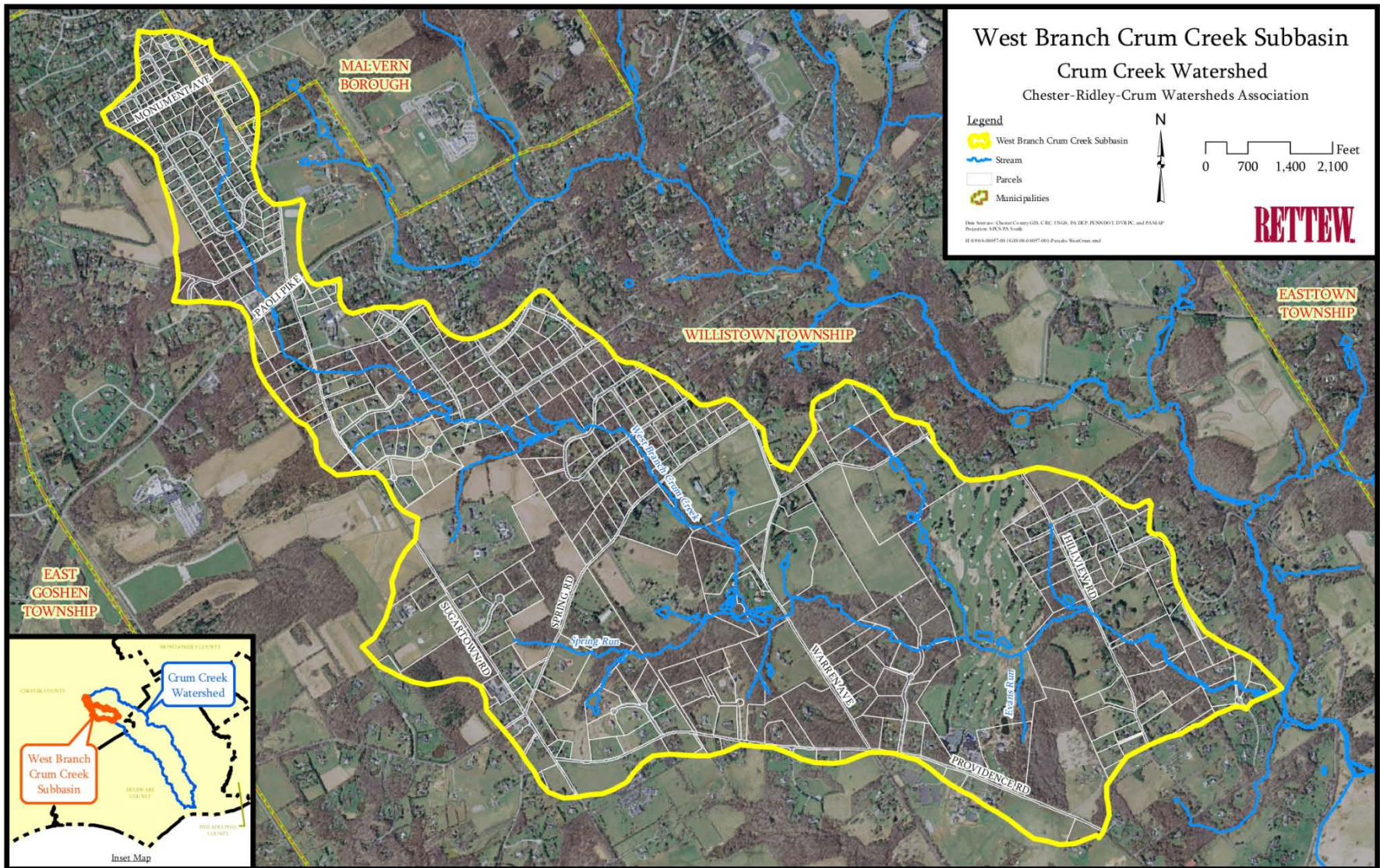


Figure 2. West Branch Crum Creek watershed map.

Other Pertinent Watershed Studies

Other studies have looked at the West Branch in context of the entire Crum Creek system. This Coldwater Conservation Plan builds upon the information gathered in these previous assessments and complements their findings. The goal of this plan is to provide property owners and the plan's conservation partners – Willistown Township, Willistown Conservation Trust, Brandywine Conservancy, and CRC – with a concise document containing site-specific recommendations that can be considered and implemented along the length of the West Branch in order to enhance stream health, water quality, and habitat for High Quality aquatic organisms, including naturally reproducing brown trout.

In 2004, Mesa Environmental Sciences and Willistown Conservation Trust completed the *Upper Crum Creek Watershed Assessment and Restoration/Protection Plan* under a PA DEP grant to Willistown Township. This plan documents historical, physical, geologic, chemical, and fluvial geomorphic conditions of the Upper Crum Creek and associated wetlands for each major subbasin, and highlights potential key restoration opportunities in order to promote better stewardship of the resource. A visual assessment was completed throughout the Upper Crum Creek watershed which qualitatively assessed stream cover, fine particle sediments, flow patterns, stream bank conditions, disruptive pressures to the riparian area, riparian vegetative zone width, and litter. The overall assessment for many stream sections in the upper half of the West Branch was “marginal” or “poor” (Figure 3). Key recommendations for the West Branch included expansion of riparian buffers; landowner outreach; maintenance of aging ponds; control of goose population; and, reduction of runoff from road surfaces. This extensive report and its appendices are available for viewing and copying upon request by contacting either CRC or Willistown Township.

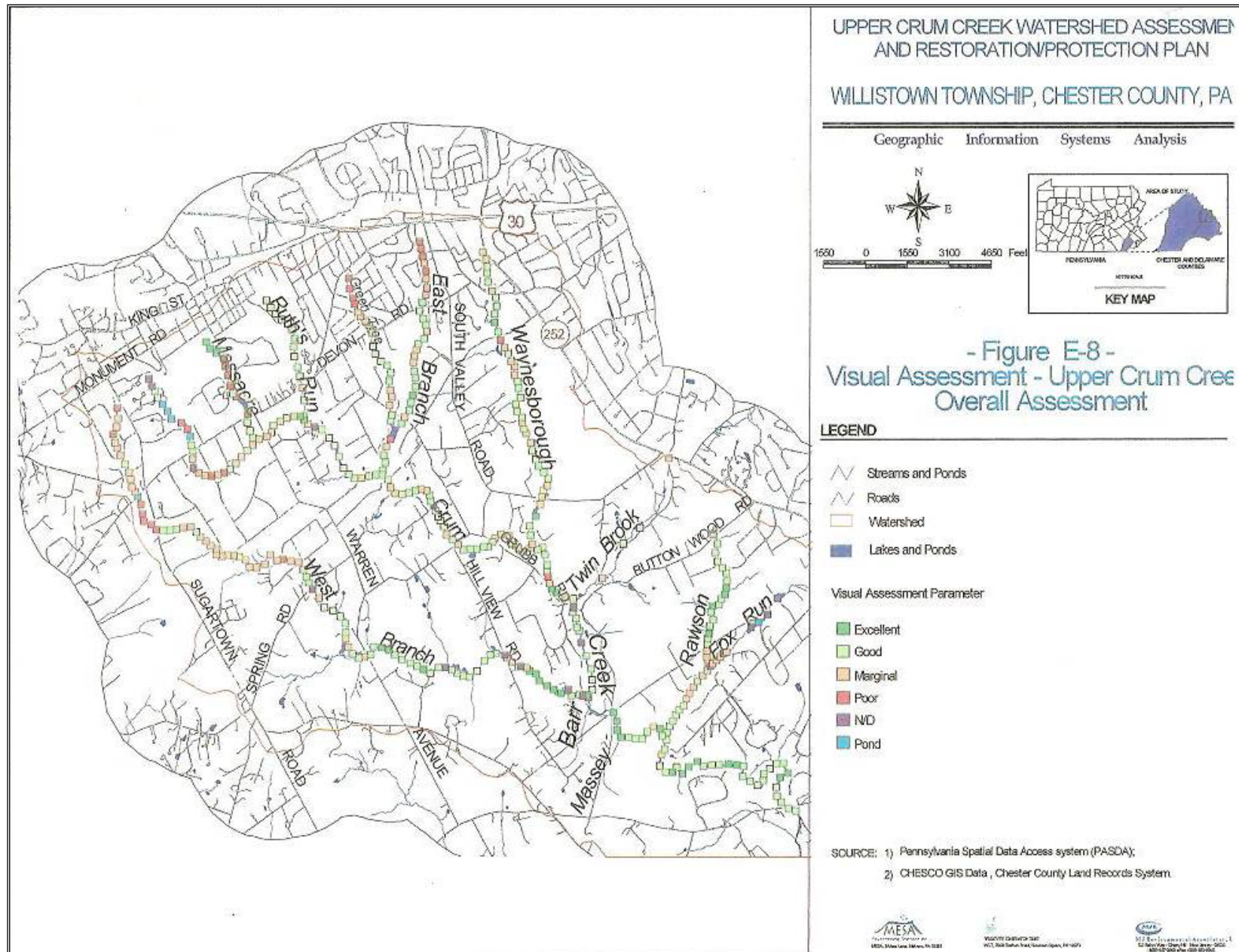


Figure 3. Overall visual assessment of Upper Crum Creek (Mesa Environmental Sciences, 2004).

In 2005, CRC completed the *Crum Creek Watershed Conservation Plan* along with project partners Natural Lands Trust, Willistown Conservation Trust, and the Crum Creek Watershed Partnership, under a grant from the PA Department of Conservation and Natural Resources (DCNR). This report documents the natural, cultural, ecological, hydrologic, and recreational resources of the watershed, outlines major issues, and sets forth an action plan. Key recommendations address land use and growth management, open space protection and restoration, woodland protection and restoration, invasive species, riparian buffer and wetland protection and restoration, stormwater management, flooding, erosion, water quality, wastewater treatment, dams, environmental education, and, recreation, greenways, trails and public access. This report is available in hard copy form through CRC or online for download from www.crcwatersheds.org or www.dcnr.state.pa.us/brc/rivers/riversconservation/registry/CrumCreek/index.aspx.

Land Use of the West Branch

Essentially the entire West Branch Crum Creek watershed is located in Willistown Township. Due to the land conservation efforts of Willistown Conservation Trust and Brandywine Conservancy, resident support for an open space bond issue, and a generally strong conservation ethic of its citizens, Willistown Township contains a large amount of green space and retains a rural character despite its proximity to Philadelphia. Approximately 28% of Willistown Township is protected through conservation easements limiting development (Willistown Township, n.d.). Thanks to the work of Willistown Conservation Trust, Brandywine Conservancy, conservation minded landowners, municipalities, government agencies, and all other conservation partners over 6,000 acres in the Willistown area have been permanently preserved in the upper watersheds of Crum, Ridley, and Darby Creeks through acquisition or conservation easements (Willistown Conservation Trust, n.d.).

High density residential and commercial development has occurred in the Upper Crum Creek watershed particularly along Route 30 and Route 3. Impervious surfaces such as driveways, roads, and rooftops are a big contributor to watershed decline. These hard surfaces intercept groundwater replenishment, resulting in “flashy” stream systems, and cause high levels of contaminated runoff as rain water flows off of these hard surfaces and often into engineered storm sewers transporting the polluted rain water directly to the stream. An extensive breakout of the impervious cover by township and sub-watershed is available in the *Crum Creek Watershed Conservation Plan*. According to calculations in this document, in 2005 the West Branch watershed had 12.2% impervious cover and 87.8% pervious. This degree of imperviousness is high when

compared to other EV watersheds in the state. Findings published by the Center for Watershed Protection concluded that relatively low levels of imperviousness (~10%) may result in stream degradation and that severe degradation may be apparent when percent imperviousness exceeds 25% (T. Scheuler and H. Holland, 2000). Efforts need to be made to limit increases in impervious surfaces, to implement stormwater best management practices (BMPs), and to seek out opportunities to remove existing impervious areas and transform them to naturally vegetated areas in order to maintain the West Branch’s existing EV status, summer water temperatures, and the propagation of coldwater species.

A further breakdown of land use types was calculated in the *Upper Crum Creek Watershed Assessment and Restoration/Protection Plan* (2004). This plan presents land use patterns by breaking the West Branch into two sections based on visual assessment results and land use trends. The first section extends from the headwaters to Warren Avenue; the second from Warren Avenue to the main branch.

Headwaters of West Branch to Warren Avenue – The West Branch headwaters west of Sugartown Road and north of Monument Avenue are dominated by single family residential lots with one agricultural lot with an in-line pond near the stream’s source. The stream continues southeasterly, flowing through single family lots and neighborhoods and one commercial property (Potters Nursery). After flowing under Spring Road it passes through partially wooded properties before reaching Warren Avenue.

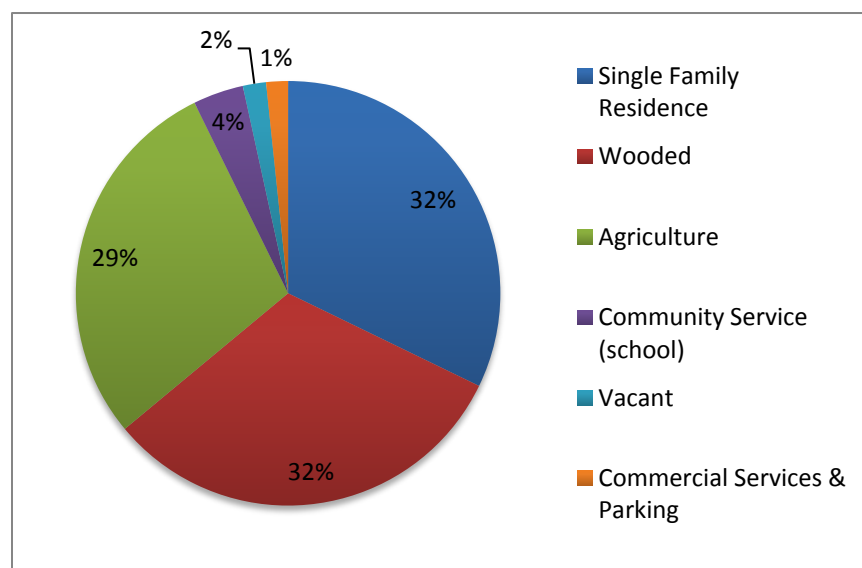


Figure 4. Land use of West Branch Crum Creek from headwaters to Warren Avenue per 2004 Upper Crum Creek Watershed Assessment and Restoration/Protection Plan.

Note: “Vacant” land use includes lawn surrounding commercial offices and athletic fields.

Warren Avenue to Main Branch above Barr/Whitehorse Road Bridge – Below Warren Avenue the West Branch continues its southeasterly flow. Single family residential parcel size increases in this reach. These larger lots often contain wooded areas, as well as landscaped areas and horse pastures. After flowing through White Manor Country Club, the West Branch enters a significant wetland upstream of Hillview Road. The stream then continues through residential lots with woods, fields, and pasture before it meets the Main Branch above the Barr/Whitehorse Road Bridge. Numerous off-line ponds and two dams exist within this lower section of the West Branch.

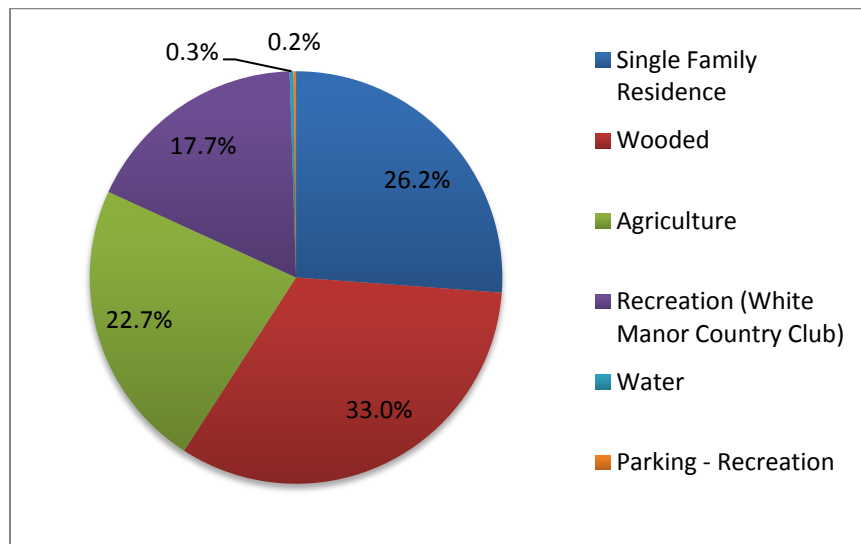


Figure 5. Land use of West Branch from Warren Avenue to Crum Creek confluence per 2004 Crum Creek Watershed Assessment and Restoration/Protection Plan.

MACROINVERTEBRATES

Importance of Macroinvertebrates to Determine Stream Health

Aquatic insects, or macroinvertebrates, many with life spans of a year or longer, can be found in streams year round. Many aquatic insects spend their entire immature development in water. Only a small fraction of their lives is spent as terrestrial adults. These insects form the base of the aquatic food chain. Macroinvertebrate species have varied tolerances to environmental pollution; therefore, they serve as excellent indicators of

stream health as their populations are directly impacted by the health of the water and our management of streamside lands.

Purpose and Methodology

In May of 2008 and 2009, as part of a larger pilot study with PA DEP to monitor EV and HQ stream health over time, Delaware Riverkeeper Network (DRN) conducted macroinvertebrate monitoring along Crum Creek. Macroinvertebrates were collected at the Warren Road sample station on the West Branch Crum Creek (EV), and two sample stations in the upper reaches of the main branch of Crum Creek (HQ). In 2009 DRN sampled a fourth station on the main branch of Crum Creek downstream of the West Branch confluence. PA DEP monitored these same sampling stations in 2000 as part of the Crum Creek upgrade petition process. At that time, the sample stations had diverse and healthy populations of macroinvertebrates and this served as the basis for DEP's upgrade. The goal of the 2008 and 2009 surveys was to document the health of these special protected areas of the Crum Creek and other EV and HQ streams in the Commonwealth to determine how effective protection is and if in fact Pennsylvania's anti-degradation policy is being achieved. Antidegradation is defined as no decrease of stream health to EV streams and limited, if any, decrease of stream health to HQ streams.

Sampling of the three sites by DRN replicated PA DEP's 2000 sampling in location, methodology, and timing. DRN sampled in early May and used the same Modified Rapid Bioassessment Protocol (modified from the EPA RBP III). Sampling was conducted using a D-frame net. Riffle habitat is the primary area where most macroinvertebrates live and diverse riffles with various regimes of fast and slow flows and deep and shallow depths within a 100-meter stream reach were sampled. A composite sample was collected combining six D-frame kick efforts in the 100-meter reach accounting for the best riffle habitat areas. Samples were preserved in alcohol streamside and transported to Normandeau Associates for processing using the same lab techniques DEP used in 2000 for sorting and identification (PA DEP Semi-Quantitative Method) (Pennsylvania Department of Environmental Protection, 2003). Habitat assessments and water quality tests were also conducted at the time of macroinvertebrate sampling at each of the reaches using methodologies described in Barbour et al. (1999).

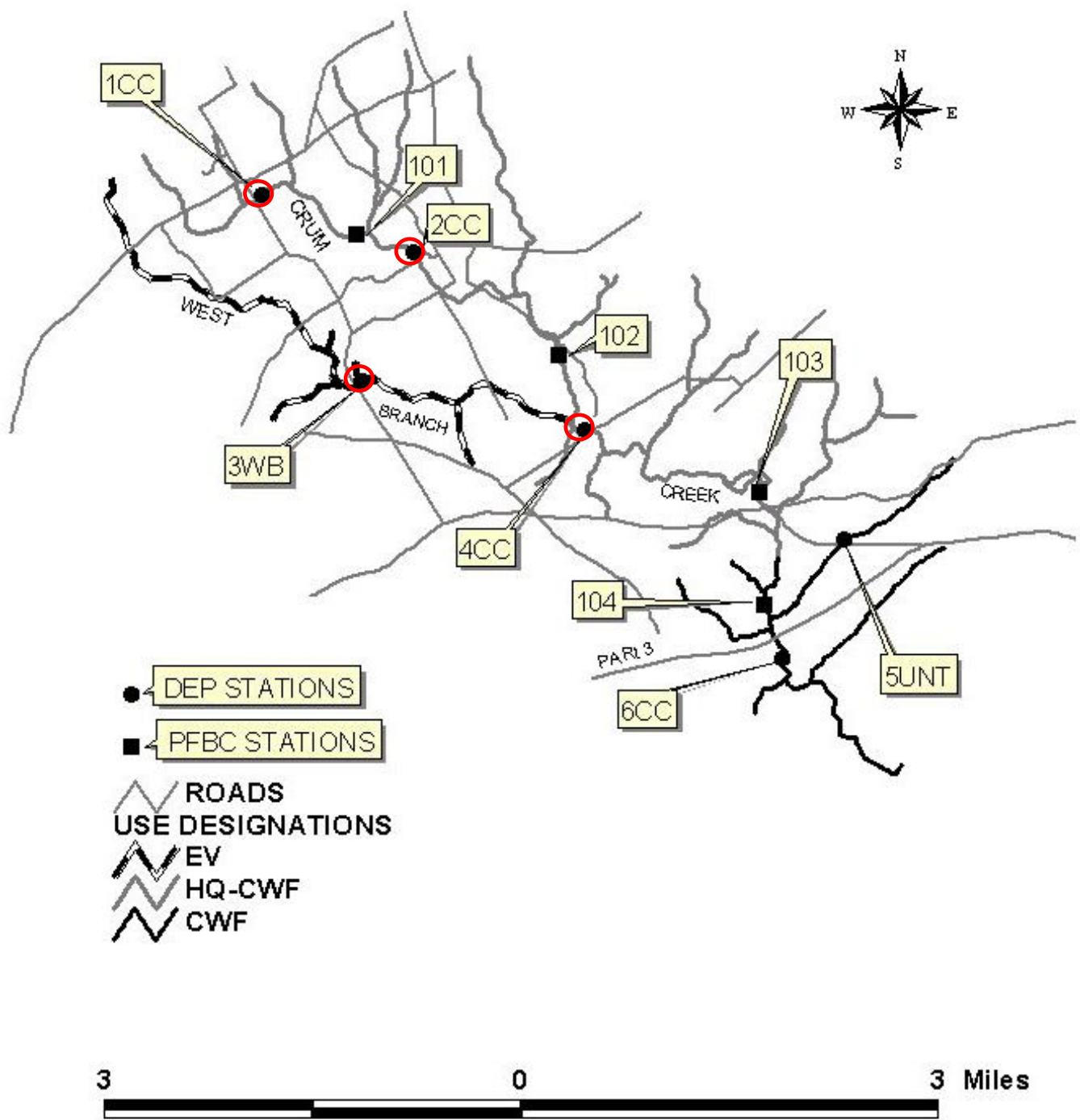


Figure 6. Crum Creek PA DEP macroinvertebrate sampling locations. Locations replicated by DRN's 2008 and 2009 sampling are circled in red. (Pennsylvania Department of Environmental Protection, 2001)

Findings and Conclusions

Table 1 below compares the multi-metrics calculated for the macroinvertebrate communities collected on May 9-10, 2000 by PA DEP, May 7, 2008 by DRN, and May 12, 2009 by DRN. Appendices A and B provide additional details on the macroinvertebrate taxa collected in 2008 and 2009 respectively.

Table 1. Upper Crum Creek macroinvertebrate RBP metrics by station for 2000 (PA DEP), 2008 (DRN), and 2009 (DRN) sampling events.

Metric	Station 3 WB (West Branch)			Station 2CC (Crum Creek)			Station 1CC (Crum Creek)		
	2000	2008	2009	2000	2008	2009	2000	2008	2009
TAXA RICHNESS	18	18	22	22	18	20	20	22	23
Cand./Reference* (%)	139	139	169	169	139	154	154	169	177
Biol. Condition Score	6	6	6	6	6	6	6	6	6
MOD. EPT INDEX	7	5	6	6	6	3	7	8	8
Cand./Reference* (%)	88	63	75	75	75	38	88	100	100
Biol. Condition Score	6	4	4	4	4	0	6	6	6
MOD. HBI	2.5	6.6	5.8	4.4	5.7	5.4	4.8	5.0	5.7
Cand./Reference* (%)	0.6	4.6	3.9	2.4	3.7	3.4	2.8	3.0	3.7
Biol. Condition Score	6	0	0	0	0	0	0	0	0
% DOMINANT TAXA	52	44	21	20	68	38	33	28	42
Cand./Reference* (%)	14	6	<0	<0	30	0.4	<0	<0	4
Biol. Condition Score	4	6	6	6	0	6	6	6	6
TOTAL BIOLOGICAL CONDITION SCORE	26	16	16	16	10	12	18	18	18
% COMPARABILITY TO REFERENCE*	87	53	53	53	33	40	60	60	60
MORISSETTA'S INDEX (Candidate vs. 2000)	NA	0.12	0.18	NA	0.34	0.53	NA	0.84	0.86

**The reference is the 2000 data from the reference stream station (R1) used during the petition process by PA DEP*

Multi-metrics above indicate that the West Branch Crum Creek may be declining in health. Morisetta's Index is a metric used to compare two different datasets; here PA DEP's 2000 sample is compared to both DRN's 2008 and 2009 samples. The highest score of 1.0 indicates there is no difference between the two datasets. The closer the score to 1.0, the more similar two comparison datasets are to one another. Using Morisetta's Index to compare aquatic communities of Crum Creek over time, there is a significant difference (0.117) between the 2000 and the 2008 communities for the West Branch Crum Creek station (3WB). This degradation is further confirmed by the 2009 survey data for the West Branch station, which also has a low Morisetta's index (0.18). This difference indicates a shift in the aquatic community and further metrics point to possible degradation occurring along this EV section of the West Branch.

The Hillenhoff Biotic Index (HBI) metric also suggests degradation along both the EV West Branch and the HQ main stem. HBI was originally developed to indicate organic pollution and considers the abundance of taxa and their tolerance to environmental stress and water quality. A lower HBI score signifies better water quality. The HBI score for the West Branch Crum Creek site was 6.6 in 2008 and 5.8 in 2009. This is a higher score (i.e., poorer health) than that of the two Crum Creek stations (2CC and 1CC). In 2000, the West Branch site had the best HBI score of the three sampling stations. Additionally the West Branch score of 6.6 and 5.8 are large increases from its HBI score of 2.2 back in 2000. A similar increase in HBI scores in 2008 and 2009 were also observed at the two Crum Creek stations, where sensitive species were reduced in numbers. This data indicates a potential decline in quality for all three sample stations over time.

At the same time, there is also a significant increase in the numbers of Chironomidae (midges), a tolerant group of insects in the Diptera (true flies) order, which could indicate a decrease in overall stream health. Stations 2CC and 3WB had particularly large increases in the number of Chironomidae. In 2000 Station 2CC had 13 Chironomidae, in 2008 the number increased to 122 and in 2009 there were 86. In 2000 Station 3WB had only 8 Chironomidae and in 2008 the number increased to 82. In 2009 there were 44 Chironomidae at the West Branch sample site. These midges thrive in streams that have high organic matter like dense algae growths and detritus and are perhaps the single most important factor in removing them by their feeding habits (McCafferty, 1998). They can represent streams where high nutrients, from things such as failing septic systems, fertilized lawns, grazing animals and horses are a factor and where riparian buffers may not be present or adequate to help take up and filter out excess nutrients.

Similarly the percent of mayflies, a much more sensitive order of insects, for the West Branch of Crum Creek has declined in comparison to the 2000 reference sample. In the 2000 3WB sample there were four types of mayflies and a total of 73 individuals, while in 2008 this same site had only two types of mayflies totaling six individuals. In 2009, this site had four types of mayflies but with only a total of 17 individuals.

Based on the 2008 and 2009 data, it appears that the protection of the West Branch Crum Creek may not be adequate to protect the existing water quality required by anti-degradation.

The 2008 stream field assessment survey of the entire West Branch found intensive mowing practices and lack of riparian buffers along this headwater stream which could be main contributors to the decline of the

West Branch. The science is clear that a forested riparian buffer protects stream health. The Stroud Water Research Center recently conducted an analysis of stream categories and conditions drawing on its eleven year macroinvertebrate study of the Schuylkill River basin (Stroud Water Research Center, 2007). In this analysis, it was found that the primary factor governing macroinvertebrate quality was forest cover, and that increased forest cover resulted in improved water quality and biological diversity. With the West Branch Crum Creek's forest coverage at 33% (Mesa Environmental Sciences, 2004) and the noted management practices of streamside properties, the reduced forest cover and lacking stream buffers are big potential factors to the degradation of this stream.

WATER QUALITY

Water Quality Findings

Water samples were collected and analyzed at the time of macroinvertebrate surveys at each of the sampling stations using HACH and Lamotte monitoring kits. Table 2 provides a summary of the results for the three benthic sites sampled.

Table 2. Upper Crum Creek water quality snapshot. Sampling occurred May 7, 2008 and May 12, 2009 by DRN.

	Station 3WB		Station 2CC		Station 1CC	
	May 2008	May 2009	May 2008	May 2009	May 2008	May 2009
Nitrate-nitrogen (mg/l)	3.0	4.0	3.0	2.5	3.0	<1.0
pH	7.5	7.5	7.5	7.5	7.0	7.0
Ortho-phosphate (mg/l)	0.08	NA	0.02	NA	0.04	NA
Conductivity (us)	166	NA	188	NA	166	NA

In addition to the benthic sampling locations, DRN also tested nutrients on May 12, 2009 along the West Branch upstream of Station 3WB at the following locations: Barr Road, Forest Lane, and Sugartown Road. Nitrate-nitrogen readings for these stations were high at 4.0 mg/l, 9.0 mg/l, and 8.0 mg/l, respectively.

Water quality data points to the need for changes in land management and establishment of vegetated buffers. In general, unpolluted streams have phosphorus levels of less than 0.01 mg/L and levels should not exceed 0.1 mg/L. Nitrate-nitrogen levels in healthy streams should not exceed readings above 1.0 mg/L. High readings of nutrients can be due to over-fertilization of lawns and manicured landscapes, agricultural

runoff or problems with leaking septic tanks as well as nutrients from stream bank erosion. The presence of riparian buffers can help filter out these excess nutrients.

STREAM VISUAL ASSESSMENT AND RECOMMENDATIONS

Purpose and Methodology

The objective of the visual assessment completed as part of this project was to identify projects that could be implemented by property owners, municipalities, local citizen organizations, and conservation organizations to improve the West Branch of Crum Creek and protect its designation from the state as an Exceptional Value water body.

DRN Restoration and CRC staff¹ walked the entire five mile length of the main channel of the West Branch of Crum Creek completing a visual assessment of the stream channel and riparian corridor. Due to the length of stream assessed, budget, and project goals, a formalized visual assessment protocol was not utilized. Staff completing the visual assessment are trained professionals in stream restoration and skilled in observing and assessing stream corridors in southeast Pennsylvania using protocols developed by US EPA, Pfankuch, Rosgen, PA Fish and Boat Commission, and others.

Project staff looked specifically for the following: channel or bank instability and associated causes; riparian buffer gaps; land management activities adversely impacting stream health; sources contributing elevated quantities of stormwater or sediment to the stream; fish barriers; and, new colonies of invasive plant species. Whenever one of these parameters was identified photographs of the area were taken and a GPS point was recorded using a handheld Garmin GPSMap60CSX. Observations and initial recommendations were written down and recorded along with the property address. All field information was compiled into an Excel spreadsheet and linked to associated maps and photographs.

Findings

Seventy-nine site-specific recommendations were noted by project staff. The majority of recommendations are small scale projects that could be implemented by homeowners and local organizations with volunteer

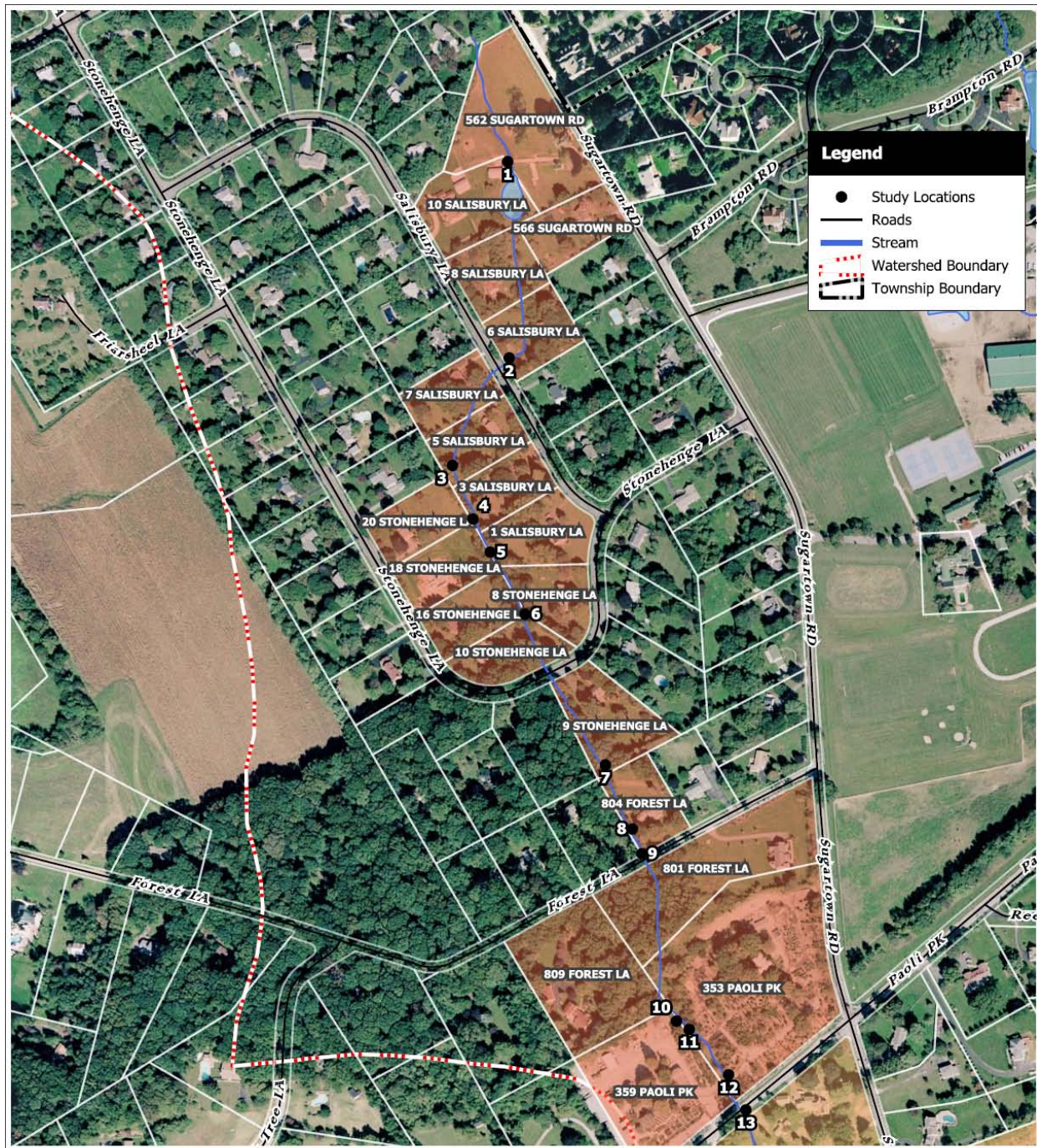
¹ E. Gutzler, A. Murphy

labor. A few sites entail more extensive projects requiring the use of consultants for design and/or implementation, and the use of heavy equipment.

For purposes of discussing the recommendations and findings of the visual assessment, the West Branch is broken into eight segments based on major road crossings. The segments are as follows:

- Segment 1 – Headwaters to Paoli Pike
- Segment 2 – Paoli Pike to Sugartown Road
- Segment 3 – Sugartown Road to Harvey Lane
- Segment 4 – Harvey Lane to Spring Road
- Segment 5 – Spring Road to Warren Avenue
- Segment 6 – Warren Avenue to Hunt Club Lane
- Segment 7 – Hunt Club Lane to Hillview Road
- Segment 8 – Hillview Road to main stem Crum Creek confluence

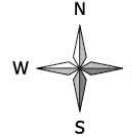
Following are maps and text for each stream segment outlining channel characteristics, streamside issues, management and restoration recommendations, and key property owners. Issues are listed in a relative order of prevalence or impact within the reach - greatest to least. Underneath each issue is a list of specific properties exhibiting impact from that issue. Properties are listed in order relative to stream flow - upstream to downstream. Recommendations were not prioritized; however, issues or properties marked with an asterisk have a high potential benefit for the West Branch of Crum Creek.



Upper Crum Creek Cold Water Conservation Plan
West Branch Stream Enhancement Opportunities



Segment 1



Source:
 1. Township Boundary, Roads, Parcels from CRC
 2. Streams, Watershed boundary from PASDA
 3. Aerial from Virtual Earth
 4. Station points from Delaware Riverkeeper Network



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Figure 7. Stream enhancement opportunities for the West Branch in Segment 1.

Segment 1 - Headwaters to Paoli Pike

Recommendations: 1 to 12

Approximate Stream Length (excluding any tributaries): 0.7 mile

Streets: NS Sugartown Road, Salisbury Lane, Stonehenge Lane, Forest Lane, NS Paoli Pike

Stream Characterization

- Intermittent headwater stream
- Defined channel
- One in-line pond near the headwaters
- Thirteen streamside properties – one commercial, one agricultural/residential, and the rest residential

Issues

- Mowing to the top of the stream bank and lack of riparian buffer
 - *562 Sugartown Road*
 - *5 Salisbury Lane*
 - *9 Stonehenge Lane*
 - *353 Paoli*
- In-line pond at headwaters receiving lots of sunlight and providing habitat to Canadian goose population
 - *10 Salisbury Lane**
- Sole Japanese knotweed stand along the West Branch with the potential for further spread
 - *1, 3 Salisbury Lane**
- Dumping of yard waste and trash in the stream channel
 - *8, 10, 16 Stonehenge Lane* - yard debris*
 - *18 Stonehenge Lane and 1 Salisbury Lane -trash*
 - *804 Forest Lane – accumulation of organic debris at culvert intake*
- Floodplain encroachment and runoff from structures
 - *804 Forest Lane*
- Low recognition of the importance of this headwater Exceptional Value stream*

Recommendations

- Pond management at 10 Salisbury Lane
 - Plant pond margins with wide buffer and native trees to provide shade and discourage geese

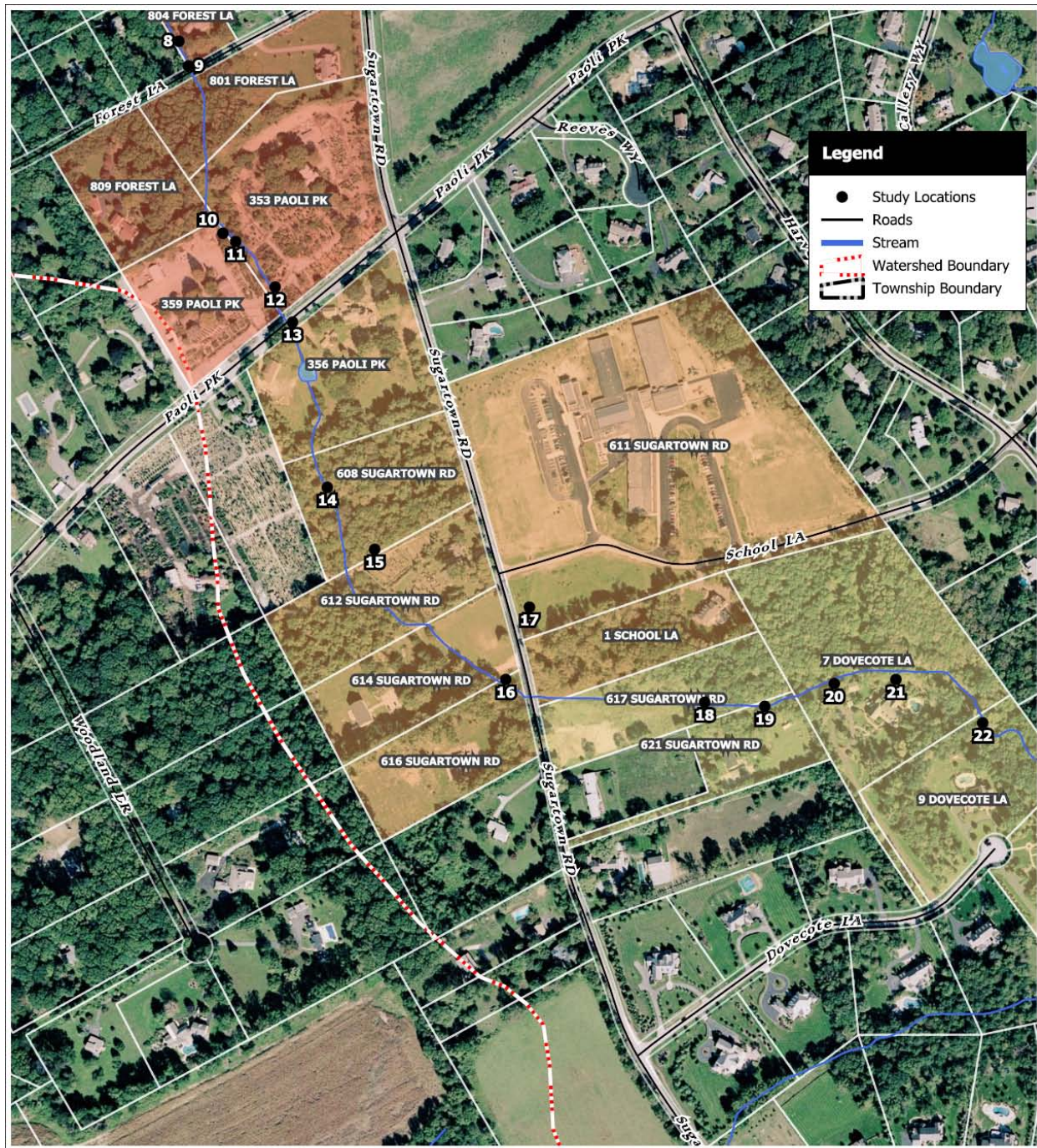
- Japanese knotweed control at 1 and 3 Salisbury Lane in 2009
- Demonstration project at 353 Paoli Pike
 - Install a native buffer
 - Remove bamboo; monitor and control phragmites
 - Incorporate an educational component
- Removal of woody debris dumped in the stream channel at 8,10,16 Stonehenge Lane
- Mailing or other outreach to homeowners regarding the importance of headwater streams, the uniqueness of the West Branch, proper yard waste disposal, and need for no-mow zones and riparian buffers
- Mailing to properties near street crossings on the importance of ensuring culverts are not blocked by debris after storm events
- Outreach to 804 Forest Lane regarding failing retaining wall and building at the top of bank
 - Redirect building gutters away from top of bank
 - Consider relocating the building
 - Establish no-mow upstream of the building

Key Properties

- 10 Salisbury Lane – headwaters – in-line pond management, Canadian goose control
- 1,3 Salisbury Lane – Japanese knotweed control, stream cleanup
- 353 Paoli Pike – commercial property; native buffer establishment, invasive vegetation removal, educational demonstration project

Table 3. Identified enhancement opportunities for the West Branch in Segment 1 – Headwaters to Paoli Pike.

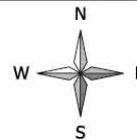
Site #	Longitude	Latitude	Address	Recommendation
1	-75.5250333	40.0265	10 Salisbury Lane, 562 Sugartown Road	Plant in-line pond margins to shade water and discourage Canadian geese; enhance goose control measures; establish woody riparian buffer along headwaters in the field upstream of the in-line pond
2	-75.5250167	40.024917	6 Salisbury Lane	Reduce mowing along stream corridor (particularly on right bank)
3	-75.5256167	40.02405	5 Salisbury Lane	Establish no-mow and plant both banks
4	-75.5254	40.023617	3 Salisbury Lane (LB), 20 (US) and 18 (DS) Stonehenge Lane (RB)	Chemically treat knotweed on left bank ASAP; once controlled plant bank with native trees and shrubs
5	-75.5252167	40.02335	1Salisbury Lane (LB), 18 Stonehenge Lane (RB)	Remove trash from channel; outreach to homeowners
6	-75.52485	40.02285	10 (DS), 16 (US RB), 8 (US LB) Stonehenge Lane	Remove large accumulation of woody yard debris from channel; outreach to homeowners
7	-75.524	40.021633	9 Stonehenge Lane	Establish 15' no-mow on left bank and plant with trees and shrubs noting overhead power lines
8	-75.5237167	40.021117	804 Forest Lane	Redirect gutter runoff from garage at top of left bank; establish no-mow upstream of garage; monitor failing retaining wall
9	-75.5236167	40.020917	Forest Lane ROW	Remove accumulated debris from upstream intake of Forest Lane culvert; following storm events monitor and remove debris as needed
10	-75.52325	40.019567	353 Paoli Pike	Monitor and control phragmites from spreading throughout stream channel; remove bamboo container stock on right bank
11	-75.5231167	40.0195	353 Paoli Pike	Possibly brush pack to protect undercut tree of left bank from failure
12	-75.5227	40.019133	353 Paoli Pike	Live stake and plant both banks in area already defined



Upper Crum Creek Cold Water Conservation Plan
West Branch Stream Enhancement Opportunities



Segment 2



- Source:
1. Township Boundary, Roads, Parcels from CRC
 2. Streams, Watershed boundary from PASDA
 3. Aerial from Virtual Earth
 4. Station points from Delaware Riverkeeper Network

0 500 ft US

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Taylor
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Figure 8. Stream enhancement opportunities for the West Branch in Segment 2.

Segment 2 - Paoli Pike to Sugartown Road

Recommendations: 13 to 16

Approximate Stream Length (excluding any tributaries): 0.3 mile

Streets: Paoli Pike, Sugartown Road

Stream Characterization

- Intermittent headwater stream
- Channel pattern has been altered and a portion of the stream diverted
- Five streamside properties – one commercial, four residential

Issues

- Mowing to the top of the stream bank and lack of riparian buffer
 - 356 Paoli Pike *
 - 614, 616 Sugartown Road
- Channel redirection
 - 608 Sugartown Road

Recommendations

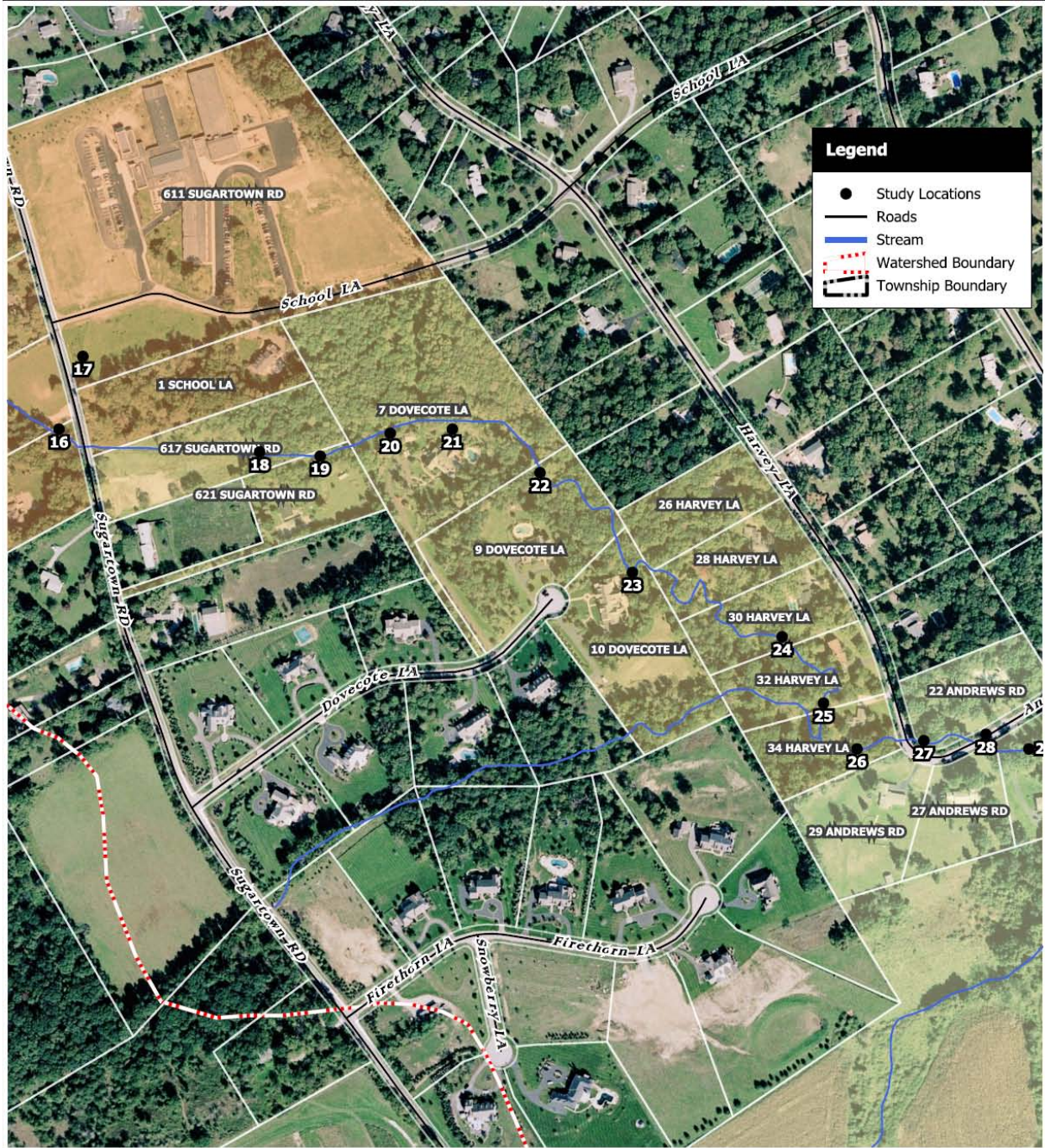
- Install native, woody riparian buffer at 356 Paoli Pike as part of their recent stream channel work
- Possible investigation with DEP and owner of 608 Sugartown Road about past channel relocation/diversion
- Mailing or other outreach to homeowners regarding the importance of headwater streams, the uniqueness of the West Branch, proper yard waste disposal, and need for no-mow zones and riparian buffers

Key Properties

- 356 Paoli Pike – commercial property; native riparian buffer installation

Table 4. Identified enhancement opportunities for the West Branch in Segment 2 – Paoli Pike to Sugartown Road.

Site #	Longitude	Latitude	Address	Recommendation
13 -	75.5225167	40.01885	355 Paoli Pike	Plant native tree and shrub species along both banks of recently graded stream bank
14	-75.52215	40.017517	608 Sugartown Road	Clean up construction debris and trash in woods - limited
15	-75.52165	40.017017	608 Sugartown Road	Investigate stream diversion
16 -	75.5202667	40.015967	614 (DS) and 616 (US) Sugartown Road	Increase no-mow and plant buffer along both sides - could utilize live staking



Upper Crum Creek Cold Water Conservation Plan
West Branch Stream Enhancement Opportunities



Segment 3



- Source:
1. Township Boundary, Roads, Parcels from CRC
 2. Streams, Watershed boundary from PASDA
 3. Aerial from Virtual Earth
 4. Station points from Delaware Riverkeeper Network

0 500 ft US

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Figure 9. Stream enhancement opportunities for the West Branch in Segment 3.

Segment 3 – Sugartown Road to Harvey Lane

Recommendations: 17 to 26

Approximate Stream Length (excluding any tributaries): 0.6 mile

Streets: Sugartown Road, Dovecote Lane, Harvey Lane,

Stream Characterization

- Perennial stream
- Upstream most sighting of fish in November 2008
- Sinuous channel with tight meander bends
- Ten streamside properties, all residential
- Nearby institutional property pipes stormwater into the stream

Issues

- Mowing to the top of the stream bank and lack of riparian buffer promoting bank erosion and contribution of fine sediment
 - *617 Sugartown Road*
 - *7 Dovecote Lane**
 - *32, 34 Harvey Lane*
- Stormwater runoff
 - *611 Sugartown Road (Sugartown Elementary)**
 - *26 Harvey Lane*
 - *30 Harvey Lane*
- Dumping of yard waste and trash in the stream corridor
 - *621 Sugartown Road – construction materials*
 - *7 Dovecote Lane – yard*
 - *34 Harvey Lane – trash*
- Encroachment on the stream and floodplain
 - *34 Harvey Lane*

Recommendations

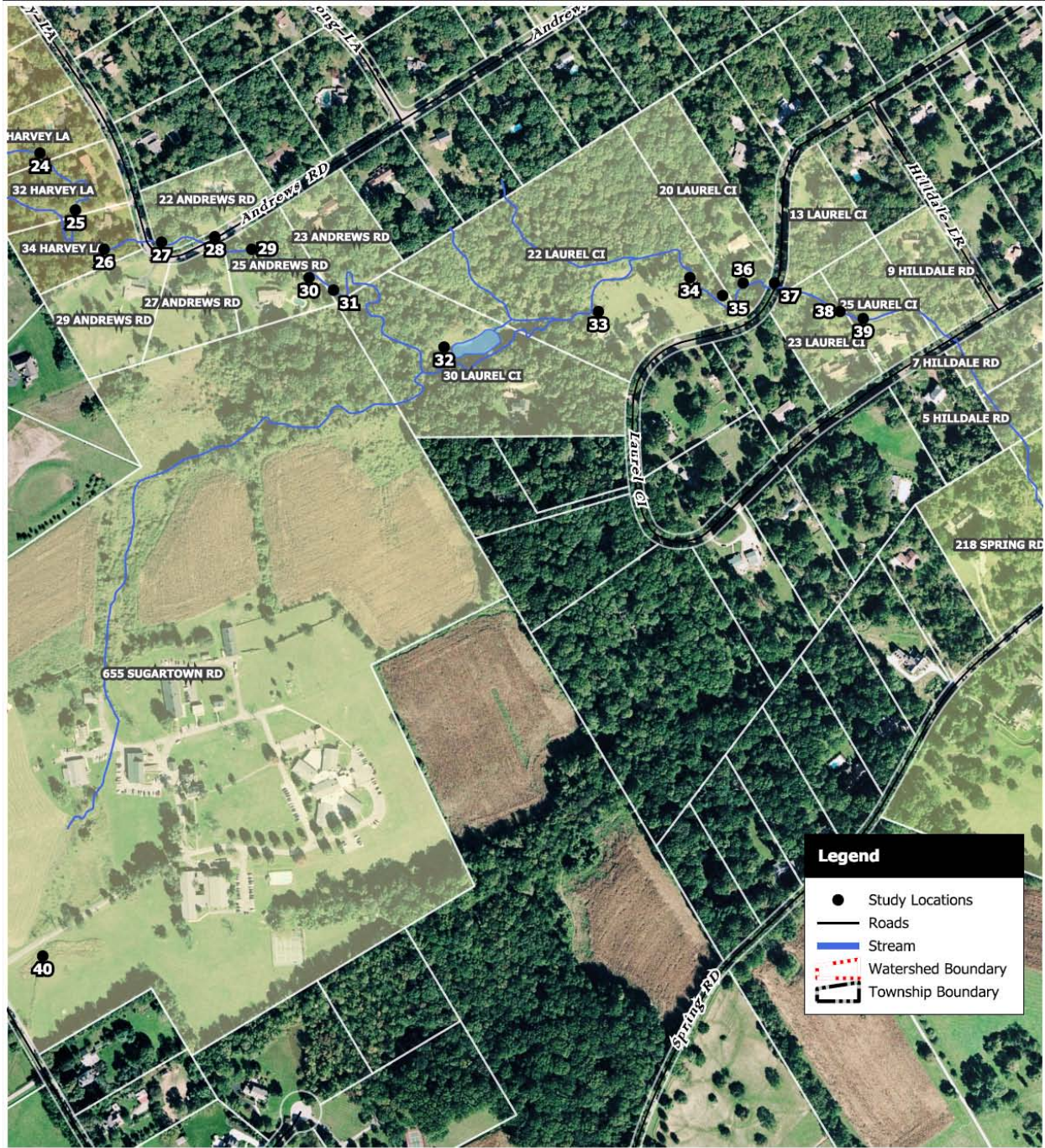
- Demonstration stormwater best management project at Sugartown Elementary School on Sugartown Road
 - Approach school and township to gauge interest
 - Pursue grant funding for design and implementation of swale and other best management practices
- Outreach and consultation to 7 Dovecote Lane on streamside management and stability
 - Establish no-mow and riparian buffer along eroding, highly sinuous reach contributing fine sediment to the stream system
 - Yard waste disposal
- Outreach to 34 Harvey Lane regarding debris dumping, importance of no-mows, and floodplain encroachment
- Mailing or other outreach to homeowners regarding the uniqueness of the West Branch, proper yard waste disposal, and need for no-mow zones and riparian buffers

Key Properties

- 611 Sugartown Road (Sugartown Elementary) – institutional property; demonstration project for stormwater best management practices
- 7 Dovecote Lane – buffer establishment to decrease bank erosion and fine sediment loading
- 34 Harvey Lane – buffer establishment, shed relocation, stream clean up

Table 5. Identified enhancement opportunities for the West Branch in Segment 3 – Sugartown Road to Harvey Lane.

Site #	Longitude	Latitude	Address	Recommendation
17	-75.5200167	40.01655	611 Sugartown Road	Enhance stormwater system - establish no-mow zone and plant existing swale, or install improved BMP's as educational demonstration project
18	-75.5181667	40.015783	617 Sugartown Road	Establish no-mow on right bank and plant
19	-75.5175333	40.01575	621 Sugartown Road	Remove lumber and cinderblocks from channel
20	-75.5168	40.015933	7 Dovecote Lane	Plant steep slope that is lacking vegetation; discontinue dumping leaves in stream corridor
21	-75.51615	40.015967	7 Dovecote Lane	Stop mowing to the top of bank - mowing is accelerating erosion and contributing fine sediment to the system
22	-75.5152333	40.015617	9 Dovecote Lane	Control limited stand of multiflora on the right bank and plant
23	-75.5142667	40.014817	26 Harvey Lane or possibly 10 Dovecote Lane	Examine how stormwater is managed from the property and adjust to limit downslope erosion on right bank; plant
24	-75.5127	40.0143	30 Harvey Lane	Fix outfalls from four small discharge pipes on the left bank to avoid gully formation
25	-75.5122667	40.013767	32 Harvey Lane	Establish no-mow on left bank and plant two trees and some shrubs at the bend
26	-75.5119167	40.0134	34 Harvey Lane	Establish no-mow on left bank; plant if possible; clean up trash and debris dumped on the right bank; explore relocation of garage on left bank



Upper Crum Creek Cold Water Conservation Plan
West Branch Stream Enhancement Opportunities



Segment 4



- Source:
1. Township Boundary, Roads, Parcels from CRC
 2. Streams, Watershed boundary from PASDA
 3. Aerial from Virtual Earth
 4. Station points from Delaware Riverkeeper Network

0 500 ft US

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Figure 10. Stream enhancement opportunities for the West Branch in Segment 4.

Segment 4 - Harvey Lane to Spring Road

Recommendations: 27 to 40

Approximate Stream Length (excluding any tributaries): 0.7 mile

Streets: Harvey Lane, Andrews Road, Laurel Circle, Spring Road

Stream Characterization

- Perennial stream with better defined riffles and pools
- Upper half characterized by vertical raw banks and mowing to the top of the stream bank
- Reach between Laurel Circle and Spring Road is well vegetated and offers good instream habitat
- One off-line pond adjacent to the stream
- Fifteen streamside properties, all residential

Issues

- Mowing to the top of the stream bank and lack of riparian buffers*
 - *22, 23, 25 Andrews Road*
 - *20, 22, 25, 30 Laurel Circle*
 - *655 Sugartown Road (Devereux Foundation) - tributary*
- Stormwater conveyance from roadways
 - *Andrews Road crossing*
- Dumping of yard waste and trash in the stream corridor
 - *22 Andrews Road - leaf*
 - *22 Laurel Circle - mulch*
 - *30 Laurel Circle - construction*
- Off-line pond receiving lots of sunlight and providing possible habitat for Canadian geese
 - *30 Laurel Circle*
- Instream rock riffle “structure”
 - *23, 25 Laurel Circle*
- Large stand of bamboo
 - *13 Laurel Circle*

Recommendations

- Demonstration project along Andrews Road

- Retrofit stormwater conveyance from Andres Road to encourage infiltration
- Beautify roadside area with native plants
- Mailing or other outreach to homeowners regarding the uniqueness of the West Branch, proper yard waste disposal, need for no-mow zones and riparian buffers, and stream encroachment permits
- Outreach to 13 Laurel Circle about bamboo control/eradication and installation of a native buffer that will provide shade to the stream

Key Properties

- 655 Sugartown Road (Devereux Foundation) – sole streamside property owner for tributary – riparian buffer establishment
- 30 Laurel Circle – property contains lengthy reach of stream and both stream banks – buffer establishment along stream channel and pond margins, streamside cleanup
- 22 Laurel Circle – property contains lengthy reach of stream, both stream banks, and is immediately downstream of 30 Laurel Circle – buffer establishment, streamside cleanup

Table 6. Identified enhancement opportunities for the West Branch in Segment 4 – Harvey Lane to Spring Road.

Site #	Longitude	Latitude	Address	Recommendation
27	-75.5112167	40.013467	22 Andrews Road	Increase no-mow on both banks; beautification project along Andrews to alleviate downslope erosion
28	-75.5105667	40.013517	Andrews Road ROW	Investigate road runoff conveyance method and alter to encourage infiltration
29	-75.5101167	40.0134	25 Andrews Road	Establish no-mow and plant shrubs
30	-75.5094167	40.013133	25 Andrews Road	Live stake lower berm on left bank
31	-75.5091167	40.013017	23 Andrews Road	Establish no-mow and plant
32	-75.5077667	40.012483	30 Laurel Circle	Establish no-mow along pond and stream; live stake along right bank; clean up debris dumped on right bank
33	-75.5058833	40.012817	22 Laurel Circle	Establish no-mow and plant right bank for channel stability and shade; further downstream on this property plant left bank
34	-75.5047667	40.013133	22 Laurel Circle	Remove dumped mulch from right bank
35	-75.5043667	40.012967	20 (LB) and 22 (RB) Laurel Circle	Establish no-mow; live stake upper ~15';
36	-75.5041167	40.013083	20 Laurel Circle	Establish no-mow and plant both banks
37	-75.5037333	40.013083	Road ROW	Control bamboo on left bank to prevent spread; plant with native trees to provide shade
38	-75.5029333	40.012817	23 (US) and 25 (DS) Laurel Circle	Evaluate fish passage of riffle rock structure and modify
39	-75.50265	40.01275	25 Laurel Circle	Establish buffer along right bank
40	-75.512753*	40.006372*	655 Sugartown Road	Outreach to Devereux Foundation on educational demonstration project; no-mow and buffer establishment

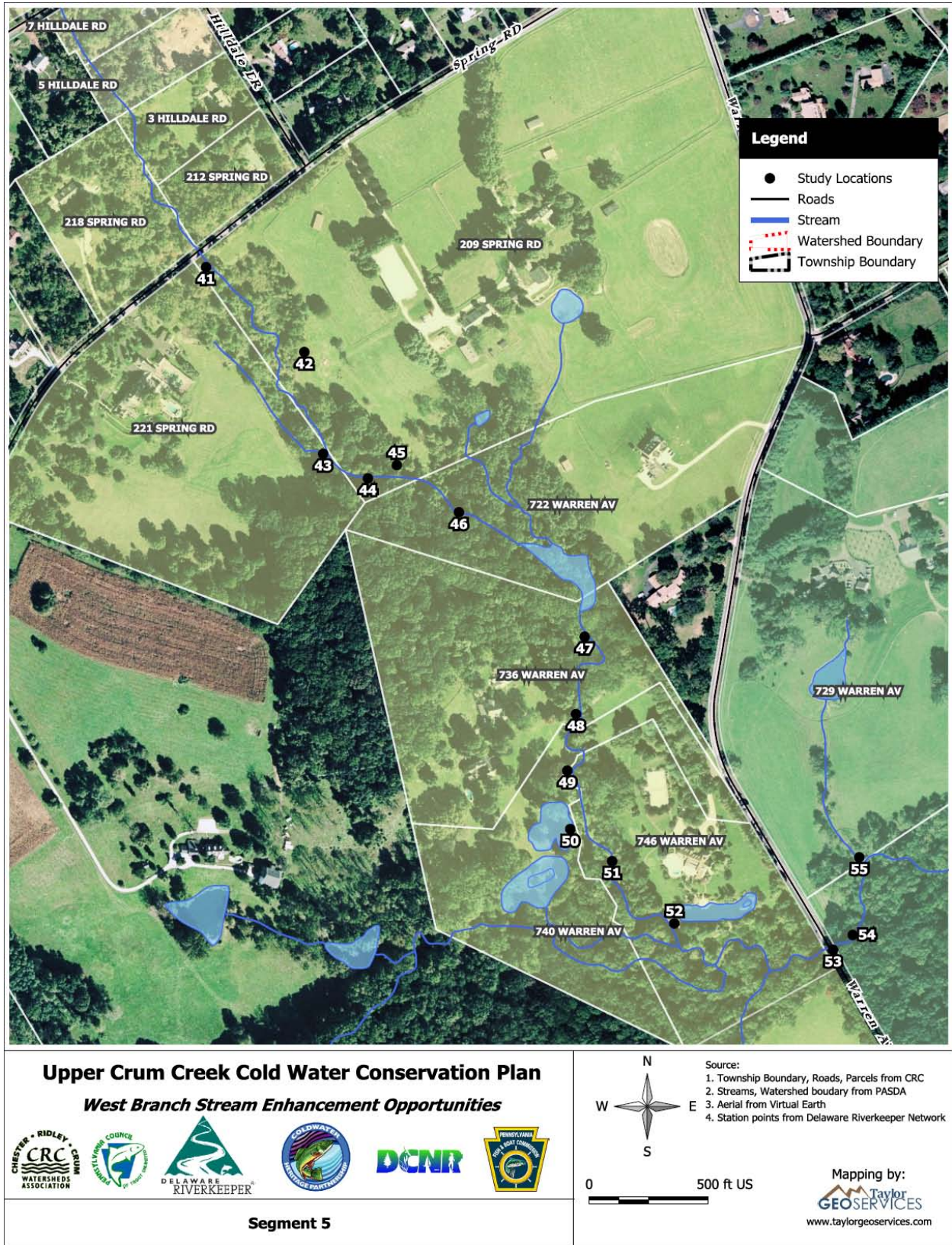


Figure 11. Stream enhancement opportunities for the West Branch in Segment 5.

Segment 5 - Spring Road to Warren Avenue

Recommendations: 41 to 52

Approximate Stream Length (excluding any tributaries): 0.7 mile

Streets: Spring Road, Warren Avenue

Stream Characterization

- Perennial stream with defined riffles and pools
- Upper two thirds forested
- Downstream third mowed to top of bank and experiencing bank erosion
- Three off-line ponds adjacent to stream
- Six large streamside properties, all residential

Issues

- Mowing to the top of the stream bank and lack of riparian buffer*
 - *209, 221 Spring Road*
 - *740, 746 Warren Avenue*
- Accelerated bank erosion in stretch where the channel is overwide with a mid channel bar forming
 - *209 Spring Road **
- Need for supplemental riparian buffer plantings
 - *221 Spring Road*
 - *736 Warren Avenue*
- Runoff from horse pastures adjacent to the stream
 - *750 Warren Avenue*
- Off-line ponds receiving lots of sun and providing habitat to Canadian geese
 - *736 Warren Avenue*
 - *746 Warren Avenue*
- Dumping of rock into the channel in attempt to stabilize eroding banks, likely without proper permitting*
 - *740 Warren Avenue*
 - *746 Warren Avenue*
- Stormwater
 - *Warren Road*

- Dumping of yard waste in the stream channel and corridor
 - *209 Spring Road – LWD*
 - *740 Warren Avenue – leaf*
- Invasive vegetation
 - *209 Spring Road – phragmites*
 - *736 Warren Avenue – multiflora rose*

Recommendations

- Consultation to 209 Spring Road regarding channel instability and possibility of stream stabilization project
 - Stream is overwide and bank has a high Bank Erosion Hazard Index and moderate near bank stress. A technical instream structure (e.g., cross vane) is needed to restore proper channel dimensions and alleviate bank stress. It is possible that a tree revetment could be used as a temporary measure.
- Site walk through with property owners of 746 Warren Avenue to discuss management of the stream on their property
 - Educate on the need for stream encroachment permits
 - Establish no-mow
 - Assess need for bank stabilization project
 - Rearrange rock in channel that is exacerbating bank erosion
 - Plant woody riparian buffer
- Outreach to 750 Warren Avenue regarding the uniqueness of the West Branch as an Exceptional Value stream and proper horse management
 - Examine runoff from pasture and adjust to minimize potential of runoff contributing elevated levels of nutrients and sediment to the system
- Outreach to township to further examine runoff from Warren Road and discuss options to distribute flow evenly over the land and prevent exacerbation of gullies
- Mailing or other outreach to homeowners regarding the uniqueness of the West Branch, proper yard waste disposal, and need for no-mow zones and riparian buffers
- Monitor large undercut oak tree on 722 Warren Avenue – currently tree is providing great cover for fish and is not leaning

Key Properties

- 746 Warren Avenue – property contains lengthy reach of stream and both stream banks – buffer establishment, bank stabilization, pond management
- 209 Spring Road – property contains lengthy reach of stream and both stream banks – buffer establishment, bank stabilization, stream cleanup, phragmites monitoring/control

Table 7. Identified enhancement opportunities for the West Branch in Segment 5 – Spring Road to Warren Avenue.

Site #	Longitude	Latitude	Address	Recommendation
41	-75.4998167	40.010233	209 Spring Rd	Establish no-mow along right bank from top of bank to fence line (minimum)
42	-75.4986833	40.009483	209 Spring Rd	Control phragmites in field to keep from spreading and establish no-mow in lower marshy area
43	-75.4984667	40.008583	209 (LB) and 221 (RB) Spring Road	Control invasive vegetation and plant banks of tributary
44	-75.49795	40.008367	209 Spring Rd	Channel is overwide and forming a mid channel bar; monitor bank erosion by installing bank pins; instream structure needed to restore channel dimensions; Christmas tree revetment may serve as a temporary measure; protect beech trees
45	-75.4976167	40.008483	209 Spring Rd	Live stake left bank - low priority
46	-75.4969	40.008067	722 Warren Ave	Monitor undercut mature oak tree that is providing great root protection to the bank and instream cover for fish
47	-75.49545	40.006967	736 Warren Ave	Plant right bank; live stake ~40' on left bank
48	-75.49555	40.006283	736 Warren Ave	Control small stand of multiflora on left bank; infill plant; examine runoff from bridge causing downslope erosion on upstream right bank
49	-75.49565	40.005783	740 (RB) and 746 (LB) Warren Ave	Establish no-mow and plant both banks; educate homeowners about the need for permits to place rock in the stream
50	-75.4956167	40.005267	740 Warren Ave	Plant edges of pond
51	-75.4951333	40.004983	746 Warren Ave	Rearrange rock along left bank which is contributing to bank erosion due to its angle
52	-75.4944167	40.004433	746 Warren Ave	Pond management

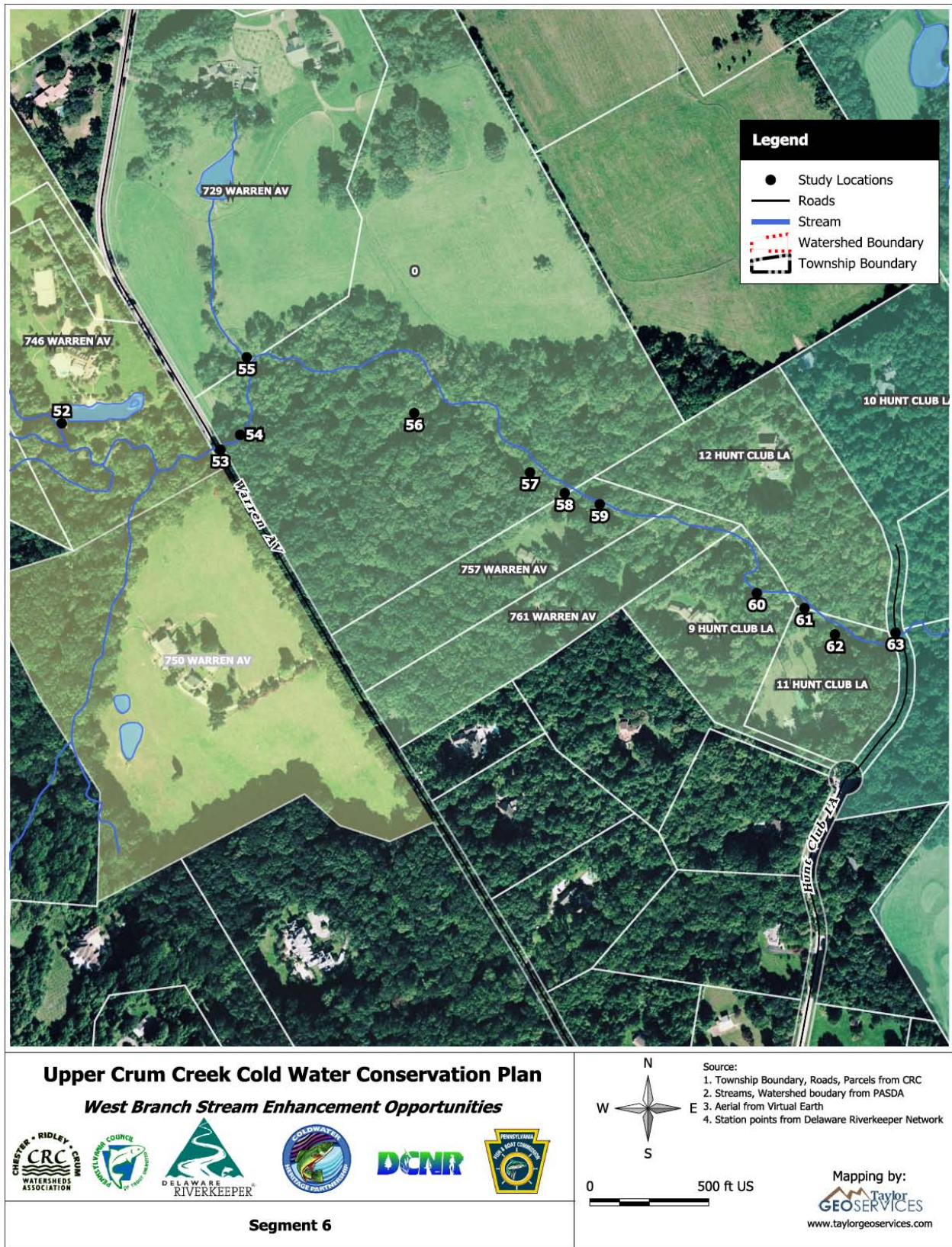


Figure 12. Stream enhancement opportunities for the West Branch in Segment 6.

Segment 6 – Warren Avenue to Hunt Club Lane

Recommendations: 53 to 62

Approximate Stream Length (excluding any tributaries): 0.5 mile

Streets: Warren Avenue, Hunt Club Lane

Stream Characterization

- Perennial stream with defined riffles and pools
- High stream banks common
- Riparian corridor forested
- Increased volume of large woody debris in the channel
- Seven streamside properties, all residential

Major Issues

- Runoff from horse pastures adjacent to the stream
 - *11 Hunt Club Lane* *
- Need for riparian buffer plantings
 - *729 Warren Avenue*
 - *757 Warren Avenue*
 - *12 Hunt Club Lane*
- Accelerated bank erosion
 - *9 Hunt Club Lane*
- Instream fence posts across the channel catching debris
 - *729 Warren Avenue* *

Recommendations

- Remove fence posts from channel downstream of the Warren Avenue culvert
- Explore possibility of stabilizing the right bank with 9 Hunt Club Lane
 - Dependent upon equipment access, log vanes or stone bankfull deflectors would alleviate near bank stress
- Outreach to 11 Hunt Club Lane regarding the uniqueness of the West Branch as an Exceptional Value stream and proper horse management
 - Examine runoff from pasture and adjust to minimize potential of runoff contributing elevated levels of nutrients and sediment to the system

- Set horse pasture back from the stream
- Mailing or other outreach to homeowners regarding the uniqueness of the West Branch, proper yard waste disposal, and need for no-mow zones and riparian buffers

Key Properties

- 729 Warren Avenue – property contains lengthy reach of stream and both stream banks – removal of fence posts in stream channel, buffer enhancement along tributary and West Branch, Canadian goose control

Table 8. Identified enhancement opportunities for the West Branch in Segment 6 – Warren Avenue to Hunt Club Lane.

Site #	Longitude	Latitude	Address	Recommendation
53	-75.492586*	40.0042*	Warren Ave ROW	Install rock bars along road or swale to prevent down slope erosion from Warren Avenue runoff
54	-75.492358*	40.004331*	728 Warren Ave	Remove old fence posts and debris from active channel
55	-75.4922833	40.005017	729 Warren Ave	Increase no-mow along tributary and left bank of West Branch; infill plant; goose management
56	-75.490352*	40.004523*	729 Warren Ave	Leave log jam - not a fish barrier and is providing good cover and flow diversity
57	-75.4890167	40.004	729 Warren Ave	Move rock away from right bank and further into channel to prevent continued localized erosion
58	-75.4886167	40.003817	757 (DS) and 729 (US) Warren Ave	Establish no-mow and plant; examine runoff contributing to down slope erosion; control limited amount of multiflora before spreads
59	-75.488212*	40.003718*	758 Warren Ave	Leave log jam - not a fish barrier and is creating a great pool!
60	-75.4864	40.002933	9 Hunt Club Lane	Monitor eroding right bank; dependent upon access install log vanes or stone deflectors; plant inside of bends to provide shade
61	-75.48585	40.0028	11 (RB) and 12 (LB) Hunt Club Lane	Horse pasture management; push back fence if possible and plant filter strip; possibly grading top of bank to prevent runoff
62	-75.4855	40.002567	11 (RB) and 12 (LB) Hunt Club Lane	Plant left bank intermixing live stakes



Figure 13. Stream enhancement opportunities for the West Branch in Segment 7.

Segment 7 - Hunt Club Lane to Hillview Road

Recommendations: 63 to 68

Approximate Stream Length (excluding any tributaries): 0.6 mile

Streets: Hunt Club Lane, Hillview Road

Stream Characterization

- Well defined stream channel in upper two thirds of the segment which disappears in the downstream third and becomes a wetland
- Upper and lower thirds are well vegetated
- Riparian buffer largely missing in the middle third
- Only four streamside properties – three residential and one institutional

Major Issues

- Lack of adequate forested riparian buffers
 - *White Manor Country Club (in certain areas)**
 - *760 Hillview Road*
- Stormwater
 - *Hunt Club Lane*
- Bank erosion
 - *6, 8 Hunt Club Lane*
- In-line pond on tributary and off-line ponds receiving lots of sun and providing habitat to Canadian goose population
 - *White Manor Country Club*
- Floodplain encroachment
 - *White Manor Country Club*

Recommendations

- Continued outreach and collaboration with White Manor Country Club
 - Expand native forested and meadow buffers along stream channels and pond margins that meet the needs of the course
 - Explore relocation of cart paths and other opportunities that will improve habitat and aesthetics of the course

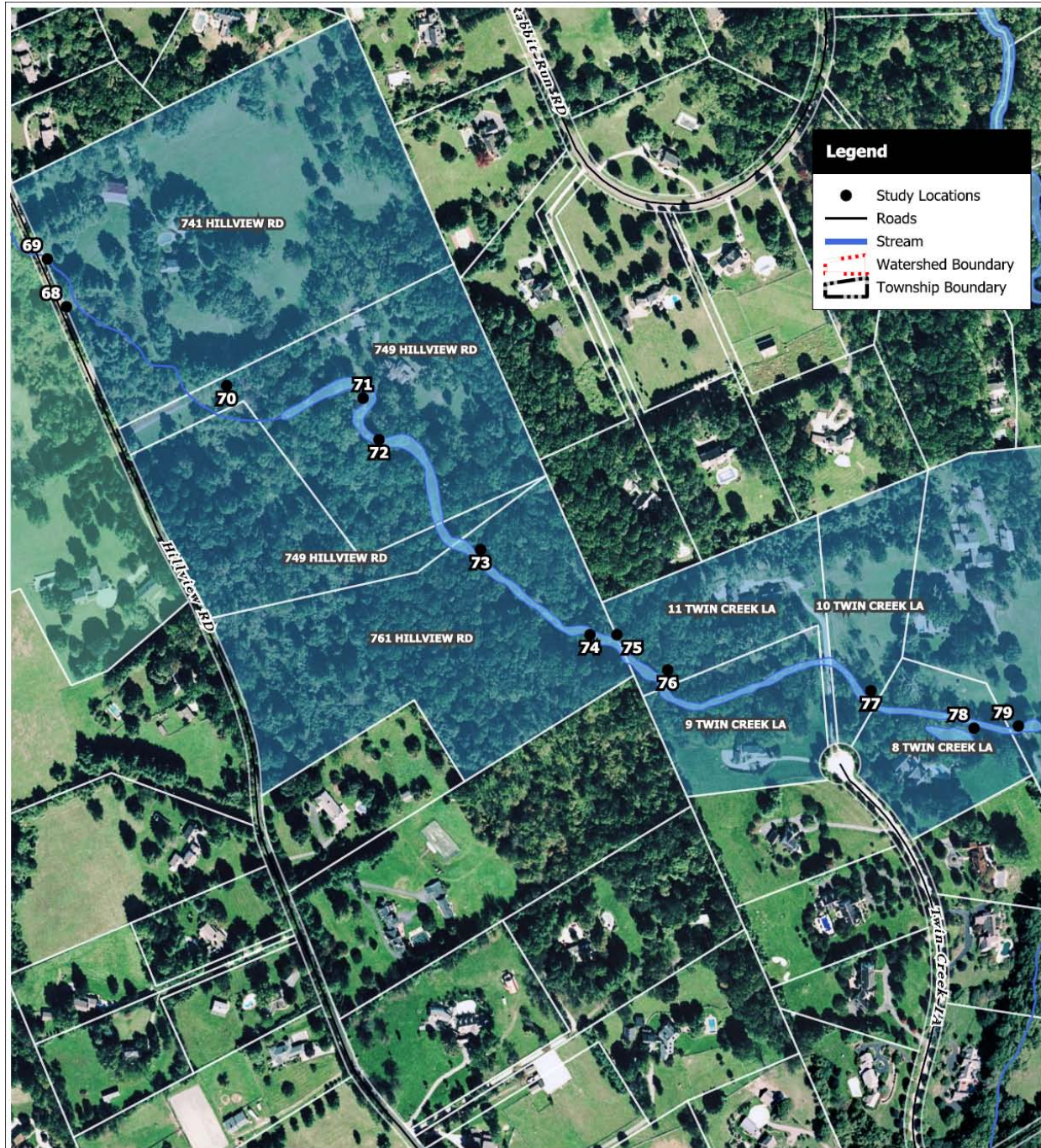
- Monitor bank erosion at 8 Hunt Club Lane and evaluate need for bank stabilization project
 - Install bank pins to monitor bank retreat rate
 - Access to the site is limited, but possibly tree revetments could be installed to provide surface protection to the bank and reduce near bank stress
- Outreach to 10 Hunt Club Lane about measures that could encourage infiltration of stormwater running off of the Hunt Club Lane bridge and prevent exacerbation of gullies
 - Grade the site to evenly distribute runoff and plant native woody vegetation

Key Properties

- White Manor Country Club – institutional property; contains lengthy reach of stream, both stream banks, and two tributaries – buffer establishment and enhancement along stream channels and pond margins, Canadian goose management, infrastructure relocation, and long term planning

Table 9. Identified enhancement opportunities for the West Branch in Segment 7 – Hunt Club Lane to Hillview Road.

Site #	Longitude	Latitude	Address	Recommendation
63	-75.4848	40.002583	10 Hunt Club Lane	Control runoff from Hunt Club Lane
64	-75.483899*	40.002764*	5 (RB) and 8 (LB) Hunt Club Lane	Monitor and stabilize eroding right bank; access is difficult
65	-75.47855	40.002417	821 Providence Road	Plant woody species where possible along West Branch, tributaries, and ponds; retain and increase no-mow zones; continue planting of little blue stem and other native herbaceous species; continued discussion on wetland creation, spillway from pond, and cart path relocation
66	-75.4781667	40.002583	760 Hillview Road	Plant ~350 square foot area on right bank
67	-75.4776	40.002517	760 Hillview Road	Protect wetland
68	-75.4741667	40.003517	741 Hillview Rd	Control runoff from Hillview Road; increase vegetation along formed channel



Upper Crum Creek Cold Water Conservation Plan
West Branch Stream Enhancement Opportunities



Segment 8



- Source:
1. Township Boundary, Roads, Parcels from CRC
 2. Streams, Watershed boundary from PASDA
 3. Aerial from Virtual Earth
 4. Station points from Delaware Riverkeeper Network

0 500 ft US

Mapping by:
Taylor
GEO SERVICES
www.taylorgeoservices.com

Figure 14. Stream enhancement opportunities for the West Branch in Segment 8.

Segment 8 - Hillview Road to Confluence

Recommendations: 69 to 79

Approximate Stream Length (excluding any tributaries): 0.7 mile

Streets: Hillview Road, Twin Creek Lane, Barr Road

Stream Characterization

- Steeper stream slope
- Significant increase in channel substrate size
- Increased volume of large woody debris in the channel
- Riparian corridor mostly forested
- Seven larger streamside properties, all residential

Major Issues

- Two dams obstructing stream flow, limiting fish migration, and raising water temperature*
 - *761 Hillview Road and 11 Twin Creek Lane*
 - *8, 10 Twin Creek Lane*
- Mowing to the top of the stream bank and lack of adequate riparian buffer
 - *741 Hillview Road*
 - *749 Hillview Road*
 - *8, 9, 11 Twin Creek Lane*
 - *8 Barr Road **
- Large woody debris and leaning trees posing threats to instream habitat
 - *749 Hillview Road*
 - *761 Hillview Road **
- Runoff from horse pastures adjacent to the stream
 - *8 Barr Road **
- Runoff from buildings and infrastructure
 - *741 Hillview Road*
 - *749 Hillview Road*

Recommendations

- Explore removal of the dams at 761 Hillview Road and 11 Twin Creek Lane, and 8, 10 Twin Creek Lane
 - Contact PA DEP and PA Fish and Boat Commission regarding dams
 - Pennsylvania Fish and Boat Commission’s Habitat Management Section may be able to assist with dam removal
- Outreach to 8 Barr Road regarding the uniqueness of the West Branch as an Exceptional Value stream and proper horse management
 - Reconfigure rocks spanning the channel and obstructing flow downstream of the bridge to lessen ponding effect and create better instream habitat
 - Pennsylvania Fish and Boat Commission’s Habitat Management Section may be able to assist with this project
 - Plant riparian buffer to help filter runoff from the pasture
 - Examine runoff from pasture and adjust to minimize potential of runoff contributing elevated levels of nutrients and sediment to the system
- Outreach and site visit to 741 Hillview Road
 - Brush pack undercut bank to protect utility pole from being undermined
 - Explore possibilities for better conveyance of runoff from Hillview Road
- Outreach and site visit to 749 Hillview Road
 - Monitor large, leaning beech tree and consider removal before it fails and destabilizes the bank
 - Examine management of stormwater runoff from buildings to prevent downslope erosion
- “Open” large woody debris jam at 761 Hillview Road
 - Supplement existing large trees on tall, steep bank with tree and shrub container stock
- Mailing or other outreach to homeowners regarding the uniqueness of the West Branch, proper yard waste disposal, and need for no-mow zones and riparian buffers

Key Properties

- 8, 10, 11 Twin Creek Lane – dam removal, buffer enhancement
- 761 Hillview Road – dam removal, manage large woody debris jam
- 8 Barr Road – horse pasture management, buffer establishment, reconfigure rocks currently impounding stream flow

Table 10. Identified enhancement opportunities for the West Branch in Segment 8 – Hillview Road to Crum Creek confluence.

Site #	Longitude	Latitude	Address	Recommendation
69	-75.4743667	40.0039	741 Hillview Road	Reduce mowing on left bank and planting; monitor and brushpack undercut utility line; control runoff from Hillview Road
70	-75.4724833	40.002883	749 Hillview Road	Plant along right bank
71	-75.47105	40.002783	749 Hillview Road	Manage stormwater and gutter runoff from building; plant steep bank
72	-75.4708833	40.00245	749 Hillview Road	Monitor large leaning beech tree and consider removal to prevent it failing and destabilizing the bank
73	-75.4698167	40.001567	761 Hillview Road	Manual control of pachysandra and vinca on left bank - low priority
74	-75.4686667	40.000883	761 Hillview Road	Break up log jam to open channel
75	-75.4683833	40.000883	761 Hillview Road (US), 11 Twin Creek Lane (DS)	Explore removal low head dam (~1.5-2' jump height); narrow channel upstream of dam
76	-75.46785	40.0006	11 (US) and 9 (DS) Twin Creek Lane	Plant shrubs/understory on left bank; stop mowing
77	-75.4657167	40.000433	10 Twin Creek Lane	Explore removal of dam (~3.5' jump height) and restore channel for fish migration purposes
78	-75.4646333	40.000133	8 Twin Creek Lane	Establish no-mow and plant right bank; pond management
79	-75.4641667	40.00015	8 Barr Road	Establish riparian buffer; limit horse access to stream; modify rock structure impounding stream flow

The majority of recommendations along the West Branch can be implemented by property owners and the community at relatively low cost and difficulty. In general recommendations fall into one of the following categories:

- ❖ Riparian buffer enhancement/no-mow establishment
- ❖ Fish passage improvement/dam removal
- ❖ Trash and debris removal
- ❖ Bank stabilization
- ❖ Stormwater management
- ❖ Pond management
- ❖ Horse pasture management
- ❖ Floodplain encroachment
- ❖ Invasive plant control

In relation to many of the identified recommendations, it should be noted that Willistown Township has adopted Riparian Buffer Area Conservation District, Floodplain Conservation District, and Steep Slope Conservation District ordinances as part of Chapter 73- Environmental Protection of its General Code. These ordinances regulate permitted and prohibited uses and disturbances of riparian buffers, floodplains, and steep slopes. The Riparian Buffer Area Conservation District ordinance creates a two tiered overlay district, one comprised of the first 25 feet along perennial and intermittent streams, and the second being the balance of a 100-foot corridor along the stream (Willistown Township, 2000). To get provisions of these ordinances waived homeowners must take their case to the Zoning Hearing Board, who will determine whether or not to grant a variance. Willistown Township’s General Code can be accessed at http://www.willistown.pa.us/township_code.html.

Riparian Buffer Enhancement

- ★ *Protect, maintain, and enhance existing riparian buffers.*
- ★ *Create native riparian buffers where they are currently absent.*
- ★ *Create a continuous vegetated riparian buffer along the length of the West Branch.*
- ★ *Educate property owners on the importance of riparian buffers.*

Vegetated buffers protect against stream bank erosion by providing structural stability to the soil and “roughness” to the channel banks. The root masses of native plants, especially woody vegetation, act to hold soil particles together and possess an amazing shear stress. Note that native plants provide greater stability than non-natives due to their rooting depths. Additionally, vegetation creates “roughness” which dissipates stream energy by increasing the friction between the flowing water and the channel banks.



Figure 15. Example location along the West Branch in need of a riparian buffer.

Trout, and the aquatic insects on which they feed, thrive in cool water streams rich in dissolved oxygen. Another benefit of a native streamside buffer is shade created by the tree cover. Reducing the amount of sunlight available for algae photosynthesis creates a healthier, more attractive stream. Shade also lowers the

water temperature in warm summer months by as much as 9°F (Klapproth & Johnson, 2000). Cooler water temperatures allow for higher dissolved oxygen levels in the water.

Buffers are an important link in the aquatic food chain. One study of small upland streams found that up to 75% of the stream’s food base is generated from the canopy of streamside vegetation (Welsch, 1991). The detritus, fruit, limbs, and terrestrial insects dropped into the stream provides for aquatic invertebrates which are food for other invertebrates and fish. A lack of riparian buffers reduces the food for trout.

Vegetated buffers act as living filters, with the ability to filter toxins, sediment, and other pollution sources from runoff. Numerous studies have been completed across the country to document the effectiveness of buffers in filtering out various contaminants. A 2001 study examined the ability of buffers of various widths to reduce nitrogen, phosphorus, and sediment. Results, summarized in Table 11, indicate that even a narrow buffer of 15 feet can significantly decrease phosphorous and sediment in runoff; however, the wider the buffer the more effective it is at reducing both phosphorus and sediment as well as nitrogen (Lowrance, R., et al., 2001).

Table 11. Findings from study on riparian buffer reduction of total nitrogen, total phosphorus, and sediment. (Lowrance et al. 2001)

Buffer Size	15 foot			35 foot			100 foot			>100 foot		
Contaminant	N	P	S	N	P	S	N	P	S	N	P	S
% reduction	5	62	60	50	65	80	80	80	90	95	90	90

There is a coalition in Pennsylvania seeking to amend Pennsylvania regulations to include buffer requirements. Their proposal is to obtain 100-foot forested buffers along the banks of every stream, 150-foot buffers along first and second order streams, and 300-foot buffers along Exception Value and High Quality streams (Pennsylvania Campaign for Clean Water). For additional information on this effort, contact DRN or the Pennsylvania Campaign for Clean Water.

Buffers afford waterways tremendous benefits and thus are a cost effective way to protect the stream from degradation and provide for both aquatic and terrestrial wildlife. Because of riparian buffers’ important functions, it is imperative that buffers be maintained where they currently exist along the West Branch and created where currently there are none. The more continuous, wider, and denser the buffer the more benefits

it will provide. Forested buffers with a 100-foot width provide the greatest level of meaningful protection and therefore should be pursued wherever possible.

No-mow Establishment

- ★ *Create no-mow zones along the entire West Branch to preclude mowing to the top of bank.*
- ★ *Educate property owners on the importance of no-mow zones and riparian buffers.*

Mowing to the top of a stream bank is one of the most common land management mistakes made by property owners everywhere; streamside residents along the West Branch are no exception. The practice of mowing to the top of the stream bank compacts soil, limits infiltration, stimulates erosion, and deprives the stream of the numerous benefits native vegetation provides a stream. While creating a buffer along the stream with native tree and shrub species is the preferred and recommended action for streamside properties, simply establishing a no-mow zone along the stream will promote plant growth, infiltration, biodiversity, habitat, and stream bank stability. Similar to planted vegetated buffers, the wider the no-mow zone along the stream the more benefits it provides. This is an easy and inexpensive way to improve the West Branch.



Figure 16. Example of mowing to the top bank along the West Branch.

The no-mow zone and buffer will also slow stormwater heading towards the stream. This prevents the formation of rills and erosion while increasing the amount of water that absorbs into the soil to become groundwater. This alleviates flooding during storm events.

Fish Passage Improvement/Dam Removal

★ *Explore removing the two West Branch Crum Creek dams in order to restore a free-flowing system.*

There are two small dams located in the lower West Branch (Segment 8). These dams are approximately 850 linear feet apart, with the downstream dam approximately 1,100 feet upstream of the West Branch's confluence with the main stem of Crum Creek. The history and construction date of these dams was unknown at the time of this report.

Jump heights on the two West Branch dams range from one to nearly four feet. While both dams are categorized as small (<15 feet), they have a large impact on the physical, chemical, and biological qualities



Figure 17. Looking upstream at upper dam on West Branch Crum Creek.

of the stream. Dams isolate segments of stream. They act as grade control features which may overly flatten or steepen channel slope and thus effect distribution of energy, water, and sediment, as well as aquatic life and fish. The dam structure itself acts as an impediment to stream flow. As flow slows at the obstruction the water's sediment load drops out. This results in the accumulation of fine sediments behind the impoundment. These fines smother channel substrate and take away habitat for benthic macroinvertebrates, an integral component of the aquatic food chain. The water that passes over the dam is devoid of sediment and is referred to as hungry water. Without sediment "hungry" water has more energy, is more erosive, and can attack channel banks and bottom in an attempt to pick up sediment resulting in downcutting of the channel bottom and excessive bank erosion.

Water temperature is an important parameter in terms of water quality and habitat which is also impacted by dams. Dams, even small dams such as those on the West Branch, change the thermal regime of a stream. The dam impoundment creates a dam pool upstream of the dam where water temperatures are elevated in comparison to the free flowing water upstream of the dam's influence. Peer-reviewed studies on small dams releasing water from the top have shown the impoundment results in elevated water temperatures downstream for at least 1.2 -1.8 miles (Lessard & Hayes, 2003). In other words the warmer water released

from the dam is not neutralized as it flows downstream but instead water temperatures remain artificially elevated for up to two miles downstream. Therefore, the dams on the West Branch are not only elevating local water temperatures around the dam but are also contributing to warmer water in the main stem of Crum Creek where the highest density and biomass of trout were found in the 1999 Pennsylvania Fish and Boat Commission survey. Like other trout species, brown trout thrive in cold, clear water streams and lakes. The preferred or optimal temperature range for brown trout is 53 to 66 degrees Fahrenheit. Various temperatures have been reported as the upper lethal limit for brown trout, ranging from 78 to 81 degrees Fahrenheit (Piper et al, 1982) (Raleigh et al, 1986). Elevated stream temperatures result in shifts of macroinvertebrate and fish assemblages, densities, and richness.

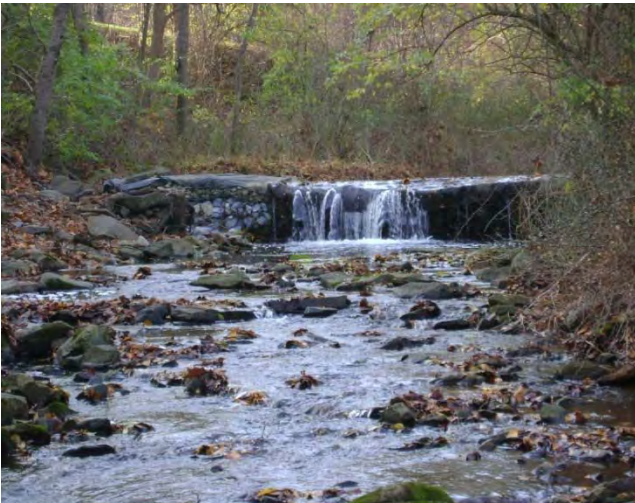


Figure 18. Looking upstream at lower dam on West Branch Crum Creek.

Dams also pose migration barriers to fish. Brown trout, like rainbow trout, are considered strong swimmers and leapers. Brown trout are stated to have a maximum jump height of 2.6 feet (Reiser & Peacock, 1985). However, jump height is dependent upon other situational variables including water velocity and the depth of the plunge pool from where they jump. Though this report cannot state conclusively, these dams likely are at least partial barriers to fish migration along the West Branch, meaning they act as barriers to certain trout life stages under certain flows.

These two dams along the West Branch do not currently provide any evident benefit to the community. It is recommended that the removal of these dams be explored with the dam owners in order to improve fish migration, decrease downstream water temperatures, and restore a free flowing system that can naturally distribute energy, sediment, and other material throughout for the benefit of this EV, wild trout stream.

Trash and Debris Removal

- ★ *Properly reuse or dispose of green yard waste. Compost grass clippings and leaves. Chip woody debris and reuse as mulch. Do not dump into the stream corridor.*
- ★ *Properly dispose of all trash and unused construction materials. Do not dump into the stream corridor.*

★ *Inspect culverts and bridge openings following storm events for accumulated debris that may block stream flow. Safely remove debris from the channel or contact the township regarding the occurrence.*

There are three categories of debris identified along the West Branch: yard waste, trash and construction waste, and natural accumulation of organic debris at culvert openings.

Yard waste is comprised of grass clippings, leaves, mulch, and brush clippings. It is estimated that every year an average person generates 200 pounds of yard waste (Janssen & Barrow, 2008). If not properly managed yard waste can accumulate and contribute excess nutrients to the stream system and degrade water quality. Yard waste should never be dumped along the stream corridor. Proper management of yard waste includes composting, grass cycling, and reusing as mulch. Grass cycling is when the yard is mowed on a regular basis and grass clippings are allowed to remain on the lawn. These clippings decompose on site and add nutrients back to the soil, reducing the need for fertilizer. Composting is a process which turns yard waste along with organic, non-meat kitchen waste into a valuable soil supplement that can be added to flower pots, garden beds, or the lawn to increase infiltration and add valuable nutrients. Tree and shrub clippings can be chipped and reused as mulch around trees and in flower beds. Proper mulching decreases the need for watering and weeding. Additionally it protects vegetation from mowers and harsh cold in the winter months.



Figure 19. Trash dumped next to the West Branch.

However, leaves and twigs naturally generated by streamside vegetation should be left alone and not removed from the stream corridor as this material provides food and habitat for fish and aquatic insects.

General trash and construction waste needs to be properly disposed of offsite and not placed in the active stream channel or floodplain.

The last category of debris needing management is the organic debris which accumulates at culverts and road crossings. Many of the West Branch's culverts are undersized as the majority cannot pass the 25-year storm (Delaware County Planning Department, 2007).

Undersized culverts result in bulbous scouring of the stream channel and banks at both the culvert intake and outfall. Debris which accumulates near culverts exacerbates this occurrence and can result in excessive, unnecessary erosion. Property owners adjacent to road crossings, bridges, and culverts should visually inspect these areas for debris which may block or hinder stream flow following storm events. After storm waters have receded this material should be broken up and/or removed from the channel.



Figure 20. Debris blocking Forest Lane culvert intake.

Bank Stabilization

- ★ *If bank or channel stabilization is required contact a consultant trained in stream processes and erosion control.*
- ★ *Utilize soil bioengineering and natural channel design techniques for stream and bank stabilization.*
- ★ *Obtain all local, county, state, and federal permits required prior to regrading stream banks or placing any material (e.g., rocks, concrete, logs) or structures (e.g., bridges, buildings) in the active channel or along the stream banks.*

Streams are dynamic systems that by their nature change over time. Erosion and deposition are components of an equilibrium allowing a stream channel to change yet remain stable in terms of its pattern, profile, and dimension. However, human impacts affect stream channels, upsetting the natural balance, and can result in excessive bank erosion. In addition to the evident bank failure and loss of land, excessive bank erosion introduces fine particles to the stream which can choke bed substrate important for fish and macroinvertebrate habitat. Therefore, excessive sediment is viewed as a pollutant and can cause a stream to be impaired by the EPA's Section 303(d) standards. As a stream is part of an interconnected system, bank stabilization and stream restoration needs to address the source of this problem not just the symptoms.

Erosion control solutions need to achieve stabilization while also protecting and enhancing stream conditions. Conventional “solutions” (e.g., concrete, rip-rap, constructed walls, and gabion baskets) stabilize through hard armoring of the banks. While these techniques temporarily stabilize the immediate problem area, they do not dissipate energy and thus often transmit the erosive force downstream and/or to the opposite bank. Preferred techniques, developed from the fields of soil bioengineering and fluvial geomorphology, provide more naturalistic alternatives that benefit both landowners and the creek itself. These methods consider the long-term stability of the stream and attempt to work with the existing trends. In the long run, these practices are not only more successful but also more cost effective.

Note that the grading of stream banks, relocation or filling of a stream channel or wetland, placement of material in the channel or along the stream bank, and/or removal of embedded material from the stream such as gravel bars and dams, requires a stream encroachment permit from the Pennsylvania Department of Environmental Protection and an approved Erosion and Sedimentation Control Plan from Chester County Conservation District. As the West Branch is an EV stream, a review by the US Army Corps of Engineers is needed as well. Additional local permits may also be required. Local environmental organizations and the conservation district may be able to provide guidance and assistance with the permitting process.

Stormwater Management

★ *Utilize BMPs to spread stormwater out and encourage infiltration.*

Today’s development and impervious surfaces result in increased runoff during rain events. This results in increased flooding, decreased stream base flow, depleted groundwater aquifers, nonpoint source pollution, and soil erosion. A comprehensive stormwater management approach involving prevention, infiltration and best management practices (BMPs) offsets the adverse impacts of stormwater and uses stormwater as an asset. Stormwater management can include the following (Delaware Riverkeeper Network, 2001):

- Protecting and reforesting open space areas;
- Protecting existing native vegetation;



Figure 21. Opportunity for stormwater BMP along the West Branch.

- Protecting and creating forested buffers along waterways;
- Retrofitting detention basins to encourage infiltration and/or retention;
- Use of porous pavement;
- Incorporating vegetated filter strips;
- Introducing bio-retention areas;
- Use of s wales and French drains along parking areas and other large paved surfaces and/or routing their runoff into vegetated areas;
- Introducing infiltration trenches;
- Programs for re-routing rooftop runoff into gardens, vegetated areas or recharge systems;
- Use of vegetated roof covers;
- Comprehensive floodplain protection and restoration.

Previously noted recommendations along the West Branch include improving stormwater management from roads and driveways, residential gutters, and impervious surfaces from an institutional property. Redirecting runoff from driveways and roads to vegetated areas and encouraging infiltration will minimize gullies and water quality pollution. Landowner education about stormwater runoff, roof leaders, rain gardens, and rain barrels can facilitate installation of BMPs which minimize erosion, encourage infiltration, and improve overall stream health.

Pond Management

- ★ *Plant pond margins to provide shade and minimize elevated pond water temperatures, and to discourage Canadian geese.*
- ★ *Evaluate need and use of existing ponds, particularly the in-line pond near the West Branch headwaters.*
- ★ *Maintain aging ponds.*

In the West Branch subbasin there are over 25 ponds (Mesa Environmental Sciences, 2004). Along the West Branch channel alone, not including any of its tributaries, there is one in-line pond and eight off-line ponds. The lone in-line pond is located at the West Branch's headwaters. The off-line ponds are concentrated in the lower half (below Spring Road) of the West Branch, with only one of them located above Spring Road.

In terms of this Coldwater Conservation Plan, ponds pose three concerns to the West Branch. Ponds by their



Figure 22. In-line pond at the headwaters of West Branch Crum Creek.

nature are heat sources and can artificially elevate stream water temperatures which can be detrimental to the West Branch's brown trout population and the insects on which they feed. Secondly, aging ponds in particular lose their depths and accumulate nutrients. This fuels algae growth and increase temperatures, both of which reduce dissolved oxygen levels. Lastly, ponds often provide habitat for Canadian geese, a recognized nuisance to water quality and other wildlife.

Horse Pasture Management

- ★ *Maintain an adequate vegetated buffer between horse pastures and the West Branch in order to help filter and slow down runoff from the pastures.*
- ★ *Properly manage horse manure to ensure excessive nutrients are not being washed into the stream during storm events.*
- ★ *Work with streamside horse pasture property owners to evaluate pasture management in order to protect water quality.*

The Upper Crum Creek watershed has a significant number of horse pastures. Proper pasture management through adequate buffers, stream bank fencing, adequate pasture area relative to number of animals, and manure management will protect against water quality degradation and stream bank erosion.

The foremost concern regarding horses and other agriculture along waterways is waste management. Manure adversely impacts water quality. It contributes to high fecal coliform counts, elevated nutrient levels which lead to algal blooms, and decreased dissolved oxygen which can result in fish kills. Horse manure needs to be managed properly. This includes containing and storing waste, composting waste, and/or reusing waste.

Additional concerns regarding horse pastures and their impact on waterways include establishing and maintaining a vegetated buffer along the stream, limiting horse access to the stream, providing off-stream watering locations, locating heavily traveled areas away from the stream, and controlling runoff from the site.

Grazing of animals within 100 feet of the West Branch is not a permitted use under the township's Riparian Buffer Area Conservation District ordinance (§73-62, B) (Willistown Township, 2000). Two sites along the West Branch were noted where horses pasture in close proximity to the stream with little or no riparian buffer. Downstream of one location, algal blooms were observed which may be due to excess nutrients from the pasture. Previous water quality studies of the West Branch documented elevated fecal coliform levels (Mesa Environmental Sciences, 2004). Outreach directed at these and other horse owners on how to properly pasture horses near streams will help to improve West Branch water quality.



Figure 23. Horse pasture within 10 feet of the West Branch.

Floodplain Encroachment

- ★ *Educate property owners on the function and importance of floodplains.*
- ★ *Relocate existing structures encroaching upon the floodplain and prevent the construction of new encroaching structures.*
- ★ *Obtain all necessary permits required for the construction or placement of any structure along the West Branch.*

Floodplains are vital features to a properly functioning stream, as they dissipate energy during storm events. Streams will top their banks on a regular basis and a healthy floodplain will be inundated approximately every 1.2-1.5 years, statistically. This is an important concept for streamside property owners to understand.



Figure 24. Shed adjacent to West Branch Crum Creek.

Because of the floodplain's critical function, it is important that encroachment of the floodplain is avoided to the greatest degree possible. Along the West Branch there are several garages and sheds adjacent to the stream and within the floodplain. These buildings should be relocated if possible so as to protect the building from damage sustained in a flood and to limit pollution to the West Branch during storm events. For example, a shed within the floodplain containing various containers of gasoline, oil, and other common

household liquids may adversely impact water quality and stream organisms as flood waters inundate the shed and transport these liquids and other items downstream. Additionally relocation of structures encroaching upon the floodplain provides the opportunity to restore the floodplain to healthy function by planting it with native vegetation.

Invasive Vegetation Control

- ★ *Eradicate the sole location of Japanese knotweed observed along the West Branch. Begin treatment in 2009.*
- ★ *Educate property owners on the negative impacts of invasive non-native vegetation and the importance of selecting native vegetation for the stream corridor.*

Nonnative invasive plant species are an ever-present and serious threat to our native ecosystems. Exotic plants are introduced to an ecosystem where they do not naturally exist and are often invasive, meaning they outcompete native plant species. Invasive species 'take over', cause a decline in native plant species, and reduce wildlife habitat and ecological diversity.

Unfortunately invasive species are thriving along the entire length of the West Branch. Due to their ubiquitous presence, the completed visual assessment did not note locations colonized by the various species or include invasive control measures in the recommendations. However, a few areas with a limited infestation were noted for invasive vegetation control in hopes that early control measures will prevent

further colonization. One site in particular where invasive control needs to occur immediately is the sole location of Japanese knotweed in the upper West Branch (Segment 1).

Some of the non-native, invasive plant species noticed during the visual assessment along the West Branch are listed below. This is not to serve as a complete list of invasive plant species for the stream corridor. Multiflora rose appeared to be the most common and prevalent invasive.

Japanese Barberry (<i>Berberis thunbergii</i>)	Shrub honeysuckles (<i>Lonicera</i> spp.)
Multiflora rose (<i>Rosa multiflora</i>)	Japanese knotweed (<i>Polygonum cuspidatum</i>)
Bamboo species	Reed canary grass (<i>Phalaris arundinacea</i>)
Phragmites (<i>Phragmites australis</i>)	Miscanthus grass (<i>Miscanthus sinensis</i>)
Japanese stilt grass (<i>Microstegium vimineum</i>)	English ivy (<i>Hedera helix</i>)
Japanese honeysuckle (<i>Lonicera japonica</i>)	Pachysandra (<i>Pachysandra terminalis</i>)
Vinca (<i>Vinca minor</i>)	

In controlling many of the exotic, invasive species that colonize regional stream banks, it is important that once the invasives are effectively treated other vegetation is planted immediately. The shade generated from native tree species will help prevent a re-colonization of many invasive plant species.

NEXT STEPS

In May 2009, the Upper Crum Creek Coldwater Plan Steering Committee met to review the West Branch Coldwater Conservation Plan's findings and to discuss how to move forward with the enhancement opportunities identified in the plan. The Steering Committee is comprised of representatives from Willistown Township, the three major conservation partners (CRC, Willistown Conservation Trust, and Brandywine Conservancy), and White Manor Country Club, a major streamside landowner. The plan is to add several other key landowners to the Steering Committee over time.

Following is a list of action items developed by the Steering Committee to guide them in working together to disseminate key findings and recommendations of this Coldwater Conservation Plan to property owners

along the West Branch of Crum Creek and to begin to implement the highest priority and most readily implemented of the plan's recommendations.

1. Educate the public through a series of articles appearing in the Willistown Township, Willistown Conservation Trust, and CRC newsletters with links to their websites for more information.
2. Develop and mail to all streamside landowners a promotional brochure for the West Branch with a watershed map and an invitation to a public kickoff meeting. All educational materials and mailings to be developed by CRC with input from the Steering Committee. Existing educational materials from other conservation groups, such as DRN and PA Trout Unlimited, will be referenced.
3. Willistown Township's strong environmental ordinances and history of upholding its ordinances is a policy tool that can be referenced in discussions with landowners in the interest of encouraging voluntary implementation of recommendations of this plan.
4. Identify several key landowners in the West Branch subbasin who will actively help promote the project and possibly implement early-on some of the recommended practices.
5. Most of the easements in West Branch subbasin are held by the Brandywine Conservancy. CRC will work with Brandywine Conservancy to develop a strategy to help easement monitoring staff reinforce and implement this Coldwater Conservation Plan's recommendations with easement holders.
6. Steering Committee organizations will jointly sponsor a public kickoff meeting with an inspirational speaker at a site in or near the watershed, such as Radnor Hunt or White Manor Country Club.
7. Find a critical cluster of landowners, possibly Segment 5, to meet with first, and walk the resource together. The goal is to put recommended practices in place so that neighboring property owners can draw upon them for guidance and inspiration.
8. Property owners who implement good streamside practices (no-mows, native riparian buffers, stormwater management, etc.) could be recognized in the Township newsletter.
9. Complete several demonstration sites along the West Branch, including White Manor Country Club.

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APPENDIX A

Semi-quantitative Macroinvertebrate Data
Crum Creek, Chester County
Delaware Riverkeeper Network
May 7, 2008

TAXA	STATION		
	1 CC	2 CC	3 WB
Ephemeroptera (mayflies)			
<i>Baetidae; Baetis</i>	12	6	4
<i>Ephemerellidae; Serratella</i>	2	3	
<i>Heptageniidae; Maccaffertium</i>	19	2	2
Plecoptera (stoneflies)			
<i>Capniidae; Allocapnia</i>	2		
<i>Leuctridae; Leuctra</i>			8
<i>Nemouridae; Amphinemura</i>	11	1	3
<i>Perlidae; Perlesta</i>	21	4	2
Trichoptera (caddisflies)			
<i>Glossosomatidae; Glossosoma</i>	1		
<i>Hydropsychidae; Cheumatopsyche</i>		4	4
<i>Diplectrona</i>		1	
<i>Hydropsyche</i>	2	1	3
<i>Limnephilidae; Pycnopsyche</i>	1		
<i>Philopotamidae; Chimarra</i>	1	2	
<i>Uenoidae; Neophylax</i>			1
Diptera (true flies)			
<i>Empididae; Clinocera</i>			1
<i>Hemerodromia</i>	1		1
<i>Simuliidae; Simulium</i>	9		
Chironomidae	52	122	82
Odonata (dragon-, damselflies)			
<i>Gomphidae; Lanthus</i>	2		
<i>Coenagrionidae; Argia</i>		1	
Coleoptera (aquatic beetles)			
<i>Dytiscidae; Hydroporus</i>	1		
<i>Elmidae; Optioservus</i>	9	2	5
<i>Oulimnius</i>	8	10	11
<i>Stenelmis</i>	18	10	4
<i>Psephenidae; Psephenus</i>	4	4	2

TAXA	STATION		
	1 CC	2 CC	3 WB
Non-insect taxa			
Acariformes (water mites)	1		
Nematoda (round worms)		3	2
Oligochaeta	6	2	51
Tricladida; <i>Dugesia</i>			1
Bivalvia (bivalve clams)			
Sphaeridae; <i>Pisidium</i>	2		
Amphipoda (side swimmers)			
Crangonycitidae; <i>Crangonyx</i>		2	

APPENDIX B

Semi-quantitative Macroinvertebrate Data
Crum Creek, Chester County
Delaware Riverkeeper Network
May 2009

TAXA	STATION			
	1CC	2CC	3WB	4CC
Ephemeroptera (mayfly)				
Baetidae; <i>Baetis</i>	4	3	5	11
Ephemerellidae; <i>Serratella</i>	2		1	1
Heptageniidae; <i>Maccaffertium</i>	7	5	9	6
Caenidae; <i>Caenis</i>		1		
Plecoptera (stoneflies)				
Capniidae; <i>Allocapnia</i>	10	1	3	
Nemouridae; <i>Amphinemura</i>	1		4	
Perlidae; <i>Acroneuria</i>				6
<i>Perlesta</i>	2			1
Trichoptera (caddisflies)				
Hydropsychidae; <i>Cheumatopsyche</i>	1	8	32	4
<i>Diplectrona</i>			1	
<i>Hydropsyche</i>		3	26	9
Glossosomatidae; <i>Glossosoma</i>	1			
Philopotamidae; <i>Chimarra</i>	1	4		2
<i>Dolophilodes</i>				1
Uenoidae; <i>Neophylax</i>	1			
Polycentropodidae; <i>Polycentropus</i>				1
Odonata (dragon-, damselfly)				
Gomphiidae; <i>Stylogomphus</i>	3		1	
Coleoptera (aquatic beetles)				
Elmidae; <i>Dubiraphia</i>	1			
<i>Optioservus</i>	18	23	24	5
<i>Oulimnius</i>		11	9	3
<i>Stenelmis</i>	28	64	1	24
Psephenidae; <i>Psephenus</i>	7	4	6	15
Non-insect taxa				
Acariformes (water mites)				
Nematoda (round worms)		1	1	3
Oligochaeta	22	2	31	5
Tricladida; <i>Dugesia</i>	1	4		
Hoplonemertea; <i>Prostoma</i>				2
Bivalvia (bivalve clams)				
Sphaeriidae; <i>Pisidium</i>		2	3	

APPENDIX C

Fish Data
Crum Creek, Chester and Delaware County
Pennsylvania Fish and Boat Commission
June 1999

SPECIES NAME	STATION			
	101	102	103	104
American eel, <i>Anguilla rostrata</i>			P	P
Rainbow trout, <i>Oncorhynchus mykiss</i> ²			R	
Brown trout, <i>Salmo trutta</i> ¹	P	P	A	C
Brook trout, <i>Salvelinus fontinalis</i> ²			R	
Cutlips minnow, <i>Exoglossum maxillingua</i>	X	C	X	X
Common shiner, <i>Luxillus cornutus</i>	X	C		C
Spottail shiner, <i>Notropis hudsonius</i>			R	X
Blacknose dace, <i>Rhinichthys atratulus</i>	X	A	A	X
Creek chub, <i>Semotilus atromaculatus</i>	X	P	P	X
Fallfish, <i>Semotilus corporalis</i>	X	P	C	X
White sucker, <i>Catostomus commersoni</i>	X	A	A	X
Yellow bullhead, <i>Ameiurus natalis</i>	X		P	X
Brown bullhead, <i>Ameiurus nebulosus</i>				X
Margined madtom, <i>Noturus insignis</i>		P	C	X
Green sunfish, <i>Lepomis cyanellus</i>		R	X	X
Redbreast sunfish, <i>Lepomis auritus</i>		R	P	P
Pumpkinseed, <i>Lepomis gibbosus</i>		R	P	P
Bluegill, <i>Lepomis macrochirus</i>	P	R	R	
Largemouth bass, <i>Micropterus salmoides</i>				X
Tessellated darter, <i>Etheostoma olmstedii</i>	X	C	C	X
Yellow perch, <i>Perca flavescens</i>			R	

¹ Mostly wild with a few stocked individuals

² Only stocked individuals

A = Abundant (<100); C = Common (26-100); P = Present (3-25); R = Rare (<3);
X = present but no relative abundance determined