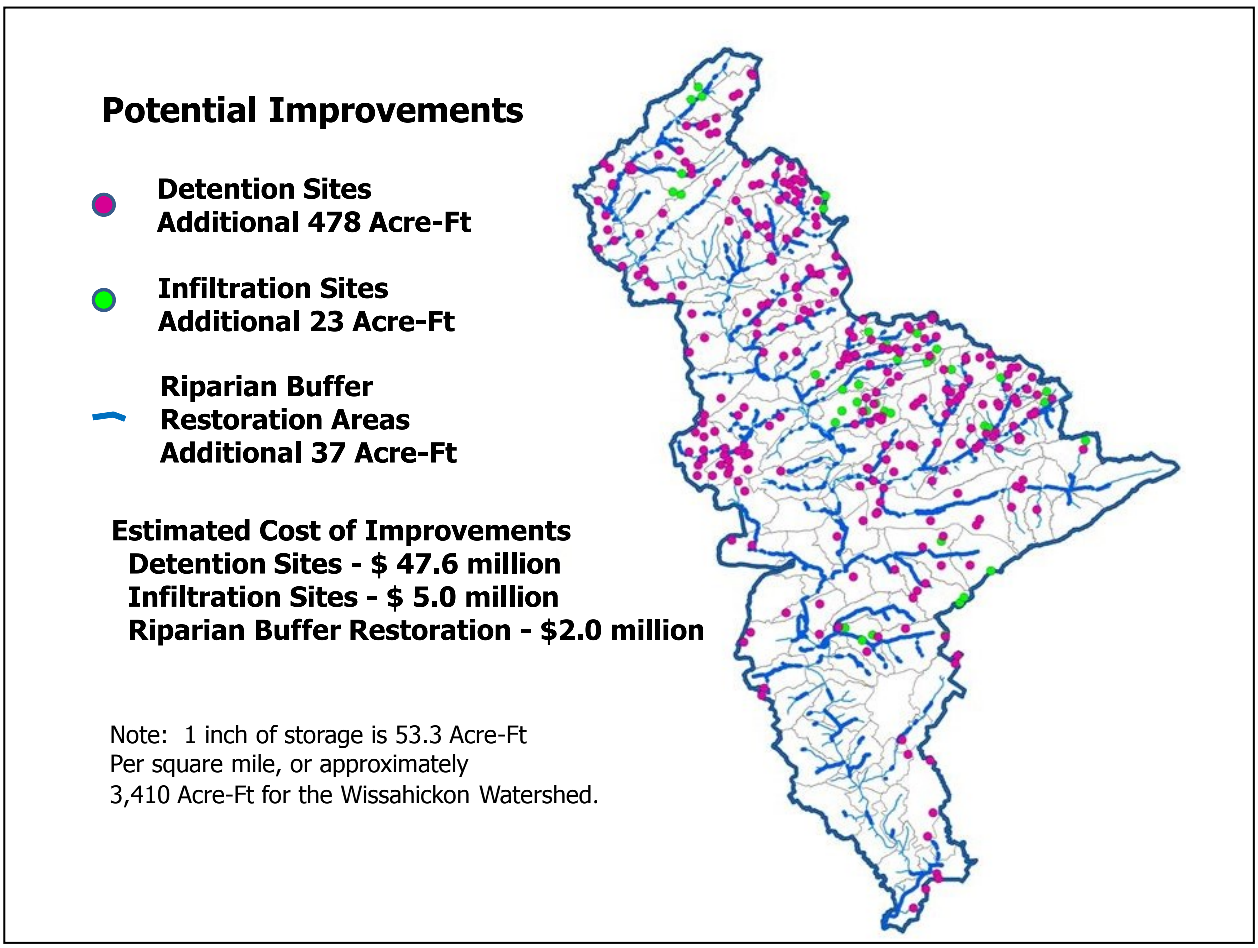
Section 6: Stormwater Improvements

A major objective of this study was to identify opportunities for improvements to address the widespread water quality impairments caused by stormwater runoff in the Wissahickon Creek Watershed. Three classes of sites were evaluated for their potential to provide expanded or new storage. These included new and retro-fit detention basins, potential infiltration sites, and stream reaches for potential restoration of riparian buffers. The distribution of these sites in the watershed is shown in Figure 6.A, along with the aggregate total storage volume and estimated total cost for each category. Appendix C provides the estimated storage and costs for the improvements at the identified facilities. The following sections summarize the evaluation steps and present additional results of hydrologic modeling of the improvements. The facilities were also ranked based on factors including catchment area, cost, and watershed location. The ranking method allows for cross-comparison of all sites.

Figure 6.A Distribution of Potential Improvements in the Wissahickon Watershed



6.1 Detention Storage Facilities

A total of 277 existing and potential detention sites were inventoried. GIS files with the locations and dimensions for 185 of these facilities were provided by the Philadelphia Water Department (PWD). The remaining sites were added by the Center for Sustainable Communities (CSC) based on field inspections as well as review of orthophotography and terrain data. Existing inventoried sites with surface areas greater than a quarter of an acre were field inspected. Factors considered for evaluating potential expansion included:

- Property access
- Drainage or flood risk to nearby properties if berm height were increased
- Water table with respect to the floor of the facility if the floor were lowered
- Availability of adjacent property for expansion

Sites where increased berm height or lowered floors appeared feasible were considered for expansion. For most sites with areas less than a quarter of an acre, a recommendation was made to both increase berm height and lower the basin floor by one foot. In some cases, increased floodplain storage was recommended as a means of providing additional detention, rather than construction of a detention facility in the floodplain. Generally, such areas are recommended as constructed wetlands. A total of 241 sites were recommended for new or expanded detention, including floodplain storage sites. Recommendations were also made to improve outlet structures and revegetate basin floors to increase extended detention. The Detention Spreadsheet in Appendix C lists the existing and potential increased storage at each of the detention sites, and provides estimated costs of the improvements. Cost estimates include 35% for design and contingency, and assumed union labor rates. A ranking based on the catchment area (a measure of the potential for extended detention during small storms), cost, and watershed locations is also included to provide a possible means of prioritizing sites. A GIS shape file is also included for detailed mapping of the improvement location, such as that shown in Figure 6.1.A. The spreadsheet includes the following fields:

- Site ID
- Subbasin
- Municipality
- Cross reference to Site ID used in the Fort Washington Area Study where applicable
- Location or nearby intersection
- Public or Private Ownership
- Current Land Use
- Receiving Watershed
- Existing Depth
- Existing Area
- Existing Volume
- Potential Additional Volume
- Estimated Cost
- Notes regarding the improvement
- Priority ranking assigned to the facility

Figure 6.1.A   Sample Detention Basin Site Map

Site UD_139 – Potential Detention/Constructed Wetland in Upper Dublin Township
On Temple University Campus between baseball field and Susquehanna Road
Potential New Storage = 3.2 Acre-Ft   Estimated Cost = $320,000

The total of existing storage from detention basins and ponds in the Wissahickon Watershed is estimated at 387 acre-feet. Potential additional storage would provide an additional 478 acre-feet of storage. This total includes 270 acre-feet of storage (to the spillway crest elevation) from the Rapp Run and Pine Run flood retarding structures in Upper Dublin Township which were constructed during the course of this study and are in place as of December 2013.

6.2   Potential Infiltration Sites

Opportunities for additional infiltration were based on field inspections of 41 sites where installation of stone-filled trenches or galleries could provide storage for runoff from large rooftops, parking areas, or athletic fields. Cost estimates were based on the design of infiltration trenches to provide storage for one inch of runoff, or four inches in several cases where infiltration galleries were recommended. The average cost for construction of infiltration facilities is over $4 per acre-ft. of storage, making infiltration more costly than detention or riparian buffer restoration. The total combined area of the identified infiltration sites is 179 acres, and the estimated infiltration volume is 23 acre-feet. The inventory focused on larger sites rather than individual residential properties where the installation of such measures as pervious paving or rain gardens could also increase infiltration. The Infiltration Spreadsheet in Appendix C lists the infiltration sites and includes the following data fields:

- Site ID
- Municipality
- Cross reference to Site ID used in original Fort Washington Area Study where applicable
- Location/Intersection
- Public or Private Ownership
- Current Land Use
- Watershed receiving largest share of site runoff
- Notes
- Infiltration Area
- Potential Infiltration Volume
- Estimated Cost
- Site Ranking

A GIS file for the infiltration sites is also provided in Appendix C and sample mapping for one of the sites is shown in Figure 6.2.A.

Figure 6.2.A   Sample Infiltration Site
Site UD_4B – Potential Infiltration Site in Upper Dublin Township
Student Parking Lot on Temple University Campus
Potential New Storage = 0.67 Acre-Ft   Estimated Cost = $128,000

6.3   Riparian Buffer Restoration

An inventory conducted by the Heritage Conservancy in 2000 and updated in 2010 identified stream reaches where riparian stream buffers could be restored on either one or both sides of streams in the Wissahickon watershed. The distribution of these locations is shown in Figure 3.2.A. To estimate the potential additional storage available, the study team assumed an average buffer width of 75 feet for each side of the stream and an average runoff volume reduction of one inch. The estimated acreage and cost of re-establishing the buffers by municipality is presented in Table 6.3.A. The total additional storage volume provided to the watershed would be 37 acre-feet. Riparian buffer restoration has the lowest average cost of the three improvement categories. It should be noted however, that land use conditions have changed in some areas since the survey was completed in 2000. Actual buffer width would vary significantly from site to site, and buffers may no longer be feasible at some locations. The lack of acceptance by property owners can also limit re-establishing buffers. GIS file with the locations of the identified buffer restoration locations is provided in Appendix C, and a sample site map is shown in Figure 6.3.A.

Table 6.3.A Potential Total Riparian Buffer Restoration Areas by Municipality

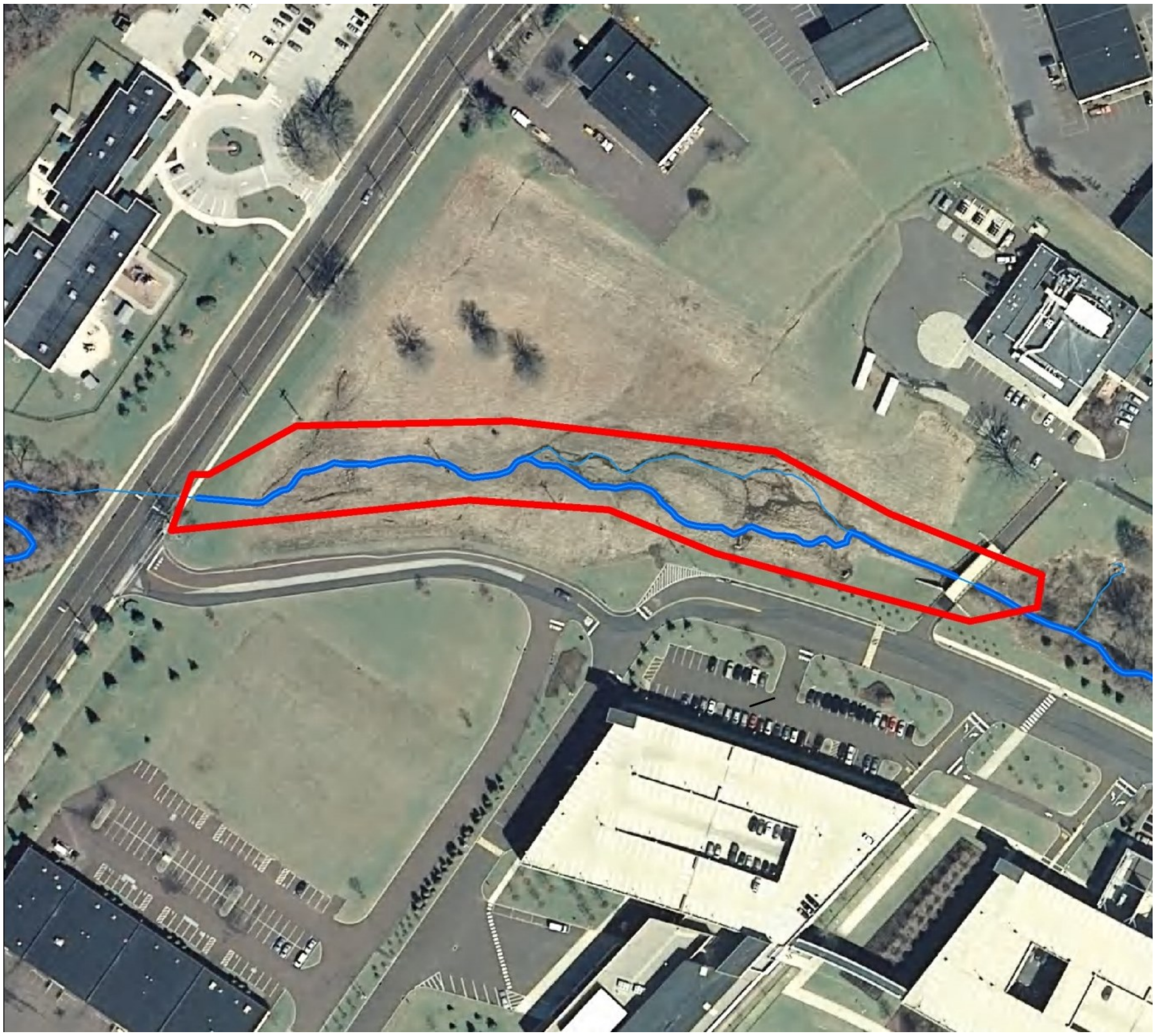
Municipality	*Acreage Requiring Riparian Buffers	**Cost Assuming $4,500 per acre	Rounded-Up Cost	Primary Affected Streams	***Average Volume Reduction per event (Acre-feet)
Abington	23.27	104,723	$105,000	Sandy Run	1.9
Ambler	5.96	26,830	$27,000	Wissahickon Creek, Rose Valley Creek	0.5
Lansdale	6.89	31,020	$32,000	Wissahickon Creek	0.6
Lower Gwynedd	68.12	306,549	$307,000	Wissahickon Creek, Penllyn Creek, Trewellyn Run, Willow Run	5.7
Montgomery	6.79	30,553	$31,000	Wissahickon Creek, Trewellyn Run	0.6
North Wales	2.84	12,797	$13,000	Tributary to Wissahickon Creek	0.2
Philadelphia	88.76	399,422	$400,000	Wissahickon Creek, Cresheim Creek	7.4
Springfield	83.34	375,032	$376,000	Wissahickon Creek, Paper Mill Run, Sunny Brook	6.9
Upper Dublin	106.22	478,008	$479,000	Sandy Run, Pine Run, Rapp Run, Tannery Run, Rose Valley Creek	8.9
Upper Gwynedd	50.40	226,778	$227,000	Wissahickon Creek, Haines Run	4.2
Whitemarsh	103.06	463,761	$464,000	Wissahickon Creek, Sandy Run	8.6
Whitpain	47.47	213,619	$214,000	Wissahickon Creek, Prophecy Creek, Willow Run	4.0

*Updated base data on riparian buffer needs were obtained from the Heritage Conservancy. These data indicate stream lengths requiring a riparian buffer, either on one side or both sides of the stream. The CSC assumed an average buffer width of 75 feet, recognizing that 50 feet may be appropriate for some locations and 100 feet for others. Acreage was derived using GIS analysis.

**Cost assumes 430 three- to four- foot high trees per acre, protective tubes, stakes, and labor, including some replacement in the second year.

*** Average volume reduction is an average value per event and assumed to be an inch of water per acre. The reduction would be the greater in the summer during dry periods, and substantially less in the winter during wet periods.

Figure 6.3.A Sample Riparian Buffer Restoration Site
Tributary to Wissahickon Creek near Dickerson Road in Upper Gwynedd Township
Potential for buffer restoration on both sides of stream



6.4 Hydrologic and Water Quality Impact of the Proposed Improvements

In order to reduce runoff peaks and volumes, a series of improvements to the watershed were evaluated. These improvements included:

- Retrofitting detention basins by rearranging the outlet structure, increasing volume by excavation or increasing berm height, etc.
- Proposing new infiltration sites
- Protecting and restoring riparian buffers to promote infiltration
- Proposing planned residential development with green infrastructure
- Promote LID/cluster development

These improvements were incorporated into a "Future Conditions" HEC-HMS model run. The modeling approach is summarized in Section 4.4 of this report. The combined potential additional storage provided by the three categories of improvements is estimated at 539 acre-feet, or 180 million gallons (assuming that the Pine Run and Rapp Run facilities are filled to their spillway crest elevations). This volume of storage is equivalent to 0.16 inches of runoff from the 63.5 square mile watershed.

Table 6.4.A shows the modeled percentage change in peak discharge and runoff volume for two locations in the Wissahickon Watershed with the improvements in place. The modeling indicates that cumulative flow and volume reductions would accrue to the watershed, with the largest impacts in the upstream portion of the watershed. In particular, the two large flood reduction facilities currently nearing completion on Rapp Run and Pine Run have a noticeable impact on outflow from the Sandy Run Watershed during large flood events. Table 6.4.B compares the peak flows for the future conditions run at several locations throughout the watershed to the peak flows for existing conditions in addition to peaks for the Green and Trend land use scenarios.

Table 6.4.A Impact of Proposed Improvements on Peak Discharge and Runoff Volume

Upstream of Sandy Run		
Storm	% difference in Peak Discharge	% difference in Runoff Volume
1-yr	-6%	-3%
2-yr	-5%	-3%
10-yr	-4%	-2%
50-yr	-4%	-2%
100-yr	-3%	-1%

Downstream of Sandy Run		
Storm	% difference in Peak Discharge	% difference in Runoff Volume
1-yr	-5%	-4%
2-yr	-4%	-3%
10-yr	-10%	-2%
50-yr	-7%	-2%
100-yr	-5%	-1%

Sandy Run		
Storm	% difference in Peak Discharge	% difference in Runoff Volume
1-yr	-8%	-5%
2-yr	-12%	-4%
10-yr	-23%	-3%
50-yr	-20%	-2%
100-yr	-11%	-2%

At Mouth		
Storm	% difference in Peak Discharge	% difference in Runoff Volume
1-yr	-5%	-4%
2-yr	-4%	-3%
10-yr	-7%	-2%
50-yr	-7%	-2%
100-yr	-5%	-1%

Table 6.4.B Comparison of Existing, Trend, Green, and Future Peak Flows (cfs)

Upstream of Sandy Run				
Storm	Existing	Trend	Green	Future
1-yr	2910.8	2927.3	2896.8	2750.7
2-yr	3914.6	3935.3	3897.5	3735.5
10-yr	7150.7	7162.9	7140.0	6843.4
50-yr	12217.5	12255.1	12212.0	11762.0
100-yr	15276.1	15317.1	15272.0	14797.5

Downstream of Sandy Run				
Storm	Existing	Trend	Green	Future
1-yr	3534.2	3553.8	3520.3	3343.0
2-yr	4967.8	4996.7	4944.7	4788.1
10-yr	10425.8	10475.4	10399.4	9407.4
50-yr	18738.8	18805.1	18720.0	17426.0
100-yr	23678.6	23732.8	23660.4	22528.0

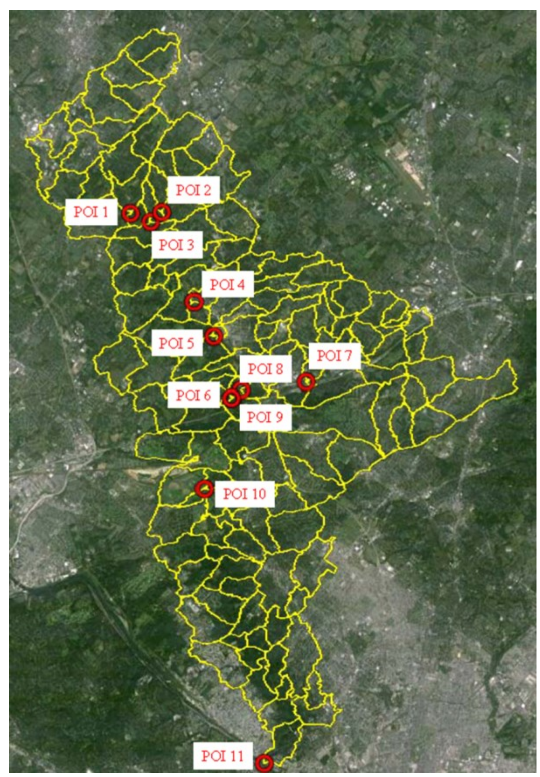
Sandy Run				
Storm	Existing	Trend	Green	Future
1-yr	1294.1	1303.8	1286.0	1196.1
2-yr	2038.2	2057.7	2028.8	1789.3
10-yr	4384.3	4410.3	4372.0	3372.2
50-yr	7657.8	7698.2	7639.9	6115.4
100-yr	9641.7	9662.8	9620.7	8569.2

At Mouth				
Storm	Existing	Trend	Green	Future
1-yr	4042.5	4066.1	4023.7	3850.2
2-yr	5591.4	5627.4	5568.3	5360.5
10-yr	10871.1	10925.4	10846.9	10118.1
50-yr	19148.4	19224.2	19121.4	17853.8
100-yr	24057.3	24135.8	24029.3	22773.0

Peak flow reductions for the 10-year event at additional of points of interest throughout the watershed are provided in Table 6.4.C. These locations are the same as those used in the modeling to determine the peak rate control management districts and are shown in the inset map below.

Table 6.4.C Existing and Future Conditions Peak Flows for the 10-year Event

Point of Interest	Existing Peak Flow (cfs)	Future Conditions Peak Flow (cfs)
J8 (POI-1)	3288.1	3189.7
J9-4 (POI-2)	2071.4	1939.3
J9 (POI-3)	3974.3	3923.8
J15 (POI-4)	5585.4	5357.9
J18 (POI-5)	6966.1	6681.2
J21 (POI-6)	7150.7	6843.4
J22-4 (POI-7)	2309.4	1159.6
J22-7 (POI-8)	4384.3	3372.2
J22 (POI-9)	10415.0	9391.3
J26 (POI-10)	10556.7	9663.2
Outlet 1 (POI-11)	10871.1	10118.1



The distribution of the proposed improvements is the most concentrated in the upper half of the watershed, where peak flow and runoff volume reductions would have the most far-reaching effects and benefit the greatest number of stormwater problem areas along the Wissahickon Creek and tributaries.

For existing facilities that were individually modeled, the peak flow and accumulated storage for the 10-Yr design storm are shown in Tables 6.4.D. The results show the significant reductions in peak flow immediately downstream resulting from improvements to these facilities. In some cases, upstream improvements also lower the inflow to a given facility for the future condition. Because the drainage area that is controlled by the off-stream detention facilities is only a small fraction of the watershed area, the peak reduction percentages are diminished for locations further downstream.

Table 6.4.D Inflow, Outflow, and Storage for the 10-year Event before and after Improvements to Existing Facilities

Detention Basin	Existing 10-year Inflow (cfs)	Existing 10-year Outflow (cfs)	Existing Peak 10-year Storage (ac-ft)	With Improvements 10-year Inflow (cfs)	With Improvements 10-year Outflow (cfs)	With Improvements Peak 10-year Storage (ac-ft)
AB_1	139.6	68.2	5.5	124.8	27.4	8.6
LG_10	19.7	2.1	2.9	19.6	1.3	3
LG_11	20.4	14.1	3.0	20.4	2.5	2.7
LG_26	10.6	9.8	0.2	10.6	2.7	1
Loch Alsh	190.7	60.7	22.6	185.8	29.5	24.4
MO_2[a]	110.2	66.6	4.6	109.2	68.9	5.6
St. Mary's Lake	98.2	81.3	8.3	100.5	53.5	11.7
UD_43	17.1	6.2	1.8	17.3	1.9	3
WP_10	6.7	4.9	0.6	6.7	1	1.2
WP_2	27.3	17.6	1.4	27.3	2.0	4.1
WP_3	44.3	23.3	2.6	44.3	4.8	6.1

a) For site MO_2, outflow is slightly higher for the 10-Yr storm in the proposed condition due to modeled outlet improvements that include addition of a 2 square foot high flow outlet to prevent overtopping of the spillway during the 100-Yr storm.

Similar model results for proposed facilities during the 10-Yr storm event are summarized in Table 6.4.E. These facilities include the newly constructed Pine Run (UD_138) and Rapp Run (UD_137) flood retarding structures in Upper Dublin Township. The modeling for this study shows that these structures provide reductions in peak flow rates of hundreds of cubic feet per second once inflowing stream stage exceeds a near bank-full condition. The structures are equipped with large spillways to meet safety requirements during extreme events. Flood reductions are still significant but reduced during events such as the 100-Yr storm because the spillways are overtopped. The structures provide a combined flood storage volume of 270 acre-ft to their spillway crests and 431 acre-ft at full spillway capacity. They are designed as flood control rather than extended detention facilities and convey flows up to near bank-full stage through a 4 foot x 4 foot opening in each structure in order not to impede normal stream flow.

Table 6.4.E Inflow, Outflow, and Storage for the 10-year Event - Proposed Facilities

Detention Basin	Existing 10-year Inflow (cfs)	Existing 10-year Outflow (cfs)	Existing Peak 10-year Storage (ac-ft)	With Improvements 10-year Inflow (cfs)	With Improvements 10-year Outflow (cfs)	With Improvements 10-year Storage (ac-ft
LG_41	N/A	N/A	N/A	1722.9	1678.2	10.2
UD_137	N/A	N/A	N/A	773.1	292.1	56.8
UD_138	N/A	N/A	N/A	840.5	288.25	61.8
UD_140	N/A	N/A	N/A	237.7	231.7	7.1
UD_52	N/A	N/A	N/A	28.6	3.4	2.4
UD_57	N/A	N/A	N/A	44.2	2.3	2.1
UD_69	N/A	N/A	N/A	22.3	0.9	2.2
WP_29	N/A	N/A	N/A	29.8	3.6	2.2

N/A – Existing inflow, outflow, and storage were listed as N/A for proposed new detention basins.

Flow reductions due to the potential stormwater improvements were calculated at each of 370 bridges and culverts inventoried as part of this study. For 31 of these structures, the design storm exceeding the capacity would shift to a less frequent event. This lowered flood frequency would help reduce structural damage to culverts and bridges and reduce instances of hazardous driving conditions at roadway crossings.

Figures 6.4.A and 6.4.B provide maps showing the modeled percent reduction in peak discharge and runoff volume from each subbasin predicted by the hydrologic model with the recommended improvements in place during the 10-year storm. The reduction in peak flows and volumes ranged from 0-40.5% and from 0-31.8%, respectively. The net effect of these reductions at the selected points of interest is shown in Table 6.4.C. Also, Tables 6.4.A and 6.4.B show the combined effects of the improvements at several locations for each of the design storms. There are a few subbasins with small increases in peak flow or volume (noted on the map with a negative reduction percentage). This is due to slightly increased curve numbers for future development, which are not compensated for by greener development practices, riparian buffer restoration, or increased infiltration and detention in the subwatershed. In some locations downstream from potential improvements, the reduction in peak flow rates is sufficient to reduce water surface elevations for smaller storms. Figure 6.4.C shows a reduction of approximately one foot in the water surface profile for the 2-Yr storm along a section of Rose Valley Creek in the Ambler area of Montgomery County.

The reductions in peak flow and volume would help reduce scour and erosion potential along stream reaches, and would be helpful where stream restoration is planned or has been completed. For example, PWD has been working to return streams to their natural state and create stable, healthy waterways able to sustain native vegetation and aquatic life. The year 2011 saw the restoration of Bells Mill—a 5,100-foot tributary to the Wissahickon with grading and rock structures in place that will help stabilize the streambank and reduce erosion as seen in Figure 6.4.D. Elsewhere in the Wissahickon watershed, stormwater wetlands at Cathedral Run and Wises Mill began functioning this year. These wetlands mitigate the impact of stormwater flows, reduce the amount of sediment that ends up in the streams and increase the diversity of aquatic vegetation in those wetland areas. In addition to reducing erosion rates, the facilities recommended by this study would provide for settling and storage of sediment in runoff and reduce sediment loading in the watershed.

Figure 6.4.A Reduction in Subbasin Peak Flow Rates for the 10-year Event With Proposed Improvements in Place

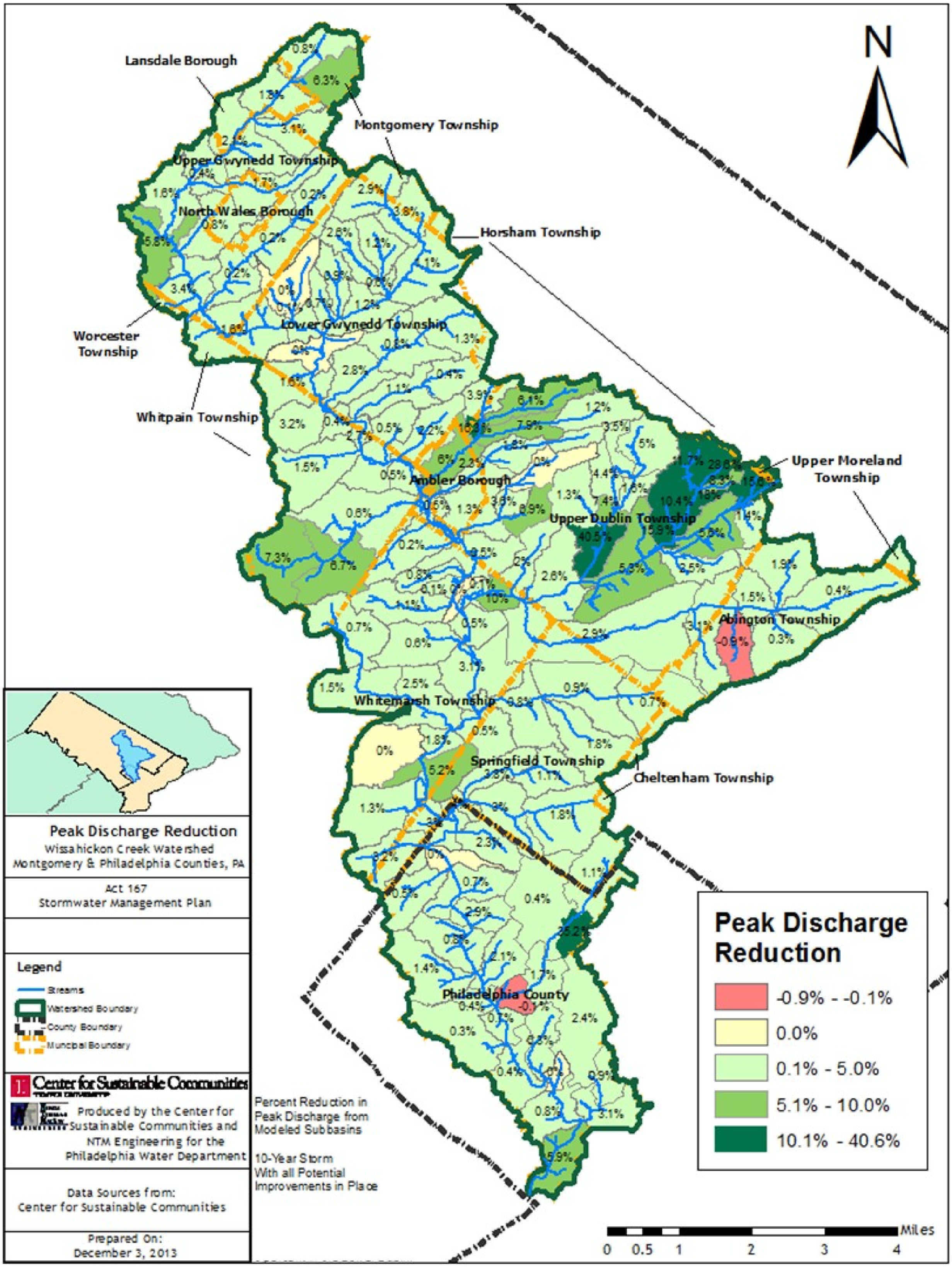


Figure 6.4.B Reduction in Subbasin Flow Volume for the 10-year Event With Proposed Improvements in Place

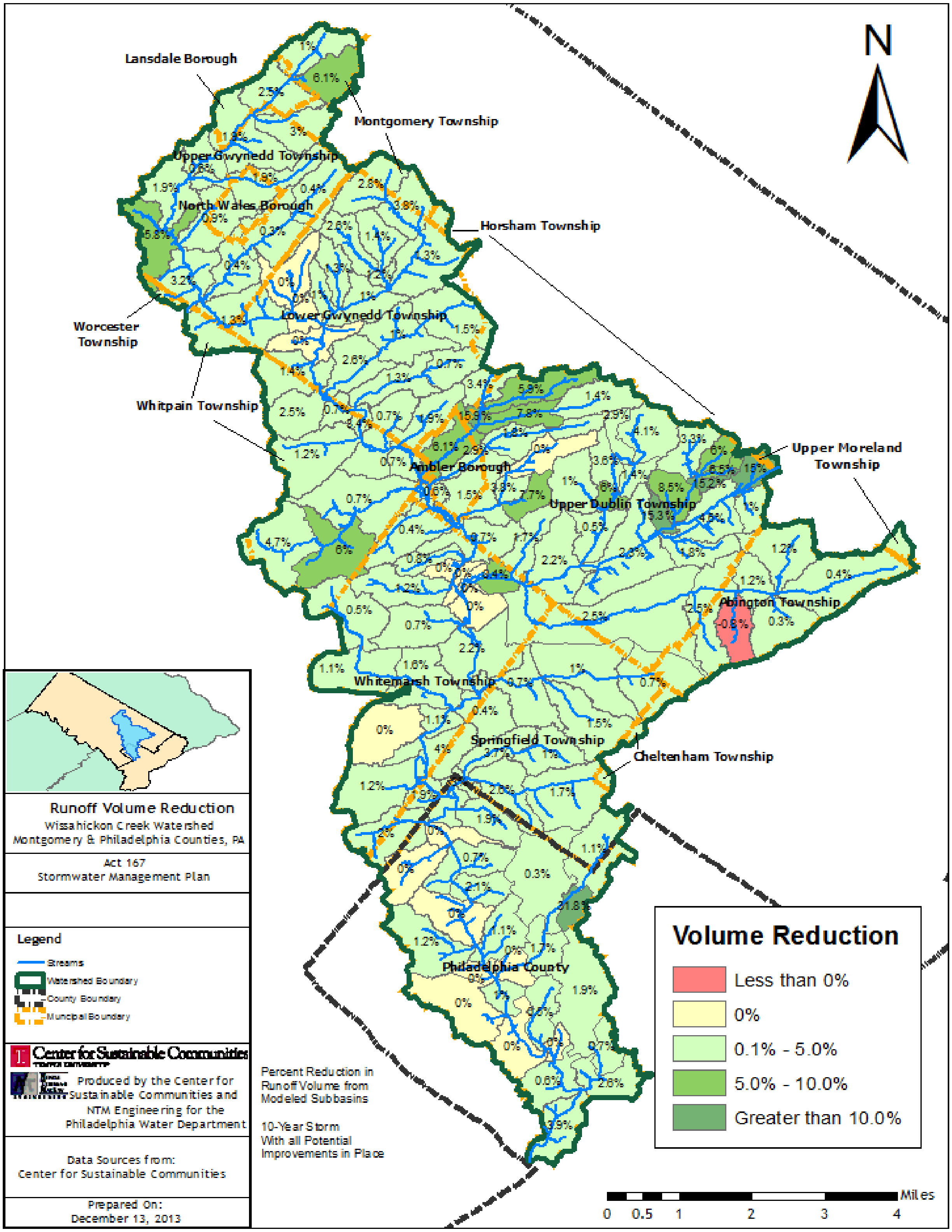


Figure 6.4.C Water Surface Elevation Profiles for 2-Yr Design Storm Rose Valley Creek in Ambler and West Ambler, Montgomery County

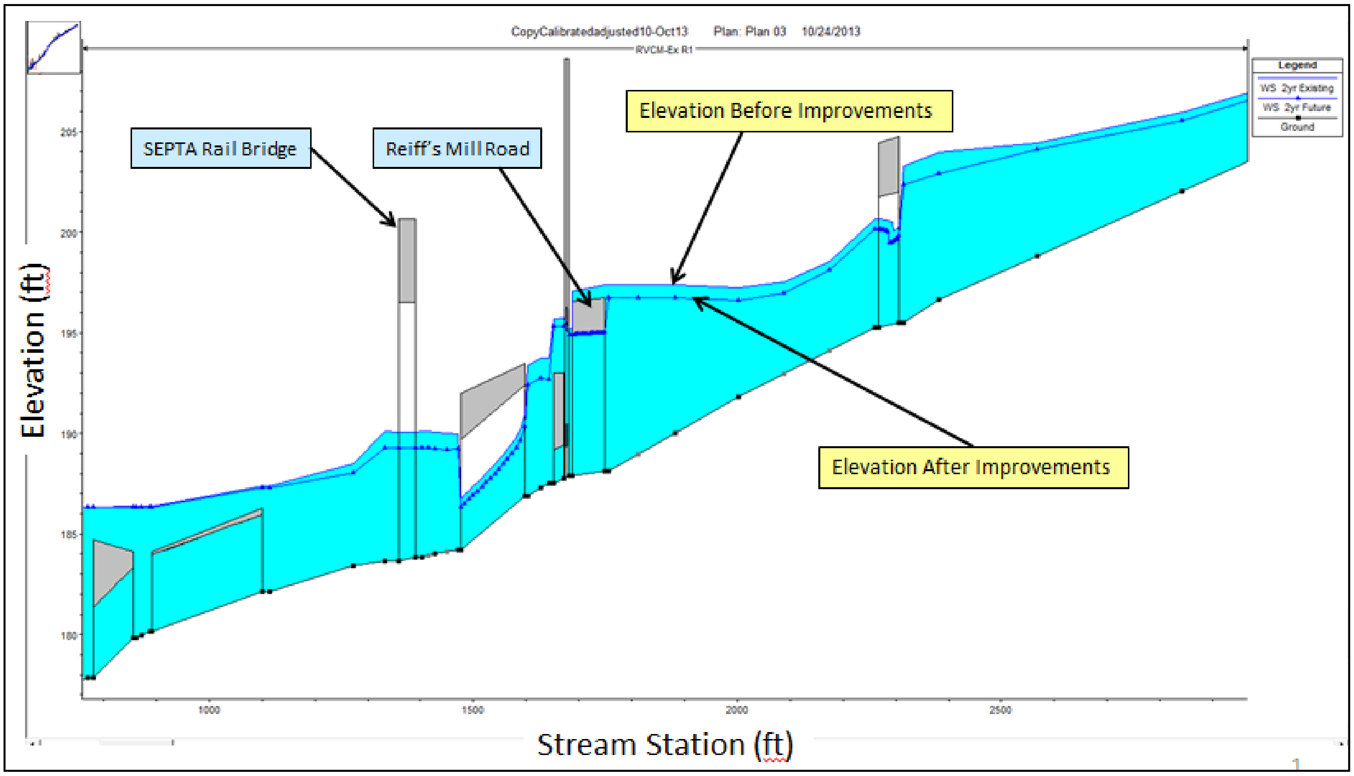


Figure 6.4.D Bells Mill Run Stream Restoration

6.5 Improvement Site Ranking

To provide a means of prioritizing further investigation of the proposed improvements, each site was rated based on three factors:

- Effective use of additional storage during small storms. This was assigned a weight of 50 percent of the total ranking. Storage at infiltration and riparian buffer restoration sites was assumed to be fully used during small storms. Use of detention storage during small storms was assumed to vary based on the ratio of the catchment area to the existing detention volume. Those detention basins where sufficient runoff would be available for additional detention during the 1-year storm received the highest score.
- Cost per acre-foot of storage provided by the site- this was assigned a weight of 25 percent of the total score.
- Location in the watershed, with the upstream portion of the watershed receiving the highest score- this was assigned a weight of 25 percent of the total score.

Figure 6.5.A shows the rankings of the detention and infiltration sites using the criteria described above. Based on this preliminary screening, sites with the higher score should receive first consideration for further site evaluation and funding. Figure 6.5.B shows the location of potential riparian buffer sites identified by the Heritage Conservancy on one or both sides of streams. All riparian restoration sites have a ranking score of 1.5 or higher.

Figure 6.5.A Location and Rank of Proposed Detention and Infiltration Improvements

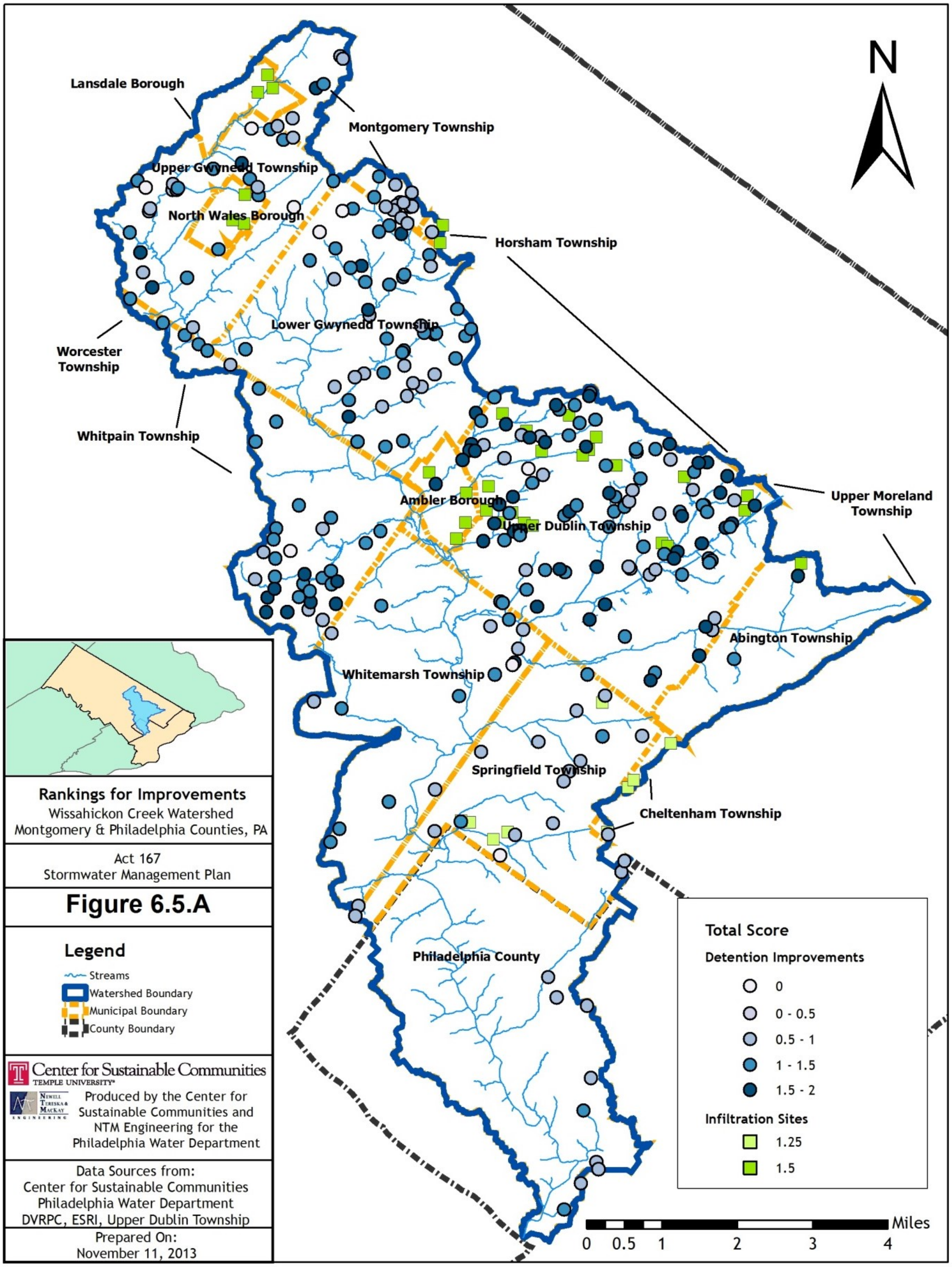


Figure 6.5.B Location of Potential Riparian Buffer Restoration Sites