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This Philadelphia Water Department Backyard Buffer Program (BYB Program) Best Management Practices Report presents the findings of the 2009 BYB Program assessment and analysis process and the resulting Living Streamside Conceptual Designs and Tip Sheets.

The focus of the BYB Program was to empower property owners with educational resources to support the restoration of a portion of their yard adjacent to a stream into a healthy riparian buffer. This was achieved for a first year program through public meetings and workshops; scientific, landscape architecture and engineering based assessments for 33 participant properties and development of previously mentioned Conceptual Plans and Tip Sheets.

Participant property assessments identified three typical properties out of the participant pool which included: 1. a Single Unit Home, 2. a Townhouse or Row Home and 3. a Condominium property. Numerous consistencies in backyard conditions were observed that became the focus of recommended Best Management Practices. These conditions included lack of multi-tiered vegetative structure (layers of plant types/heights including low growing herbaceous plants, shrubs and trees) along the streambanks, mowing up to the banks, and the presence of invasive plants.

Additionally some properties with more severe or extreme streambank erosion were also observed including complete bank failure and undermining of large trees and property fencing. Numerous properties included some remedial bank stabilization in the form of creative reinforcement measures implemented by property owners or others. These included placement of concrete fragments along eroded banks as well as stock piling grass clippings and leaf litter along eroded banks. Another common remedial measure observed was planting of the non-native bamboo.

Although reconnaissance level assessment showed that bank erosion hazard levels and bank stress are typically high along almost all of the creeks observed, stream data analysis shows velocities associated with the bankfull flows are sufficiently low enough to allow for the application of vegetative Best Management Practices (BMPs). Participant properties included portions of streambank where more gradual slopes (e.g.; 3:1) provided potential application of live stakes with the floodplain available for planting/seeding a no-mow zone with long native grasses, wildflowers, trees and shrubs. Portions of streambank observed where more severe slopes and undermining are present may require further geomorphologic study and engineering planning to design appropriate stabilization measures.

BMPs presented in Living Streamside Conceptual Designs and Tip Sheets offer practical measures that can be implemented as individual elements as they can be afforded by the property owner. Many of these BMPs are projects that do not involve work directly along the streambank and can be implemented with readily available materials and minimal assistance such as rain barrel, compost bin, or rain garden installation, and tree/shrub planting. Some BMPs may require assistance from a landscape contractor or handy volunteers, such as installation of permeable pavers.

URS has prepared this report on behalf of the Philadelphia Water Department (PWD) as part of the Backyard Buffer Program (BYB Program). PWD detailed the Program's goals and objectives in the April 25, 2008 Request for Proposal (RFP) "General Design Services for the Backyard Buffer Program" and contracted URS Corporation (URS) on March 12, 2009 with an established scope of work. URS provided the scientific and management prime contractor services and subcontracted with CHPlanning Limited (CHP) for the planning and landscape architecture components of this project.

"The goal of the program is to provide property owners with the knowledge to restore an optimal area of their yard adjacent to the stream to a healthy riparian buffer that will protect the property from erosion, significantly improve the stability of the streambank, and enhance the ecological habitat of the buffer and stream." (PWD RFP April 25, 2008). The program was offered at no cost to property owners living within Philadelphia who reside along the Pennypack Creek, Poquessing Creek or their tributaries (Figure 1).

PWD requested expertise in the ecological restoration of streambanks and riparian buffers with a goal of incorporating Best Management Practices (BMPs) involving landscape design, native plants, stream restoration technologies and habitat enhancement.

Program Objectives:

- Ensure PWD's vision is effectively communicated to homeowners through participation and feedback (public workshops, design materials and interview questionnaire);
- Review & assess existing streambank conditions along participant properties;
- Provide conceptual landscape designs that can be practically implemented; and
- Promote community based partnerships to forward the program's goal.

To fulfill these objectives URS & CHP have performed the following activities with the assistance of PWD:

- Conducted a public outreach program
- Reviewed existing conditions
    - Desktop evaluation
    - Field assessments
- Developed BMP Recommendations
- Developed Conceptual Design Plans

The purpose of this report is to present the methods and findings of the BYB Program assessment process, the resulting recommendations for backyard buffer Best Management Practices, and conceptual designs that provide guidance to homeowners on how to employ these practices.

This report includes seven sections. Beyond this initial section, which additionally presents background information, a methods section (Section 2) describes how the evaluation portion of the program was performed including public outreach efforts and analysis of existing conditions. A findings section (Section 3) describes public response/participation, desktop and field assessment observations and results of analysis. This is followed by a description of the BMPs and resulting conceptual designs that exhibit these BMPs (Section 4). Cost estimates for these conceptual designs are also provided (Section 5). This report closes with conclusions and recommendations (Section 6) giving a synopsis of the program's findings and future steps that could be taken to further the BYB Program. References are presented in Section 7.

1.1 BACKGROUND

This report focuses on streambank and property conditions for the Pennypack Creek, the Poquessing Creek and their tributaries located within Philadelphia County (Figure 1). Public outreach efforts described later in this report resulted in the successful recruitment of 33 property owners whose parcels lie adjacent to one of these waterbodies.

Fifteen of the participant properties were located within the Pennypack Creek Watershed and 18 were located within the Poquessing Creek Watershed. For reference purposes these parcels have been grouped within an assigned "Study Area" which is included in Table 1A (Participant Study Area Summary for Pennypack Creek Watershed) and Table 1B (Participant Study Area Summary for Poquessing Creek Watershed). These tables include additional information such as physiographic province and stream data analysis results which are described later in this report. Study areas are numbered and labeled according to the watershed in which they reside, either PPACK Study Area-# for reaches within Pennypack Creek Watershed (Figure 2, 2A-2E) or POQ Study Area-# for reaches within Poquessing Creek Watershed (Figure 3, 3A-3I).

Participant properties ranged in stream frontage (length of property located adjacent to the waterbody) from 10 feet to 480 feet. The average stream frontage was 130 feet for the participant pool based on available Geographical Information System (GIS) data.

The physical settings of each of these watersheds are briefly described in the following sections. These sections describe the physiography, geology, soils and land use features with particular focus on how these characteristics may affect stream buffers. Developing an understanding of these features and how they may influence the hydrological conditions observed for the subject properties helped to provide a basis for developing the most appropriate BMPs specific to the immediate streambanks and riparian buffer. Additional detailed information for both watersheds can be found in the *Pennypack Creek Watershed Rivers Conservation Plan* (F.X. Browne 2005), the *Pennypack Creek Watershed Study* (Center for Sustainable Communities 2006) and the *Poquessing Creek Watershed Rivers Conservation Plan* (Borton Lawson Engineering 2007).

1.1.1 Pennypack Creek Watershed Characteristics

The Pennypack Creek is a tributary of the Delaware River (Figure 1). The Pennypack Creek Watershed is located in southeastern Pennsylvania and spans 56 square miles of the Piedmont physiographic province and Atlantic Coastal Plain regions. The dividing line between these two regions is near Route 1 which runs in a northeast/southwest direction within Philadelphia County (the City of Philadelphia is wholly within Philadelphia County). Pennypack Creek originates in Montgomery County and to a lesser extent, Bucks County. Its primary tributaries located within Philadelphia County include Rockledge Branch and Sandy Run. Within the city limits, much of the area northwest of Route 1 is within the Piedmont region while all of the area southeast of Route 1 is in the Atlantic Coastal Plain region (F.X. Browne 2005).

The underlying geology of Philadelphia County portion of the Pennypack program study area is metamorphic rock, specifically the Wissahickon Schist. In some areas the schist is covered by depositional sand, gravel, silt and clay. The presence of this unconsolidated material is indicative of the transition area between the Piedmont and Atlantic Coastal Plain Provinces. Most of the soils (53%) in the Pennypack watershed are classified as urban, made land or other disturbed soil groups. F.X. Browne (2005) indicates that these soil types are not well suited for infiltration and groundwater recharge during precipitation events. Within the City of Philadelphia, soils are better drained, however, the significant amount of impervious cover and soil compaction limits the capacity of these soils to absorb stormwater.

A majority of the participants (11 properties) were located in the Piedmont Province on three separate tributaries of Pennypack Creek. None of the participants were located along the main stem of Pennypack Creek. Four additional participant properties were located on two separate tributaries of Pennypack Creek within the Atlantic Coastal Plain Province. These Study Areas including parcel data are depicted in Figures 2-A through 2-E.

Land use in the watershed ranges from urban cover types to public parks and other natural areas. The upper portions of the Pennypack watershed are in Bucks and Montgomery counties where it flows through residential and commercial areas. Once within the City of Philadelphia, the lower section of the watershed lays both within protected lands (700+ acres which includes a portion of Fairmount Park) as well as the same type of developed land uses found in Montgomery and Bucks counties. Land within the watershed was largely developed over a 30 year span between the 1950s and 1980s, which resulted in increased impervious cover, loss of riparian buffers, and increased stormwater runoff that together reduced water quality (Center for Sustainable Communities 2006).

1.1.2 Poquessing Creek Watershed Characteristics

The 21.5-square mile Poquessing Creek watershed lies east of the Pennypack Creek watershed and is also located within the Piedmont and Atlantic Coastal Plain physiographic provinces. Similar to the Pennypack Creek watershed, the Philadelphia County portion of the Poquessing Creek is also largely classified as Atlantic Coastal Plain. The Poquessing Creek originates in Montgomery and Bucks counties and flows through the northeast section of Philadelphia to the Delaware River (Figure 1). The main stem of the Creek is nearly 10 miles long and its main tributaries within the City include Byberry Creek, Black Lake Run and Walton Run.

Six of the 18 participant Poquessing Creek watershed properties were located within the Piedmont Province along one unnamed tributary of Poquessing Creek. The remaining twelve properties were located within the Atlantic Coastal Plain Province. Six of which were located along four different tributaries of Poquessing Creek and six were located along the main stem of Poquessing Creek. These Study Areas are depicted in Figures 3-A through 3-I.

The geology of the Pennypack and Poquessing watersheds are similar within the City of Philadelphia. The Poquessing Creek Watershed is underlain by Wissahickon schist interspersed with areas of unconsolidated sand, gravel, silt and clay. A band of dolomite near the Philadelphia/Montgomery County borders stores water to supply base flow during dry conditions. There are two soil types within the watershed including the Chester-Glenelg-Manor group and the Urban-Westbrook-Pits group. The former group is characteristically very deep, well drained and moderately permeable; the latter group is a more disturbed mixture of soil, rock, and miscellaneous man made material. Borton Lawson Engineering (2007) indicated that the soils in this watershed have a high runoff potential given the dense development within the City. Compaction in areas that are not paved also contributes to high runoff conditions.

With the exception of some wooded areas associated with Fairmount Park lands, the Poquessing Watershed is highly urbanized by residential, commercial and industrial uses.

This section describes the procedures followed to solicit public participation and gain an understanding of citizen concerns regarding stream conditions in their watershed. This section also details the process followed in performing the desktop and field assessments and resulting stream data analysis.

2.1 PUBLIC OUTREACH PROGRAM

An initial public meeting was held to invite participation at the inception of the BYB Program. During the assessment portion of the program, a participant interview questionnaire was distributed and response collected to gain feedback about participant concerns and interests. The BYB Program was also represented through presentations at two additional watershed meetings to promote awareness of the program. Copies of all three presentations are provided on compact disc in Appendix A of this report.

2.1.1 Public Invitation and Orientation Presentation

The BYB Program was kicked off and initial public participation was solicited through an orientation meeting. PWD distributed invitation mailers to approximately 600 homes located within 50 feet of the subject waterbodies. This meeting was held to invite property owners to join the program and have their property assessed for the development of recommended backyard buffer BMP.

URS, CHP and PWD teamed to provide the BYB Program "Public Invitation and Orientation Presentation" on January 22nd, 2009 (6:30-8:30 pm) held at the Community College of Philadelphia.

2.1.2 Participant Interview Process

An interview questionnaire was assembled with input from PWD, CHP & URS and dispersed the week of June 1, 2009 to the participant pool through the mail (including a cover letter and self-addressed stamped envelope), an interactive website located on PWD's website (www.phillyriverinfo.org) and a follow-up call to participants. Website access was indicated in the mailer.

The purpose of the interview questions was to gain an understanding of participants' interests, questions and concerns regarding the BYB Program and the waterbody located in their backyard. This questionnaire also sought to gauge participant willingness and ability to implement BMPs if additional guidance was provided to them.

2.1.3 Other Community/Watershed Meetings

URS participated in the following two watershed meetings to provide progress reports on the BYB Program and increased interest in the program:

- June 4, 2009 Pennypack Watershed Partnership Comprehensive Characterization Report Meeting
- June 9, 2009 Poquessing Watershed Partnership Integrated Watershed Management Plan Kick-off Meeting.

2.2 REVIEW OF EXISTING CONDITIONS

To gain a better understanding of watershed conditions, available reports were reviewed along with available GIS data. Following this desktop evaluation a field assessment was conducted to gather on the ground data to be analyzed using hydrologic modeling software. The results of this analysis were then used to prepare a basis for design of BMPs for backyard implementation.

2.2.1 Desktop Evaluation

In preparation of field assessments, design planning and report development, existing information was reviewed to better understand the watershed characteristics, physical setting and stream channel conditions. The following resources were included in this review:

- Watershed River Conservation Plans (F.X. Browne, Inc. 2005; Borton-Lawson Forbes Environmental. 2007) and studies (Center for Sustainable Communities, Temple University. 2006)
- GIS data provided by PWD including: stream geomorphology and parcel information
- Conservation Buffers Design Guidelines for Buffers, Corridors, and Greenways (Bentrup, G. 2008)
- Adopt-a-Buffer Toolkit (Delaware Riverkeeper Network. 2003)

In addition to these resources, URS reviewed available in-house and web-accessed GIS data sources such as: stream and watershed information (United States Geological Survey National Hydrography Dataset) and soils data (Natural Resources Conservation Service Web Soil Survey).

2.2.2 Field Assessment

URS conducted field assessments of participant backyard buffers and adjacent streams from mid-March through the end of July 2009. Prior to conducting these assessments all participants signed an Access Agreement prepared by URS and approved by PWD. Data packets compiling the documentation described below are provided in Appendix B (Site Data) and are presented specific to the property being assessed. Some documentation contains data for more than one participant property in cases where properties were located across the stream or adjacent to one another.

2.2.2.1 Backyard Field Assessments

For each participant property, backyard landscape and layout conditions were documented, stream geomorphology data was collected, photographs taken, and a site sketch was produced. In addition a landscape architect conducted assessments of a subset of participant properties evaluating associated stream frontage and backyards to gain an understanding of the representative cross-section of typical property conditions. Photographs of representative or typical participant properties are provided in Appendix C.

A Standard Site Data Form and Site Drawing sheet were created for the BYB Program based on a variety of existing data collection examples/methods including: Massachusetts *Adopt-a-Stream Program's Riparian Area Survey*, Delaware Riverkeeper Network's *Adopt-A-Buffer Toolkit* and

Watershed *Assessment of River Stability and Sediment Supply Near-Bank Stress* methodology (Rosgen, D. 2006).

A pair of investigators walked the backyard of participant properties documenting landscape practices and general features/conditions (mowed lawn, tree/shrub plantings, location of structures, etc.) and then chose a cross-section in the stream representative of the stream's channel and banks. At the representative cross-section the Site Data Form, Site Drawing sheet and a Bank Erosion and Hazard Index (BEHI) data sheet were completed and photographs were taken from the center of the stream facing: upstream, downstream and facing both banks (Downstream Left Bank (DSLB) & Downstream Right Bank (DSRB)). In order to create a reference for future bank erosion, monitoring bank pins were installed in proximity of most participants' properties.

The Site Data Form included the following information:

- Riparian buffer characteristics (general landscape practices, width, dominant species, etc.)
- Stream channel observations (stream length observed, channel dimensions, general bed composition, vegetation)
- Evidence of stormwater features/conveyance (pipes, ditches, sediment deposition, overland flow)
- Near-Bank Stress evaluation elements (Methods 1 & 5) (Rosgen, D. 2006)

The Site Drawing sheet included the following information:

- Property owner/address
- Flow path and north arrow
- Location of where Site Data Form was documented
- Toe pin location (if applicable) associated with bank pin installations
- Reference Cross-section location (if applicable)
- General property details (structures, backyard area, waterbody, landscape conditions)

Two Near-Bank Stress (NBS) Methods (Rosgen, D. 2006) were used to assess energy distribution variables which identify a rating from "Very Low" to "Extreme" values. Data collection for both of these methods was entered into the Site Data Form in the field. NBS Method #1 is a rapid check of channel pattern features that create disproportionate energy distribution near the bank region (e.g.; channel bars and extensive deposition). NBS Method #5 calculates the ratio of the near-bank maximum bankfull depth to the mean depth from a riffle cross-section. Ratings that result from NBS Method 5 range from "Very Low" for proportional ratios when the two depth measurements are close and "Extreme" when these numbers vary greatly and yield a disproportionate ratio.

Bank Erosion Hazard Index (BEHI) (Rosgen, D. 2006) data sheets were completed in the field and provide a tool to evaluate multiple variables of potential susceptibility to erosion and based on a rating from "Very Low" to "Extreme" bank hazard conditions. This method looks at the banks face and accounts for the following elements when they are present: root depth, root density, bank angle and surface protection and an adjustment is made for bank material (bedrock providing lower propensity of erosion whereas sand adjusts for high propensity for erosion to occur).

2.2.2.2 Toe Pin and Bank Pin Installation

In support of future bank stability monitoring and to further document existing conditions, bank pins were installed at participant properties and a Bank Pin Data Sheet was created for this program. Bank pins were installed when this procedure was deemed feasible and appropriate to provide a reference for future monitoring efforts. In some instances physical barriers (e.g., large rip-rap or concrete banks, or unsafe conditions) were present that prevented installation. Bank pins were also not installed at a few participant properties in instances where the properties were close together and conditions were thought to be redundant or when the participant's property was not actually connected to the stream bank but was instead located adjacent to the floodplain.

Bank pins were installed as follows:

1. A toe pin (4-foot long rebar rod) was driven flush into the channel bed in proximity (i.e., 2-3 feet) of the bank face and capped with a "PWD Survey" label cap cover. Each toe pin was surveyed using a Trimble GeoExplorer Global Positioning System (GPS).

2. Bank pins (5/16 inch diameter x 3 feet long smooth steel rods) affixed with red duct tape and pink-white striped flagging at one end were driven perpendicular, into the bank face and at a cross-section location closest to the installed toe pin. Typically one or two bank pins were installed at each stream bank face.

3. Bank pins were installed below and above the bankfull elevation whenever feasible. However, in some cases bankfull elevation also corresponded with the top of the bank and was at a low enough elevation (approximately 2-3 feet above toe of slope) to warrant installation of only one bank pin.

4. Following installation, measurements (elevation starting from toe pin and vertical distance from rod to bank) were taken horizontally to top of bank from a rod positioned vertically over the toe pin.

A Toe Pin Data Sheet was completed to document field measurements. This sheet includes vertical and horizontal measurements yielding a Vertical Bank Profile of either the Downstream Left or Downstream Right bank. Bank pin locations are noted and their exact horizontal and vertical measurements are provided in tabular form to the nearest 10^{th} of a foot. The Toe pin location is also shown as a reference for vertical rod placement when taking future monitoring measurements.

Standard documentation described above (Site Data Form, Site Drawing, Photographic Log and Bank Erosion Hazard Index) and Bank Pin Data Sheets (prepared when applicable) are provided in Appendix B (Site Data) in data packets specific to the property being assessed.

2.2.2.3 Reference Cross-section Data Collection

Lastly, reference cross-sections and a longitudinal profile were surveyed using a laser level at three representative study areas (POQ Study Area-1, PPack Study Area-2 and PPack Study Area-4) to collect data for hydrologic modeling.

Visual indicators of bankfull such as a break in slope, exposed roots, terraced or benched side bank features were documented for use with reference in modeling software described further in Section 2.2.3.

2.2.3 Stream Data Analysis

Watershed and hydrology data was analyzed to evaluate flow at three representative/reference cross-sections located in both watersheds. URS used flow data to model anticipated velocities of each cross-section and compare representative stream velocities with published data that provides thresholds for the application of vegetative bank stabilization methods (e.g., live stakes and native grasses). These thresholds were then used to assist in preparing appropriate BMP recommendations.

URS coordinated with PWD to obtain available stream survey information from previous investigations. Two PWD cross-sections (summer 2008 data collection) were identified in proximity of participant properties/study areas. URS replicated these cross-section surveys at the same locations in spring of 2009. These cross-sections are identified as PQMSD18 (POQ Study Area-1) and PPPR06 (PPACK Study Area-2) by PWD. URS used these two cross-sections to gauge reference elevations observed in the field such as bankfull stage. URS also used the reference cross-sections URS created (2009) in hydrology modeling described below.

Reference cross-section data collected by URS was input to modeling software to determine if any channel forming processes may limit or guide the design of BMP recommendations. This was performed to provide quantitative comparison between representative stream channels flow velocity and available data regarding stabilization applications that could potentially be used in the BMP recommendations. This evaluation was also conducted to gauge visual observations of bankfull conditions made in the field which play an important role in the modeling process.

The following modeling tools were used for assessment (calibration) of stream bank conditions relative to applicable BMP recommendations:

- The Reference Reach Spreadsheet for Channel Survey Data Management (v4.3L) Ohio Department of Natural Resources (ODNR),
- FlowMaster (v7.0) Haested Methods Inc.
- Technical Release (TR-55), Urban Hydrology for Small Watersheds, Natural Resources Conservation Service (NRCS)
- StreamStats (web-based Geographical Information System) United States Geological Survey (USGS)

<u>Hydrology</u>

A hydrologic analysis was performed for each stream segment in order to determine the storm event (1 year, 1.5 year, 2 year, etc) that would result in the bankfull flow. The USGS web based application StreamStats was used to determine peak discharges in each stream segment. StreamStats uses empirically derived regression equations to determine peak flows. The regression equations are designed for use with watersheds that are greater than 2.02 square miles. In each of the cases studied for this report, the contributing watershed was less than this value (POQ Study Area-1: 1.54 sq. mi.; PPACK Study Area-2: 1.87 sq. mi.; PPACK Study Area-4: 0.53 sq. mi). For this reason, a second hydrologic analysis was performed using the TR-55 method, using the areas that were determined using StreamStats. While the StreamStats results were not used, they are presented for comparison purposes.

Using the drainage areas as determined with StreamStats, a Curve Number and Time of Concentration were developed for each of the drainage areas. Rainfall values were determined using the methodology contained in Chapter 7, Appendix A of the PennDOT Drainage Manual.

A representative cross-section from each stream segment was modeled using FlowMaster by Haested. FlowMaster is an open channel modeling program that can be used to model flow in individual cross-sections. FlowMaster was used to determine channel flow (in cubic feet per second) in each stream segment based on the observed bankfull condition. This flow was then compared to results of hydrologic modeling to determine the corresponding rain event.

As a check on the results from FlowMaster, the POQ Study Area-1 segment was modeled using HEC-RAS. While FlowMaster evaluates a single cross-section, HEC-RAS is a one-dimensional flow model that uses several cross-sections to develop a water surface profile for a stream segment. The comparison was performed using the bankfull flow as determined in the field. For this comparison, cross-section PQMSD18 was used.

This section details the outcome of the public outreach efforts taken to increase awareness about the BYB Program and solicit feedback in the development of the program. This section of the report also summarizes the desktop evaluation, field assessment and stream data analysis findings.

3.1 PUBLIC OUTREACH PROGRAM

Three public meetings were held in which the BYB Program was discussed in a public forum. As previously stated, copies of each presentation can be found in the back of this report on a compact disc in Appendix A.

3.1.1 Public Invitation and Orientation Presentation

Approximately 36 members of the public attended this presentation that introduced the program's objectives and invited property owners to join the program. Of the attendees (including a few additional residents who signed up in the following months) a total of 33 property owners signed access agreements to participate in the program.

Additional support for this meeting included speaking representatives from the following organizations: Pennsylvania Audubon Society (Audubon At Home program), Fairmount Park (Pennypack Environmental Center), The Friends of Poquessing Watershed Inc. of Philadelphia and Bucks County, Friends of Pennypack Park (could not attend but contact information was provided) and The Pennypack Watershed Partnership.

A majority of the homeowners present expressed concern about moderate to serious erosion experienced on their properties. Many felt that vegetation and other backyard buffer BMPs described may not help and that hard armoring or other engineered means would be necessary to prevent further erosion of stream banks adjacent to their properties.

3.1.2 Participant Interview Process

The interview questions asked about participant motivation and expectations of the program, experience with flood and erosion and interest in implementing landscape practices that may improve the riparian buffer on their properties. The following 17 questions were presented to each participant through a mailed letter and interactive webpage:

1. What motivated you to sign up for the backyard buffer program?
2. What are your expectations of this program?
3. How long have you lived at the property?
4. Is there any landscaping or planting advice you were specifically hoping to gain from this program?
5. What are your observations of changes in the stream channel over time?
6. Does the stream ever flood over the banks and onto your property? If so, how many times a year and how far onto your property does flooding occur?
7. Does flooding or any other stream conditions cause any property issues that concern you?

8. Are you experiencing erosion on your property?

9. Are you willing to consider creating a no-mow zone along the stream bank section of your property?

10. Are you willing to add some tree and/or shrub plantings along the stream bank section of your property?

11. Do you plan on doing any of the suggested work yourself (i.e., planting shrubs and seeding) when design plans are developed for this program or would you look to hire a contractor?

12. If we are able to organize enough owners to purchase plants at wholesale or discounted retail prices, would you be interested in buying plants for your property?

13. Can we use photographs of your property for workshops or other educational purposes? URS Corporation, Philadelphia Water Department and CH Planning Limited will keep your identity and property address anonymous.

14. Do you have any photographs of flooding or relevant historic stream patterns you could share?

15. How do you use your backyard? (e.g.; kids area to play, barbecues, pets, outdoor relaxation, etc.)

16. What type of landscaping or changes to your property in regards to stormwater management have you done up to this point?

17. If you plant the recommended backyard buffer design that is provided for your property, can PWD check in with you on a yearly basis to see how you and your yard are doing? We'd like to get your advice and feedback to continually improve this program.

A total of 18 participants responded to the questionnaire. Six responded through the website, 12 responded through the mail and no one participated in a phone call based interview. However, the phone call initiative likely promoted some participants to complete the interview who may have forgotten to do so.

Response to the questionnaire included the following interest/concerns:

- Almost all stated observations of bank erosion and heavier flows following rain events.
- Many reported some form of vegetation loss, including the loss of trees and shrubs.
- Many were looking to gain landscaping recommendations for erosion control.
- Many considered it a possibility to create a no-mow zone and/or add some trees and shrubs to their yards.

One participant was interviewed during the property assessment and was not included in the questionnaire process due to the extreme nature of their yards soil failure and bank erosion. URS relayed this information to PWD.

3.1.3 Other Community/Watershed Meetings

URS provided a short presentation for two watershed meetings (June 4 and 9, 2009) to promote the mission of BYB Program and invite community members in addition to the program participants to join the July 22, 2009 Living Streamside Workshop. The short presentations summarized the progress of the BYB Program assessment process and gave some preliminary explanation of findings and developing BMP recommendations.

3.2 REVIEW OF EXISTING CONDITIONS

Desktop evaluations, field assessment and stream data analysis described in the sections to follow identified consistent or representative conditions that were used in preparation of BMP recommendations. These representative conditions identified three typical property types or layouts and also provided a reference for potential limitations in the application of some stream bank specific vegetative measures that are included in the BMP recommendations.

3.2.1 Desktop Evaluation

Physiographic province was noted to assess if potential bank stability could be influenced by the difference in geology and topography. Participant properties and their physiographic province are listed in Table 1A (Participant Study Area Summary Pennypack Creek Watershed) and Table 1B (Participant Study Area Summary Poquessing Creek Watershed).

Aerial photography reviewed in GIS provided an overview of access points and constraints for planning field work. It also provided a reference for riparian buffer canopy cover for confirming general site observations such as tree versus lawn cover and identifying drainage patterns of unnamed tributaries not identified on published maps.

Numerous desktop and web-based references were used as a basis for the selected BMPs and these are discussed in detail in Section 4.0.

3.2.2 Field Assessment

Field assessment observations found three typical properties representative of the participant pool. These typical properties were: 1. a Single Unit Home, 2. a Townhouse or Row Home and 3. a Condominium property. As previously stated, photographs are provided in Appendix C (Typical Property Photographs) that give a representative visual depiction of these typical properties.

Photographs 1 and 2 which are of two separate properties show the typical Single Unit Home with a mowed lawn mixed with flood-tolerant ground cover (very often non-native Lesser celandine (*Ranunculus ficaria*)) with a few shrubs and trees present. Photographs 3 and 4 show similar backyard conditions observed for the typical Townhouse or Row Home as were observed for the Single Unit Home. A few of these type homes (represented by Photograph 3) were located at the top of steep slope which limited access to the immediate banks of the backyard creek.

Photographs 5 and 6 are of a typical condominium participant property. This property had a floodplain or stream buffer containing mowed grasses and the non-native Lesser celandine ground cover. Photograph 6 depicts a drainage swale and outlet that likely drains to the nearby creek.

Portions of these three typical properties all exhibited conditions that could support improvements to their backyard buffers. Most participant properties included some portion that could likely benefit from supplemental planting of trees and shrubs as well as establishment of a zone where mowing was ceased and native plants were established. As well, many properties contained portions of banks that could potentially benefit from live stake installations. While portions of streambanks on some properties will need further assessment to identify more in-depth measures to abate erosion.

Additionally some properties with more severe or extreme streambank erosion were also observed. Photographs 7 and 8 provide two of the worst cases observed including complete bank failure (Photo 7) and undermining of large trees and property fencing (Photo 8).

Numerous properties included some remedial bank stabilization in the form of creative reinforcement measures implemented by property owners or others. These included placement of concrete fragments along eroded banks as well as stock piling grass clippings and leaf litter along eroded banks. Another common remedial measure observed was planting of the non-native bamboo.

The primary landscape observations that may contribute to stream bank erosion included: lack of multi-tiered vegetative structure (layers of plant types/heights including low growing herbaceous plants, shrubs and trees) along the stream banks, mowing up to the banks, and presence of invasive plants.

BEHI and NBS documented for the participant properties indicated qualitatively through a rapid reconnaissance level assessment that bank erosion hazard levels and bank stress are typically high along almost all of the creeks observed. Although these properties contained areas with high results of hazard and stress these conditions were present for portions of the bank segments and in contrast as well, portions of the same banks contained less extreme conditions. For example, Photograph 1 of the banks along the 630 Maple Avenue property shows a gradually sloping (approximately 3:1 slope) directly in contact with the floodplain where floodwaters can escape the channel and appropriately flood the floodplain. This property also exhibited more eroded banks with closer to right angle (90 degree) banks as well which correspond with the more susceptible bank erosion conditions. Many participant properties contained the variation in conditions similar to this situation.

Bank pin installation was conducted for future monitoring of bank erosion. Tables 2A (Toe/Bank Pin Summary Pennypack Creek Watershed) and 2B (Toe/Bank Pin Summary Poquessing Creek Watershed) document toe pins surveyed at each property using GPS and identifies corresponding bank pins. Table 3 (Toe Pin GPS Coordinates List) presents the location of all toe pins installed and their respective GPS coordinates for ease of future reference, location and monitoring.

3.2.3 Stream Data Analysis

URS conducted analysis of representative cross-sections to evaluate anticipated flow velocities and compare this information with reported threshold parameters identified for vegetative BMP applications. It should be noted that this was a limited survey effort and was not intended to be exhaustive in nature. The intent of the hydrologic and hydraulic modeling was to determine what flow velocities would be expected during the bankfull condition, and during what storms that would occur. This information could then be used as a guide in the selection of vegetative practices to provide bank stabilization.

Cross-sections were taken at representative participant parcels for a small subset of the participant pool. The nature of the BYB Program was to provide conceptual landscape BMPs that a homeowner can perform. Advanced engineered designs were not included in this program and thus extensive stream geomorphology, hydrology and hydraulic evaluations were not performed. This section provides findings of the stream data analysis that was performed for three reference cross-sections that helped identify appropriate BMPs described in Section 4.

Locations in either the Piedmont or the Atlantic Coastal Plain were generally found to have high to extreme bank stress indicators. Therefore the delineation between physiographic provinces was not determined to be significant in BMP development.

Based on field observations of what URS interpreted in the field to be bankfull elevation at the POQ Study Area-1, PPACK Study Area-2 and PPACK Study Area-2 sites, water surface elevations (WSE) corresponding to the bankfull condition were determined for each stream segment. For purposes of this study, the bankfull condition is not the maximum WSE that the channel can contain, but rather the WSE that corresponds to frequently occurring stream flow. This elevation is important because it corresponds to a primary channel forming discharge and based on interpretation and entry into modeling software, it influences cross-sectional area and flow/velocity estimates. Field observations were tabulated using a spreadsheet model developed by the Ohio Department of Natural Resources (ODNR). This spreadsheet uses cross section data collected in the field and, among other values, produces flow velocities and shear stress values.

Hydrology

Results of both the StreamStats and TR55 analyses are summarized in Table 4A (Hydrology - Estimated Peak Flows). StreamStats is a web-based application, made available through the USGS, that uses empirically derived regression equations to estimate peak flows in ungaged streams. Developed by the NRCS, Technical Release 55 (TR-55) is commonly used to develop the peak rate of runoff, as well as runoff volume, for small watersheds using the curve number method.

TR-55 tends to produce conservatively high estimates of peak flows. This is evident in the larger (50 and 100 year) storms that were modeled. Peak flow results from the TR-55 analysis for storms of interest for the Backyard Buffer program (the 1-year to 5-year storms) are in relatively close agreement with StreamStats and considered accurate for use in a hydraulic analysis.

A representative cross section from each stream segment was modeled using FlowMaster by Haested. FlowMaster is an open channel modeling program that can be used to model flow in individual cross sections. FlowMaster was used to determine channel flow (in cubic feet per second) in each stream segment based on the observed bankfull condition. This flow was then compared to results of hydrologic modeling to determine the corresponding rain event. Results of this analysis are summarized in Table 4B (Hydrology - Bankfull Storms).

Velocity

Expected flows during the bankfull condition for each stream segment were modeled to determine the anticipated velocity. Flow velocity is a critical factor in determining the appropriate method for streambank stabilization. In general, lower velocities (< 6 ft/sec) can be treated with vegetative practices. When velocities are greater than 6 ft/sec more structural methods (key stones, rip rap, etc) may become necessary. Velocities as determined using the ODNR spreadsheet and FlowMaster are summarized in Table 5 (Expected Velocities).

In the ODNR method, the slope is calculated using thalweg measurements taken over the length of the reach, while the slope for the FlowMaster calculations was determined using data from the bounding cross sections. This resulted in variation between velocities as calculated by the two methods. In each case however, the calculated velocity is within the permissible range for application of vegetation to support bank stabilization.

Comparison Check

As a check on the results from FlowMaster, the POQ Study Area-1 segment was modeled using HEC-RAS. While FlowMaster evaluates a single cross-section, HEC-RAS is a one-dimensional flow model that uses several cross sections to develop a water surface profile for a stream segment. The comparison was performed using the bankfull flow as determined in the field (234 cfs). For this comparison, station PQMSD 18 was used as it was felt that is was representative on a general level to the larger pool of participants. Both FlowMaster and HEC-RAS WSE were very close in elevation, 101.3 ft and 101.17 ft, respectively with reported velocities of 4.7 ft/sec and 5.05 ft/sec respectively.

The close correlation between the HEC-RAS and FlowMaster results validates the use of FlowMaster for this study. The differences in water surface elevation and velocity are negligible and attributable to the different computation methods used by the two models.

The findings of the stream data analysis shows that while BEHI and NBS survey show extensive areas of high to extreme bank erosion hazard and bank stress, the velocities associated with the bankfull flows are sufficiently low to allow for the application of vegetative BMPs.

Field assessments and stream analysis results were used to develop recommendations of appropriate BMPs and identify potential limitations for these applications. These recommendations were applied to graphic renderings of the three typical participant properties (Single Unit Home, Townhouse or Row Home, and a Condominium) and resulted in the Living Streamside Conceptual Plans (Appendix D). The BMPs were then refined to provide property owners a general guidance presented in the eight Living Streamside Tip Sheets listed below (and provided in Appendix E):

- Tip Sheet #1 *No-mow Zone*
- Tip Sheet #2 *Green Lawn Basics*
- Tip Sheet #3 *Native Plants for Pennsylvania*
- Tip Sheet #4 *Tree & Shrub Planting Basics*
- Tip Sheet #5 *Composting*
- Tip Sheet #6 *Rain Barrels*
- Tip Sheet #7 *Permeable/Porous Pavers*
- Tip Sheet #8 *Live Stakes*

These tip sheets serve as the BMPs for the project. The only one that is not an actual BMP and is more of an informational resource is Tip Sheet #3 (Native Plants for Pennsylvania).

Many of the developed BMPs were based upon simplified stormwater practices presented in Philadelphia Stormwater Management Guidance Manual (City of Philadelphia. 2008) and other guidance publications including: A Homeowner's Guide to Stormwater Management (PWD, Office of Watersheds. 2006), The Tree Tenders Handbook (Pennsylvania Horticultural Society. 2005) and the Adopt-a-Buffer Toolkit (Delaware River Keeper Network. 2003).

Table 6 (Permissible Velocity for Selected Bed and Bank Applications) has been compiled using available research (Center for Watershed Protection. November 2004 and Fischenich, C. May 2001) to compare velocity thresholds of certain bank stabilization materials with velocities estimated for reference cross-sections taken within the BYB Program study areas.

Specifically, Tip Sheets #1 (No-Mow Zone) and Tip Sheet #8 (Live Stakes) advocate the use of plant materials landward above the bankfull elevation (No-Mow Zone) and on the face of the streambank (Live Stakes). As identified in data presented in Section 3.2.3, expected velocities for the overall study set ranged from 2.4 to 5.06 ft/sec. According to the research cited, vegetation such as long native grasses has a threshold limit of 4 to 6 ft/sec indicating that it has a chance to become established in a number of locations. Live willow stakes are reported to have a threshold limit of 3 to 10 ft/sec which is also within the range of potential application for the study sites.

Table 7 (Participant BMP Summary) provides the BYB Program participants with the BMPs that are recommended for each participant's property. Please note that these recommendations are based on a conceptual level planning assessment of representative site conditions and application of BMPs may require further assessment and design on a case by case basis.

Conceptual Designs as described in Section 4.0 are defined by Tip Sheets and are depicted in Living Streamside Conceptual Plans for the three typical properties participating in the BYB Program. Six of the eight tip sheets contain implementation guidance and associated costs. The remaining two tip sheets (Tip Sheet #2 Green Lawn Basics and Tip Sheet #3 Native Plants for Pennsylvania) are informational resources that do not define actual activities with associated costs.

Estimated conceptual level costs for the following BMPs/tip sheets have been summarized in Table 8:

- Tip Sheet #1 *No-mow Zone*
- Tip Sheet #4 *Tree & Shrub Planting Basics*
- Tip Sheet #5 *Composting*
- Tip Sheet #6 *Rain Barrels*
- Tip Sheet #7 *Permeable/Porous Pavers*
- Tip Sheet #8 *Live Stakes*

Tip Sheet #1 (*No-mow Zone*) details the costs associated with site preparation and seeding of a streamside buffer. Based on the range of observed property frontages (average length of approximately 130 feet) and available material unit sizes, 100 linear feet of frontage was assumed and applied to a 10-foot wide buffer. This provided for 1,000 square-feet of no-mow zone development at a cost of approximately $425.

Tip Sheet #4 (*Tree & Shrub Planting Basics*) details tree and shrub planting costs associated with the same 1,000 square-foot buffer identified for Tip Sheet #1 (*No Mow Zone*). This planting is not a complete riparian streamside restoration buffer design rather a starting point of planting that is an affordable initial planting that can be expanded upon. This planting includes four trees and eight shrubs. Total cost for the plant materials not including installation or delivery totals approximately $540.

Tip Sheet #5 (*Composting*) identifies the cost of two sizes of commercially available plastic compost bins. Sizes reported by local home/hardware stores ranged from $100 for an 80 gallon unit and $160 for a 170 gallon unit. Many municipalities and the Penn State University Cooperative Extension offer classes where free or discounted compost bins are offered for around $30 to $40.

Tip Sheet #6 (*Rain Barrels*) identifies the cost of two different models of commercially available rain barrels. A simple plastic pre-fabricated barrel cost $100 and a more decorative wooden barrel cost $250. This sheet also describes availability of rain barrel workshops offered by PWD as well as other civic partners and non-profit organizations.

Tip Sheet #7 (*Permeable/Porous Pavers*) details costs associated with the installing a 10-ft by 20-ft patio or driveway. Since this is not a typical homeowner/do-it-yourself project, landscape contractors in the Philadelphia area were contacted for cost estimates. Prices for fully installed permeable or porous pavers ranged from $15 to $20 per square foot. Thus, total cost for the paving a 200 square foot area ranges between $3000 and $4000.

Tip Sheet #8 (*Live Stakes*) details costs associated with installing stakes over a four foot high streambank face for a distance of 100 feet. It was assumed that the stakes would be planted four foot on-center requiring 24 total stakes be installed. Six additional stakes were included as a level of safety factor to compensate for possible plant mortality. A total of 30 live stakes would cost approximately $50.

Most of the properties within the participant pool are suitable for application of several BMPs. As an example, a homeowner could potentially take both the compost and rain barrel classes and for less than $50 have both of these BMPs with minor acquisition and installation effort. The same homeowner could also gain the assistance of some friends and install a No-mow zone for around $425 and could also plant the recommended number of trees and shrubs for approximately $540. In summary a home employing four BMPs (compost bin, rain barrel, no-mow zone and tree and shrub plantings) that would have a potentially significant impact on their property and contribute to watershed benefits could do so for around $1,000.

The BYB Program goal of empowering property owners with educational resources to support the restoration of a portion of their yard adjacent to a stream into a healthy riparian buffer was achieved for a first year program through public meetings and workshops; scientific, landscape architecture and engineering based assessments; and development of conceptual plans and resource Tip Sheets.

Public outreach efforts beginning with a mass mailer sent to 600 individual homes located within fifty feet of the study area waterbodies resulted in 36 property owners attending an initial orientation meeting. Of the 36 attendees approximately 30 ended up signing access agreements enabling them to become participants in the BYB Program. Another three property owners joined the program through contact with field staff or through other means of communication. Further discussion with consulting planners is recommended and may result in determining more effective means of soliciting response in addition to mailer recruitment. Variations in recruitment methods should be considered for future outreach efforts such as newspaper announcements and mailers included with bills sent to customers. Although out of 600 mailers only 6% of property owners responded and attended the orientation meeting, over 80% of attendees at the meeting ended up participating in the program.

An interview questionnaire sent to each of the 33 BYB Program participants resulted in completion of the questionnaire by 12 participants supplying valuable comments from personal experience. This 36% response rate is considered a positive outcome and is recommended for the continuation of future program initiatives to gather participant feedback and initiate dialog.

Three typical property layouts (Single Unit Home, Townhouse/Row Home, and Condominium) were identified in the participant pool. General landscape and backyard stream buffer conditions consistently included: mowing to top of the streambank, presence of invasive or non-native plant species and the lack of a healthy and multi-tiered vegetative structure and buffer. Field assessment observations also documented moderate to extreme bank erosion including conditions that would require more in-depth geomorphologic and engineering based assessments to provide adequate restoration approaches. Numerous properties could also benefit from simple techniques like the ceasing of mowing activities within the immediate stream buffer and some supplemental planting of trees and shrubs and application of native wildflower and grass seeding.

Tip Sheets and Conceptual Plans were provided to the participants and a larger community audience on July 22, 2009 and these resources provide low-cost methods and practical landscaping measures that can help prevent streambank erosion and improve the backyard/riparian buffer.

In support of future bank erosion monitoring, bank pins were installed at 25 properties. A plan for future monitoring of these bank pins is recommended to further understand how bank stability along study streams may be changing. As well, if BMPs are installed at participant properties, monitoring will also help to determine the effectiveness of the BMPs under studied conditions.

Analysis of stream data was performed for three representative sets of cross-sections as an initial gauge to assess vegetation based bank stabilization applications. This study suggested that planting of a riparian backyard buffer (live stakes, long native grasses, and shrubs/trees) is appropriate for most of the participating property owners' bank conditions. In certain cases with extreme erosive conditions, additional study and planning may be prudent to help guide more extensive stabilization efforts beyond the scope of this project.

It is also recommended that resources be focused on continued monitoring of installed bank pins and data collection as well as implementation of demonstration projects at residential, commercial and/or public properties to demonstrate benefits of recommended BMP installations.

Expansion of the BYB Program may also be considered into other watersheds in Philadelphia and continued partnership building with the watershed organizations and other resource groups that promote volunteer and community based support initiatives for the “greening” of Philadelphia.

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APPENDIX A
Workshops/Presentations (Single Compact Disc)

APPENDIX B
Site Data (Site Data Form, Site Drawing, Photographic Log, BEHI Data Sheet, Bank Pin Data Sheet)

APPENDIX C
Typical Property Photographs

APPENDIX D
Living Streamside Conceptual Plans

APPENDIX E
Living Streamside Tip Sheets