PLANNING AND IMPLEMENTING GREEN STORMWATER INFRASTRUCTURE

Altje Hoekstra, EIT, LEED AP
Senior Water Resources Designer
Meliora Design

Seung Ah Byun, PhD, P.E., LEED AP
Senior Planner for Water Resources
Brandywine Conservancy

APA-PA Conference (Allentown, PA)
October 16, 2016
OUTLINE

• Water Cycle
• CSOs
• Philadelphia
  • Green City, Clean Waters
  • Planning process
  • GSI Examples
• What’s happening in other cities
• New Municipal Stormwater Regulations
• Regulatory Tools for GSI
• GSI Implementation in Small Municipalities
• Incentive Program for GSI
Meliora Design

WHO WE ARE

• Civil engineering
• Specialize in Sustainable Site Design and Stormwater Management
• Planning
• Advocacy
• Certified Women-owned Business Enterprise (WBE)
Natural Water Balance
Philadelphia, PA

Annual Rainfall: 45 in.
Evaporation: 22 in.
Runoff: 11 in.
Infiltration: 12 in.

Annual Rainfall

Philadelphia, PA

45 in.
22 in.
11 in.
12 in.
RAINFALL: 45” per year on average

**Frequency:** Most of the time, it rains 1 inch or less

Annual Percentages of Volume from Storms

- 0-1” Storms: 61%
- 1-2” Storms: 27%
- 2-3” Storms: 8%
- 3”+ Storms: 4%

Small storms comprise most of the annual **Volume** of rainfall.
Philadelphia

Image Source: Google Earth
Combined Sewer Systems (CSS)

Overflow to waterway
Combined Sewer Overflows (CSO)
Green City
Clean Waters
The City of Philadelphia’s Program for Combined Sewer Overflow Control
A Long Term Control Plan Update

5 Down, 20 to Go: Celebrating 5 Years Neighborhoods

As of June 1, 2016 the Green City, Clean Waters program has established 837.7 Greened Acres, exceeding the five-year regulatory target and reducing pollution from stormwater runoff and combined sewer overflows by more than 1.5 billion gallons annually.

- Public Green Stormwater Infrastructure Projects
- Incentivized Stormwater Infrastructure Projects
- (Re)Development Green Stormwater Infrastructure
Live Slides web content

To view

Download the add-in.
liveslides.com/download

Start the presentation.
Planning for Success

• Mapping
• Site Analysis

• Capital Projects are an opportunity for GI:
  • Sidewalk improvements
  • Intersection improvements
  • Water and sewer line work

• All municipal and public projects maximize GI (schools, parks, streets, etc.) are opportunities

• Public involvement early on
• Project tracking
• Maintenance Plans & Training
GIS BASEMAP LAYERS

- Conceptual Work
  - GSI SMP Footprint Concept
  - GSI Drainage Area Concept

- Planning Group Layers
  - Project Opportunity Parcels in CSO
  - Planning Study Areas

- Existing Projects
  - CAPIT Projects
  - SW Permit Tracking
  - GSI Project Areas
    - Green Stormwater Infrastructure
    - Green Stormwater Infrastructure Drainage Area

- PWD Infrastructure
  - Sewer
    - Combined System (CSO)
      - Inlet
      - Manhole
      - Sewer Inlet Pipe
      - Sewer
      - Waste Water Vent Pipes
    - Separate & Green System (SS)
      - Stormwater Manholes
      - Stormwater Inlets
      - Stormwater
      - Stormwater Inlet Pipes
      - Stormwater Vent Pipes
  - Water
    - Fire Hydrant

- Environmental
  - Flow Network
    - Ridges
    - Nodes
    - Valleys
    - Streets
  - Impervious and Sewersheds
  - Philadelphia Major Watersheds
  - Sewersheds
  - Modelsheds

- Reference
  - Neighborhoods
  - Council Districts 2016
  - Land Use
  - Philadelphia Planning Districts
  - Philadelphia Parks & Recreation
  - Philadelphia City Limits

- Base Layers
  - Streets
  - PWD Parcels
  - Topographic 2’ Contours
  - Curbs
  - Hydrology Centerline
  - Hydrology Polygon
  - Aerial Imagery 2012
PREVIOUS STUDIES
DRAINAGE AREA MAPPING
UTILITY MAPPING
GSI SIZING

- DRAINAGE AREA > 5,000 SF
- DOWNSTREAM OF EXISTING INLET
- 3’ BUFFER FROM ROW LINE
- 5’ BUFFER FROM ADJACENT PROPERTY LINE
- 4’ MINIMUM TREE TRENCH WIDTH
- 3’ BUFFER FROM UTILITIES
- 20’ MINIMUM STREET WIDTH FOR BUMPOUTS
GSI OPPORTUNITIES

- UTILITIES
- SUFFICIENT SPACE FOR SMP FOOTPRINT
- MATURE TREES
- STEEP TOPOGRAPHY
- PREFER: SCHOOLS, PARKS, VACANT LOTS, TAX DELINQUENT PARCELS
## GIS Layer – Constraints

<table>
<thead>
<tr>
<th>Field</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drainage Area ID</td>
<td></td>
</tr>
<tr>
<td>PlanIT ID</td>
<td>&lt;Null&gt;</td>
</tr>
<tr>
<td>Drainage Area Feasibility</td>
<td>&lt;Null&gt;</td>
</tr>
<tr>
<td>Constraints 1</td>
<td>&lt;Null&gt;</td>
</tr>
<tr>
<td>Constraints 2</td>
<td>&lt;Null&gt;</td>
</tr>
<tr>
<td>Constraints 3</td>
<td>&lt;Null&gt;</td>
</tr>
<tr>
<td>Obscuring Utilities 1</td>
<td>&lt;Null&gt;</td>
</tr>
<tr>
<td>Obscuring Utilities 2</td>
<td>&lt;Null&gt;</td>
</tr>
<tr>
<td>Obscuring Utilities 3</td>
<td>&lt;Null&gt;</td>
</tr>
<tr>
<td>Notes</td>
<td>&lt;Null&gt;</td>
</tr>
<tr>
<td>Editor</td>
<td>&lt;Null&gt;</td>
</tr>
<tr>
<td>Edited By</td>
<td>&lt;Null&gt;</td>
</tr>
<tr>
<td>Consultant</td>
<td>&lt;Null&gt;</td>
</tr>
<tr>
<td>GlobalID</td>
<td>9E2B359E-75D6-491B-B3EC-6957BCD</td>
</tr>
<tr>
<td>OR_Drawnby</td>
<td>&lt;Null&gt;</td>
</tr>
<tr>
<td>OR_Drawndate</td>
<td>&lt;Null&gt;</td>
</tr>
<tr>
<td>Shape.STArea()</td>
<td>30,900</td>
</tr>
<tr>
<td>Shape.STLength()</td>
<td>1875.136371</td>
</tr>
</tbody>
</table>
## TRACKING DATA

<table>
<thead>
<tr>
<th>Data Tracking (Recommended): Study Area</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>GSI Project</strong></td>
</tr>
<tr>
<td>---</td>
</tr>
<tr>
<td>FC10</td>
</tr>
<tr>
<td>FC11</td>
</tr>
<tr>
<td>FC62</td>
</tr>
<tr>
<td>FC63</td>
</tr>
<tr>
<td>FC64</td>
</tr>
<tr>
<td>FC65</td>
</tr>
<tr>
<td>FC66</td>
</tr>
<tr>
<td>FC67</td>
</tr>
<tr>
<td>FC68</td>
</tr>
<tr>
<td>FC69</td>
</tr>
<tr>
<td>FC70</td>
</tr>
<tr>
<td>FC71</td>
</tr>
<tr>
<td>FC72</td>
</tr>
<tr>
<td>FC73</td>
</tr>
<tr>
<td>FC74</td>
</tr>
<tr>
<td>FC75</td>
</tr>
<tr>
<td>FC76</td>
</tr>
<tr>
<td>FC77</td>
</tr>
<tr>
<td>FC78</td>
</tr>
</tbody>
</table>
SITE VISITS

1. Confirm parcel name (if applicable)
2. Inlet locations - identify type and current condition
3. Tree locations - identify location and note condition.
4. Access points - identify locations of gates, doors, curb cuts and driveways
5. Utility mark-outs- identify type and distance from front of curb
6. Valves and manholes - identify type (gas, sewer, water, unknown)
7. Handicap ramp locations and condition
8. Bus stops and other public transit
9. Sidewalk widths
10. Sidewalk condition
11. Curb reveal- identify material and reveal
12. Parking-identify no parking zones and the type and location of parking spaces
13. Bike lanes - note location
14. Overhead wires - identify location and clearance
15. Runoff flow directions (i.e. surface flow directions)
16. Misc. features such as fire hydrants, bollards, traffic lights, and poles
PROJECT SHEETS

901 EAST WESTMORELAND STREET

Legend
[Legend details provided]

Existing Site Photos

Utility Crossings For Drainage Areas

H STREET
- 6" Gas Line, 3'-0" Cover (Source: PCW)
- 30" RCP Saver Line, Cover Unknown (Source: PWD)
- 5" Abandoned Water Line, Cover Unknown (Source: PWD)
- 8" DI Water Line, Cover Unknown (Source: PWD)

Relevant Site Notes
- Middle parcel – Tax Delinquent 12 Years
- Other two parcels are Project Opportunity Parcels
- Young existing tree in southwest corner

Relevant Site Constraints
- Existing laterals - assumed to be abandoned
- Steep topography
- Fire hydrant on east side of H street
- Low wooden fence

VICINITY MAP
Green infrastructure provides stormwater filtration, storage, and infiltration, enhances aesthetics, and reduces flooding and burdens on storm sewer systems.
Recommended Plants for Urban Stormwater Management Publication

Image Source: PHS
**PLANT PALETTE**

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Botanical Name</th>
<th>Syn</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lady Fern</td>
<td>Athyrium filix-femina</td>
<td>AF</td>
</tr>
<tr>
<td>Horsemom</td>
<td>Carpenteria caroliniana</td>
<td>CC</td>
</tr>
<tr>
<td>Southern Bush Honeysuckle</td>
<td>Dierama longilabium</td>
<td>DL</td>
</tr>
<tr>
<td>Sheedy's St. John's Wort</td>
<td>Hypericum prolificum</td>
<td>HP</td>
</tr>
<tr>
<td>Christmas Fern</td>
<td>Polygala amaraeoides</td>
<td>PA</td>
</tr>
</tbody>
</table>

**STREETSMARTS**

**DESIGNER**

John Meunier, Certified Ecologist, Meunier Ecological Services, Hatfield, PA

Meunier has worked in applied ecology since the 1970s and has earned professional certifications in Wetlands and ECOlogy. He has designed ecological restoration plans for forests, grasslands, shorelines, waterways, and wetlands in northeast North America.

**DESCRIPTION**

This planter design meets many of the ecological needs of a stormwater environment. Shapes, size, adaptability, and structural characteristics were also considered. Designed as a true demonstration planting, monitoring will be crucial, taking particular note of the individual set of stresses present at the installation site. The recommended plants are a mix of woody and herbaceous F&GW plants that will thrive in partial shade or sun.

**DETAILS AND MAINTENANCE NOTES**

+ Annual pruning.
+ Wintering necessary only in the fast growing season.

---

Recommended Plants for Urban Stormwater Management Publication

Image Source: PHS
Tree Trench
**Traffic Island**

Overflow water exits to an inlet

Bio-retention

Water from the street enters through a trench drain

**PASSYUNK AVENUE (S.R. 3019)**
Porous Asphalt – Independence Charter School
Greenfield School

Image Source: Viridian Landscape Studio
Evapotranspiration by plants

Excess Runoff is Infiltrated

Image Source: Viridian Landscape Studio
Lea School

Excellence in GSI Awards Ceremony: Celebrating the Triple Bottom Line

Excellence in GSI

INAUGURAL AWARDS

THURSDAY, MARCH 31 2016

Image Source: SALT Design Studio
1. TREE IN BOSQUE PLANTING DETAIL

ADJACENT PLAYGROUND SAFETY SURFACE
CUT CLEANLY EDGE OF EXISTING ASPHALT

4' OPENING AT TREE PIT, TYP.

2
L.105
METAL EDGING AT TREE PIT, TYP.

Image Source: SALT Design Studio
Philadelphia Zoo
Stormwater Management Plan

STORMWATER MANAGEMENT RECOMMENDATIONS

LEGEND
- Impervious Area Captured
- Infiltration Bed
- Cistern
- Rain Garden / Planter Box
Parking Lot Retrofit
Tiger Lot

N 34TH STREET

LEGEND
- 4' WIDE PEDESTRIAN CROSSING
- SURFACE FLOW TO CURB CUT
- STONE BED
- RAIN GARDEN

GOING GREEN!
We're fixing an old storm sewer which will help ensure that rainwater, that can pick up dirt, oils, and litter, won't leak into the ground water and pollute our rivers. And we're planting trees and a rain garden to help absorb rainwater.
KidZooU: Trees

Rendering by Viridian Landscape Studio
KidZooU: Trees
KidZooU: Trees

Photos by Arborilogical Services, Inc.
KidZooU: Utility Coordination
KidZooU: Stormwater Infiltration Beds
KidZooU: Stormwater - Cisterns

Saving Water Saves Animals

Why does it matter?

1. Treating water and delivering water to our homes and businesses uses an enormous amount of energy.
2. Wasting water creates more greenhouse gases that contribute to climate change, which affects animals all over the world.
3. The amount of energy we use each year to treat water generates as much carbon dioxide as 10 million cars.
4. Check out our sustainable restrooms for tips on how to save water at home and save energy.

Start with Rainwater
KidZooU: Rain Gardens
Cliveden

Image Source: PHS
Cliveden

Image Source: PHS
Cliveden

Image Source: PHS
Cliveden

Image Source: PHS
Cliveden

Image Source: PHS
Cliveden

Image Source: PHS
Cliveden

Image Source: PHS
Cliveden
Detention Basin Retrofit
Detention Basin Retrofit

Volunteers planted 300 live stakes and 200 container grown trees and shrubs.

After planting the basin was seeded with wet and dry native grass and forb mixes.

April 2006
Detention Basin Retrofit
Provide a simple maintenance plan

**FIRST YEAR MAINTENANCE**

**LOW-MOW TURF GRASS:**
1. Moni turf areas as soon as top growth is tall enough to cut. Mow to 2-3 inches in height. Repeat mowing to maintain specified height without cutting more than 40 percent of grass height. Do not delay mowing until grass blades bend over and become matted. Do not mow when grass is wet.

**WATER OR SUPPLEMENTAL NATURAL RAINFALL TO PROVIDE A MINIMUM RATE OF 1 INCH PER WEEK.**

**PET & DRY MEADOW AREAS:**
1. Mow meadow areas to a height of 6 inches when weeds reach 10 inches in height.

**SECOND YEAR MAINTENANCE**

**LOW-MOW TURF GRASS:**
1. Mow turf areas as soon as top growth is tall enough to cut. Mow to 2-3 inches in height. Repeat mowing to maintain specified height without cutting more than 40 percent of grass height. Do not delay mowing until grass blades bend over and become matted. Do not mow when grass is wet.

**PET & DRY MEADOW AREAS:**
1. Mow meadow areas to a height of 6 inches in mid spring before warm season grasses emerge. Mow to 2-3 inches. Repeat mowing to maintain specified height. Mow pet & dry meadow areas to a height of 6 inches in mid spring. Mow in late fall. Remove or finely chop and redistribute mowing.

**GENERAL REQUIREMENTS:**
1. Do not mow or use weed whackers near trees & shrubs.
2. Do not mow to less than recommended mowing height.
3. Inspect and maintain seeded areas for bare spots (greater than 1 square foot) in late summer. Mow bare areas with appropriate seed mixer during the fall seeding season (Aug 10 - Sept 30) or sprays seeding season (April 1 - June 15).
4. Replenish mulch around trees and shrubs each spring to suppress weeds. Mow to hand as needed. Vegetative weed control is needed for the first three years. Mow to a height of 6 inches in spring. Mow in late fall. Remove or finely chop and redistribute mowing.
5. To maintain meadow and prevent succession to woody habitat, mow to a height of 6-8" once every two years in mid spring. Remove or finely chop and redistribute mowing.

**L2.0 MAINTENANCE PLAN**
Pittsburgh GSI – Panther Hollow Park
Infiltration Trench

Section

- Swale at center line
- Overlap non-woven geotextile
- Continuously perforated HDPE pipe - distributes water throughout the trench
- Continuous non-woven geotextile
- Clean uniformly graded coarse aggregate
- Uncompacted subgrade

Profile

- Standard pipe filled with stone - facilitates water moving through system during a heavy storm
- Overflow to level spreader
- Area below overflow pipe is storage volume
- Sediment trap - avoids system clogging

Meliora Design
Civil, Water Resources, and Structural Engineering
Infiltration Trench
Golf Course – Infiltration Berms

- Infiltration Berm – Reduces Runoff, Promotes Recharge
  - Allows runoff to naturally pond along the contour and infiltrate into the soil.
What’s happening in Bartholdi Park?

Originally created in 1932, when the U.S. Botanic Garden (USBG) was moved to its current location, Bartholdi Park has served as a two-acre home demonstration garden for 84 years, but has not undergone a renovation since its construction.

The USBG and the Architect of the Capitol are renovating the park to include accessible pathways, improved access to the American Veterans Disabled for Life Memorial, increased safety via new lighting, improved stormwater collection, updated irrigation, new plantings, and restoration of the small fountain at the northwest corner.

Bartholdi Park will continue to have demonstration and educational gardens, featuring additional seating, native American plants, patio gardens, rain gardens, an edible garden, and accessible gardening areas. Many of the larger woody plants are being saved in place and much of the plant material will be used elsewhere at the USBG and on the grounds of the Library of Congress, the Supreme Court of the United States, and D.C. public schools.

Follow the progress of the renovation through construction fence windows and from across the street on the canopy walkway in The Tropics room of the Conservatory. We look forward to welcoming you to the renovated Bartholdi Park in 2016!

www.usbg.gov/bartholdi
Washington D.C. – USBG Bartholdi Park

- 95th Percentile = 1.7”
- Stormwater Credits
- SITES
Lancaster, PA

The U.S. Environmental Protection Agency enforces strict regulations on polluted stormwater. The City faces potential fines of up to $37,500 per day if we cannot show progress towards eliminating at least 750 million gallons of polluted water discharged into the Conestoga River. To recover the costs of services the City is mandated to provide, the City has adopted a stormwater management fee—an equitable, fair and low-cost solution.

Revenue raised through the fee would be specifically dedicated to important infrastructure repairs and improvements that will not only help avoid Federal fines, but also make Lancaster a healthier and greener place to live.
Planning for Success

• Mapping
• Site Analysis
• Capital Projects are an opportunity for GI:
  • Sidewalk improvements
  • Intersection improvements
  • Water and sewer line work
• All municipal and public projects maximize GI (schools, parks, streets, etc.) are opportunities
• Public involvement early on
• Project tracking
• Maintenance Plans & Training
MUNICIPAL SEPARATE STORM SEWER SYSTEM (MS4) REQUIREMENTS
Municipal Stormwater Regulations

- National Pollutant Discharge Elimination System (NPDES)
  - 1990 - “Phase I” MS4 municipalities (medium and large, as defined by federal regulations) required to get NPDES permits
  - 1999 - “Phase II” MS4 municipalities (small municipalities in urbanized areas and other municipalities designated by the permitting authority) required to get NPDES permits
NPDES Requirements for Small MS4s

• The NPDES requires operators of Small MS4s to:
  • Apply for NPDES permit coverage (individual or general)
  • Develop a stormwater management program which includes the 6 minimum control measures
  • Implement the stormwater management program using appropriate stormwater management controls, or best management practices (BMPs)
  • Develop measurable goals for the program
  • Evaluate the effectiveness of the program.
Six Minimum Control Measures (MCMs)

Operators of regulated small MS4s are required to include these 6 minimum control measures in their stormwater management programs:

1) Public Education and Outreach
2) Public Participation/Involvement
3) Illicit Discharge Detection and Elimination
4) Construction Site Runoff Control
5) Post-Construction Runoff Control
6) Pollution Prevention/Good Housekeeping
NEW MS4 REGULATIONS FOR PA MUNICIPALITIES

PAG-13

AUTHORIZED TO DISCHARGE UNDER THE
NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES)
GENERAL PERMIT FOR STORMWATER DISCHARGES FROM
SMALL MUNICIPAL SEPARATE STORM SEWER SYSTEMS (MS4s)
APPROVAL OF COVERAGE

NPDES PERMIT NO.

In compliance with the provisions of the Clean Water Act, 33 U.S.C. Section 1321 et seq. (the Act) and
Pennsylvania’s Clean Streams Law, as amended, 32 P.S. Section 6911 et seq.,

is authorized to discharge from a regulated small municipal separate storm sewer system (MS4) located in
County to in Waterbody(s) in accordance with effluent limitations, monitoring requirements, and
other conditions set forth herein.

APPROVAL OF COVERAGE TO DISCHARGE UNDER THIS GENERAL NPDES PERMIT IS AUTHORIZED
BEGINNING ON . WHEN THE GENERAL PERMIT IS RENewed, REISSUED OR MODIFIED, THE
FACILITY OR ACTIVITY COVERED BY THIS APPROVAL FOR COVERAGE MUST COMPLY WITH THE FINAL
RENEWED, REISSUED OR MODIFIED GENERAL PERMIT.

The authority granted by coverage under the General Permit is subject to the following further qualifications:

1. The permittee shall comply with the effluent limitations and reporting requirements contained in this General Permit.

2. Following initial coverage under this General Permit, the submission of Annual NOI Status Reports in
   accordance with Part A II D of the General Permit shall constitute the permittee’s Notice of Intent (NOI) for
   continued coverage under the General Permit. The permittee shall be responsible for complying with the
   final renewed, reissued or amended General Permit. If the permittee is unable to comply with the renewed
   or amended General Permit, the permittee must submit an application for an individual NPDES permit within
   90 days of publication of the final General Permit.

3. The NOI and its supporting documents are incorporated into this approval of coverage. If there is a conflict
   between the NOI or its supporting documents and the terms and conditions of this General Permit, the terms
   and conditions of this General Permit shall apply.

4. Failure to comply with the terms, conditions, or effluent limitations of this General Permit is grounds for
   enforcement action, permit termination or revocation.

5. (IF APPLICABLE) The permittee shall implement Pollutant Control Measures as specified in Appendix (A,
   B and/or C).

6. (IF APPLICABLE) The permittee shall achieve pollutant loading reductions for [sediment, Total
   Phosphorous and/or Total Nitrogen] as specified in Appendix (D or E) by [Date - 3 years from
   Effective Date of Coverage].

This approval of coverage is authorized by:

[Signature]

[Title]

[Agency]
## PA DEP MS4 Requirements Table

<table>
<thead>
<tr>
<th>MS4 Name</th>
<th>NPDES ID</th>
<th>Individual Permit Required?</th>
<th>Reason</th>
<th>Impaired Downstream Waters or Applicable TMDL Name</th>
<th>Requirement(s)</th>
<th>Other Cause(s) of Impairment</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Chester County</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DOWNINGTOWN BORO</td>
<td>PA0120140</td>
<td>No</td>
<td></td>
<td>Beaver Creek</td>
<td>Cause Unknown (6a), Other Habitat Alterations, Water Flow Variability (4c)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>East Branch Brandywine Creek</td>
<td>Cause Unknown (6a), Other Habitat Alterations, Water Flow Variability (4c)</td>
<td></td>
</tr>
<tr>
<td>EAST BRADFORD TWP</td>
<td>PA110323</td>
<td>Yes</td>
<td>TMDL Plan, SP, IP</td>
<td>Plum Run</td>
<td>Water Flow Variability (4c)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Valley Creek</td>
<td>Appendix C-PCB (4a), Appendix B-PHOSPHATE (5), Appendix E-Sediment (5)</td>
<td>Cause Unknown (5), Other Habitat Alterations, Water Flow Variability (4c)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Blackhorse Run</td>
<td></td>
<td>Other Habitat Alterations, Water Flow Variability (4c)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Broad Run</td>
<td></td>
<td>Water Flow Variability (4c)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Christina River basin sediment</td>
<td>TMDL Plan-Sediment, Suspended Solids (4a)</td>
<td>Other Habitat Alterations (4c)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Taylor Run</td>
<td></td>
<td>Other Habitat Alterations (4c)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Unnamed Tributaries to East Branch Brandywine Creek</td>
<td></td>
<td>Other Habitat Alterations (4c)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>East Branch Brandywine Creek</td>
<td>Cause Unknown (6a), Water Flow Variability (4c)</td>
<td></td>
</tr>
<tr>
<td>EAST BRANDBYWINE TWP</td>
<td>PA110324</td>
<td>Yes</td>
<td>SP, IP</td>
<td>Unnamed Tributaries to Beaver Creek</td>
<td>Appendix E-Sediment (4a)</td>
<td>Cause Unknown (6a), Other Habitat Alterations, Water Flow Variability (4c)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Beaver Creek</td>
<td></td>
<td>Other Habitat Alterations (4c)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Cullerton Run</td>
<td>Appendix E-Sediment (4a)</td>
<td>Other Habitat Alterations (4c)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>East Branch Brandywine Creek</td>
<td>Cause Unknown (6a), Other Habitat Alterations, Water Flow Variability (4c)</td>
<td></td>
</tr>
</tbody>
</table>
## PA DEP MS4 Requirements Table

<table>
<thead>
<tr>
<th>MS4 Name</th>
<th>NPDES ID</th>
<th>Individual Permit Required?</th>
<th>Reason</th>
<th>Impaired Downstream Waters or Applicable TMDL Name</th>
<th>Requirement(s)</th>
<th>Other Cause(s) of Impairment</th>
</tr>
</thead>
<tbody>
<tr>
<td>NEW GARDEN TWP</td>
<td>PA/130516</td>
<td>Yes</td>
<td>TMDL Plan, SP, IP</td>
<td>East Branch White Clay Creek</td>
<td>Appendix B-Pathogens (5)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Egyptian Run</td>
<td>Appendix B-Pathogens (5)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Buckhorn Creek</td>
<td>Appendix C-PCB (4a)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Christina River Basin Sediment</td>
<td>TMDL Plan-Sediment, Suspended Solids (4a)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Christina River Basin Nutrients</td>
<td>TMDL Plan-Nutrients, Organic Enrichment/Low D.O. (4a)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>White Clay Creek</td>
<td>Appendix B-Pathogens (5)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Trout Run</td>
<td>Appendix C-Pesticides (4c)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Broad Run</td>
<td>Appendix B-Pathogens (5)</td>
<td>Water/Flow Variability (4c)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>West Branch Red Clay Creek</td>
<td>Appendix C-PCB (4a)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Walnut Run</td>
<td>Appendix B-Pathogens (5)</td>
<td>Water/Flow Variability (4c)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Unnamed Tributaries to East Branch</td>
<td>Other Habitat Alterations (4c)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>White Clay Creek</td>
<td>Appendix C-PCB (4a)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Red Clay Creek</td>
<td>Appendix C-PCB (4a)</td>
<td></td>
</tr>
<tr>
<td>NEW LONDON TWP</td>
<td>PA/130526</td>
<td>Yes</td>
<td>TMDL Plan, SP, IP</td>
<td>White Clay Creek</td>
<td>Appendix B-Pathogens (5)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>West Branch White Clay Creek</td>
<td>Appendix B-Pathogens (5)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Middle Branch White Clay Creek</td>
<td>Appendix B-Pathogens (5)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>East Branch Big Elk Creek</td>
<td>Appendix E-Organic Enrichment/Low D.O. (5)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Christina River Basin Nutrients</td>
<td>TMDL Plan-Nutrients, Organic Enrichment/Low D.O. (4a)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Chesapeake Bay Nutrients/Sediment</td>
<td>Appendix D-Nutrients, Sediment (4a)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Christina River Basin Sediment</td>
<td>TMDL Plan-Sediment, Suspended Solids (4a)</td>
<td></td>
</tr>
</tbody>
</table>
What is a TMDL?

- Total Maximum Daily Load
- EPA - “a calculation of the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards”
- Pollution diet
- TMDLs provide EPA and states with a mechanism to address pollution from both point and nonpoint sources.
# Example Allocations for the Christina Basin Sediment TMDL

<table>
<thead>
<tr>
<th>Subbasin</th>
<th>Total Baseline Load (ton/day)</th>
<th>Total TMDL Allocation (ton/day)</th>
<th>Percent Reduction (%)</th>
<th>% of TMDL Allocated to MS4s</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brandywine Creek</td>
<td>23.19</td>
<td>12.16</td>
<td>47.6%</td>
<td>78.8%</td>
</tr>
<tr>
<td>White Clay Creek</td>
<td>105.95</td>
<td>46.93</td>
<td>55.7%</td>
<td>88.0%</td>
</tr>
<tr>
<td>Red Clay Creek</td>
<td>60.16</td>
<td>30.17</td>
<td>49.9%</td>
<td>91.4%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>189.31</strong></td>
<td><strong>89.26</strong></td>
<td><strong>52.9%</strong></td>
<td><strong>87.9%</strong></td>
</tr>
</tbody>
</table>
TMDL Plans

• Explains how the municipality plans to reduce stormwater pollution consistent with WLA requirements
• For the current permit cycle, it may be submitted in two parts:
  • TMDL Strategy (due at time of application – already submitted)
  • TMDL Design Details (due one year after permit application is approved)
• Next permit cycle (2017 application), TMDL Plans are expected to be submitted in a single step with the permit application.
Pollutant Reduction Plans (PRPs)

- PRP is a planning document that is designed to guide BMP selection in a manner that will reduce pollutant loading to impaired waters.
- Describe expected municipal upgrades and look for opportunities to implement BMPs that will reduce sediment and nutrient pollution to affected water body by 10% and 5% over the 5-year permit term.
- For next permit cycle, DEP proposes that the following municipalities will be required to submit PRPs:
  - Municipalities that discharge to waters impaired by nutrients and/or sediment without a TMDL
  - Municipalities that discharge to Special Protection Waters (HQ/EV)
Multi-Municipal Collaboration for MS4s

- PA DEP allows for municipalities to work together on meeting pollution reductions

Drivers
- NPDES/PA DEP Municipal Stormwater Requirements
- Challenges to addressing impaired streams
- Local economic/resource limitations
- Existing multi-municipal planning initiatives and collaboration
- Local champion/coordinating organization
- Public pressure

Examples – York County, Wissahickon Watershed, Christina Watersheds Partnership, Oxford Region
The Brandywine Conservancy

Our Mission is:
To conserve the natural and cultural resources of the Brandywine watershed and other selected areas with a primary emphasis on water quality and quantity of the Brandywine watershed.

Photo by Chuck Bowers
Resource Protection Tools

Comprehensive Plan

Zoning Ordinance
- Ag. Preservation
- Conservation Design
- Natural Resource Protection
- Timber Harvesting
- Transferable Development Rights
- Renewable Energy

Subdivision & Land Development Ordinance
- Existing Resources and Site Analysis
- Sketch Plan
- Site Visit
- Erosion & Sedimentation
- Low Impact Development Standards
- Public Land Dedication or Fee In-Lieu

Stormwater Ordinance
- Site Design
- Best Management Practices

Official Map
- Right of first refusal

BRANDYWINE CONSERVANCY
LITTLE CONESTOGA WATERSHED
(LANCASTER COUNTY, PA)

Municipal Ordinances to Address Stormwater and Promote GSI
Little Conestoga Watershed
**Little Conestoga Watershed – Community Watershed Approach**

- Local Partnership Efforts
  - Little Conestoga Watershed Alliance formed (2000)
  - Watershed Assessment and Restoration Plan (2003)
- NFWF Grant Awarded in 2012 to Conservation Foundation of Lancaster County
  - Work proceeded 2012-2015
- Little Conestoga Partnership:
  - Alliance of the Chesapeake Bay, Brandywine Conservancy, Chesapeake Bay Foundation, Habitat MT, Lancaster Area Sewer Authority, Lancaster Clean Water Consortium, Lancaster County Conservancy, Lancaster County Conservation District, Lancaster county Planning Commission, Little Conestoga Watershed Alliance, Penn State University, PA Landscape and Nursery Association, PADEP, PA DCNR
Little Conestoga Partnership
Municipal Assistance

• Municipal Team – worked with interested municipalities to demonstrate municipal tools to address stormwater from future development

• Tools to Address Stormwater from New Development
  • Aligning SALDO, zoning ordinance provisions (site planning process)
  • More stringent stormwater ordinance provisions
  • Assessments for 4 municipalities (Manor, Mannheim, Penn, and West Hempfield Townships)
  • Toolboxes developed for 2 Little Conestoga municipalities

• Challenges include “ordinance fatigue”
RIPARIAN BUFFER PROTECTION THROUGH ORDINANCES
Trees as THE Best Management Practice
Lots of data showing lots of things, depending on study structure.

- Erosion control: 30 to 98 feet
- Water quality: 49 to 164 feet
- Nutrients: 49 to 164 feet
- Pesticides: 49 to 328 feet
- Biocontaminants (fecal, etc.): 30 feet or more
- Aquatic habitat: 33 to 164 feet
- Wildlife: 33 to 164 feet
- Litter/debris: 50 to 100 feet
- Temperature: 30 to 230 feet
- Terrestrial habitat: 15 to 330 feet
So….municipalities can get tough on protection!

- Within a Zoning Ordinance
  - Overlay district
  - Protection standards
- Within a SALDO
  - Design standards
- Within a Stormwater Ordinance
  - Riparian buffer requirements
Guidance for Pennsylvania’s Municipalities

Riparian Buffer Protection Via Local Regulation
A Guide For Pennsylvania Municipalities

Introduction

Forested or, to a lesser extent, otherwise vegetated lands—bordering streams, lakes and other water bodies—provide tremendous public benefits. Pennsylvania municipalities may ensure the protection and restoration of riparian buffers with their land use regulations.

Overview

Riparian Buffers Defined
Riparian buffers are vegetated lands, ideally forested, that border streams, rivers, reservoirs, ponds, lakes, wetlands and other water bodies. A variety of definitions adopted by governments, academic and research institutions, and others can be found in the world wide web but most if not all of them are consistent with the definition provided here.

Services Provided By Buffers
Scientific research clearly documents that riparian buffers, particularly forested buffers, deliver tremendous public benefits.

A Scientific Foundation for Shaping Riparian Buffer Protection Regulations

Estimate scientific research documents that riparian strips of land along water bodies—provide numerous water quality and other environmental benefits. These benefits include: water quality, public health, and safety benefits. Only when a wetland is state designated as Exceptional Value or High Quality and, even then, in certain circumstances do state regulations protect these riparian buffers.

Pennsylvania’s Local Regulations

Riparian buffer regulations in Pennsylvania are often inconsistent and inadequate. The Pennsylvania Land Trust Association (PALTA), a non-profit organization, works to enhance, maintain, and protect Pennsylvania’s riparian buffers.

A Local Regulatory Pathways for Protecting Riparian Buffers

Zoning Or SADDO Regulations

A 2011 Stormwater Management Ordinance

Other Regulatory Tools

Elements Of Good Riparian Buffer Protection Regulations

Purpose And Intent

Definitions

Applicability

Riparian Buffer Erosion

Use Permitted

Buffer Restoration And Planting Requirements

 Modifications To Riparian Buffer Standards

Case Studies

Hahnsfield’s Riparian Buffer Overlay Zoning District

Shrewsbury’s Critical Environmental Areas

Related Resources at ConservationTools.org

Last updated on April 25, 2014

Model Riparian Buffer Protection Overlay District
Proposed Regulations for Use in a Municipal Zoning Ordinance
Second Edition

Prepared by the
Brandywine Conservancy and
Pennsylvania Land Trust Association

in consultation with the
Stroud Water Research Center, Natural Lands Trust, and Fronelis Crawford, Jr., Esq.

and financially supported by the
William Penn Foundation, Colcomb Foundation, and Community Conservation Partnerships Program, Environmental Stewardship Fund, under the administration of the Pennsylvania Department of Conservation and Natural Resources, Bureau of Recreation and Conservation.

Find the most recent edition at
ConservationTools.org

3/11/2016
Preserves existing riparian buffers

**Forested Riparian Buffers (existing)**

- Minimum of 60% native tree canopy in riparian buffer
- Limited Disturbance
- Top of Bank

Minimum of 60% native tree canopy in riparian buffer
Impacted Riparian Buffer (Existing)

Restoration to minimum 60% native tree canopy in riparian buffer

Restores impacted riparian buffers
CONSERVANCY MODEL APPLIES TO WETLANDS

AND CAN BE MODIFIED FOR WIDE FLOODPLAINS AND STEEP SLOPES.
Modifications to Buffer Requirements

- Municipalities can get tough on protection provided…
  - A “safety valve” exists for unique/unforeseen circumstances
- Simpler modification process proposed
  - Requested at the time of conditional use, special exception, or variance approval, or subdivision or land development approval
  - Limited to minimum adjustment necessary to allow relief while adhering to riparian buffer purposes
Riparian Buffer Ordinance Adoption

3 Confirmed
- East Bradford
- East Brandywine
- Pennsbury

4 In Process
- London Grove
- Pocopson
- West Bradford
- New London
A Few Observations

- The minimum forested buffer width could be larger (or smaller)
- Should avoid terms such as “special protection waters” or “impaired streams” in ordinance
- Regulation of agricultural uses is very difficult from practical, political, and pre-emption perspectives
- Requiring restoration is a legitimate use of regulatory powers
- Seek MS4/TMDL credit for ordinance implementation
Riparian Buffer Restoration

Best Management Practices on Farmland
East Brandywine Township

2013
• 1200 trees planted

2014
• 650 trees planted
East Fallowfield Township Park

2015

- 265 trees planted
Oxford Area School District

Nottingham Elementary School,
East Nottingham Township
2014
• 1200 trees planted
Upper Oxford Township Park – Rain Garden
Upper Oxford Rain Garden – After Installation
Catch the Rain
Green Stormwater Rebate Program
CATCH THE RAIN IN THE WHITE CLAY CREEK WATERSHED
BEFORE...

EXISTING STORMWATER FLOW GOES TO THE STREET, UNFILTERED
AFTER...

Trees shade house and pavement.

Lawn area is reduced.

Rain gardens catch roof runoff.

Pervious pavers absorb rain.
Treatment Train Approach
Why Native Plants?

- **Non Natives**
  - Spirea
  - Daylily
  - Fescue lawn
  - Fountain grass

- **Natives**
  - Prairie Dropseed
  - Black-eyed Susan
  - Buffalo Grass
  - Ninebark

**Root Depth in Feet**

- 1
- 2
- 3
- 4
- 5
- 6
- 7
- 8
- 9
- 10
- 11
- 12
- 13
- 14
- 15
<table>
<thead>
<tr>
<th>Catch the Rain Practice</th>
<th>Residential Rebate Amount</th>
<th>Practice Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Total Maximum</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Rebate = $2500/parcel</strong></td>
<td></td>
</tr>
<tr>
<td>Rain Gardens</td>
<td>Typical cost: $4–25/sq. ft.</td>
<td>Minimum size: 120 sq. ft. Rain capture: min. 1&quot; max. 2.7&quot; Location must pass percolation test</td>
</tr>
<tr>
<td>Conservation Landscapes</td>
<td>Typical cost: $4–10/sq. ft.</td>
<td>Minimum size: 250 sq. ft. Rain capture: must receive drainage from impervious surface and must have a microberm around the downhill perimeter to help slow and infiltrate water.</td>
</tr>
<tr>
<td></td>
<td>Rebate: $3/sq. ft., $1200 max.</td>
<td></td>
</tr>
<tr>
<td>Permeable Paving Retrofit</td>
<td>Typical cost: $16–25/sq. ft.</td>
<td>Minimum size: 150 sq. ft. of existing impervious surface must be replaced. Must be installed by a certified ICPI contractor with an additional certification in PICP</td>
</tr>
<tr>
<td></td>
<td>Rebate: $4/sq. ft., $1200 max.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Rebate: $5/sq. ft. for conversion to conservation landscape; $2/sq. ft. for conversion to turf (grass), $2000 max.</td>
<td></td>
</tr>
<tr>
<td>Rain Barrels</td>
<td>Typical cost: $100</td>
<td>Minimum size: 60 gallon barrel</td>
</tr>
<tr>
<td></td>
<td>Rebate: $50/barrel. First rain barrel free if combined with another approved practice, $250 max.</td>
<td></td>
</tr>
<tr>
<td>Canopy Trees</td>
<td>Typical installed cost: $75–250/tree</td>
<td>Minimum size: #7 pot or larger, 8’ tall or 1” caliper. Tree must be planted 10–25’ from permanent buildings. Planting shall occur between Sept. 15 and April 30. Tree must be mulched and have protection from deer.</td>
</tr>
<tr>
<td></td>
<td>Rebate: $100/tree, $1000 max.</td>
<td></td>
</tr>
</tbody>
</table>
Rain Gardens

- Cost: $4-25/ sq. ft.
- Rebate: $10/sq. ft. ($2000 maximum)
- 120 square feet or more
- Minimum 1” rain capture
- Successful percolation test
Conservation Landscapes

- Cost: $4-10/ sq. ft.
- Rebate: $3/sq. ft. ($1200 maximum)
- At least 250 sq. ft.
- Must receive drainage from impervious surface
- Must have a micro-berm (12” high or so) on the downhill edge to help slow and infiltrate water.
Catch the Rain - Canopy Trees

Shade Trees

Conservation Landscaping

Pervious Paving

Rain Barrel

Catch the Rain in the White Clay Creek Watershed
Canopy Trees

- **Cost**: $75-250/tree
- **Rebate**: $100/tree
  - ($1000 max.)
- **Minimum size**: #7 pot, 8’ tall or 1” caliper
- **At least 10-25’ from buildings**
- **Shade to pavement/buildings**
- **Mulch AND deer Protection.**
Tree protection is required!
Rain Barrels

- Typical cost: $100
- Rebate: $50/barrel
- First rain barrel free if combined with another approved practice
- $250 max rebate
- Minimum size: 60 gallon

http://www.camels-hump.com/
Catch the Rain – Paving Removal

Shade Trees

Conservation Landscaping

Pervious Paving

Rain Barrel

Rain Garden

CATCH THE RAIN IN THE WHITE CLAY CREEK WATERSHED
Options for Paving Removal

• Remove existing and install pavers (requires certified professional installer)

• Remove existing and plant
  • Lawn, Conservation Landscaping, or Rain Garden.
Permeable Paver Retrofit

- Cost: $16-25/ sq. ft.
  - $1200 maximum
- At least 150 sq. ft. of existing impervious surface must be replaced
- Must be installed by a certified ICPI contractor with an additional certification in Permeable Interlocking Concrete Paving.
Pavement Removal and Revegetation

- Cost: $3-5 sq. ft.
- Rebate: $5/sq. ft. for conversion to conservation landscape
- $2/sq. ft. for conversion to turf (grass)
- $2000 max rebate
- Minimum size: 100 sq. ft.
Monitoring and Management

- Catch the Rain provides maintenance plan.
- Homeowner must agree to weed, water, and carefully monitor all plantings.
- Maintenance is more intensive at first and becomes easier as the plants mature.
Thank you!
Questions?

Altje Hoekstra, EIT, LEED AP
Senior Water Resources Designer
Meliora Design
altjeh@melioradesign.com

Seung Ah Byun, PhD, P.E., LEED AP
Senior Planner for Water Resources
Brandywine Conservancy
byuns@brandYWine.org