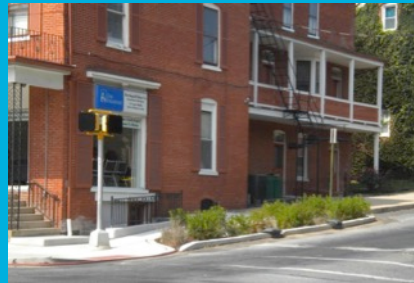# Green Infrastructure for Flood Reduction?
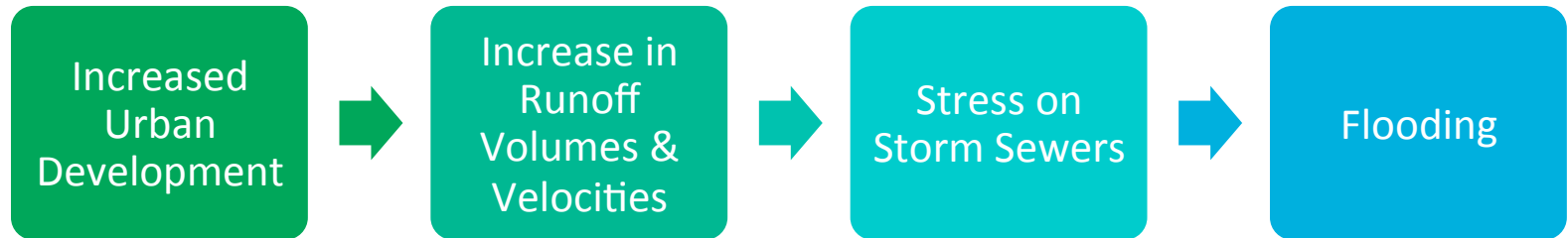
Case Studies in Modeling Green Infrastructure for Flood Mitigation

NEWEA & NYWEA Joint Spring Meeting

June 8, 2016

ch2m SM

Overview

- The Problem:

Increased Urban Development	→	Increase in Runoff Volumes & Velocities	→	Stress on Storm Sewers	→	Flooding

- Objective:

  – Explore green infrastructure as a compliment to traditional grey stormwater management strategies for flood mitigation

Case Study Overview
City of Alexandria, VA & Radnor Township, PA

Both municipalities face flooding that ranges from nuisance to hazardous.

City of Alexandria

- Comprehensive storm sewer capacity analysis
- GI was explored as solution for flooding across the city in a more general context

Radnor Township

- Detailed analysis of specific problem areas
- GI was modeled based on specific concept plans
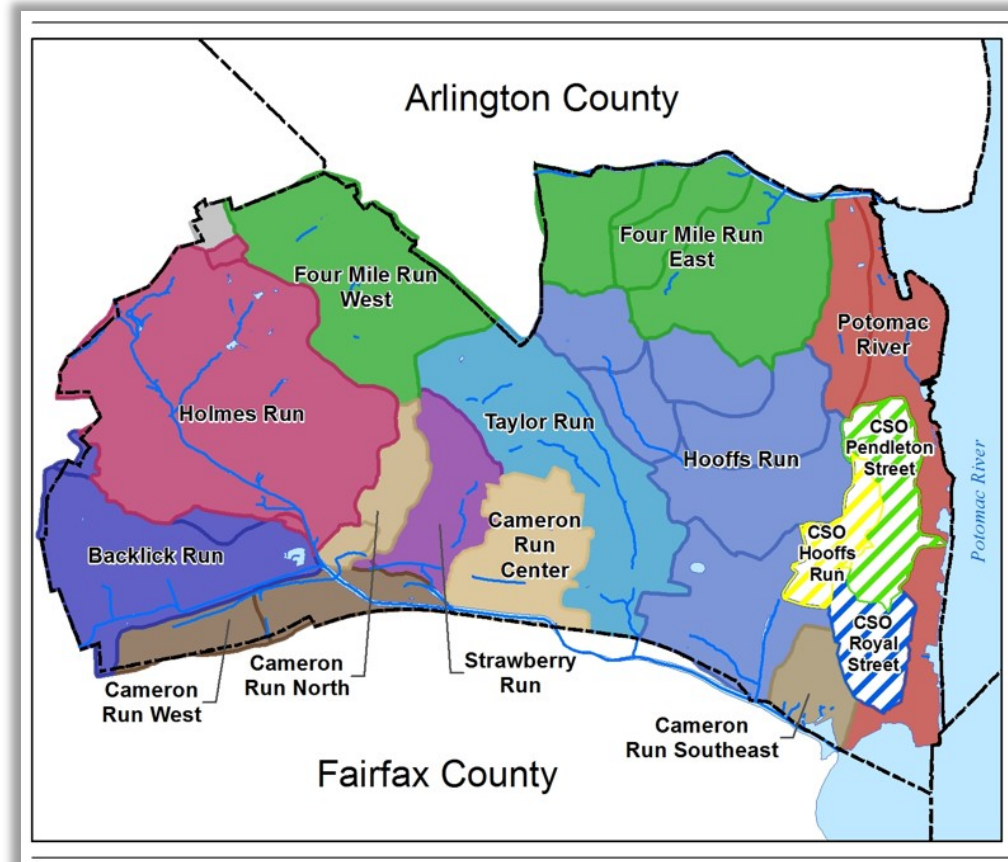

Radnor, PA

Alexandria, VA

Case Study:
City of Alexandria, VA

City of Alexandria Case Study
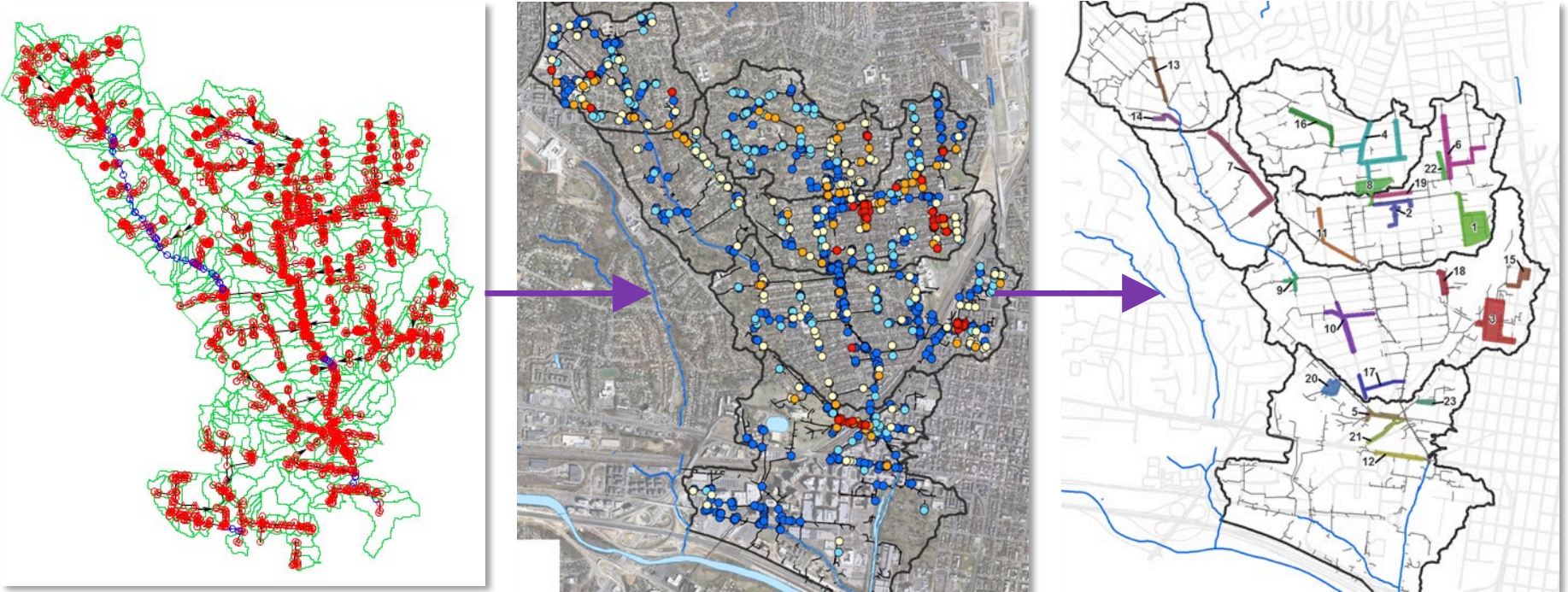# Project Introduction

- City of Alexandria, Virginia

- Population: 150,000

- Size: 10,000 acres
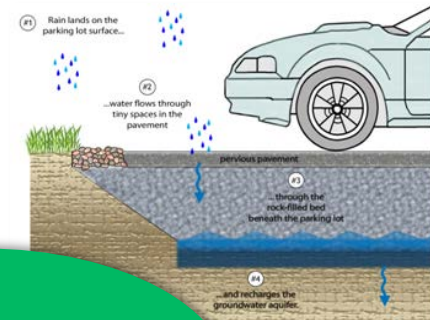
- Imperviousness: 44%

City of Alexandria Case Study
Project Overview

- Develop existing conditions models for all 8 watersheds

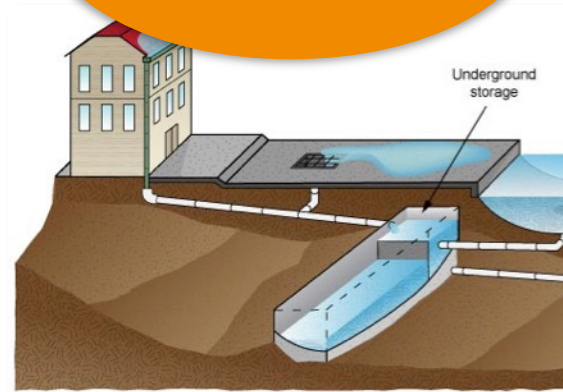- Identify problem areas

- Develop solutions for problem areas

City of Alexandria
Solution Development

Conveyance

Green Infrastructure

Storage
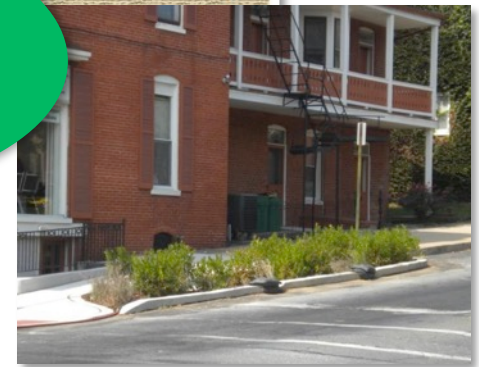
City of Alexandria
Potential GI opportunities were identified across the city

LEGEND

GI Program Opportunities
- Blue Streets
- Green Parking
- Green Roofs
- Green Schools
- Green School Roofs
- Green Streets
- Watersheds

0   0.25   0.5   1 Miles

Green Infrastructure Opportunities in the City of Alexandria
City of Alexandria Storm Sewer Capacity Analysis

CH2MHILL
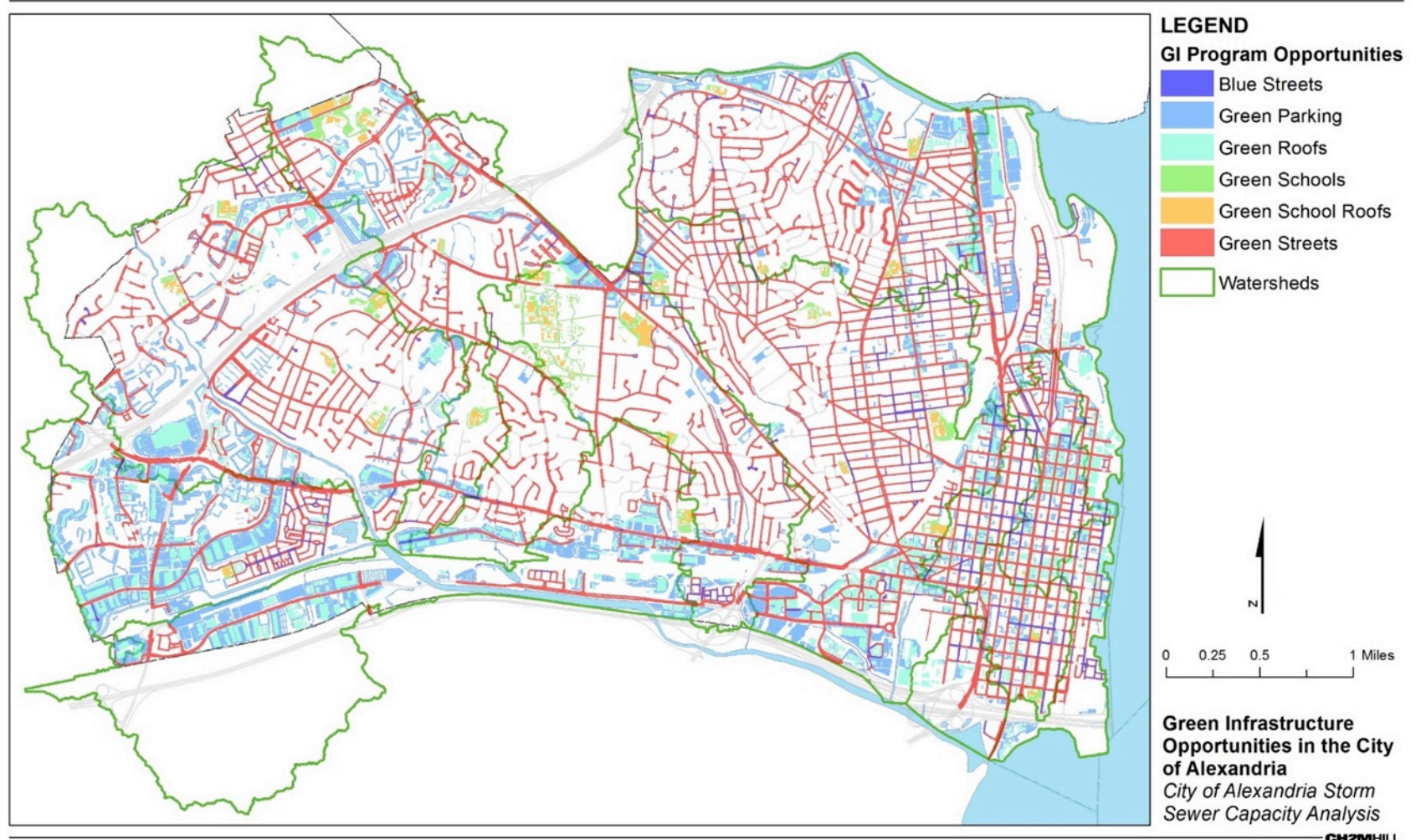
City of Alexandria
Potential GI opportunities were identified across the city

Total Impervious Area (ac)	3,918
Total GI Opportunity Area (ac)	2,792
Total GI Opportunity Area (%)	71%

- Green Buildings
- Green Parking
- Green Roofs
- Green Schools
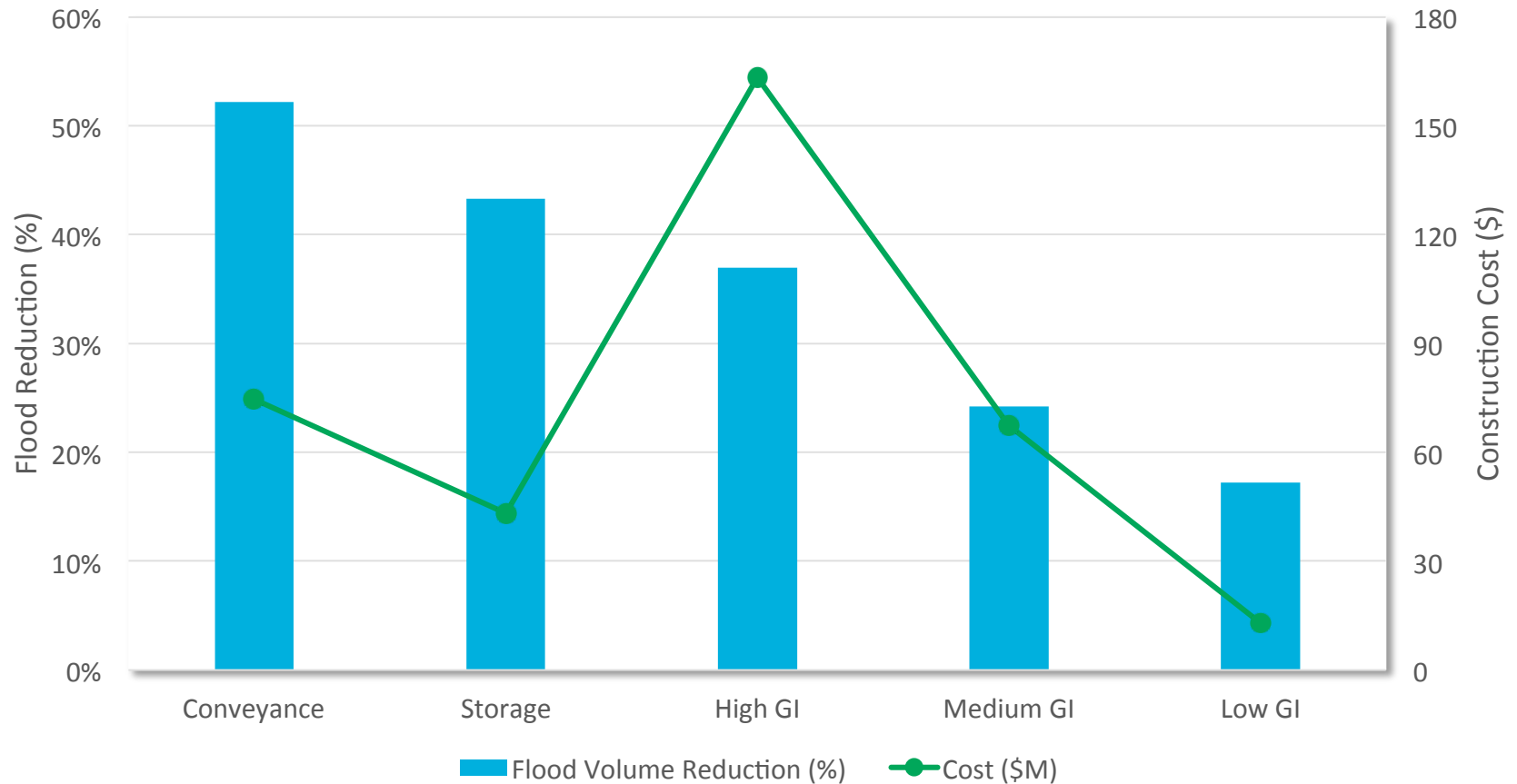- Green Streets
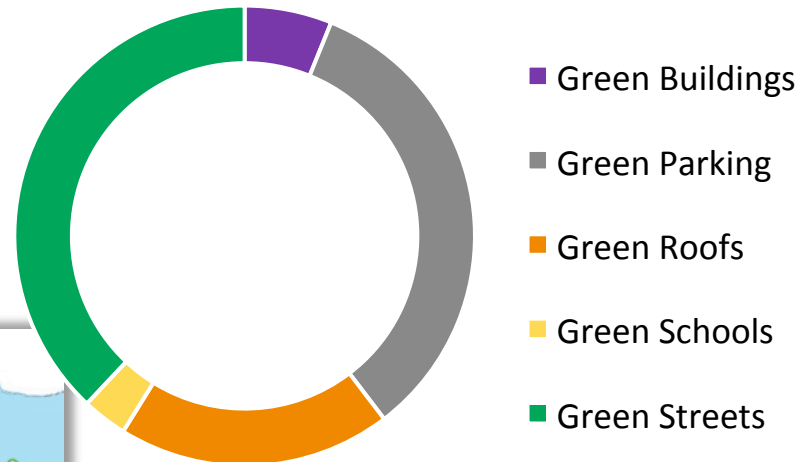
City of Alexandria
GI Modeling Approach

GI was modeled as a reduction in impervious area in the problem area drainage areas.

Three levels of potential GI implementation were modeled based on the opportunities analysis:

- Low (10% imperviousness reduction)

- Medium (30% imperviousness reduction)

- High (50% imperviousness reduction)

City of Alexandria
GI Modeling Results

City of Alexandria
Key Conclusions & Results

Storage can be cost effective when space is available

Conveyance projects are often most cost effective, especially at the downstream end of a system

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Integration of green and grey infrastructure can combine triple bottom line benefits of green infrastructure with the predictability and perceived reliability of grey infrastructure

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GI provides triple bottom line benefits in a single project

■ Conveyance ■ Green Infrastructure (Low, Medium, or High) ■ Storage

Case Study:
Radnor Township, PA

Radnor Township
Project Overview

- Establish a framework for identifying potential stormwater solutions for the most severe flooding locations

  – Reduce flooding

  – Achieve multiple other objectives, such as community enhancements, groundwater recharge and water quality improvements

- Develop high-level categories (or "programs") of potential solutions for selecting flooding locations throughout the watershed

- Identify potential partnering opportunities and functional relationships with other existing and/or proposed stormwater solutions within the watershed
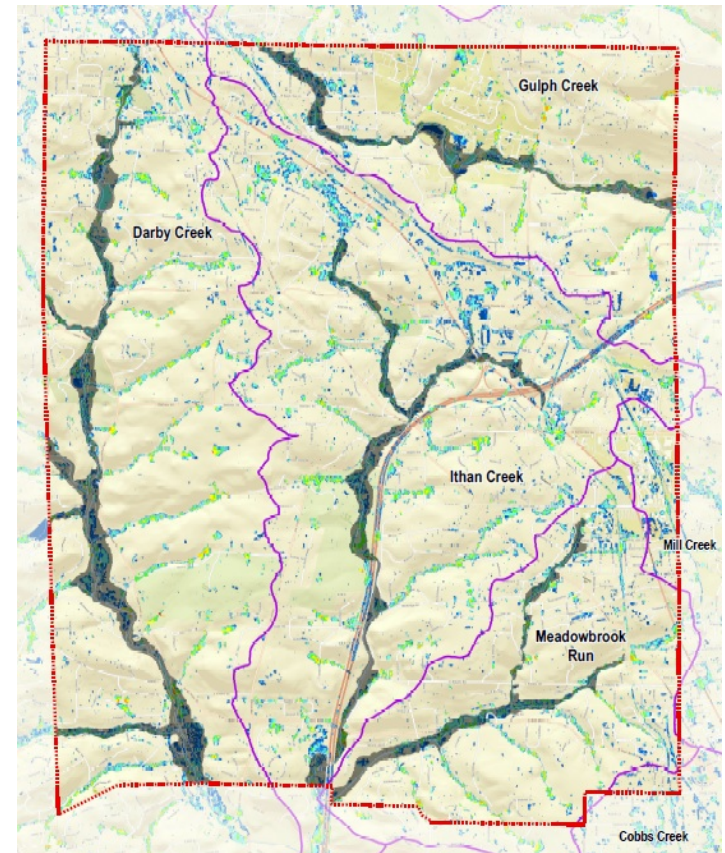
Radnor Township
Project Approach

Used **Flood Modeller FAST**, to yield **a quick 2D representation of location, extent and severity of known flooding locations & ID new locations**

Simulated several rainfall events

Identified **High Flood Risk Areas** based on model simulation results in conjunction with known flooding areas

Delineated **drainage areas** to each location using GIS surface flow analysis tools

Developed solutions to **reduce most severe flooding**

Legend

Surface Waterways
Radnor Township Boundary
Radnor Township Watersheds
100-year FEMA Flood Zone

25-year, 1-hour Flood Depth Results
0.1 - 0.5 ft
0.5 - 1 ft
1 - 3 ft
3 - 5 ft
5 - 10 ft
10 - 25 ft
> 25 ft

Radnor Township
Solution Development

Three types of solutions proposed:

- Volume reducing retrofits (GI)

- Enhancement of existing facilities

- Conveyance system improvements

Solutions focused on:

- Township owned parcels (parking lots, parks, etc.)

- School District

- Public right-of-way

- State roads

- General residential BMPs (Backyard BMPs)

Limited existing storm infrastructure information available, data quality uncertain

Radnor Township
High Flood Risk Location: Banbury Ave & Francis Ave

1-year, 1-hour Max Flood Depth Results

- 0.1 - 0.5 ft
- 0.5 - 1 ft
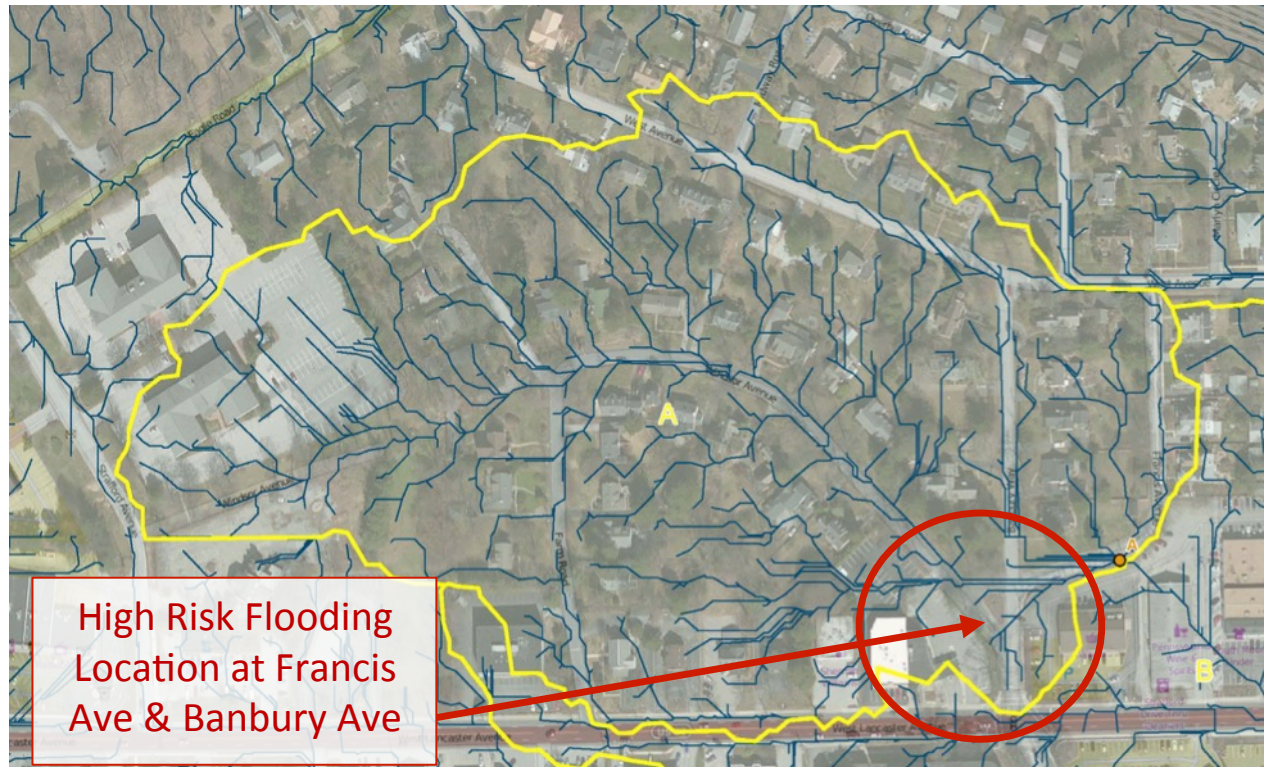- 1 - 3 ft
- 3 - 5 ft
- 5 - 10 ft
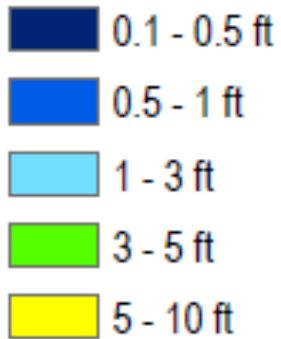
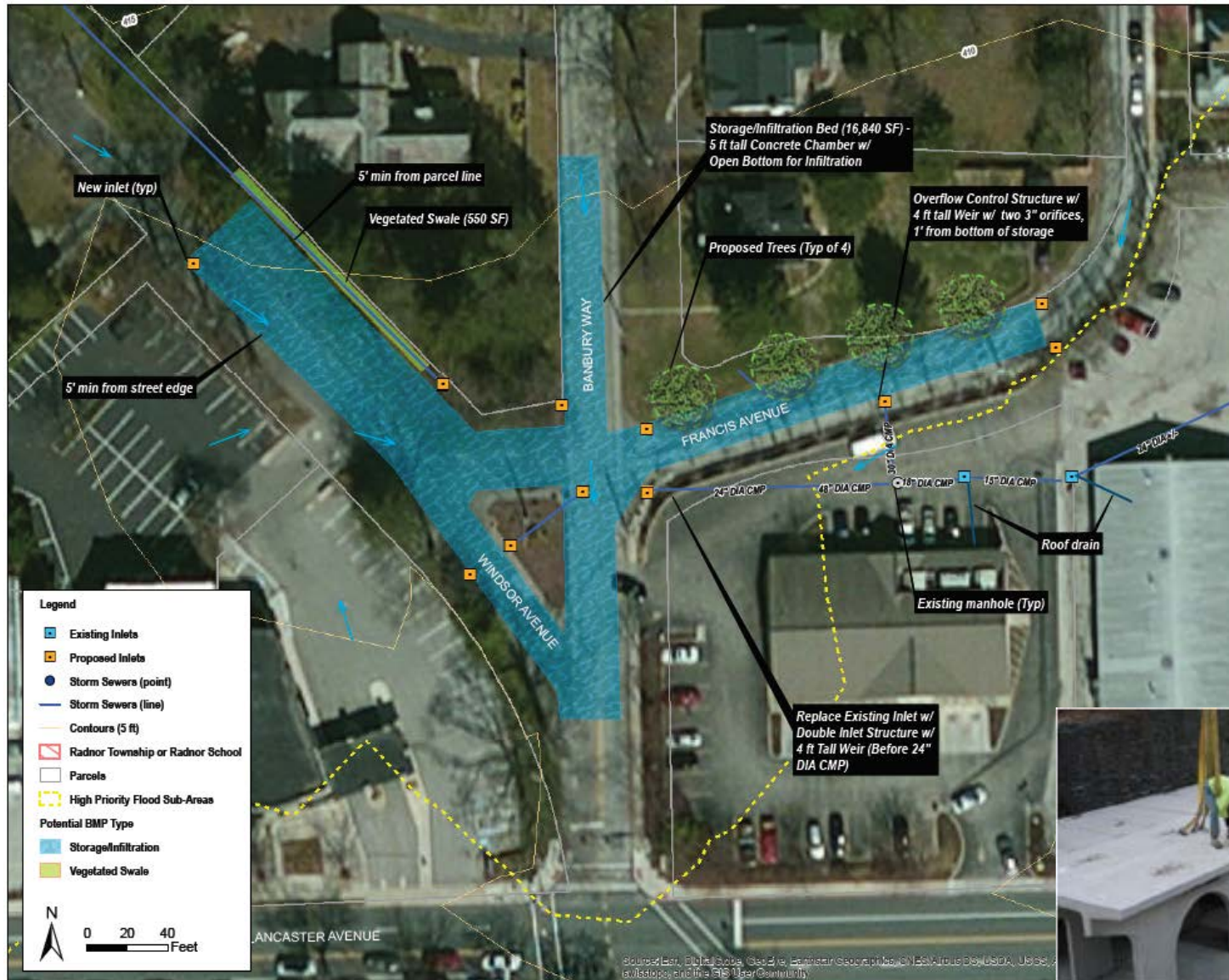# Radnor Township
Drainage Area to Banbury Ave & Francis Ave

Drainage area was delineated using GIS surface flow analysis tools:

- Pervious drainage area = 13.7 acres

- Impervious drainage area = 8.4 acres

High Risk Flooding Location at Francis Ave & Banbury Ave

Radnor Township
GI Stormwater Concept for Banbury Ave & Francis Ave

Radnor Township
Stormwater Infiltration Concepts

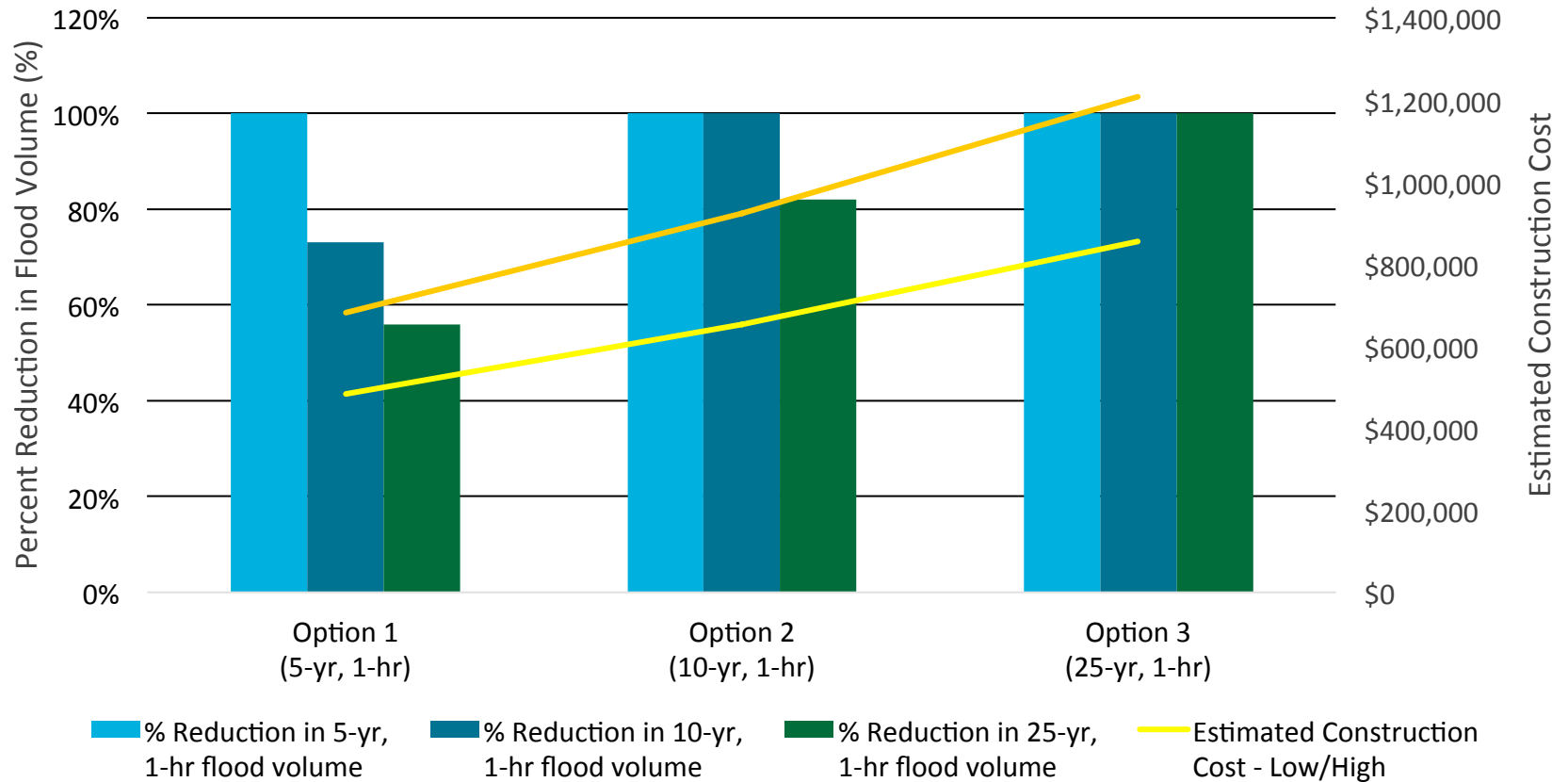| Concept	Storage Footprint Area (sf)	Storage Depth (ft)	Weir Description	Orifice Description
25-year, 1-hour	16,000	5	(2) weirs, both 4' from storage invert	(2) orifices, 3"diam, 1' from storage invert
10-year, 1-hour	14,000	4	(2) weirs, both 3' from storage invert	(1) orifice, 3" diam, 6" from storage invert
5-year, 1-hour	10,000	4	(2) weirs, both 3' from storage invert	(1) orifice, 3" diam, 6" from storage invert

Radnor Township
SWMM Model Representation of GI Stormwater Concept

- Represented stormwater infiltration chamber in SWMM as a storage node

- Represented overflow structure with a series of weirs and orifices

- Designed system volume and overflow configurations for three design alternatives, corresponding to the elimination of flooding during the following events:

  - 5-year, 1-hour (1.77 inches)

  - 10-year, 1-hour (2.03 inches)

  - 25-year 1-hour (2.38 inches)

Radnor Township
Construction Cost Estimates & Flood Reduction Benefits

Percent Reduction in Flood Volume (%)

Estimated Construction Cost

	120% — $1,400,000
	100% — $1,200,000
	80% — $1,000,000
	— $800,000
	60% — $600,000
	40% — $400,000
	20% — $200,000
	0% — $0

Option 1
(5-yr, 1-hr)

Option 2
(10-yr, 1-hr)

Option 3
(25-yr, 1-hr)

■ % Reduction in 5-yr,
1-hr flood volume

■ % Reduction in 10-yr,
1-hr flood volume

■ % Reduction in 25-yr,
1-hr flood volume

━ Estimated Construction
Cost - Low/High

Notes:
-High costs (+20%); low costs (-15%)
-Soft costs (survey, geotech, design, etc.) not included
-% reductions in flood volume based on EPA SWMM model

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Radnor Township
Key Conclusions & Results

- Stormwater infiltration chamber can effectively eliminate flooding in a problem area

- Radnor Township has decided to proceed with constructing a stormwater infiltration system to control the 25-year, 1-hour storm event based on modeling results

Thank You

Contact

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