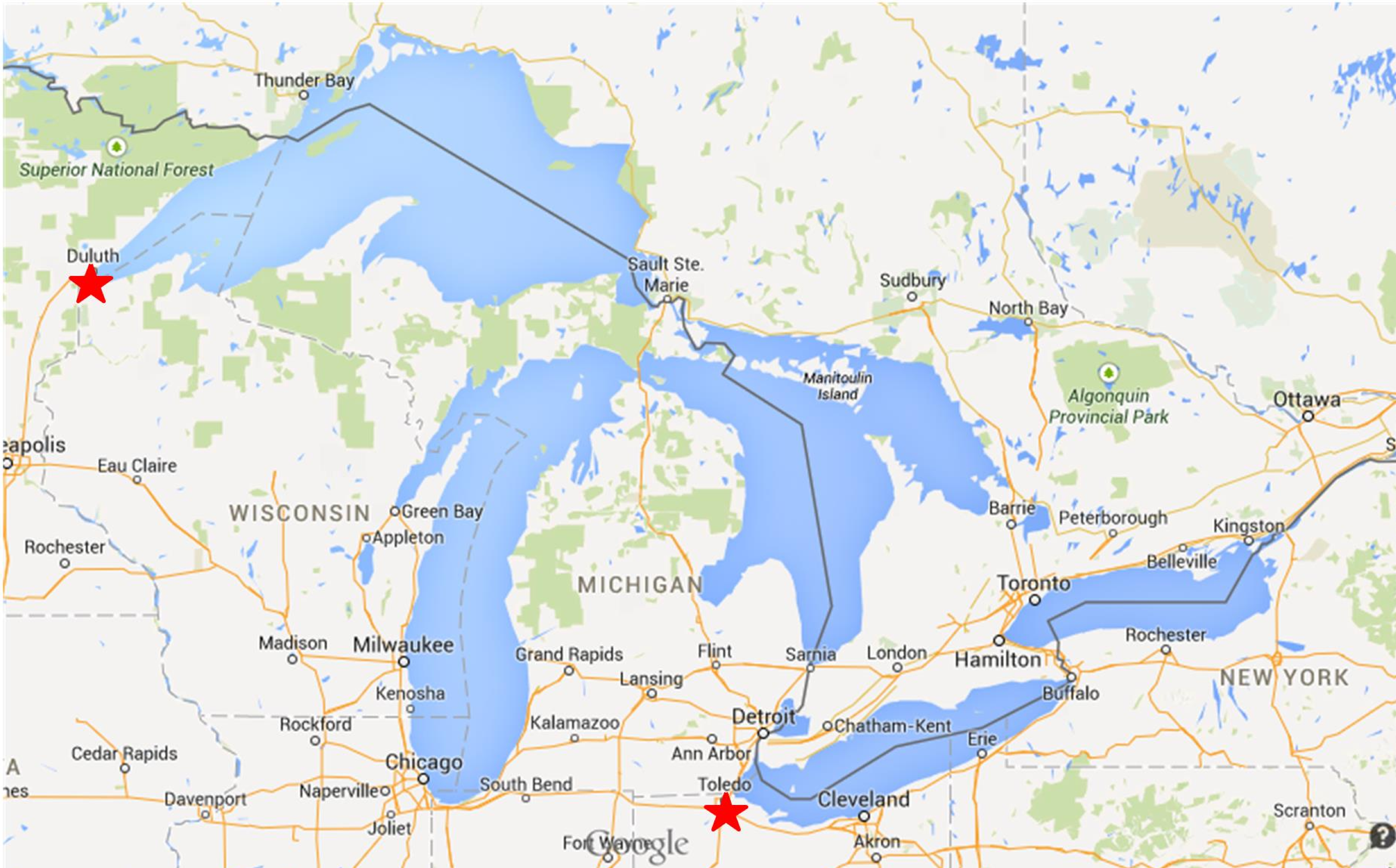
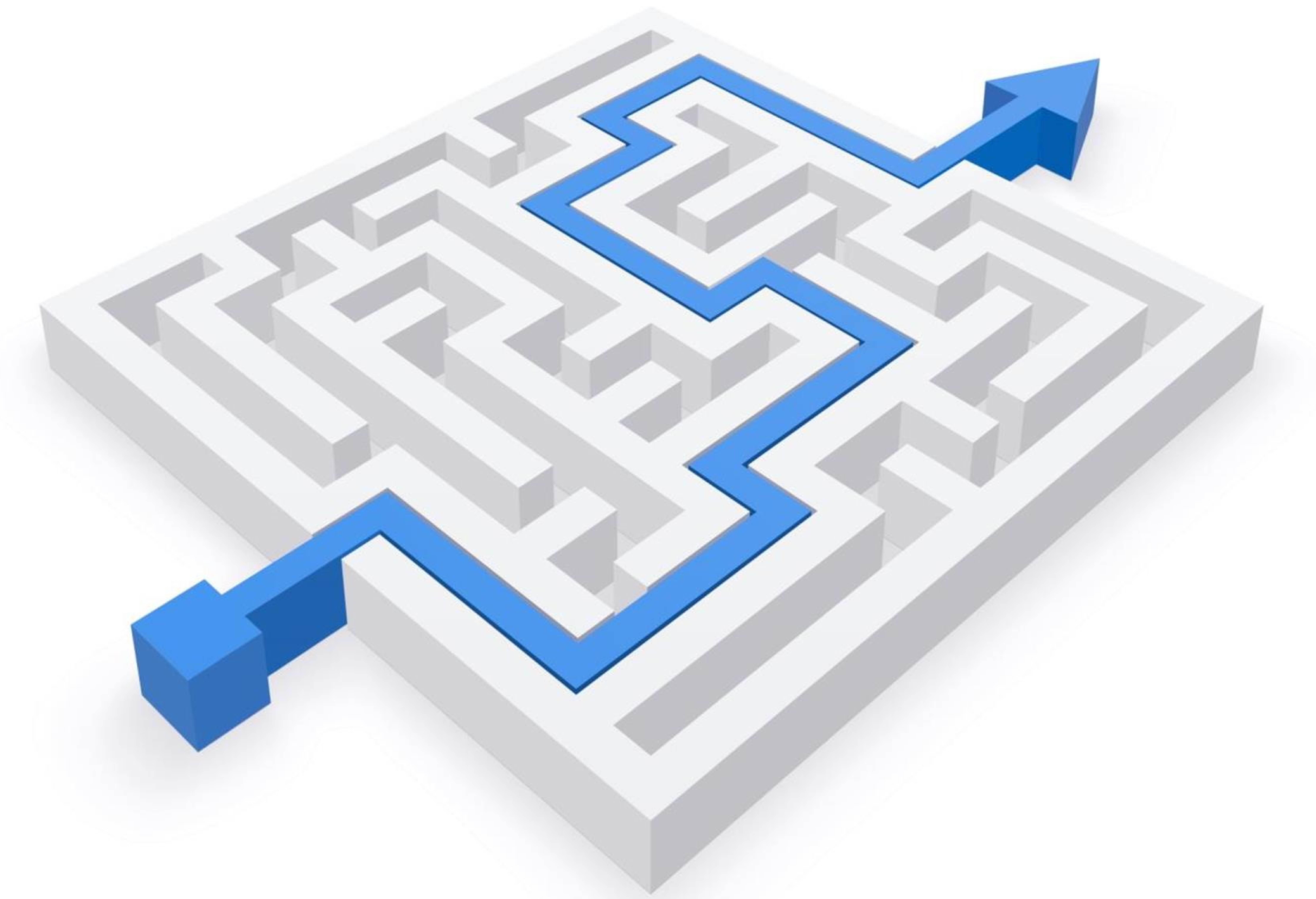
Tale of Two Cities

Assessing Green Infrastructure Costs and Benefits

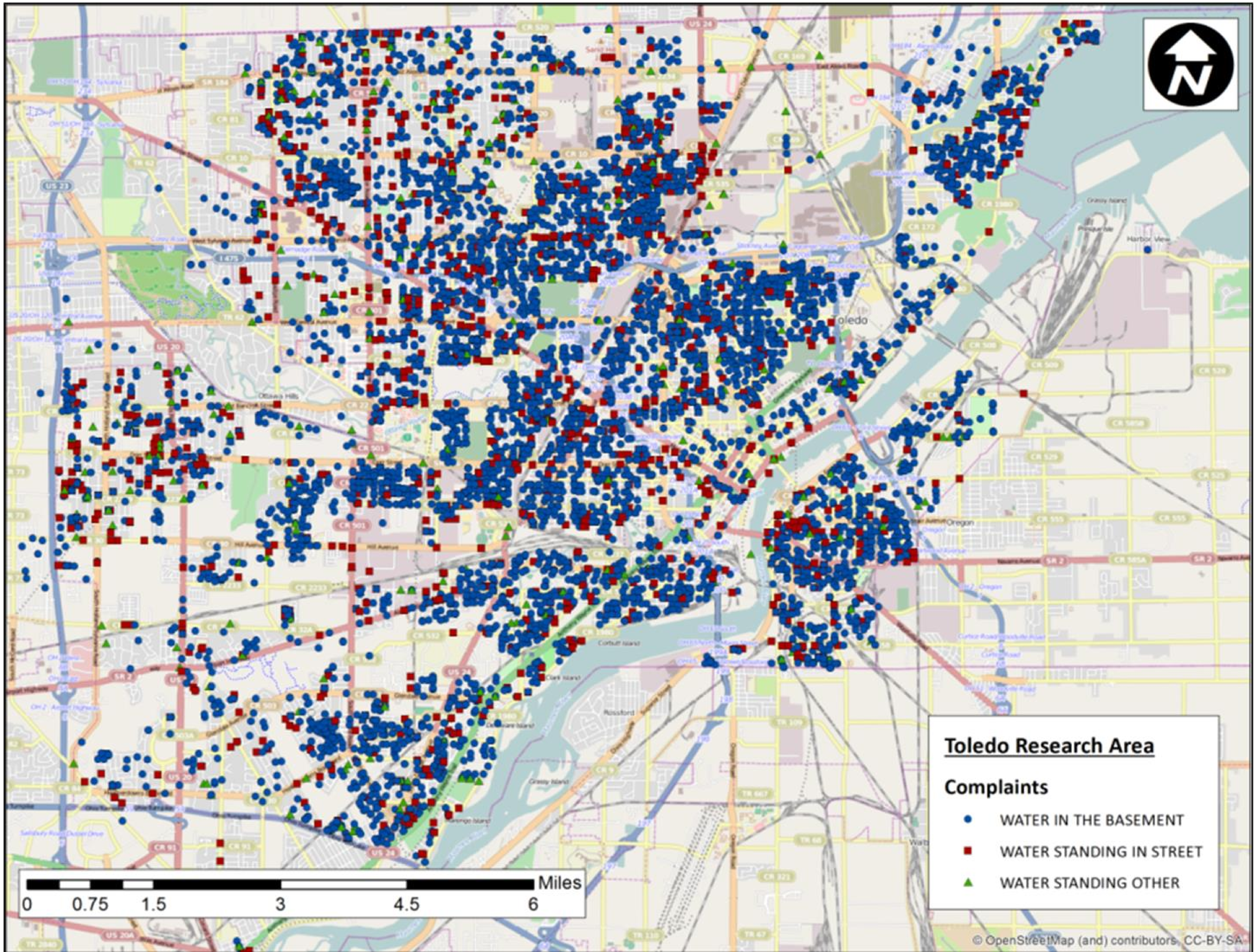
Study Sites


Thunder Bay
Superior National Forest
Duluth
Sault Ste. Marie
Sudbury
North Bay
Manitoulin Island
Algonquin Provincial Park
Ottawa
eapolis
Eau Claire
WISCONSIN
Green Bay
Appleton
Rochester
MICHIGAN
Barrie
Peterborough
Kingston
Belleville
Toronto
Rochester
Hamilton
NEW YORK
Madison
Milwaukee
Grand Rapids
Flint
Sarnia
London
Lansing
Buffalo
Kenosha
Rockford
Kalamazoo
Detroit
Chatham-Kent
Erie
Cedar Rapids
Ann Arbor
Chicago
Toledo
Cleveland
Davenport
Naperville
South Bend
Scranton
Joliet
Fort Wayne
Akron
Google

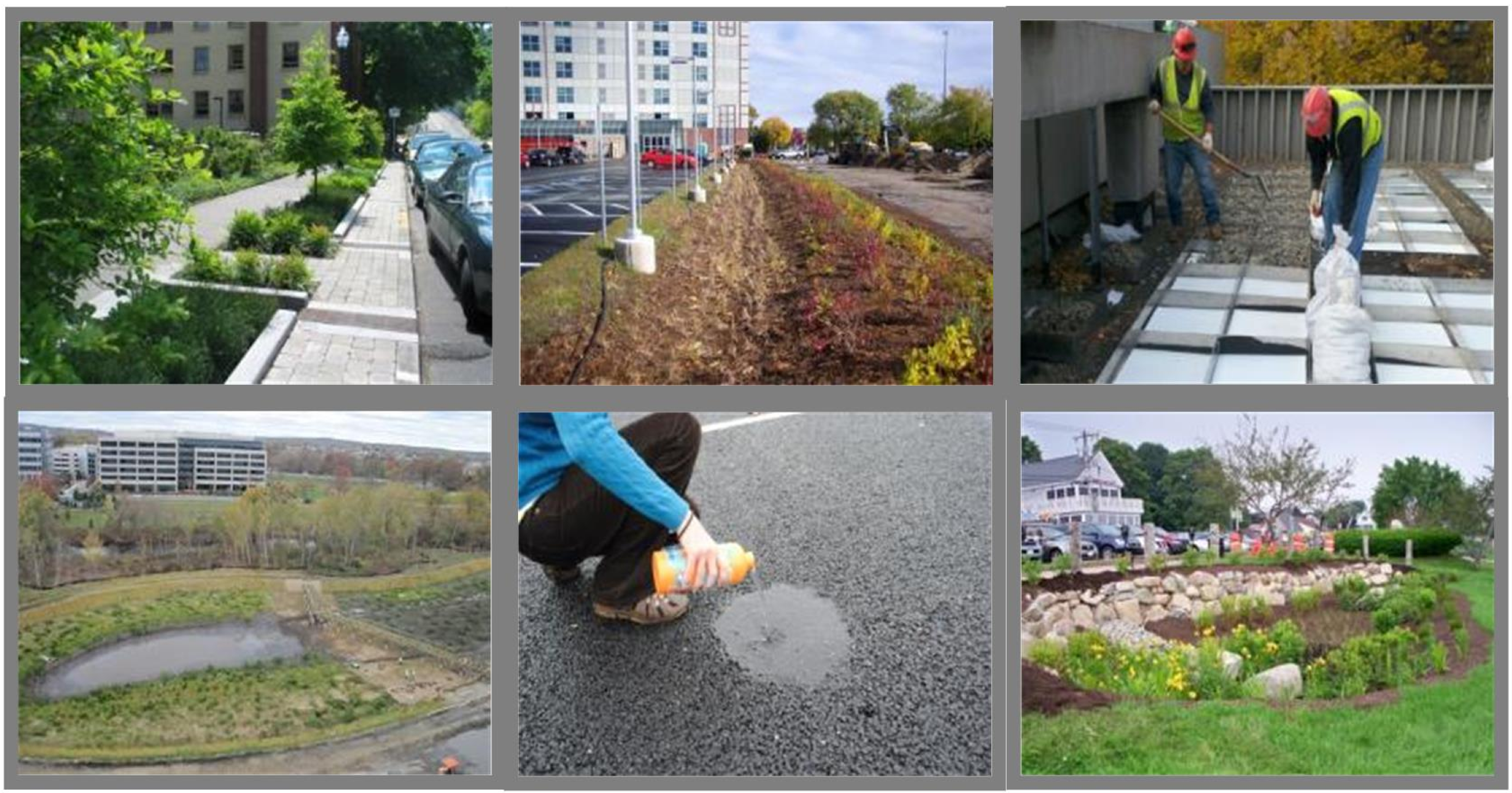


For Planning Purposes

Basement and Street Flooding Complaints 2007 - 2012



Help with long-term planning green infrastructure



But where do we start?

Tell us…

So we worked with…

- Minnesota Sea Grant
- City of Toledo
- U.S. Army Corps of Engineers
- Association of State Floodplain Managers
- Eastern Research Group, Inc.
- American Rivers
- Old Woman Creek NERR

Framework

1. Define flood problem
2. Assess flooding scenarios
3. Identify how flood reduction can be met with green infrastructure
4. Assess flooding scenarios with green infrastructure
5. Estimate benefits and costs
6. Identify and communicate green infrastructure strategy

Step 1: Define flood problem

Scale of Study

Watersheds

Duluth, Minnesota

Toledo, Ohio


Step 2. Assess current
and future flooding

Flood Impact Scenarios

1. Current precipitation and current land use

2. Future precipitation (2035) and future land use

Flood Reduction Scenarios

3. Current precipitation and current land use using GI

4. Future precipitation (2035) and future land use using GI

How much rain now and in the future?

How much water could cause flooding?

Where could flooding occur?

Toledo Flood Damage Costs

Damage to buildings = $740K

Toledo Flood Damage Costs

Damage to buildings = $930K

Duluth Flood Damage Costs

Flood damage to buildings = $400K

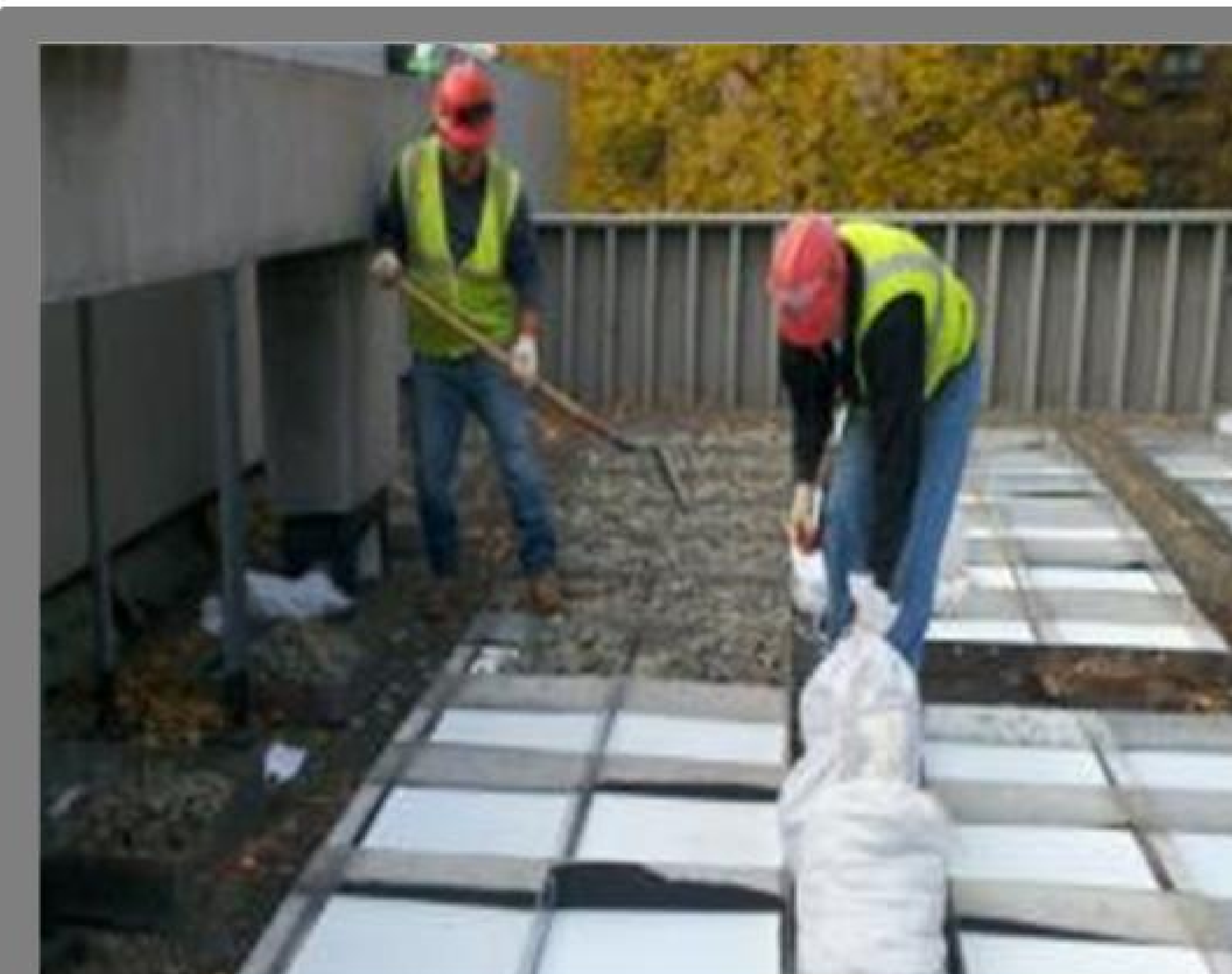
Duluth Flood Damage Costs

Flood damage to buildings = $420K

Step 3. Identify Green Infrastructure Options

Many Options






Target: reduce peak discharge by

DULUTH

20%

TOLEDO

10%

How much green infrastructure storage is needed to reach this target?

Duluth	Toledo
76 acre-feet (current conditions)	**30** acre-feet (current conditions)
86 acre-feet (future conditions)	**32** acre-feet (future conditions)

What and how much of each?

Green Infrastructure
Options of Interest

- Bioswales
- Blue Roofs
- Permeable Pavement
- Underground Storage
- Parcel Buy-Outs
- Extended Detention Wetlands

Pilot Study Team identifies opportunities for green infrastructure

Duluth

Pilot Study Team identifies opportunities for green infrastructure

Step 4. Assess how much flooding is reduced using green infrastructure

Flood Reduction Scenarios

3. Current precipitation and current land use using GI

4. Future precipitation and future land use using GI

Toledo

How much are flood damages reduced using green infrastructure?

$740K*

$453K*

***Flood damage to buildings**

Toledo

How much are flood damages reduced using green infrastructure?

$930K*

$527K*

***Flood damage to buildings**

Duluth

How much are flood damages reduced using green infrastructure?

$400K*

$296K*

***Flood damage to buildings**

Duluth

How much are flood damages reduced using green infrastructure?

$420K*

$352K*

***Flood damage to buildings**

Toledo

Risk Reduced with Green Infrastructure Storage

No Green Infrastructure Storage

Current land use/current precipitation: 1%*

Future land use/future precipitation: 1.45%*

RISK

With Green Infrastructure Storage

Current with green infrastructure providing flood storage: 0.50%*

Future with green infrastructure providing flood storage: 0.71%

*Percent chance that a storm will occur in a year with peak discharge of 1,255 cfs and cause damages

Duluth

Risk Reduced with Green Infrastructure Storage

No Green Infrastructure Storage

Current land use/current precipitation: 1%*

Future land use/future precipitation: 1.84 %*

RISK

With Green Infrastructure Storage

Current with green infrastructure providing flood storage: 0.24%*

Future with green infrastructure providing flood storage: 0.51%*

*Percent chance that a storm will occur in a year with peak discharge of 1,530 cfs and cause damages

Step 5. Compare costs and benefits

Estimated unit cost of green infrastructure

Example of calculating storage cost

30 acre-feet of storage

Option 1: Stormwater wetland costs ~$1.30/cubic foot

- Cost = $1.77M

Option 2: Underground storage costs ~$41.30/cubic foot

- Cost = $55M

Costs of green infrastructure to meet target storage

Toledo	Duluth
30 acre-feet of storage with least expensive GI = $1.77M	76 acre-feet of storage with least expensive GI = $4.3M

Benefits = Damages Avoided

Toledo's Benefits

- For 20-year period: $700K not spent on flood damages to buildings ($1.77M for GI)

- For 50-year period: $1.77M not spent on flood damages to buildings ($1.77M for GI)

Duluth's Benefits

- For 20-year period: $1.63 million not spent on flood damages ($4.3M for GI)

- For 50-year period: $4.6M not spent on flood damages ($4.3M for GI)

Study Results: Costs and Benefits Analysis

- Benefits are seen when using a longer planning horizon

- Need more data on flood damages and the monetary values of ecosystem services

Data You Need

- Buildings
- Roads
- Stormwater infrastructure
- Recreation
- Wages
- Land damages

What We Had

- Buildings (*Both communities*)
- ~~Roads~~
- Stormwater infrastructure (*Duluth only*)
- Recreation (*Duluth only*)
- ~~Wages~~
- Land damages (*Duluth only*)

How Toledo Is Using Results

Under construction bioswale

Bioswale with native OH grass

How Duluth Is Using Results

Lessons Learned

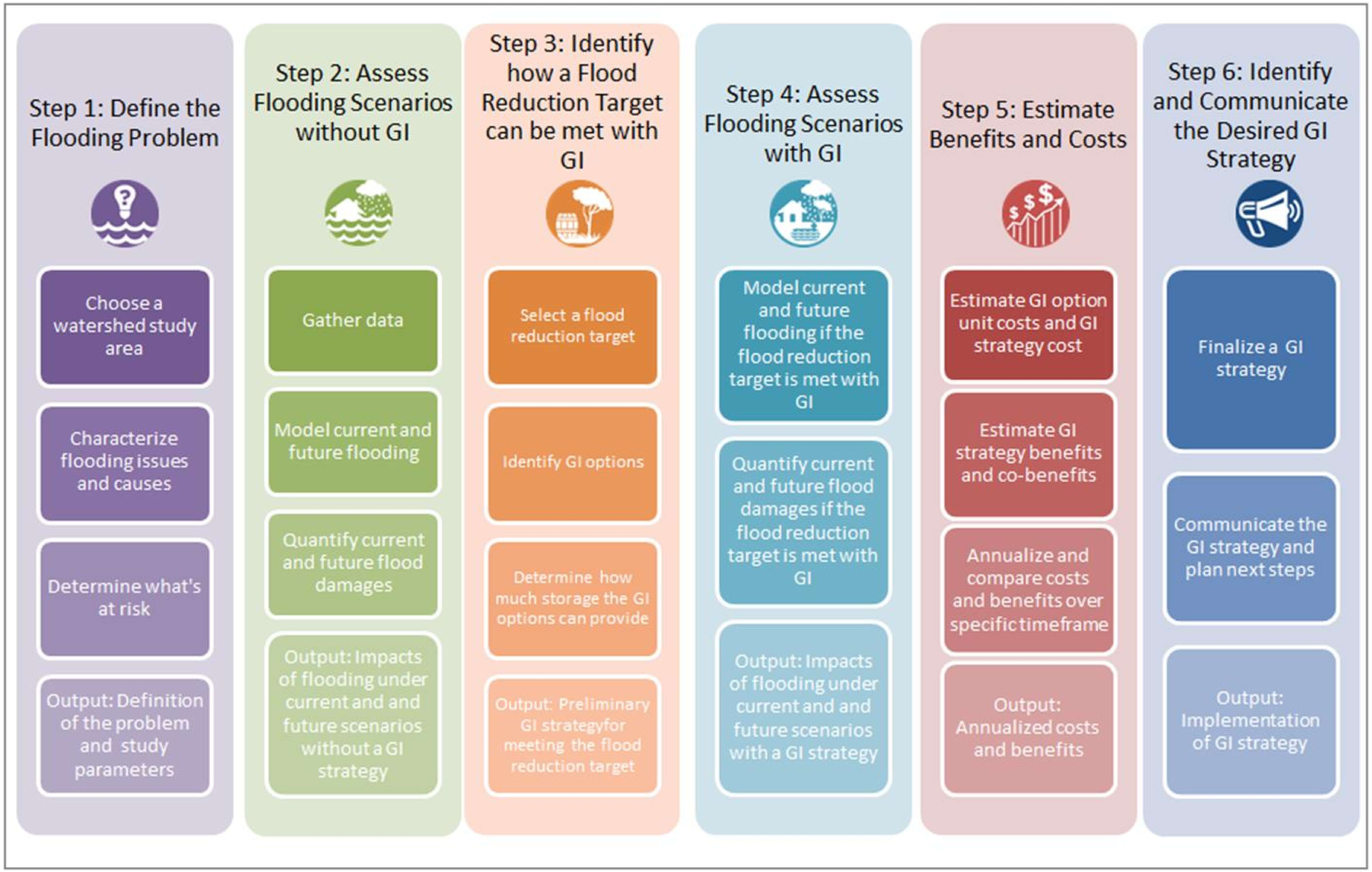
- Focus on longer term
- Hard to get all the data
- Look to implement GI over time
- Leverage other infrastructure investments
- Get a champion that is not elected or works for the city
- Consider benefits that cannot be monetized in decisions
- Partners are critical

What's Next for NOAA?

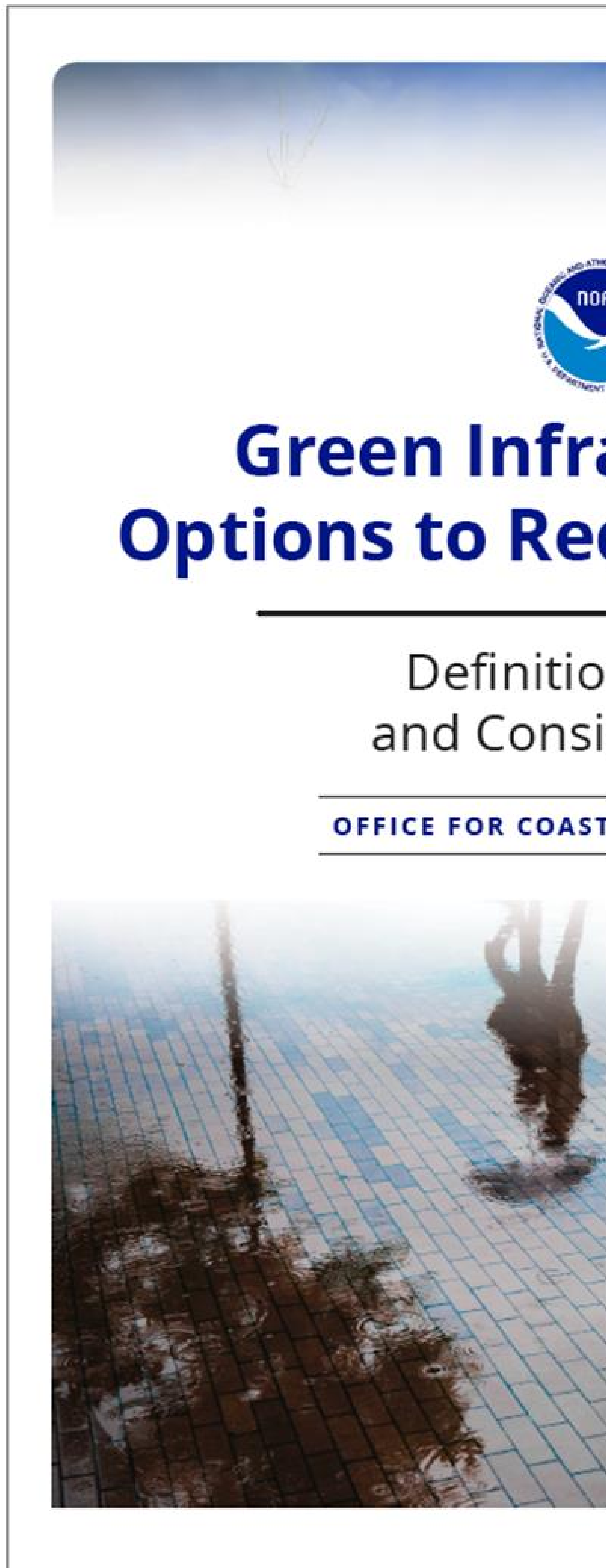
Sharing what we have learned!

- Guide
- Data Matrix
- Green Infrastructure Options to Reduce Flooding

A Guide to Assessing Green Infrastructure Costs and Benefits for Flood Reduction



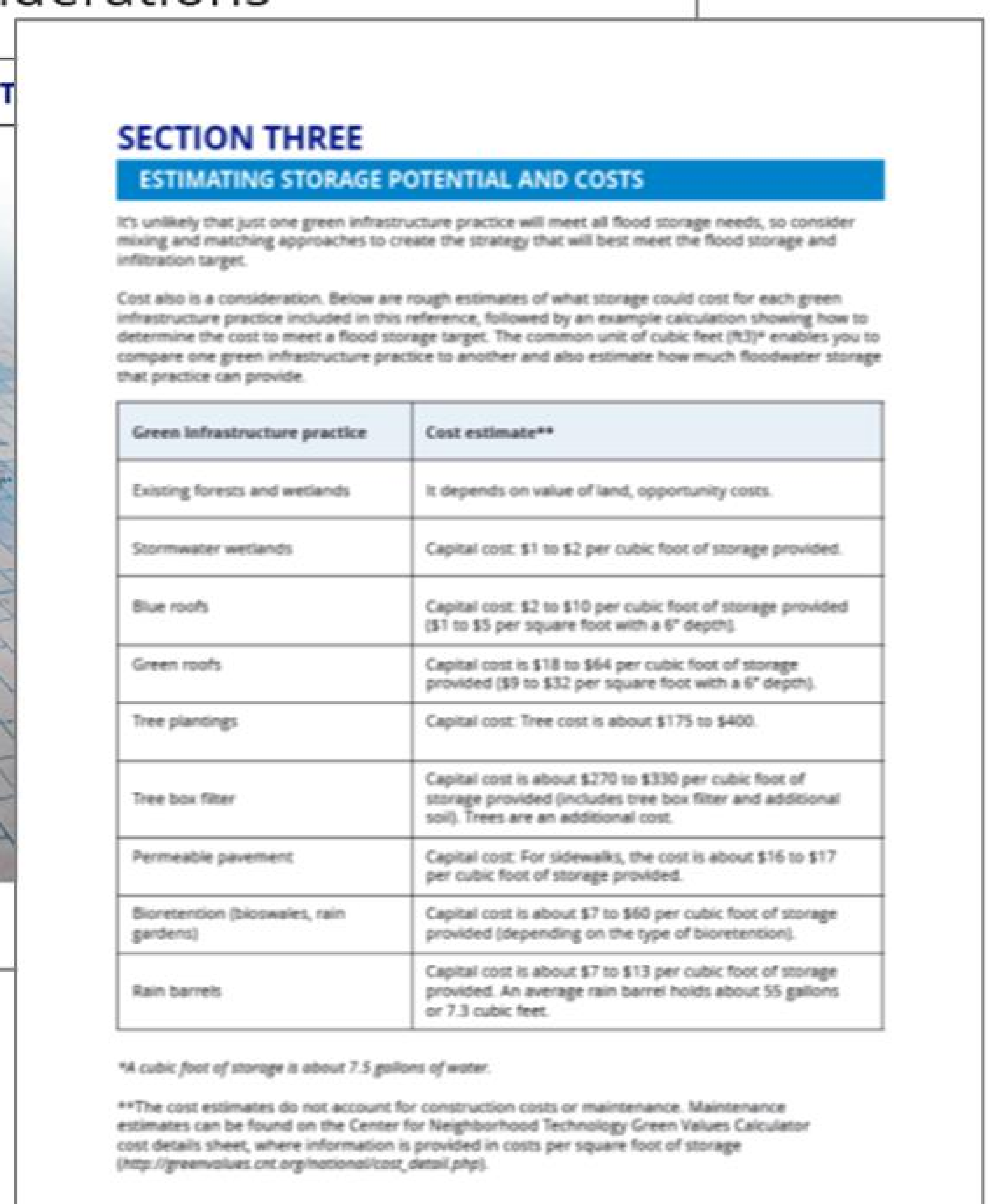
Companion Pieces



Green Infrastructure Options to Reduce Flooding

Definitions, Tips, and Considerations

OFFICE FOR COAST



SECTION THREE

ESTIMATING STORAGE POTENTIAL AND COSTS

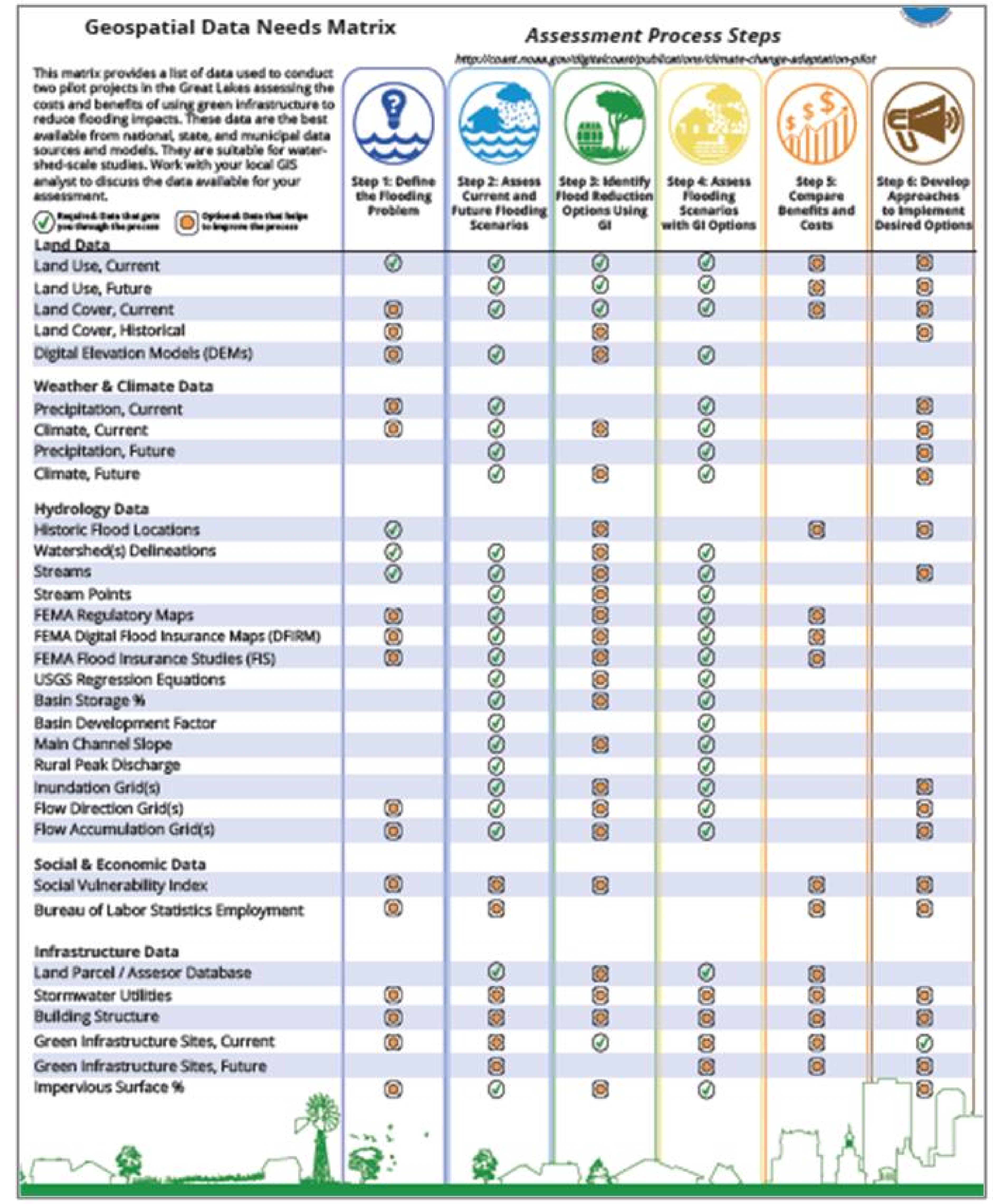
It's unlikely that just one green infrastructure practice will meet all flood storage needs, so consider mixing and matching approaches to create the strategy that will best meet the flood storage and infiltration target.

Cost also is a consideration. Below are rough estimates of what storage could cost for each green infrastructure practice included in this reference, followed by an example calculation showing how to determine the cost to meet a flood storage target. The common unit of cubic feet (ft3)* enables you to compare one green infrastructure practice to another and also estimate how much floodwater storage that practice can provide.

Green Infrastructure practice	Cost estimate**
Existing forests and wetlands	It depends on value of land, opportunity costs.
Stormwater wetlands	Capital cost: $1 to $2 per cubic foot of storage provided.
Blue roofs	Capital cost: $2 to $10 per cubic foot of storage provided ($1 to $5 per square foot with a 6" depth).
Green roofs	Capital cost is $18 to $64 per cubic foot of storage provided ($9 to $32 per square foot with a 6" depth).
Tree plantings	Capital cost: Tree cost is about $175 to $400.
Tree box filter	Capital cost is about $270 to $330 per cubic foot of storage provided (includes tree box filter and additional soil). Trees are an additional cost.
Permeable pavement	Capital cost: For sidewalks, the cost is about $16 to $17 per cubic foot of storage provided.
Bioretention (bioswales, rain gardens)	Capital cost is about $7 to $60 per cubic foot of storage provided (depending on the type of bioretention).
Rain barrels	Capital cost is about $7 to $13 per cubic foot of storage provided. An average rain barrel holds about 55 gallons or 7.3 cubic feet.

*A cubic foot of storage is about 7.5 gallons of water.

**The cost estimates do not account for construction costs or maintenance. Maintenance estimates can be found on the Center for Neighborhood Technology Green Values Calculator cost details sheet, where information is provided in costs per square foot of storage (http://greenvalues.cnt.org/national/cost_detail.php).



Geospatial Data Needs Matrix

Assessment Process Steps

http://coast.noaa.gov/digitalcoast/publications/climate-change-adaptation-pilot

This matrix provides a list of data used to conduct two pilot projects in the Great Lakes assessing the costs and benefits of using green infrastructure to reduce flooding impacts. These data are the best available from national, state, and municipal data sources and models. They are suitable for watershed-scale studies. Work with your local GIS analyst to discuss the data available for your assessment.

✓ Required: Data that gets you through the process
● Optional: Data that helps to improve the process

	Step 1: Define the Flooding Problem	Step 2: Assess Current and Future Flooding Scenarios	Step 3: Identify Flood Reduction Options Using GI	Step 4: Assess Flooding Scenarios with GI Options	Step 5: Compare Benefits and Costs	Step 6: Develop Approaches to Implement Desired Options
Land Data						
Land Use, Current	✓	✓	✓	✓	●	●
Land Use, Future		✓	✓	✓	●	●
Land Cover, Current	●	✓	✓	✓	●	●
Land Cover, Historical	●		●			●
Digital Elevation Models (DEMs)	●	✓	●	✓		
Weather & Climate Data						
Precipitation, Current	●	✓		✓		●
Climate, Current	●	✓	●	✓		●
Precipitation, Future		✓		✓		●
Climate, Future		✓	●	✓		●
Hydrology Data						
Historic Flood Locations	✓		●		●	●
Watershed(s) Delineations	✓	✓	●	✓		
Streams	✓	✓	●	✓		●
Stream Points		✓	●	✓		
FEMA Regulatory Maps	●	✓	●	✓	●	
FEMA Digital Flood Insurance Maps (DFIRM)	●	✓	●	✓	●	
FEMA Flood Insurance Studies (FIS)	●	✓	●	✓	●	
USGS Regression Equations		✓	●	✓		
Basin Storage %		✓	●	✓		
Basin Development Factor		✓		✓		
Main Channel Slope		✓	●	✓		
Rural Peak Discharge		✓		✓		
Inundation Grid(s)		✓	●	✓		●
Flow Direction Grid(s)	●	✓	●	✓		●
Flow Accumulation Grid(s)	●	✓	●	✓		●
Social & Economic Data						
Social Vulnerability Index	●	●	●		●	●
Bureau of Labor Statistics Employment	●	●			●	●
Infrastructure Data						
Land Parcel / Assesor Database		✓	●	✓	●	
Stormwater Utilities	●	●	●	●	●	●
Building Structure	●	●	●	●	●	●
Green Infrastructure Sites, Current	●	●	✓	●	●	✓
Green Infrastructure Sites, Future		●		●	●	●
Impervious Surface %	●	✓	●	✓		●

Flood Hazard Visualization Tool

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Digital Coast Green Infrastructure Resources

coast.noaa.gov/digitalcoast/topic/green-infrastructure

Technical Report

coast.noaa.gov/digitalcoast/publications/climate-change-adaptation-pilot