

Integrating Green and Gray Infrastructure for Stormwater Management and Flood Risk Reduction

7th Annual Texas Regional Stormwater Conference
New Braunfels, Texas
January 16, 2025

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Flooding in Hoboken, NJ in April 2007

1

Our team

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Max Wallack, MBA, MS, P.E.
Senior Water Engineer

Ten years' experience in power generation and municipal water sectors, including civil site, stormwater controls, pump stations, and chemical feed systems. He leads facilities design work in the central Texas area and has supported projects in the Northeast, Midwest, and South U.S.



Mark Van Auken, P.E., CPMSM, ENV SP
Stormwater and Green Infrastructure
Practice Leader

Thirty-four years' experience in the analysis, design, and construction phases of a variety of stormwater projects. He specializes in municipal stormwater management, with experience leading stormwater planning and permitting projects in more than 20 states. He is a frequent speaker on webinars and at conferences throughout the country, having made more than 70 presentations on subjects ranging from stormwater asset management to green infrastructure maintenance.

2

Agenda

- | | | | |
|---|---|---|-----------------------------------|
| 1 | Traditional Use of Green & Gray & Emerging Trends | 4 | Maintenance |
| 2 | How to Combine Green & Gray for Flood Mitigation | 5 | Lessons Learned on Implementation |
| 3 | Case Studies | 6 | Questions and Discussion |

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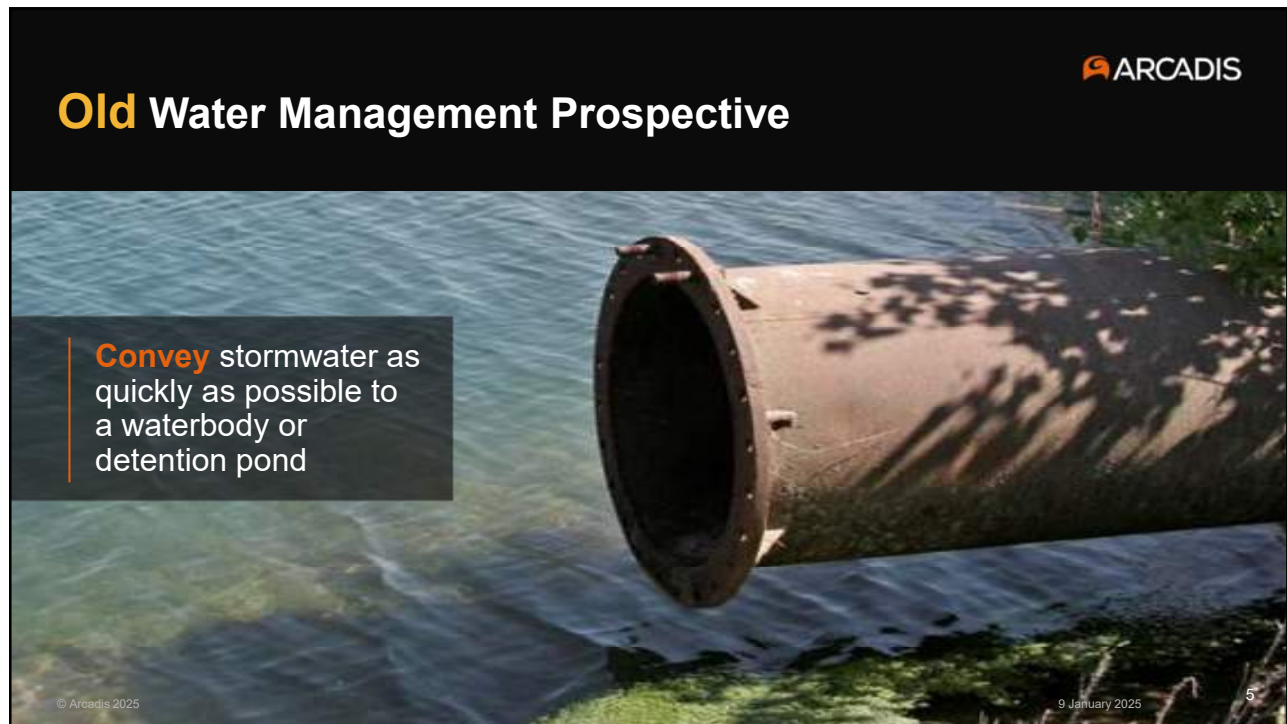
Traditional Use of Green and Gray and Emerging Trends

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NIBS Report on Resiliency

- A 2023 National Institute of Building Sciences report states a **savings of \$11 for every \$1 spent** across all hazards including flood mitigation



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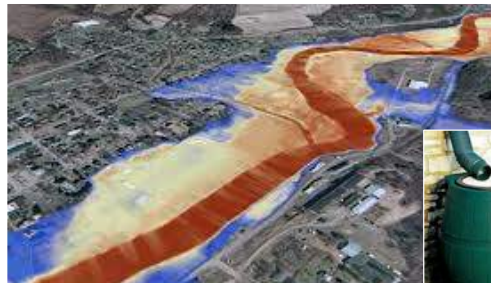


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Key Flood Control Issues

- Designing and adapting to larger and more frequent storm events
- Enhancing floodplain and riparian areas
- Moving toward rainfall volume management
- Use of multi-layered urban flood protection strategy
- GI has historically been used for WQ and gray for storage/conveyance



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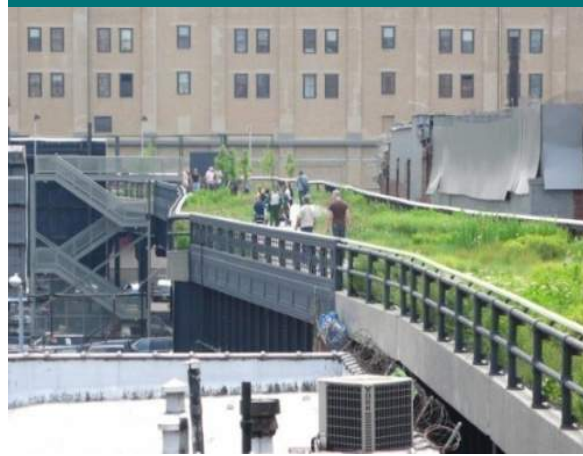
New Approach to Green and Gray: Multi-Purpose Projects

Gray Infrastructure



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Green Infrastructure



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How To Combine Green & Gray for Flood Mitigation

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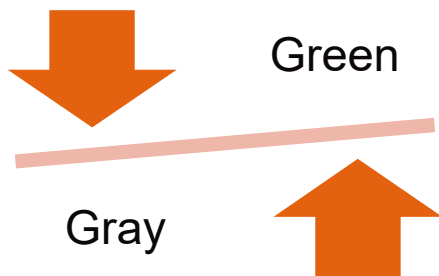
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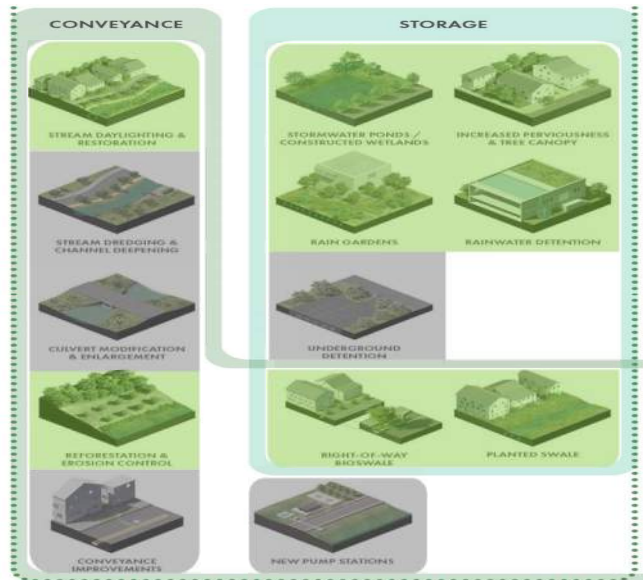
Building Blocks to Mitigate Flooding

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- What's the right combination?
- When to prioritize one vs. the other?
- What are project drivers?



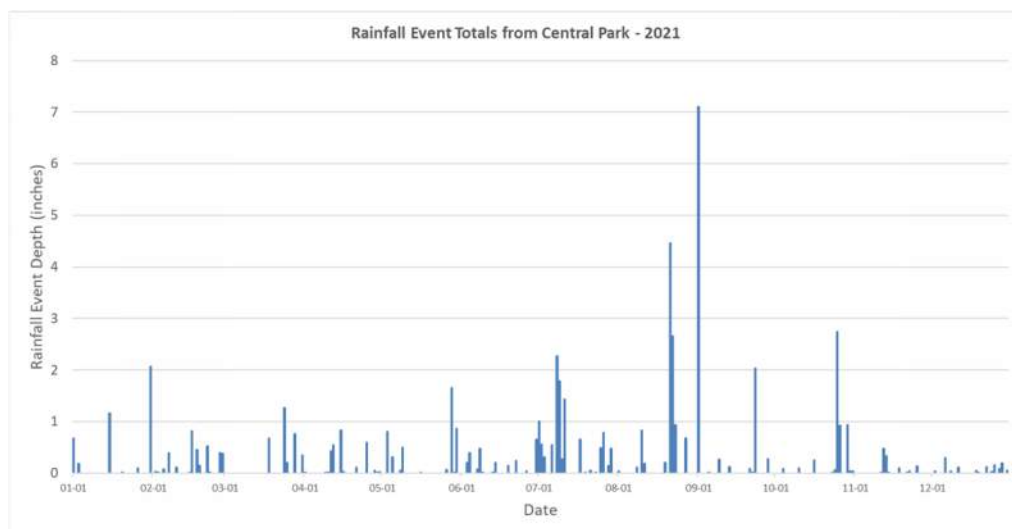
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Rain Event Severity Can Vary Significantly Over the Course of 1-Year

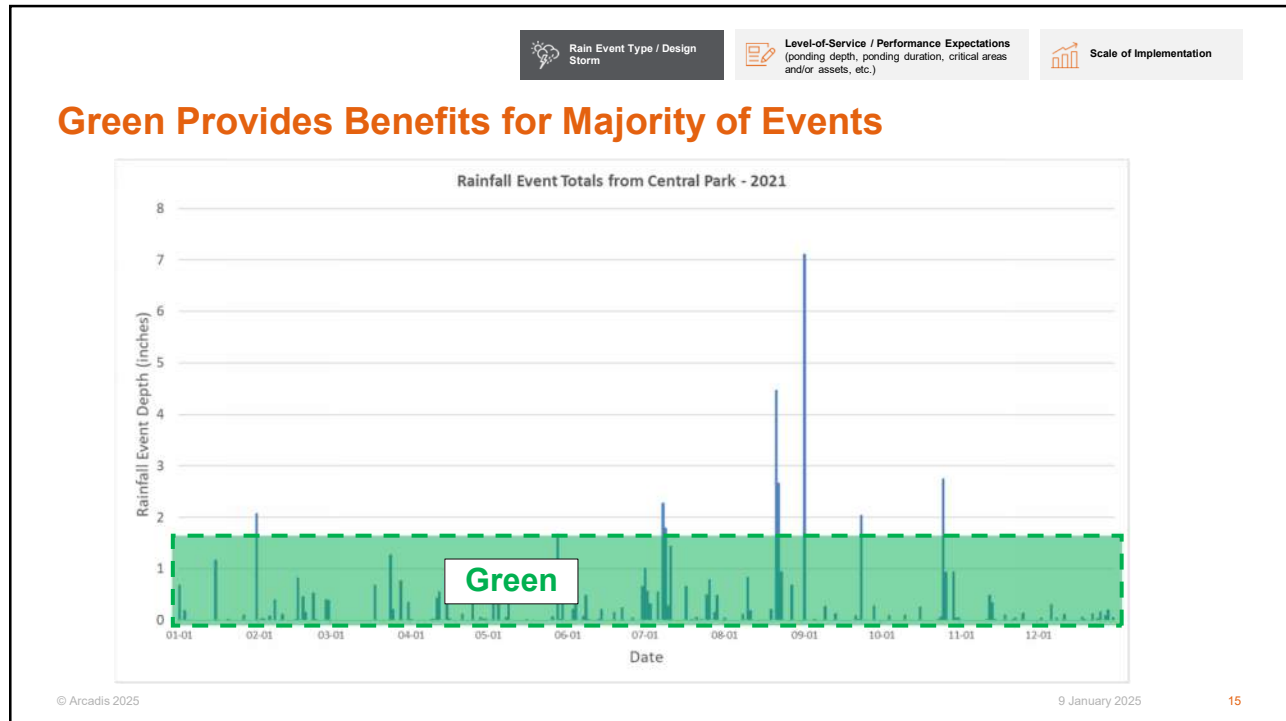


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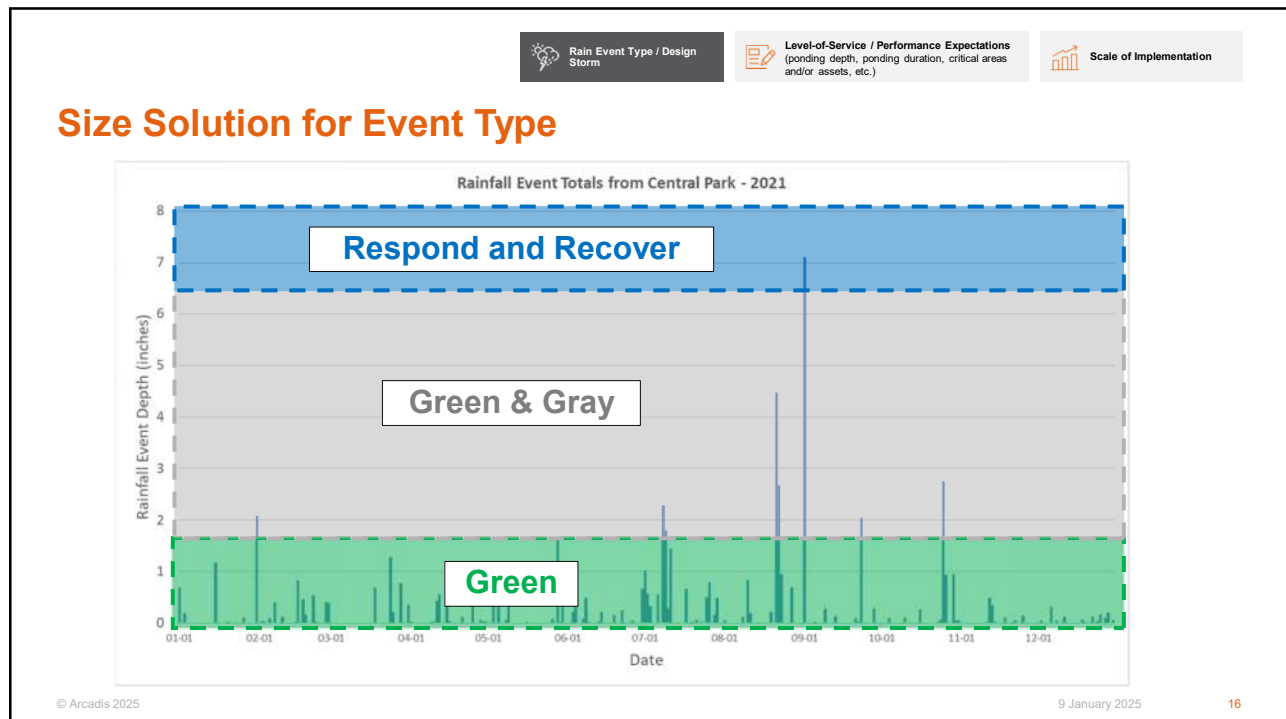
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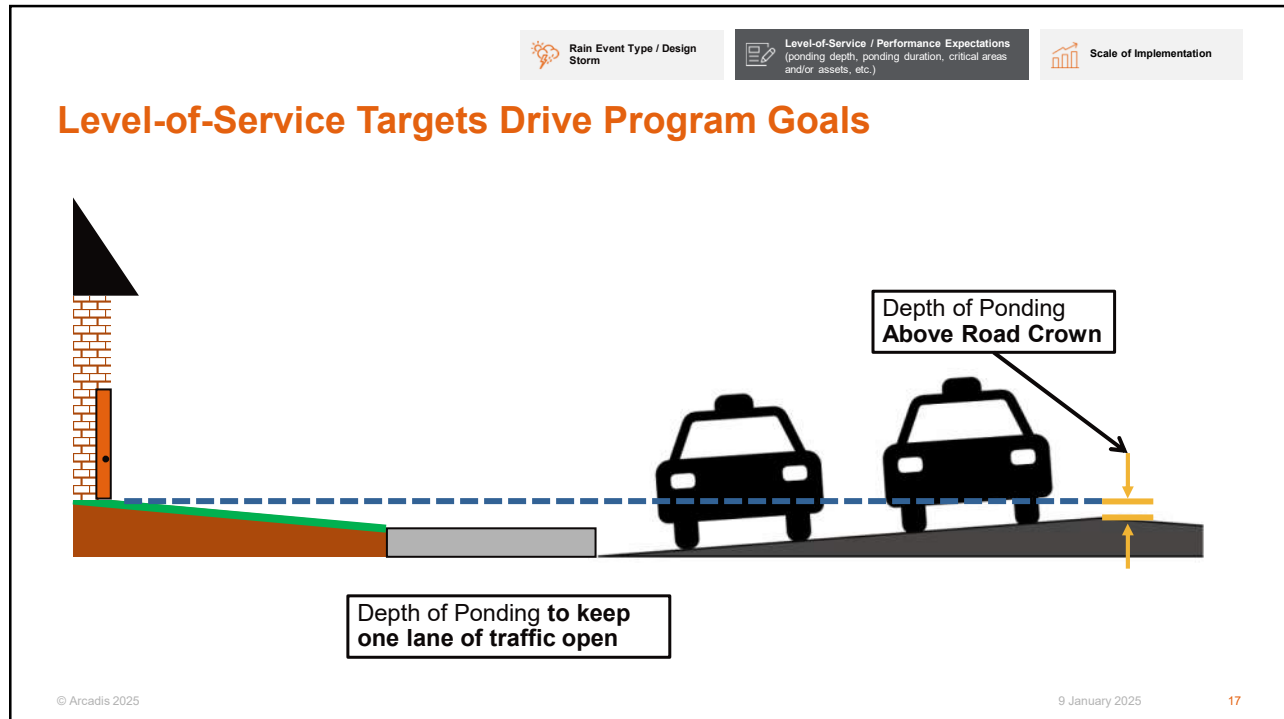
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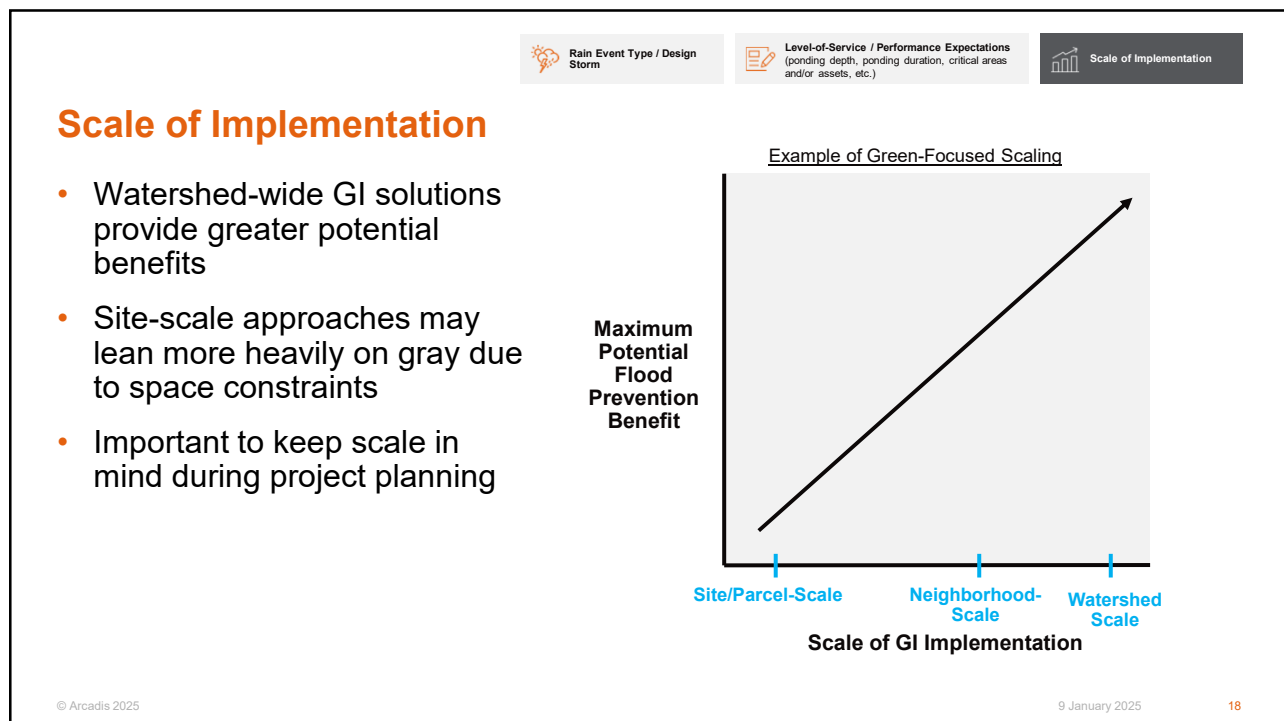
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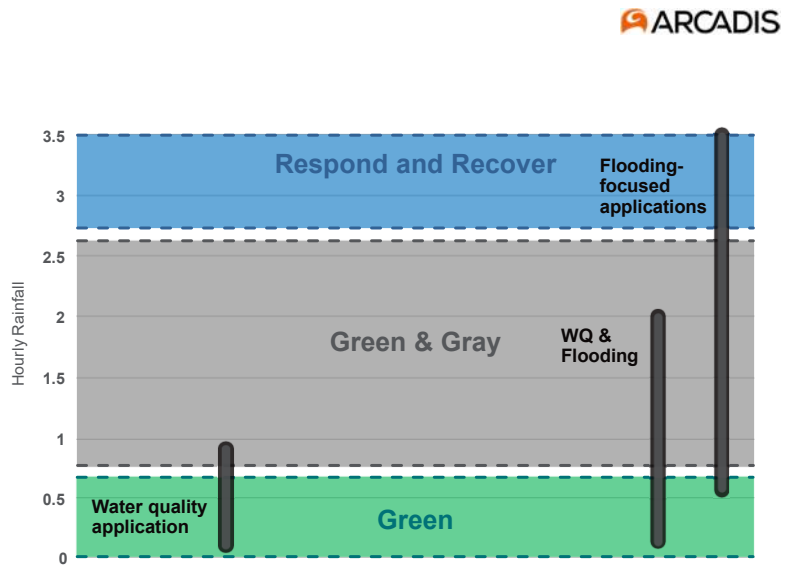


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Scale of GI vs. Gray – Considerations on Application



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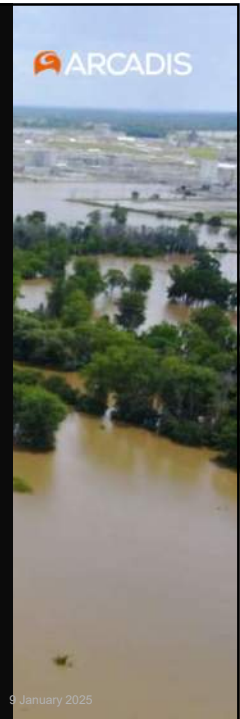
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3 Case Studies

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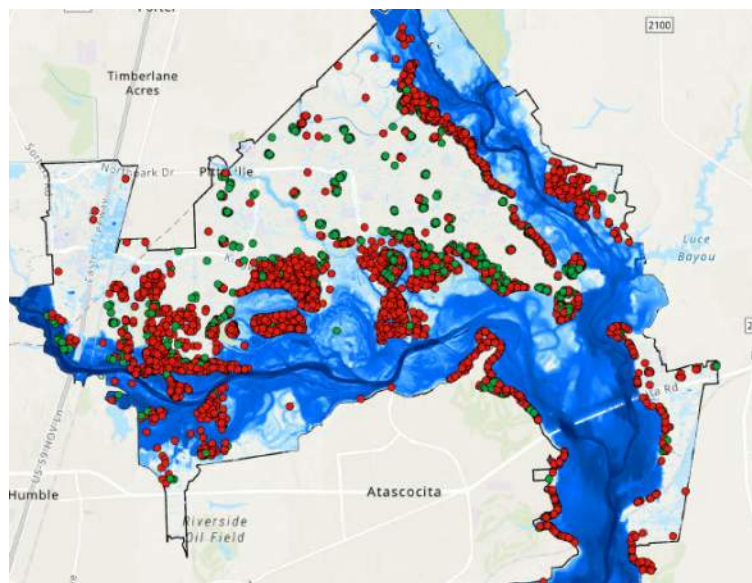
Texas Case Studies

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Houston, Texas Stormwater Master Plan



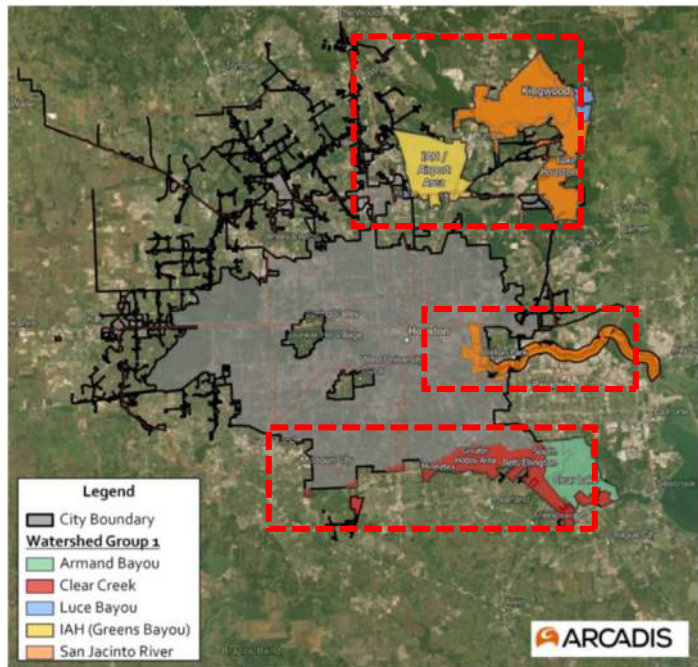
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Background

- Project Scope
 - 11 Watersheds were modeled
 - Arcadis was responsible for 5 watersheds
 - Total area is 178 square miles
 - More than 880 miles of storm system features
 - 9,800 storm conduits



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Hydrology

- Offsite Hydrology
 - Due to data availability and scope limitations, offsite areas were not modeled within 2D zone
 - Offsite areas were delineated using available GIS data, LiDAR, and previous studies
 - Offsite areas hydrologic parameters
 - Areas > 100 acres → Basin Development Factor (BDF)
 - Areas ≤ 100 acres → Rational method

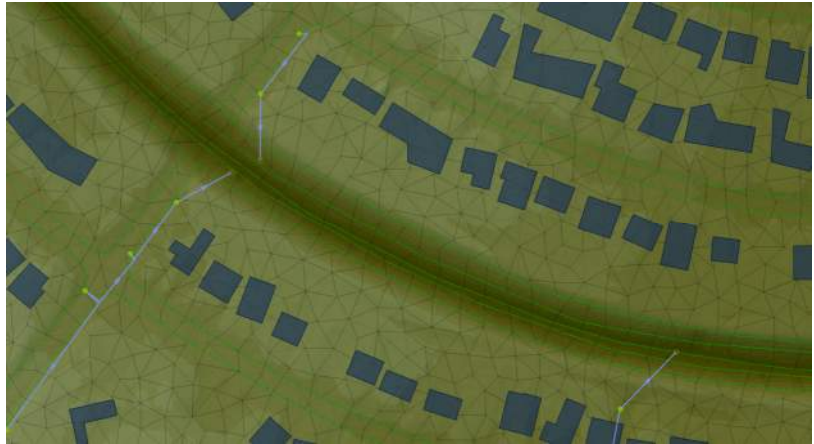


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2D Modeling

- Main Inputs
 - Roughness zones
 - Breaklines
 - Buildings
 - Meshing Parameters
- Modeled Features
 - Studied Channels/Bayous
 - Roadside Ditches



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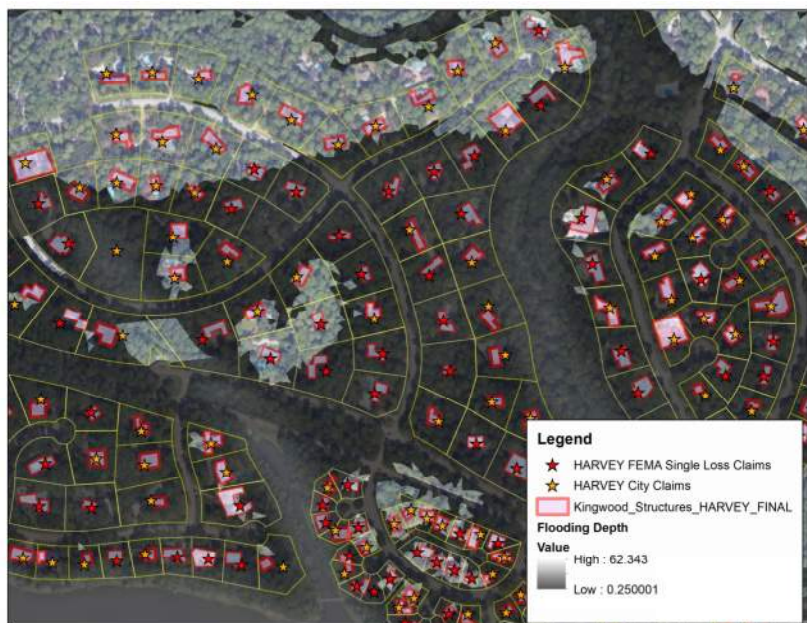
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Validation Criteria

- 50% match between flooded structures based on flood claims and model results
- 75% match between flooded parcels based on flood claims and model results



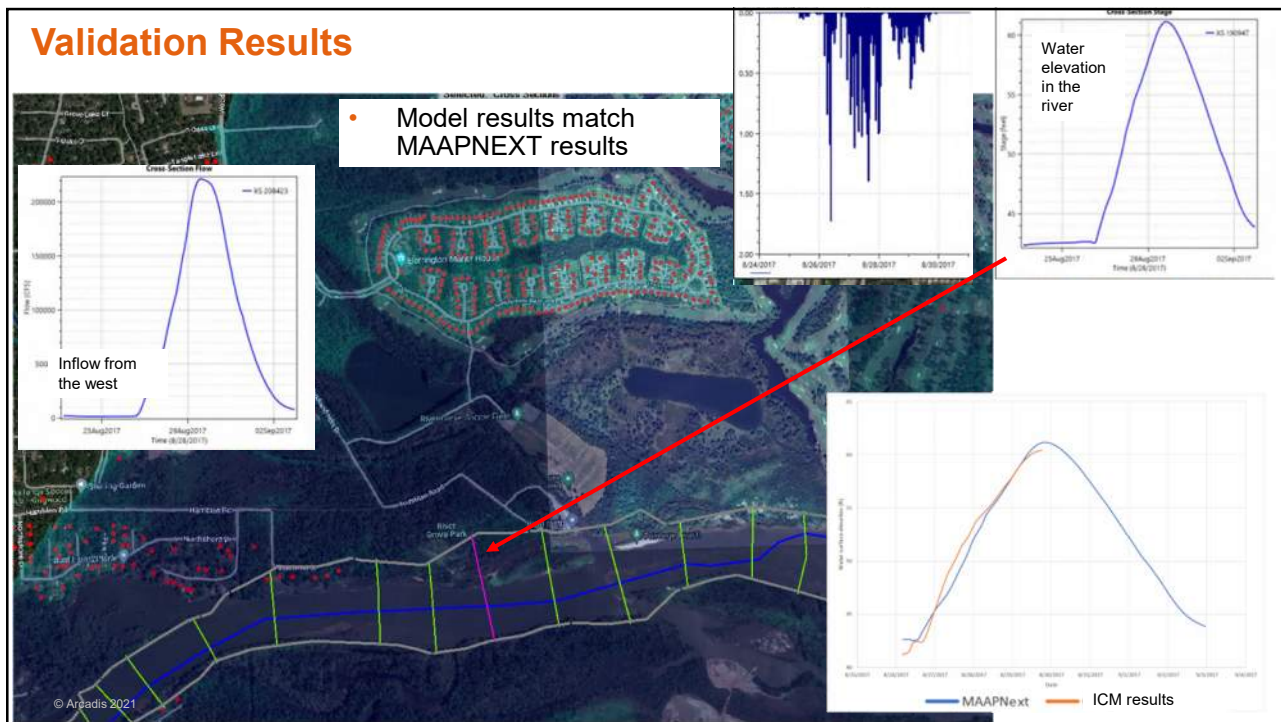
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Validation Results



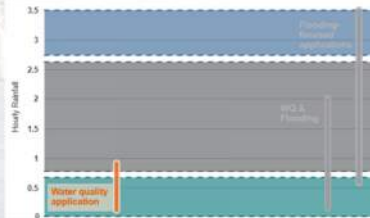
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Lessons Learned

- Input quality reduces the time needed to stabilize and validate the model:
 - Storm Sewers
 - Roughness Zone, Buildings and Edge of Pavement Layers
 - Channel Breaklines
 - 1D Channel Centerline and Banklines
- Apply initial conditions or baseflow where needed – dry river reaches, upstream of dams
- Plan adequate time to troubleshoot the model

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El Paso, Texas WWTP Reuse and Wetlands Treatment



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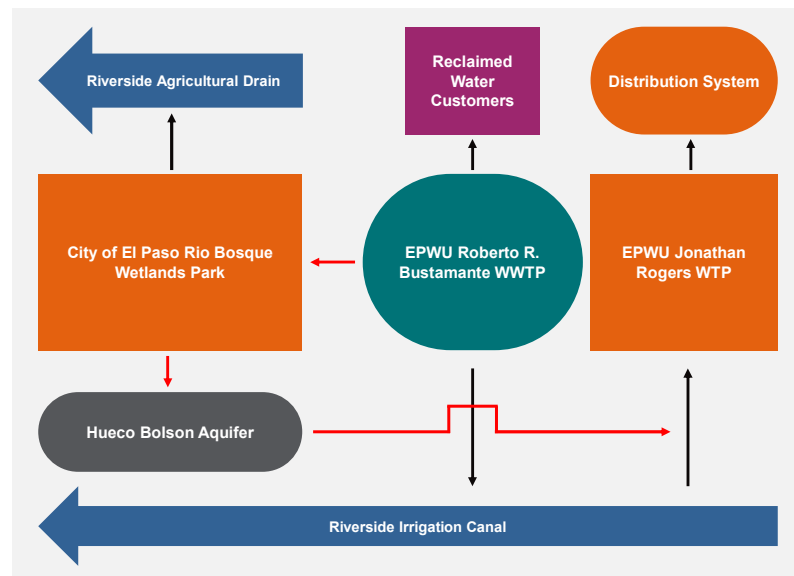
Roberto R. Bustamante WWTP (foreground)
Jonathan Rogers WTP (background)

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Water Flow Diagram

- WWTP treats 12 MGD with 5 MGD of reclaimed water
- Reclaimed water is discharged to the Rio Bosque Wetlands Park
- Recharges groundwater in the Hueco Bolson aquifer and provides water to the Riverside Agricultural Drain
- Supplemental raw water supply for the Jonathan Rogers WTP



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National Case Studies

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MWRD of Greater Chicago Little Calumet River/Cal Sag Channel Stormwater Master Plan



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Range of Green/Gray Solutions Evaluated

- No change (baseline)
- Gray infrastructure
- Green infrastructure
- Green/gray hybrid infrastructure
- Green infrastructure on private property
- Gray infrastructure on private property
- Raising of flood-prone properties
- Purchase of flood-prone properties



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Different Solutions Identified for Each Land Use Type



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ENLACE, San Juan, Puerto Rico Caño Martín Peña Comprehensive Infrastructure Master Plan



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Holistic Solution Included Green Infrastructure

FLOODING - CATASTROPHIC

CIMP MACROSTRATEGIES

A LEVEE OR SEAWALL SEPARATE FROM THE SHEET PILE WALL LOCATED OUTBOARD OF THE MANGROVE RESTORATION

This option would prevent surge flooding from entering the neighborhoods by providing a levee or seawall separate from the sheet pile wall. Pluvial flooding could still occur in the event of a surge depending on the final interior drainage design, but construction of new pump stations and outfalls should allow stormwater to be removed from the District as a timely manner if a surge occurs.

The sheet pile wall would likely need to extend below grade to the limestone stratum. The wall would be designed to resist hydrodynamic and seismic forces. Extensive geotechnical exploration will be required to design the wall but is of the same general type as the canal wall being designed by the Army Corps of Engineers.



IMPLEMENTATION SCALE: DISTRICT

CO-DEPENDENCIES:



BENDORM SEASCAPE, SPAIN



POTOMAC PARK LEVEE, WASHINGTON DC

SCORE CARD



OVERALL SCORE



FEASIBILITY CONSIDERATIONS

No violent actionemque aut etiamque
supra, quidem unde quia si concludam
id non quodam undecim non enim con
perio ineluctum. Quia expugnata eorum
impugnatum ad de volum quia esseque, qui
cus.

Milia consero tu elestem fugitatis vellesque
plagui dolorem mercesque, tem fugitia quo et aut
volorem ut qui autatem.



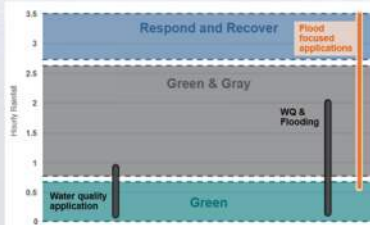
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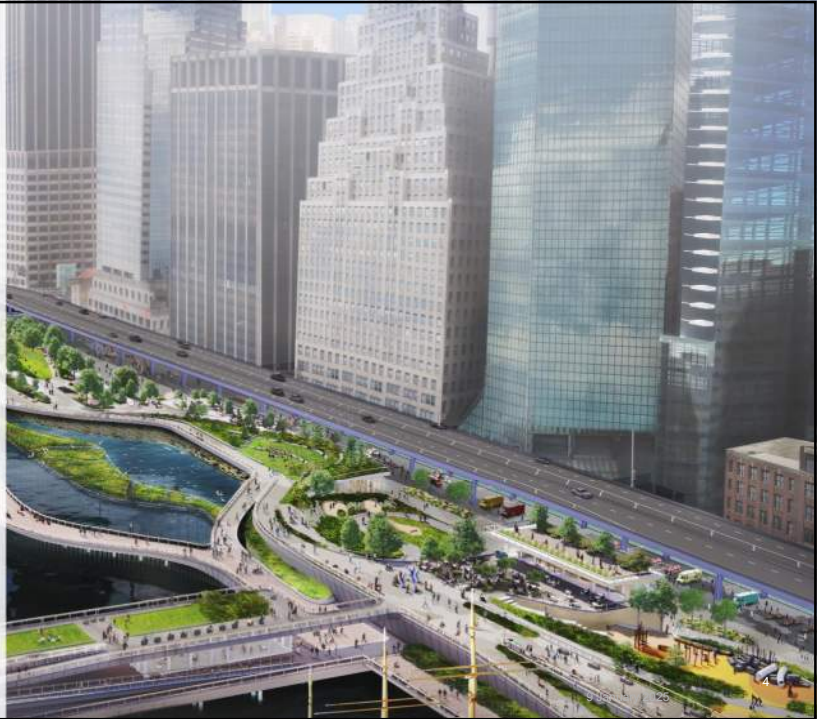
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Seaport-FiDi Coastal Resilience

Managing Rainfall Behind a Coastal Flood Protection System



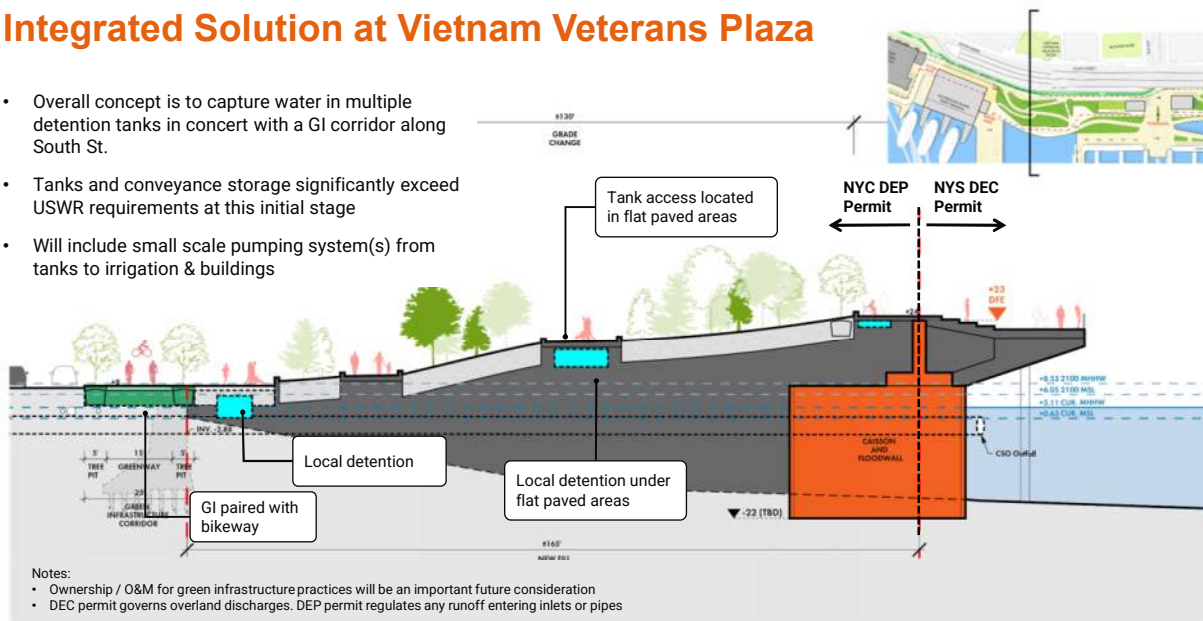
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Integrated Solution at Vietnam Veterans Plaza

- Overall concept is to capture water in multiple detention tanks in concert with a GI corridor along South St.
- Tanks and conveyance storage significantly exceed USWR requirements at this initial stage
- Will include small scale pumping system(s) from tanks to irrigation & buildings



Notes:

- Ownership / O&M for green infrastructure practices will be an important future consideration
- DEC permit governs overland discharges. DEP permit regulates any runoff entering inlets or pipes

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Fayetteville, North Carolina

Blounts Creek Watershed Master Plan



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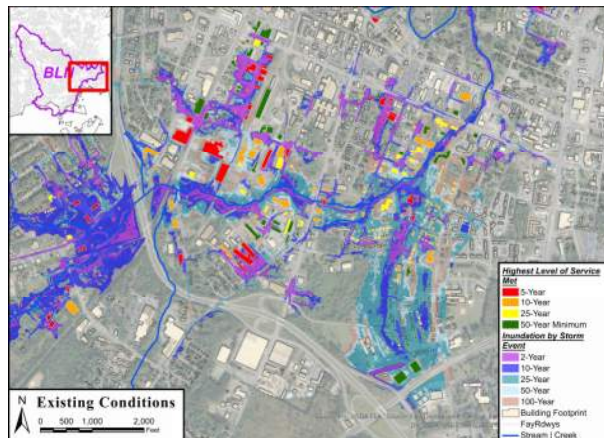


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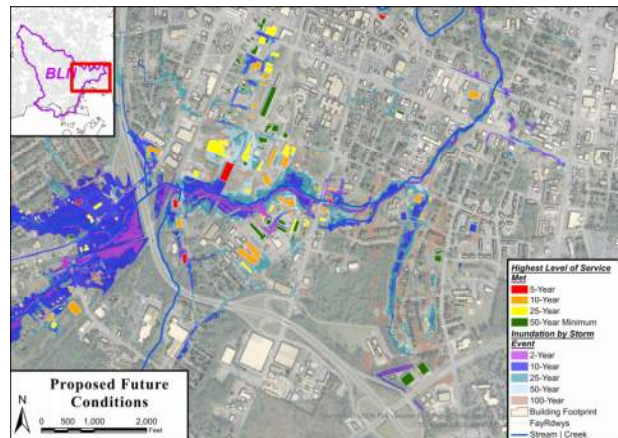
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Flood Mitigation Solution Involves Replacement of 4 Bridges



- Eliminates 3.3 miles of impacted lane length.
- Eliminates 3 traverse road crossings
- Eliminates 125 disconnected structures
- Removes # of Impacted Structures:
 - 10-year (77)
 - 25-year (130)
 - 50-year (144)

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- This solution intersects with 12 concern areas and will reduce flood impacts for each
- Will provide a \$24.7 million dollar benefit in flood risk reduction and property damage
- Stream enhancements will provide an environmental and public benefit contributing to a resilient watershed

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Portsmouth, Virginia Resiliency Strategy



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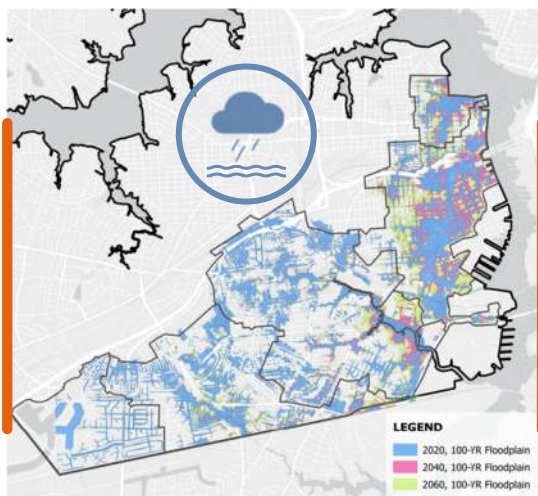
STORM SURGE FLOODING



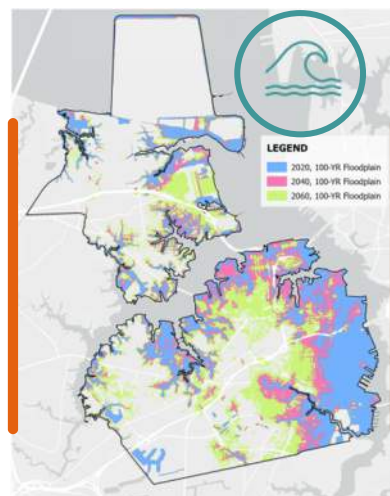
RAINFALL FLOODING

41

Comprehensive Long-term Flood Resilience Strategy



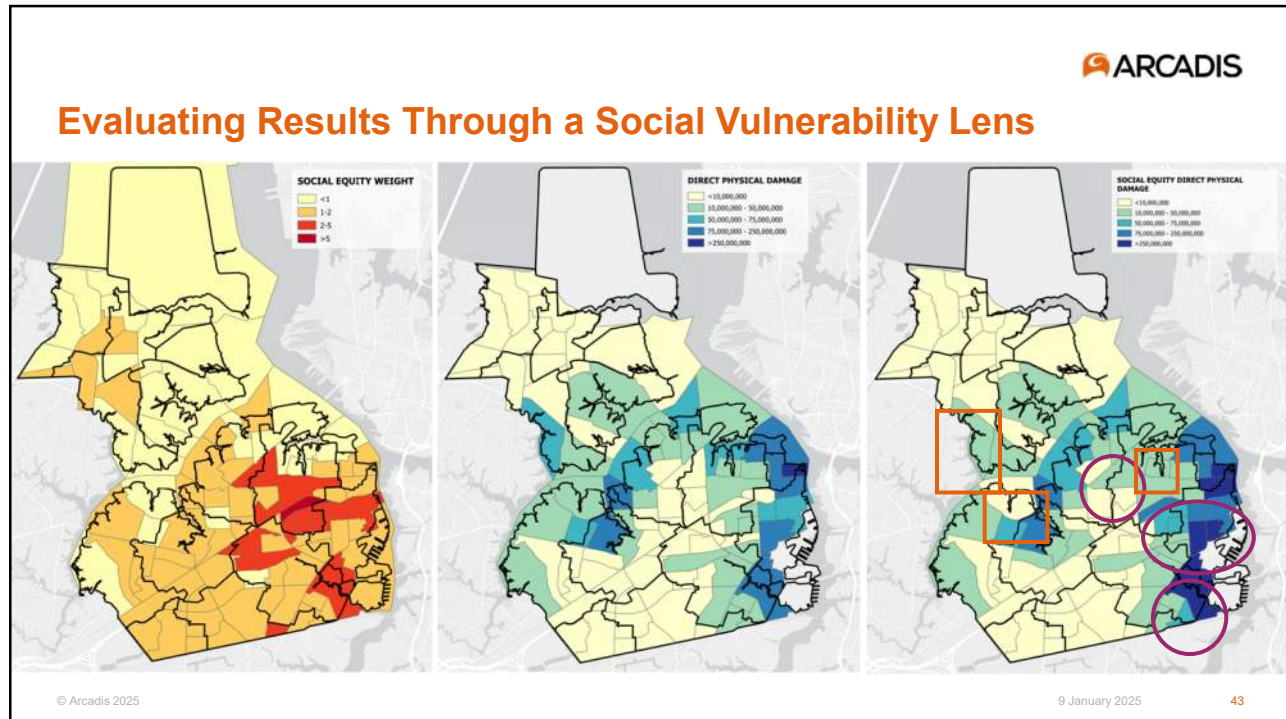
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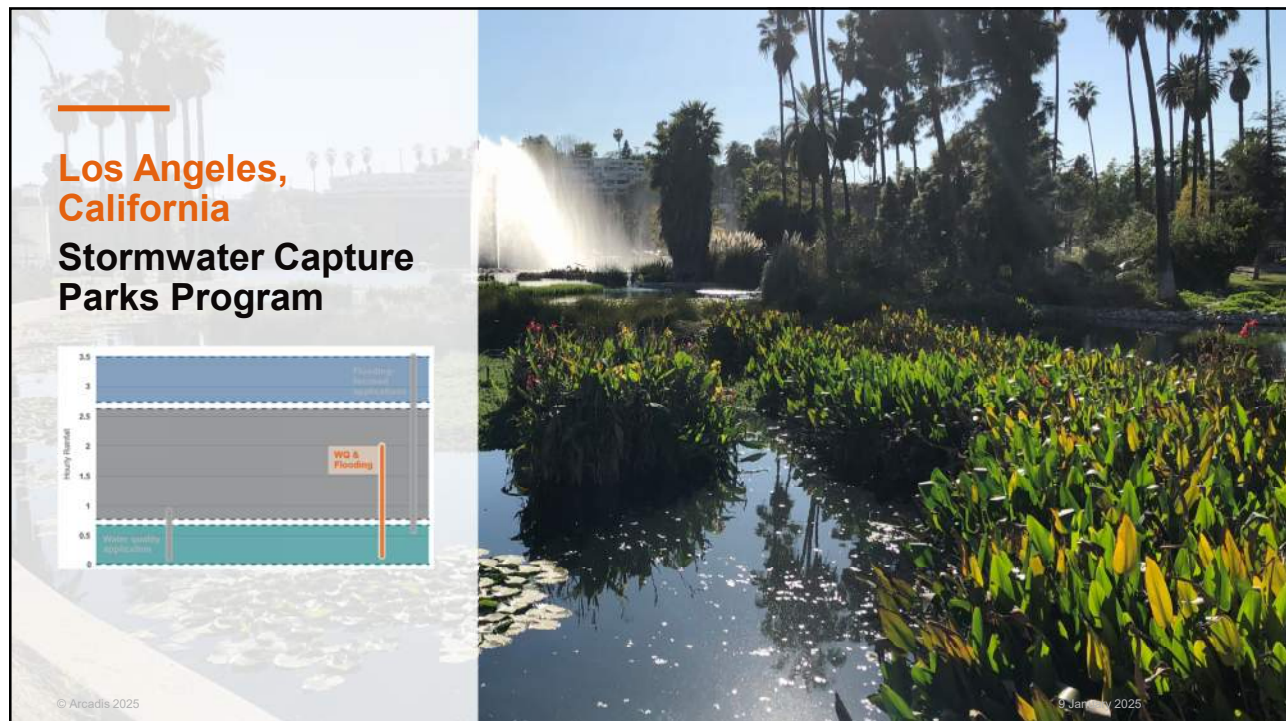


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Green Infrastructure Ranking Tool Power BI Interface



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Large Underground Storage in Parks Captures Stormwater to Recharge Groundwater



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Norfolk, Virginia Ohio Creek Watershed Improvement Project



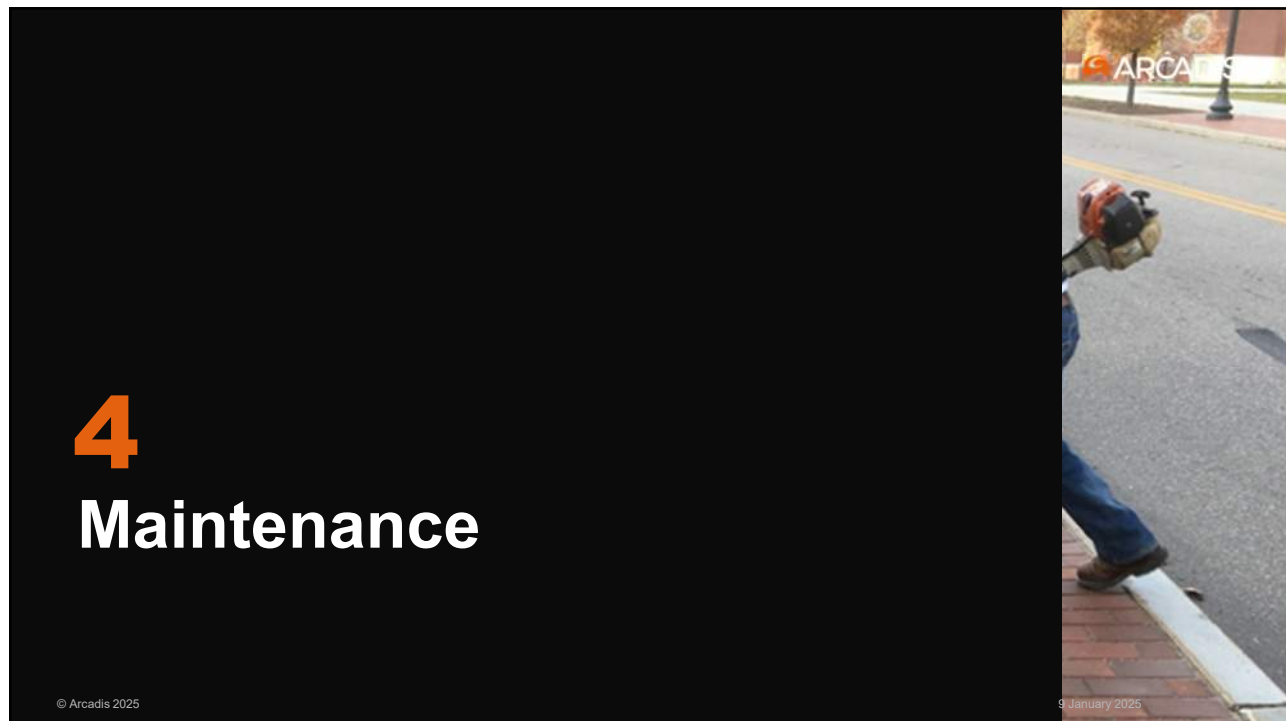
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Design Criteria & Maintenance Protocols Need to Improve

- The effectiveness of a stormwater management program depends largely on how well and how safely assets perform over time
- Some gray and green drainage systems have failed
- Routine maintenance is not being performed because of funding constraints and ownership issues
- Performance feedback is needed to address design and maintenance needs and to justify funding needs

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Gray Infrastructure Maintenance



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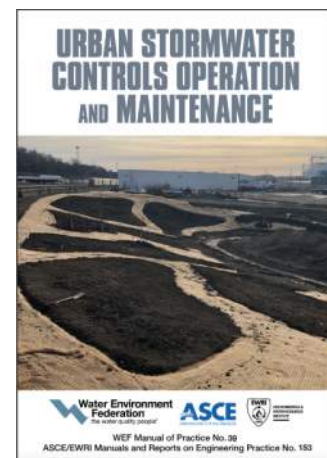
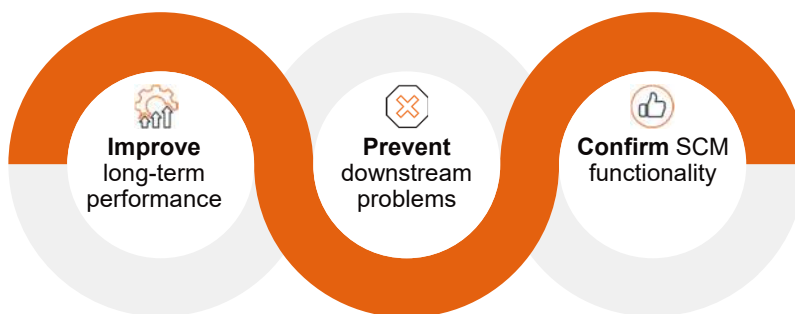
GI Has Different Maintenance Needs

GI category	GI types	
Basins	• Dry basins • Cisterns and rain barrels • Wetlands • Oil/water separators	• Wet basins • Vaults and swirl concentrators • Forebays
Swales, strips, stream restoration	• Swales • Outfall treatment, level spreaders	• Vegetated strips • Stream restoration
Filters	• Surface and subsurface sand filters • Landscaped / vegetated roofs • Manufactured filters (boxes)	• Bioretention • Drain inlet inserts • Subsurface gravel wetlands
Infiltrators	• Infiltration basins • Dry wells	• Bioretention (infiltration) • Infiltration trenches and vaults • Permeable pavement
Gross pollutant traps and mechanical operations	• Screens • Baskets • Hoods	• Nets • Racks

Adapted from "Design of Urban Stormwater Controls" (WEF Press, McGraw Hill, 2012)

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Inspections & Maintenance of GI is Critical



Need a manual to describe the importance of O&M and present best practices

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5 Lessons Learned

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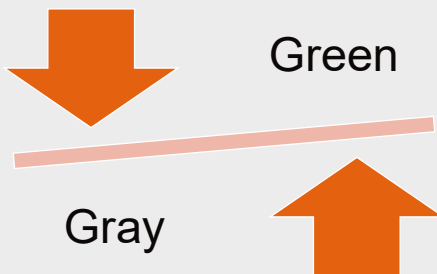


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How Best to Combine Green and Gray?

- What's the right combination?
- When to prioritize one vs. the other?
- What are project drivers?



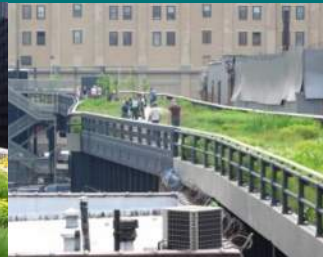
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Gray Infrastructure



Green Infrastructure



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Lessons Learned from Municipalities Across the U.S.

- Future routine maintenance will be critical to the success of green and/or gray improvements.



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Lessons Learned from Municipalities Across the U.S.

- Take proposed solutions to the public to get feedback and gain buy-in
- Provide education on stormwater management (green vs gray, public vs private, etc.)
- Consider demographics/ community budget when selecting alternatives



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Lessons Learned from Municipalities Across the U.S.

- Political support is critical
- Significant investment is needed
- Well structured programs can provide cost efficiencies
- Use adaptive management approach for continual improvement



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Questions?

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Contact us



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