

C2E2 Review  
May-20-2024

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***RAMP Overview and Discussion***

May 2024



# Agenda

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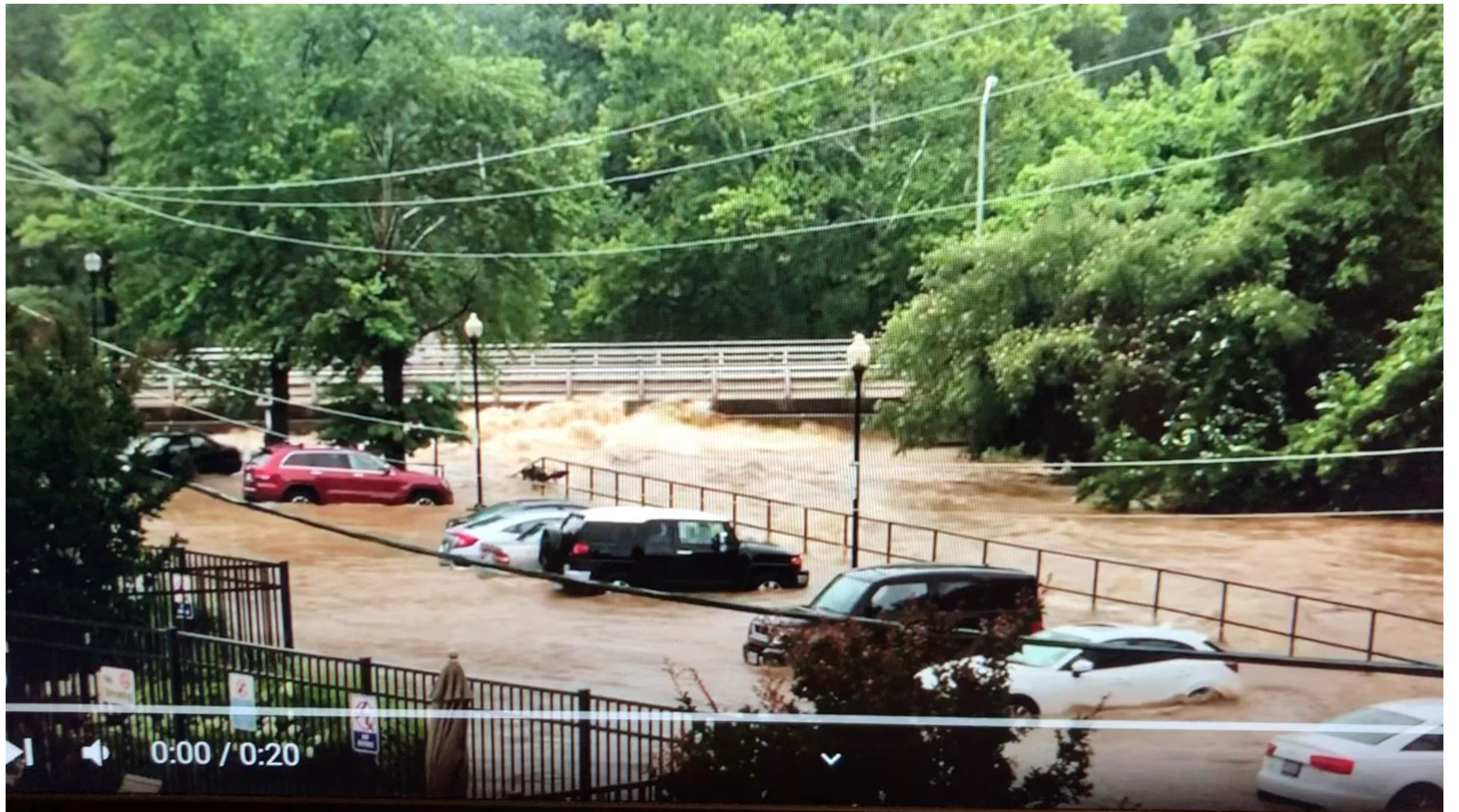
- **The Legacy, the Challenge and the Response**
  - Pivot to Flood Resilient Arlington
  - **Deploy Risk-Management Strategy**
- **RAMP-ing Up for Storms**
  - Executive Summary - Scope & Deliverables
  - Analytics – Vulnerability and Risk
- **Conveyance / Detention Projects**
  - Including Cost-Benefit Analyses
- **Program / Policy Recommendations**
- **Wide Use and Application of the RAMP**
- **Internal/Public Engagement**
- **What Follows the RAMP**





# The Legacy, the Challenge, the Response

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This is what it looks like when the stormwater system overflows

# Environmental Risks and Cascading Impacts

- Economic disruption
  - Property loss, supply chain disruption, economic activity interruption
  - Re/insurance markets
  - Bonding / Cost-of-Debt
- Physical damage
  - Damage to roads, utilities, assets, communications, buildings, facilities
- Health and public safety
  - Loss of life, interruption in critical emergency services
- Population displacement
  - Short term displacement, long term relocation





# ***Pivot to Flood Resilient Arlington***



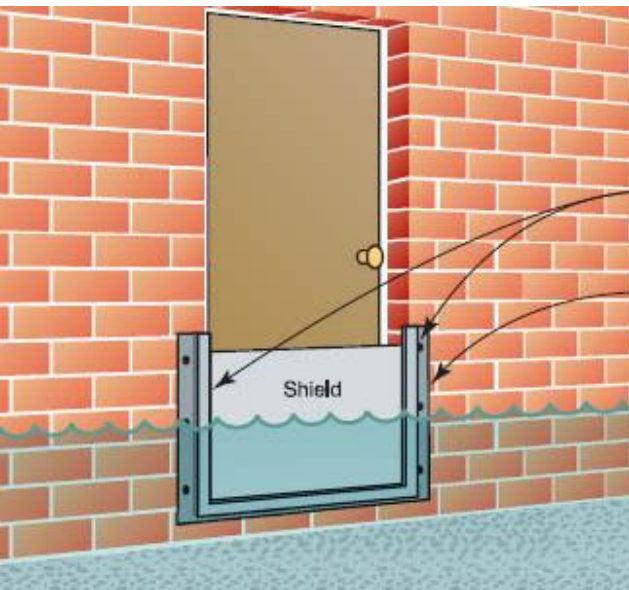
Analytics and Data Assessment



New Types and Locations for Capacity Projects



Increased Stormwater Requirements



Increased Funding



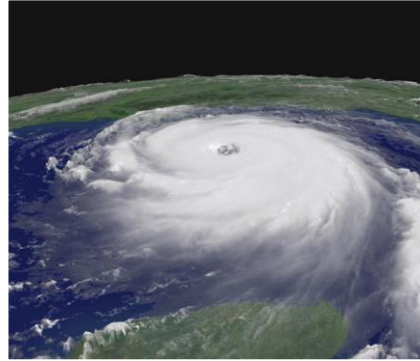
Voluntary Property Acquisition



Floodproofing Outreach

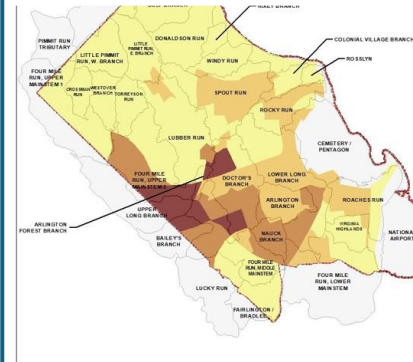
# RAMP Resilience Planning Approach

## Develop Framework



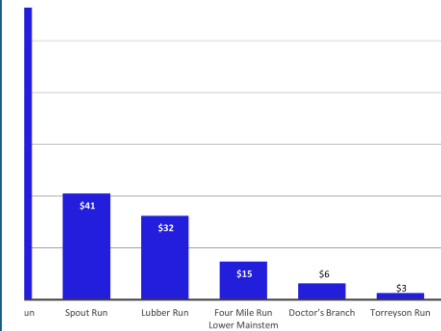
Goals  
Climate  
Scenarios  
Tools

## Identify Vulnerabilities



Facility inventory  
Flood modeling  
Vulnerability  
Assessments  
Risk Analysis

## Adaptation Strategies



Cost benefit  
analysis  
Programmatic  
strategies







# RAMP-ING UP FOR STORMS

## RISK ASSESSMENT AND MANAGEMENT PLAN

RAMP, the County's Risk Assessment and Management Plan, is a comprehensive framework for modeling, measuring and reducing risk in the face of the increasing frequency and intensity of storms and flood-related impacts influenced or caused by climate change.

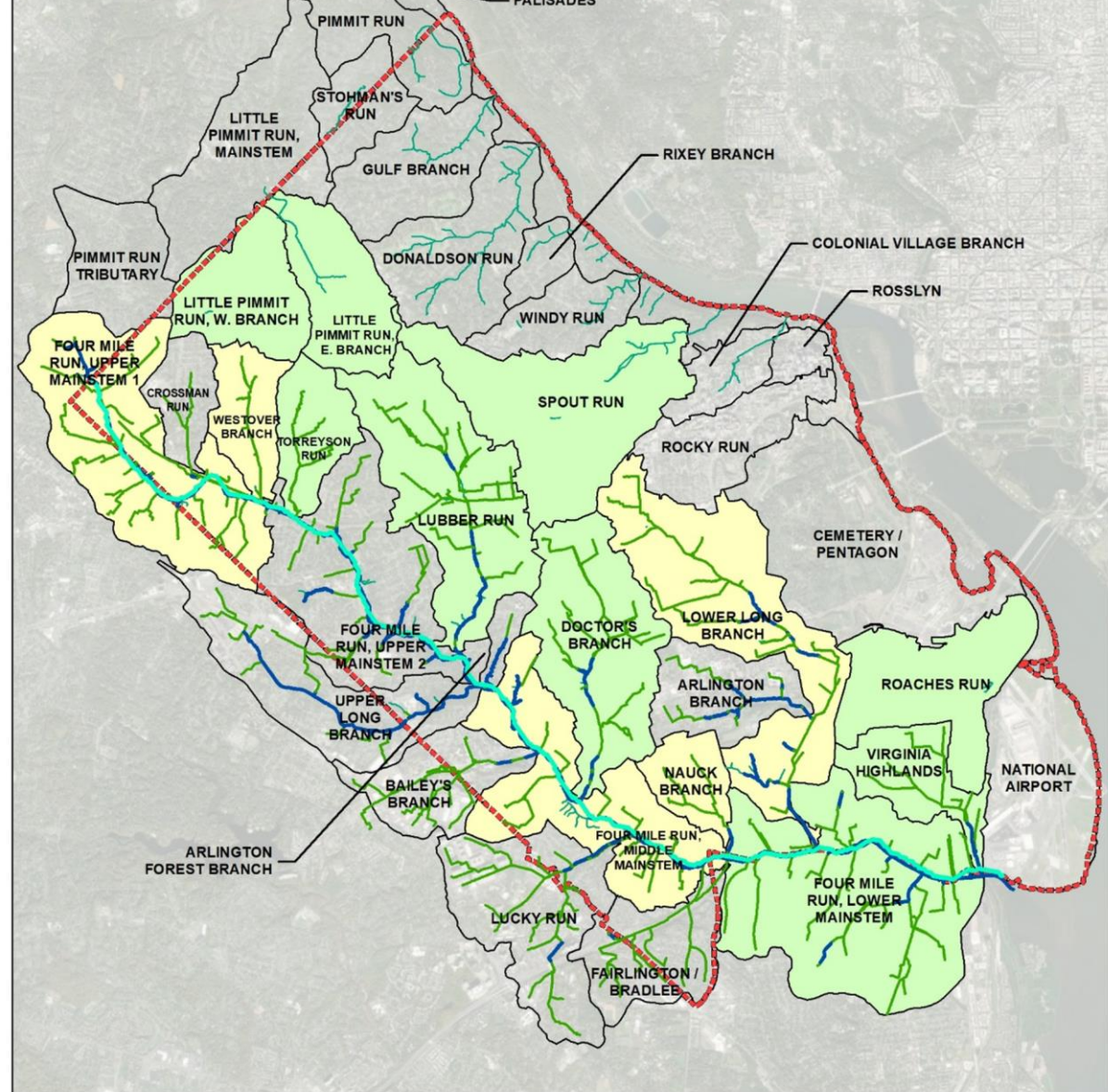
The RAMP has updated Arlington's climate projections for flooding, sea level rise and storm surge using 2040, 2070 and 2100 as the climate time horizons. Further, the RAMP has created inundation maps for each of the climate time horizons, identified Critical Government Facilities and completed Vulnerability and Risk Assessments for nine priority watersheds. The Risk Assessments combine economic, environmental and social risk; the latter designed to reflect vulnerability and risk specific to moderate- to high-Social Vulnerability Index communities.

Staff will launch public information on the RAMP in March and anticipate a public engagement workshop in the second quarter of 2023.









# RAMP (Risk Assessment and Management Plan)

- Prior to the RAMP, flood mitigation planning used ATLAS 14, a common and widely-used NOAA Tool
- ATLAS 14 lags in updates but, critically, uses past and present storm/flood data only (temporal stationarity)
- **The RAMP expands upon past and present data, with climate projections and modeling for 2040, 2070, and 2100**
  - RCP 8.5 with moderate forcing
  - Inland flooding, sea level rise, and storm surge
  - Present and future 2-D flood mapping within the key watersheds identified as flood-vulnerable

# Watersheds Analyzed in the RAMP



## LEGEND

-  FEMA FMR HEC-RAS Model
-  Modeled Storm Mains
-  Modeled Streams
-  2019 County Streams
-  County Boundary
-  1D/2D PCSWMM Model
-  FAST Analysis
-  Arlington County All Watersheds

0 0.5 1 2 Miles

# Climate Scenarios for Modeling are Based on Climate Change Threats: Rainfall, Sea Level Rise and Storm Surge

Precipitation



2- to 10-year storms

100-year storms

Stormwater/ Drainage Management



- Localized flooding
- Increased SSOs/CSOs

Riverine Floodplain Management



- Regional flooding

Sea Level Rise



Tidal flooding

Miami Herald Miami Beach

Rain or no rain, beachfront streets flood due to 'spring tide'



Moses Schwartz calls for a tow truck after his Nissan SUV sinks into the standing water on the 800 block of Alton Road in Miami Beach on Thursday, Oct. 17, 2013. WALTER BRICHT / MIAMI HERALD STAFF

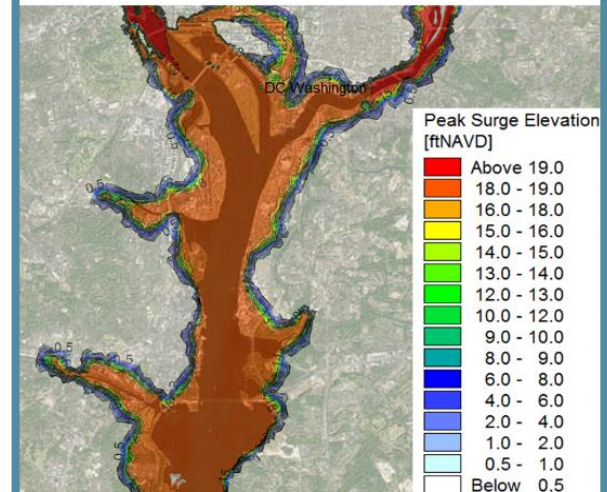
BY PHILIPPE BOUTEAU  
PHILIPPEBOUTEAU@MIAMIHERALD.COM  
Miami Beach residents can expect high tides through Saturday — not just on the sand, but in the street.  
Alton Road near 10th Street, on the bay side of the island, became a flood zone Thursday, the result of poor drainage and rising waters. So did parts of Purdy Avenue, and West Avenue.  
In Broward County, Hollywood also reported flooding.  
Rain or no rain, the waters still rose.  
Moses Schwartz is one of the latest victims. He was pulling his Nissan to the curb along Alton to

Recurrent flooding from increased tide levels

Storm Surge



Tropical storms



Coastal flooding

# RAMP at a Glance

## Final Document Suite

- Executive Summary
- Full Report
- Appendices Report – Technical Memoranda

## Technical Memoranda

- Climate Projections and Scenarios
- Arlington Interior and Riverine Flooding
- Coastal Surge Modeling
- Arlington Flood Vulnerability Assessment
- Arlington Flood Risk Assessment
- Arlington Flood Mitigation and Adaptation Strategy
- Programmatic Strategies for Flood Management
- Market Analysis

# Core RAMP Elements

- **Updated Climate Projections**
  - Multiple climate vulnerabilities and climate “horizons” or timeframes
- **Inundation Maps / Updated IDF Curves**
  - modeled on a Watershed-Scale over multiple climate horizons (2040, 2070, and 2100)
- **Vulnerability Assessments**
  - Calculations factoring critical civil/civic assets, environmental impacts, and social vulnerability
- **Risk Assessments**
  - Direct, indirect and cascading impacts based on 1) total loss or replacement, lost revenue, increased costs of O&M, loss of economic activity
- **Capital Projects, Programs and Policies to Mitigate and Manage Flooding in Arlington County**
  - By type and cost-benefit calculations
- **Market Impacts and Analysis**
  - Impacts on bonding/cost of debt, re/insurance, land use

# Total Area Flooded by Watershed

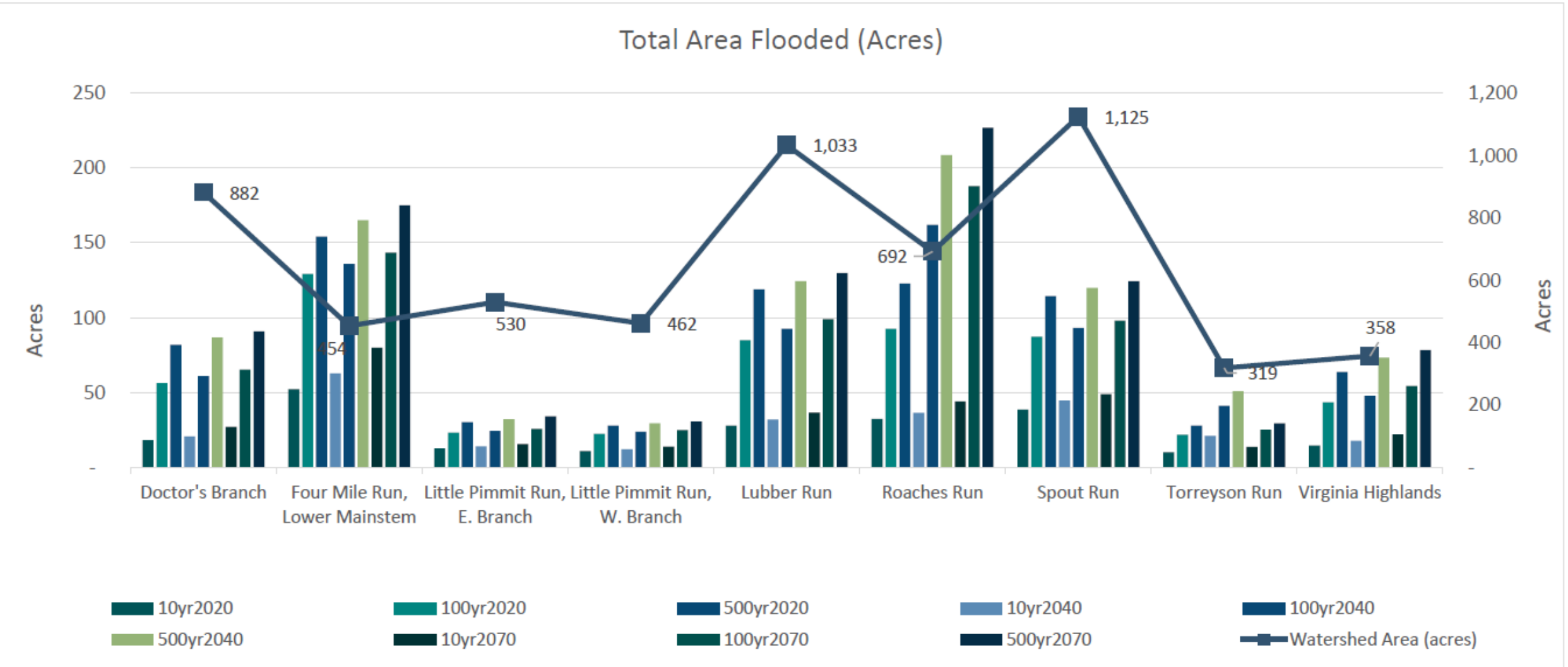
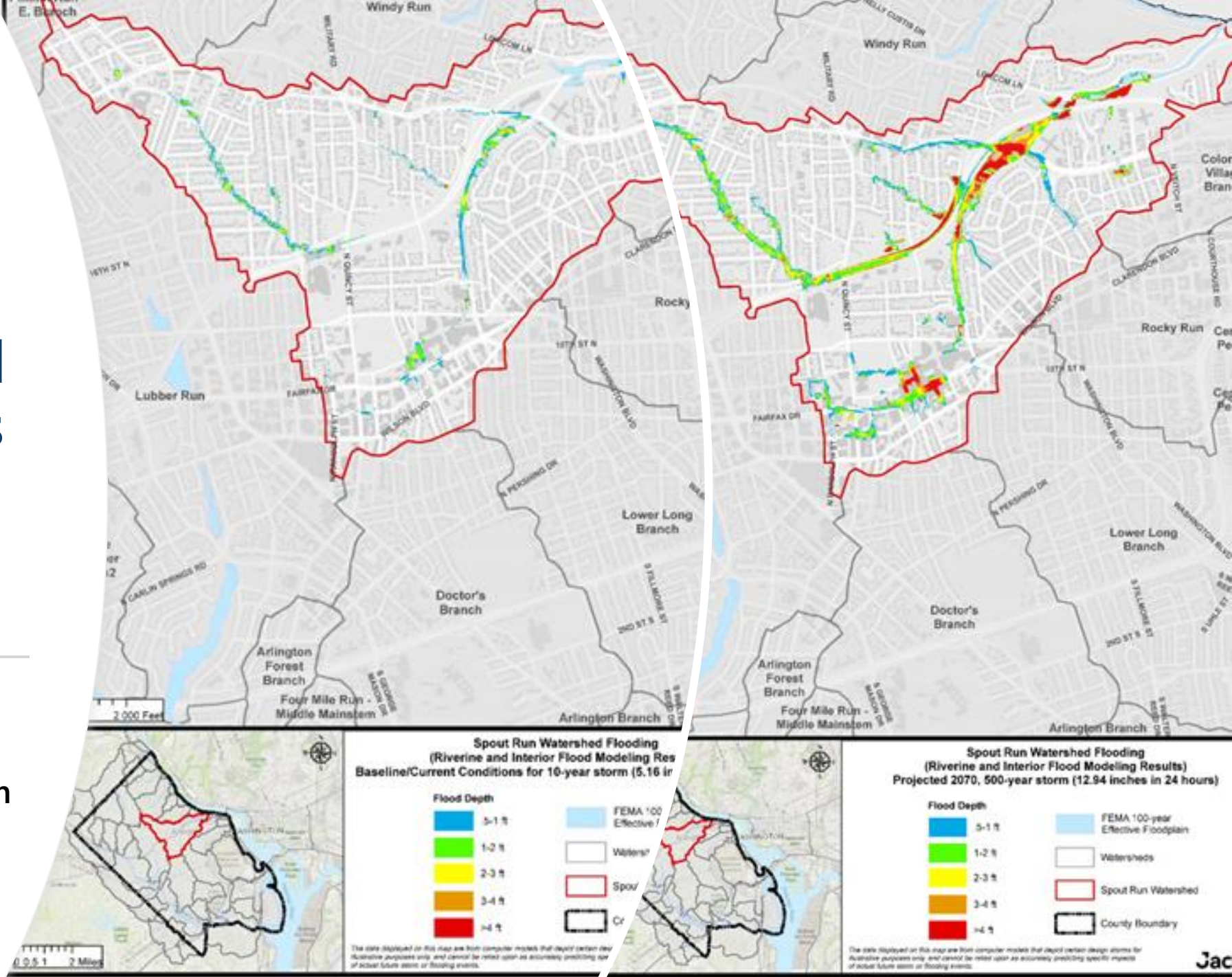


Figure 3-2. Extent of Flooded Areas by Watershed Under Different Scenarios



# Climate Adjusted Inundation Maps for Varying Size Storms

Spout Run 10 year storm, baseline vs. 2070 500 year storm



# Updated IDF Curves Allow for Future Ready Design

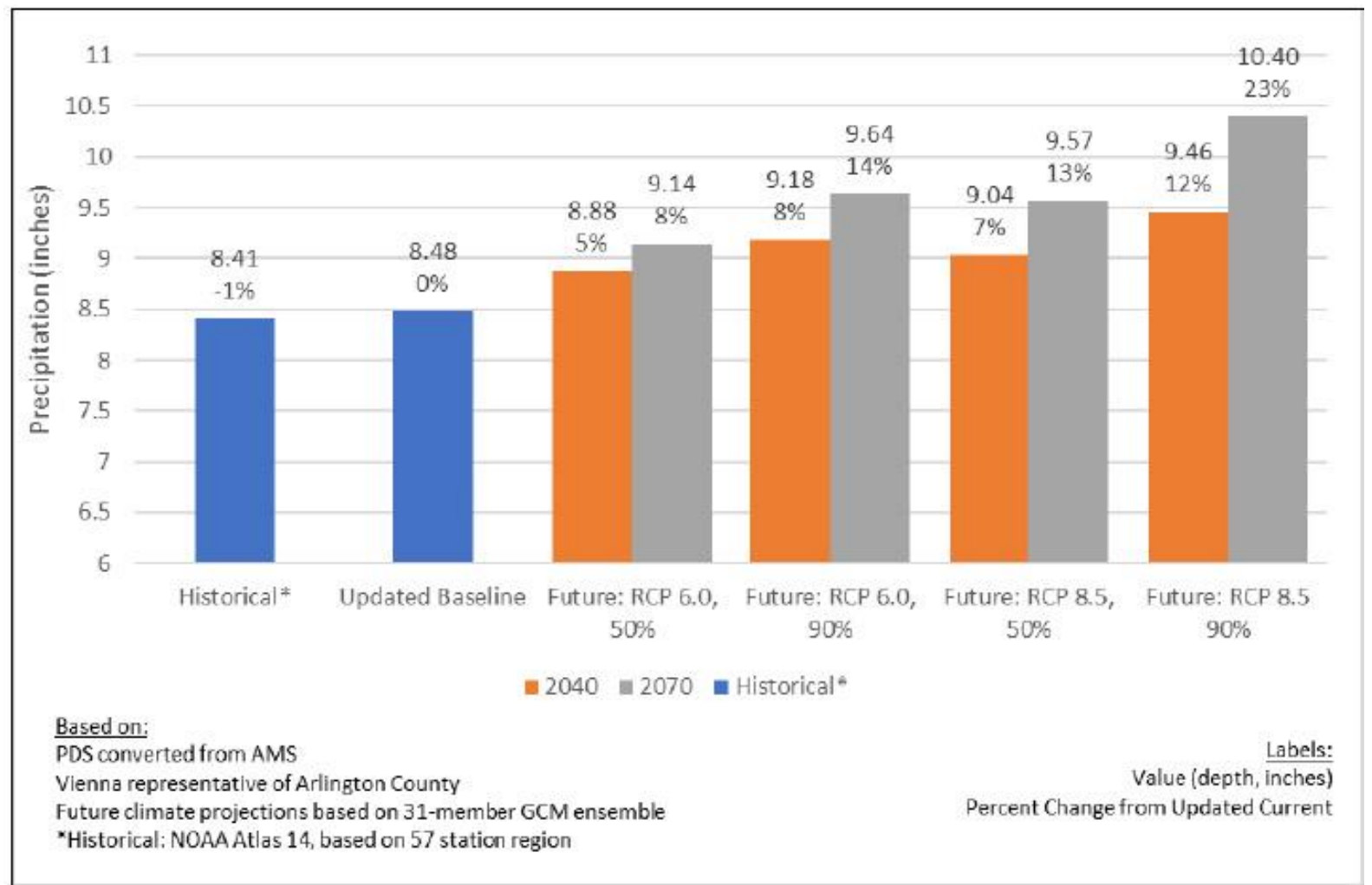


Figure ES-1. Baseline and Future 100-year 24-Hour Precipitation Depths for Arlington County

Engineers use precipitation records, known as intensity, duration, frequency curves (IDF curves) in designing stormwater infrastructure. Arlington’s previous IDF curves were developed by NOAA and had not been updated since 2000. The RAMP provides updated rainfall depths for Arlington County based on different climate scenarios

RCP stands for representative concentration pathway and is a prediction of future greenhouse levels/impacts.



# Critical Facilities

Vulnerability to flooding

Facility need for public health, safety, and emergency response

Service impacts if the facility operations were interrupted

- Arlington Transit (ART) Operations and Maintenance (O&M) Facility, located in Four Mile Run Lower Mainstem
- Cardinal Elementary School, located in Torreyson Run
- Cherrydale Health and Rehabilitation Center (Cherrydale Center), located in Spout Run
- Gunston Middle School and Community Center, located in Four Mile Run Lower Mainstem
- Little Falls Booster Station, located in Little Pimmit Run East Branch
- Thomas Jefferson Middle School and Community Center, located in Doctor's Branch
- Trades Center Department of Parks and Recreation (DPR) Building and Network Operations Hub, located in Four Mile Run Middle Mainstem Trades Center Equipment Bureau, located in Four Mile Run Middle Mainstem
- Virginia Hospital Center, located in Lubber Run
- Water Pollution Control Plant (WPCP), located in Four Mile Run Lower Mainstem

# Critical Facilities Cost-Benefit Analyses

**Table 5-3. Critical Facility Cumulative Monetized Risk and Benefits with Mitigation Strategies, Based on Direct Equipment Damage**

Facility	Sum of Cumulative Monetized Risk Without Strategy (2022-2042) (thousands \$)	Alternative 1 Benefit (thousands \$)	Alternative 2 Benefit (thousands \$)
Cherrydale Center	1	1	1
Gunston Middle School	60	58	58
Little Falls Booster Station	100	52	52
Thomas Jefferson Middle School	1,798	1,764	1,770
Virginia Hospital Center <sup>[a]</sup>	5,659	5,586	5,586
WPCP (North)	10,137	9,401	Not computed <sup>[b]</sup>
WPCP (South)	32,270	27,368	Not computed <sup>[b]</sup>

<sup>[a]</sup>This does not reflect the mitigation provided by the Virginia Hospital Center stormwater improvements, as described in Section 3.4.

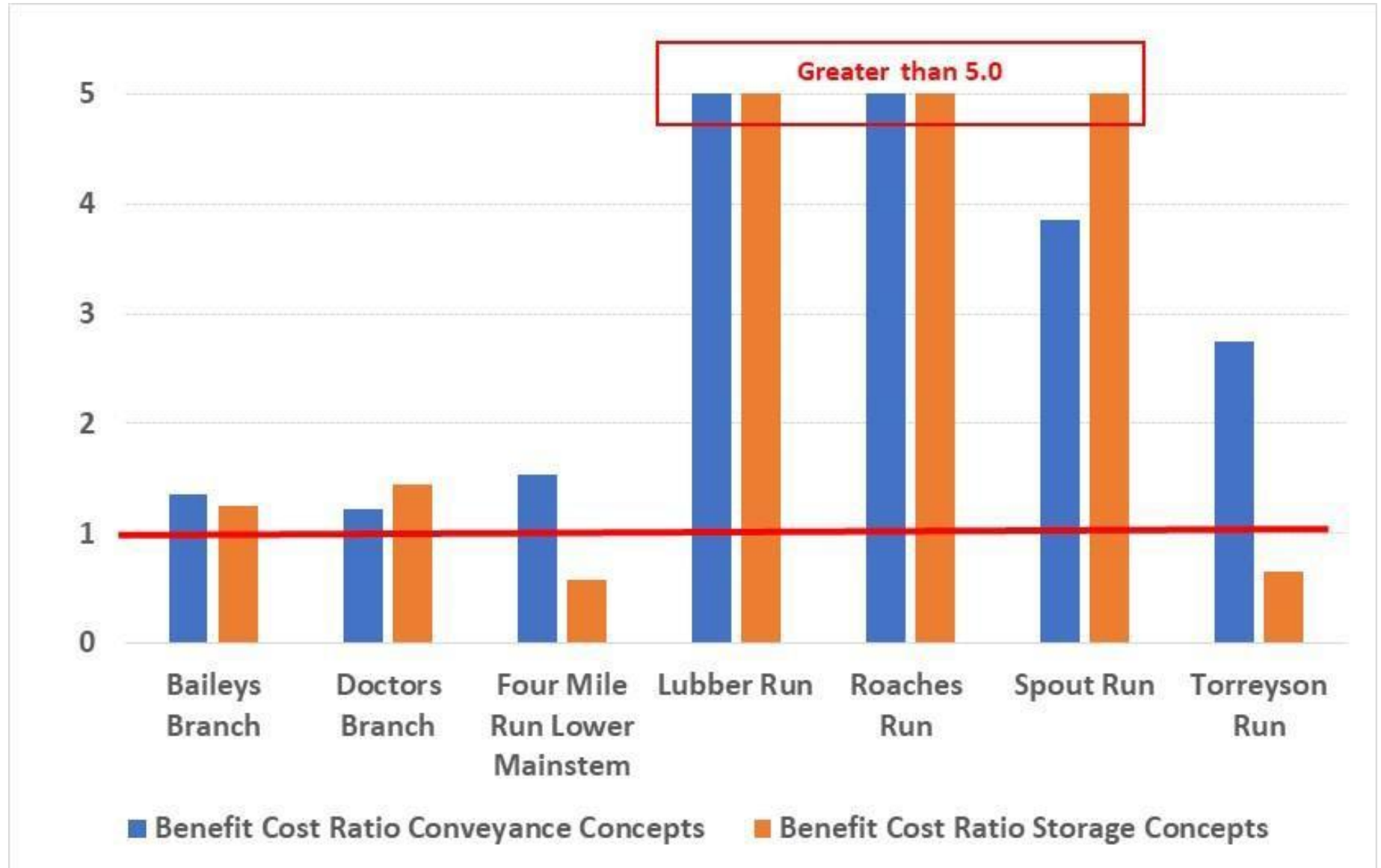
<sup>[b]</sup>The Alternative 2 strategy for the WPCP North and South uses the USACE floodwall. Cumulative monetized risk cannot be accurately calculated with the Task 6 critical facilities model; however, the floodwall would provide significant protection to both North and South facilities.

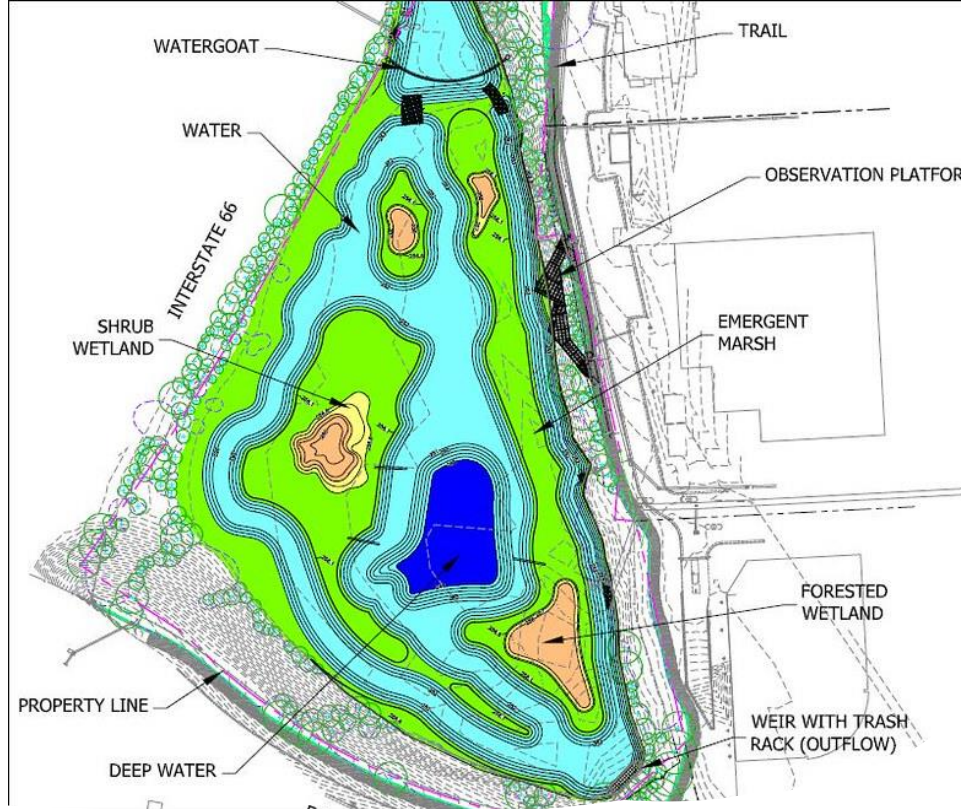
# Economic Risk by Watershed - "Cost of Inaction"

Watershed	Annualized Risk of Losses (millions \$)	Potential Losses for 100-year Storm (millions \$)	
		100-year Storm in 2020: 8.5 Inches in 24 Hours	100-year Storm in 2070: 9.6 Inches in 24 Hours
Roaches Run	112.8	718.9	803.5
Spout Run	41.0	234.4	263.4
Lubber Run	32.4	297.1	344.2
Four Mile Run Lower Mainstem	14.7	109.2	136.8
Doctor's Branch	6.4	39.0	46.1
Torreyson Run	2.6	17.9	19.7
Bailey's Branch	1.0	7.5	n/a

# Capital Projects Cost Benefit Analysis

Allows for prioritization of projects and community understanding of investments





## RAMP-Informed Projects – Conveyance, Detention and Overland Relief

# Ballston Wetlands Park

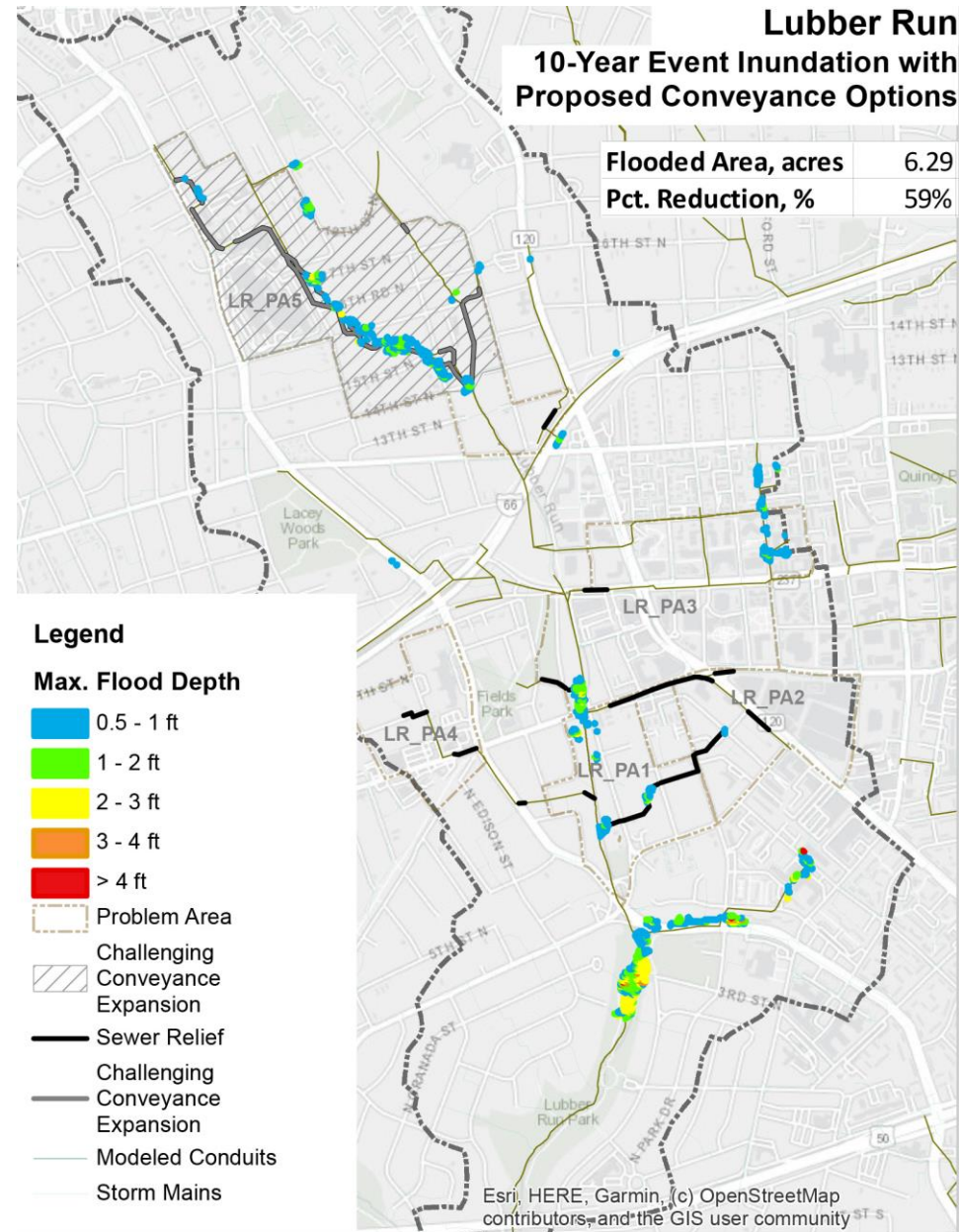
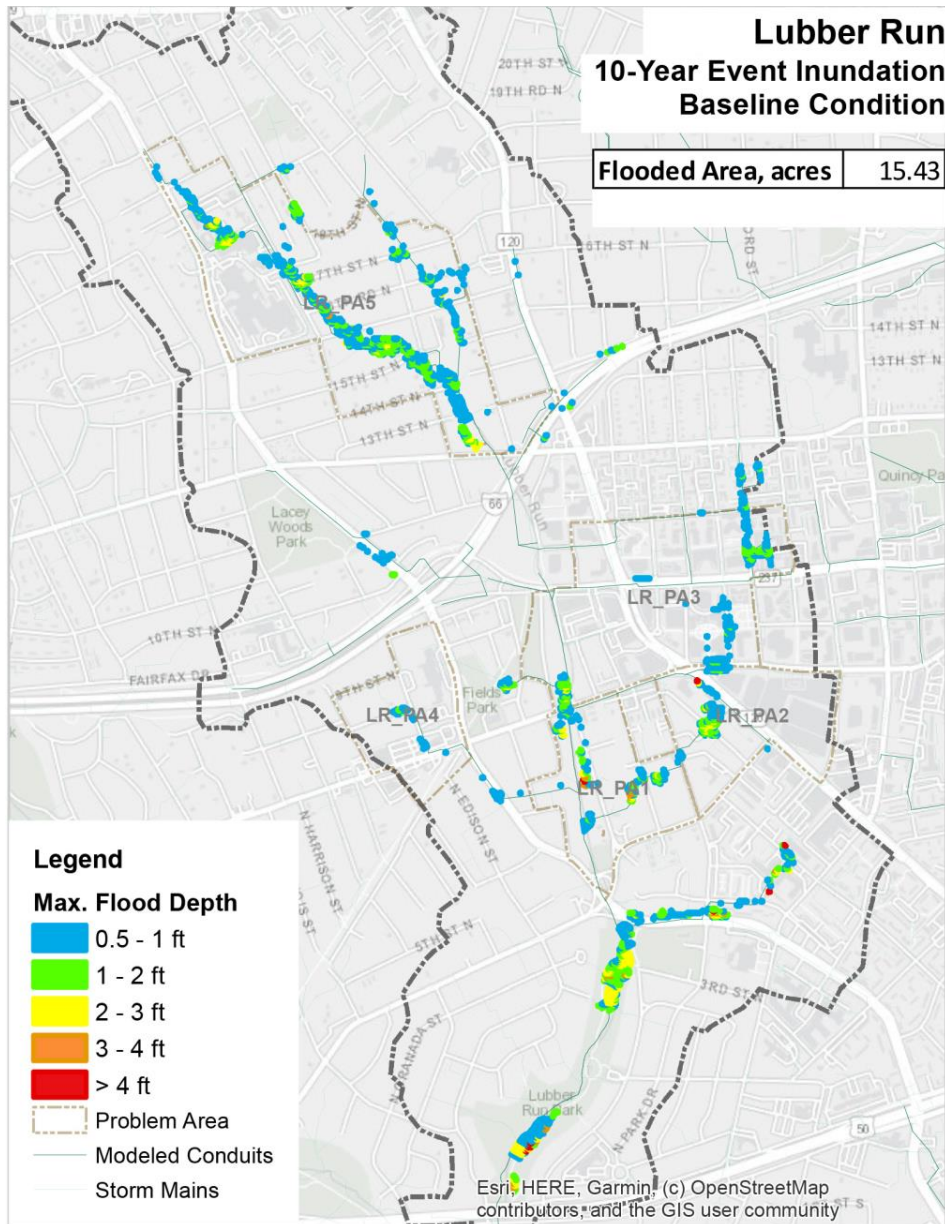


March 2022



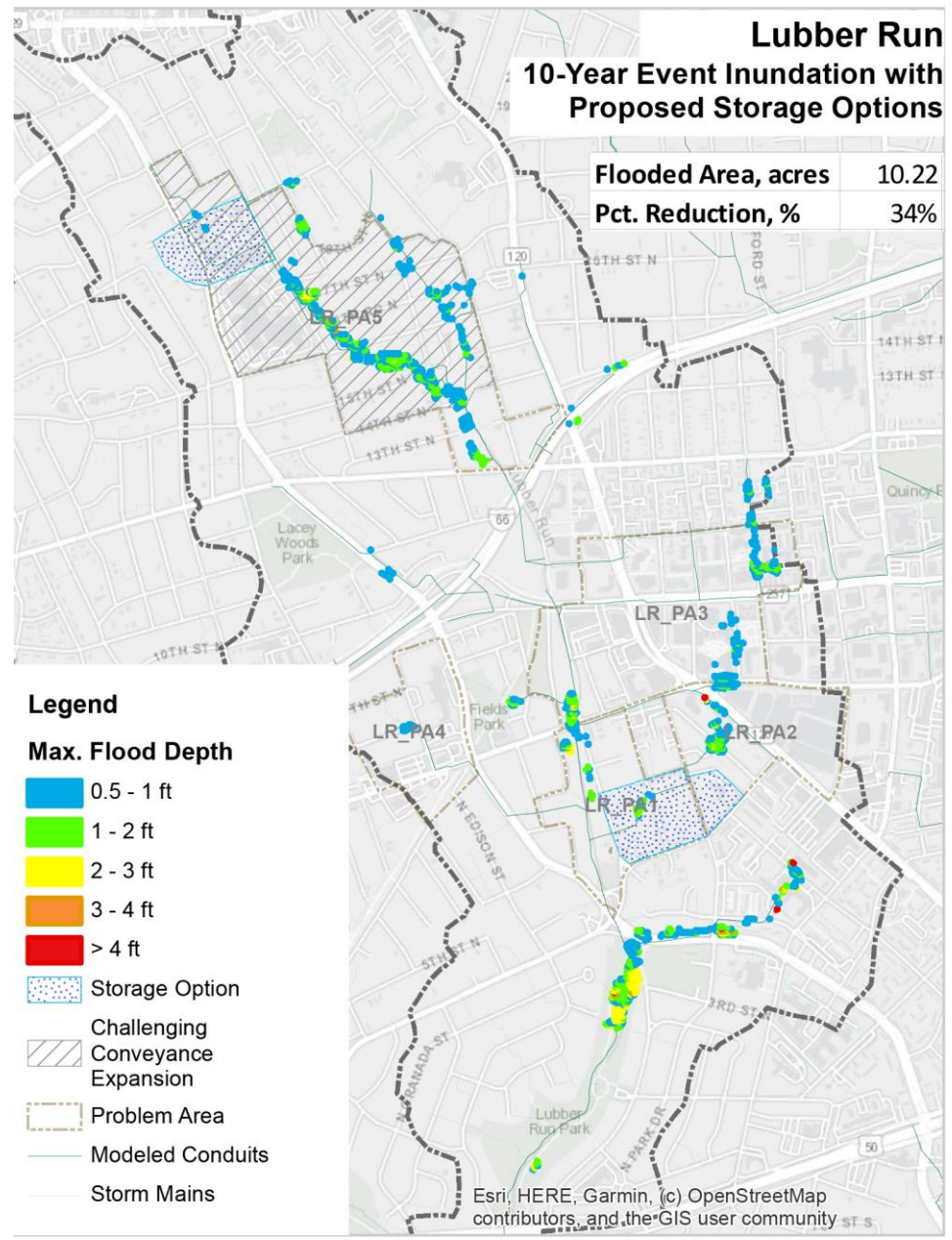
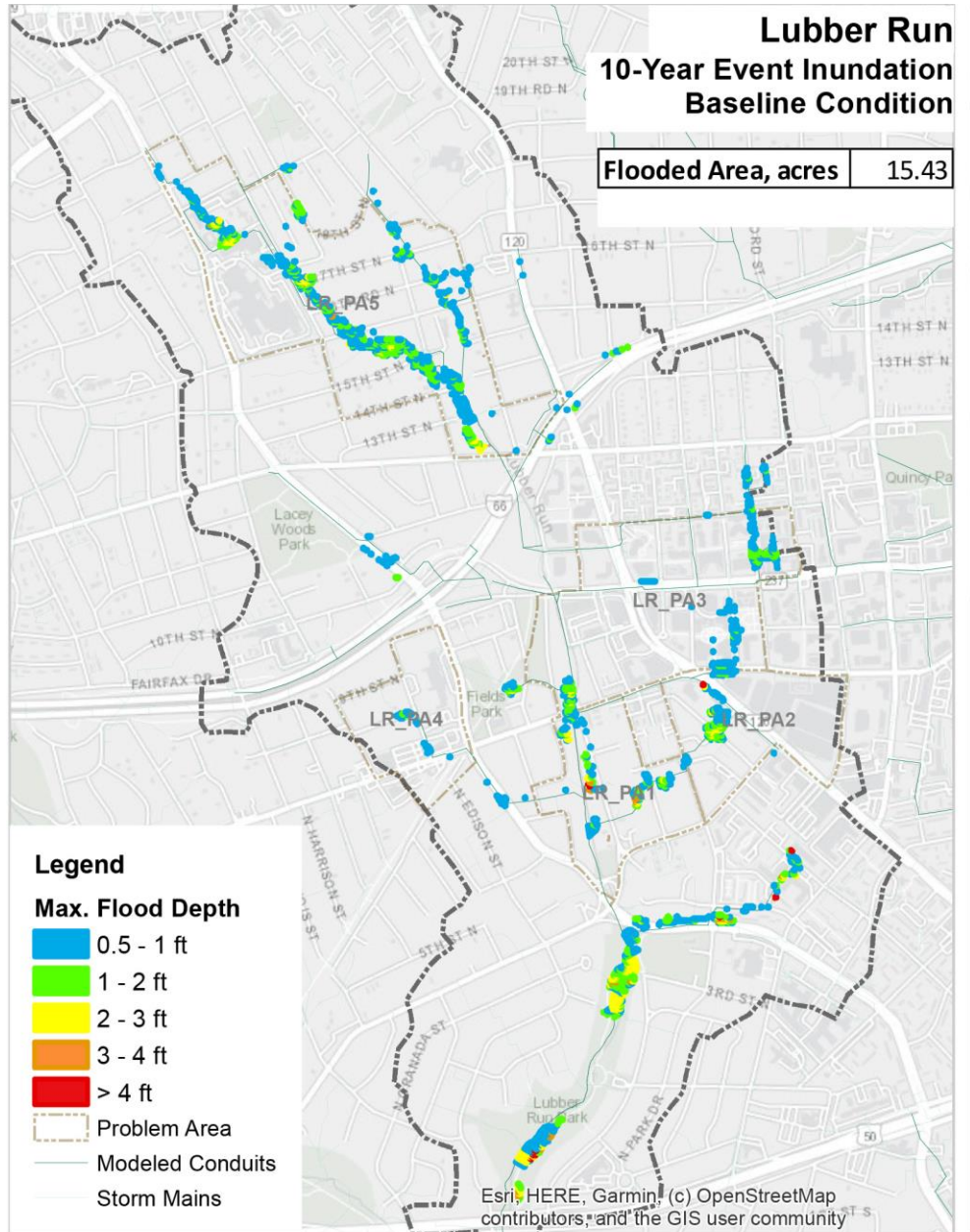
September 2023

# Lubber Run 10 -Year Storm at Baseline and with proposed Conveyance Upgrades



**Percent reduction in flooded area 59%**

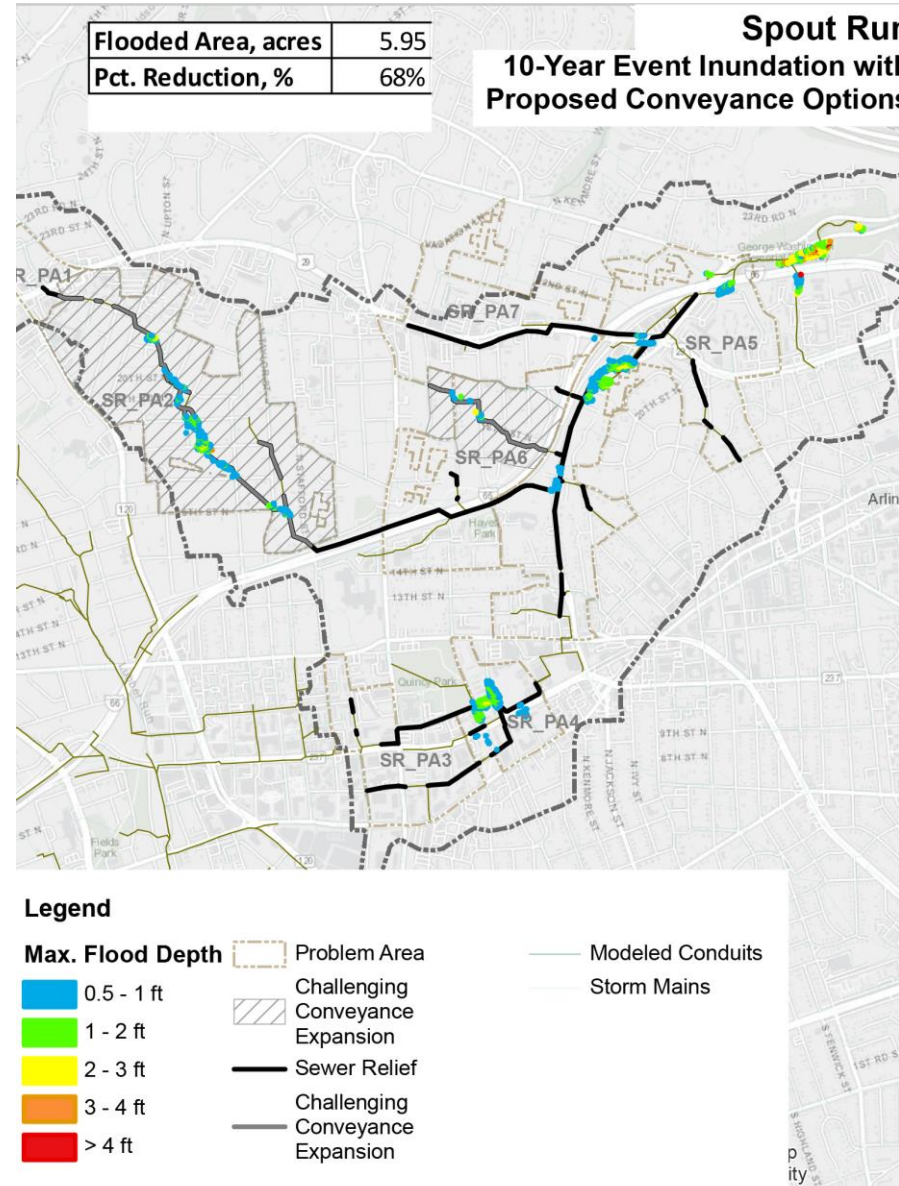
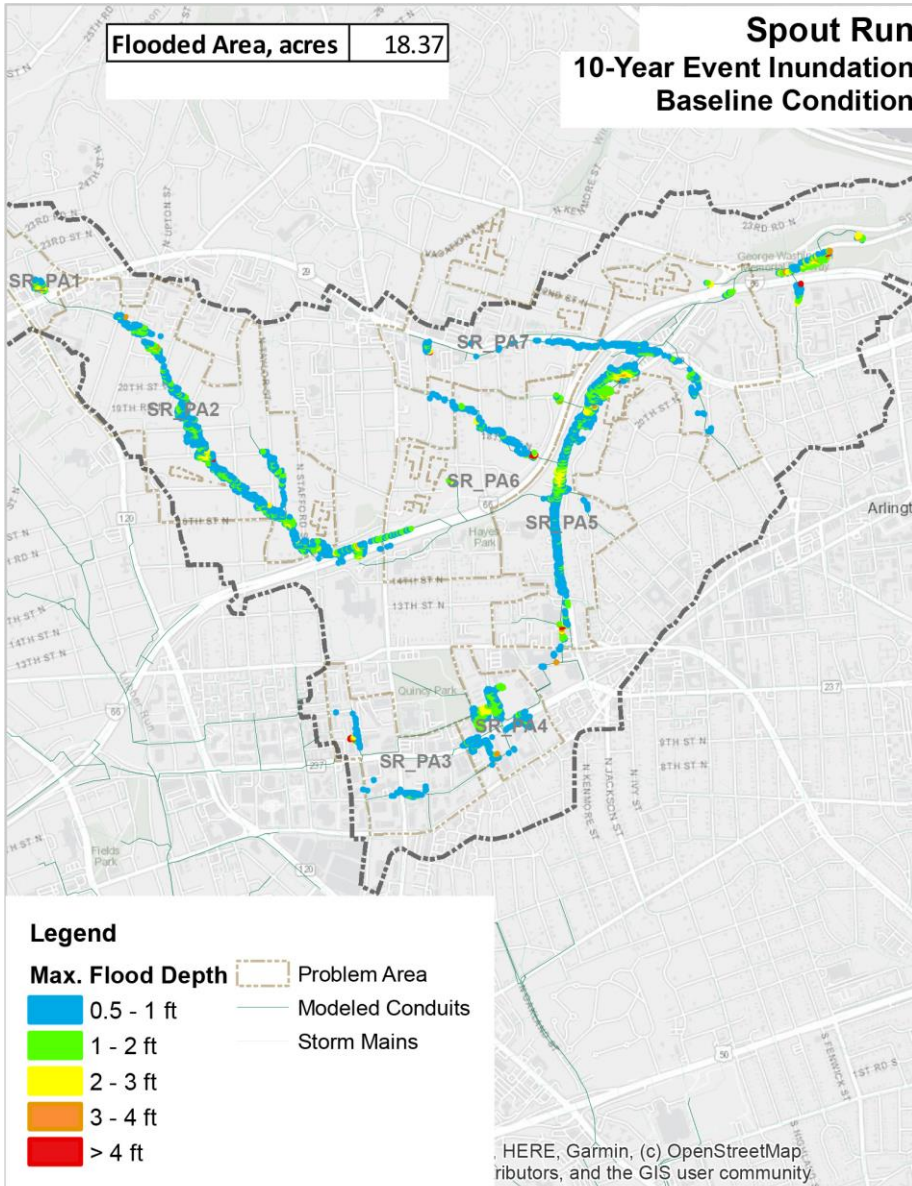
# Lubber Run 10-Year Storm at Baseline and with proposed **Storage** Upgrades



**Percent reduction in flooded area 34%**

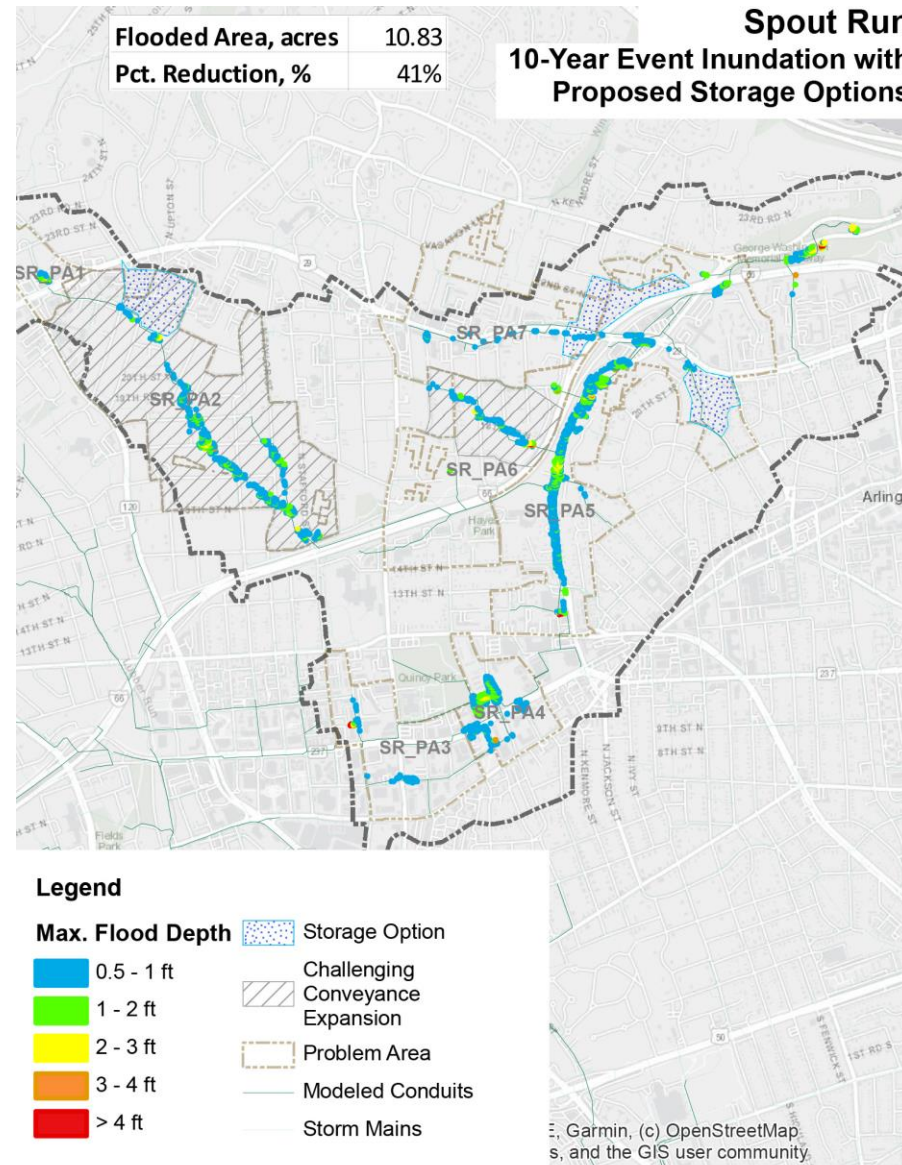
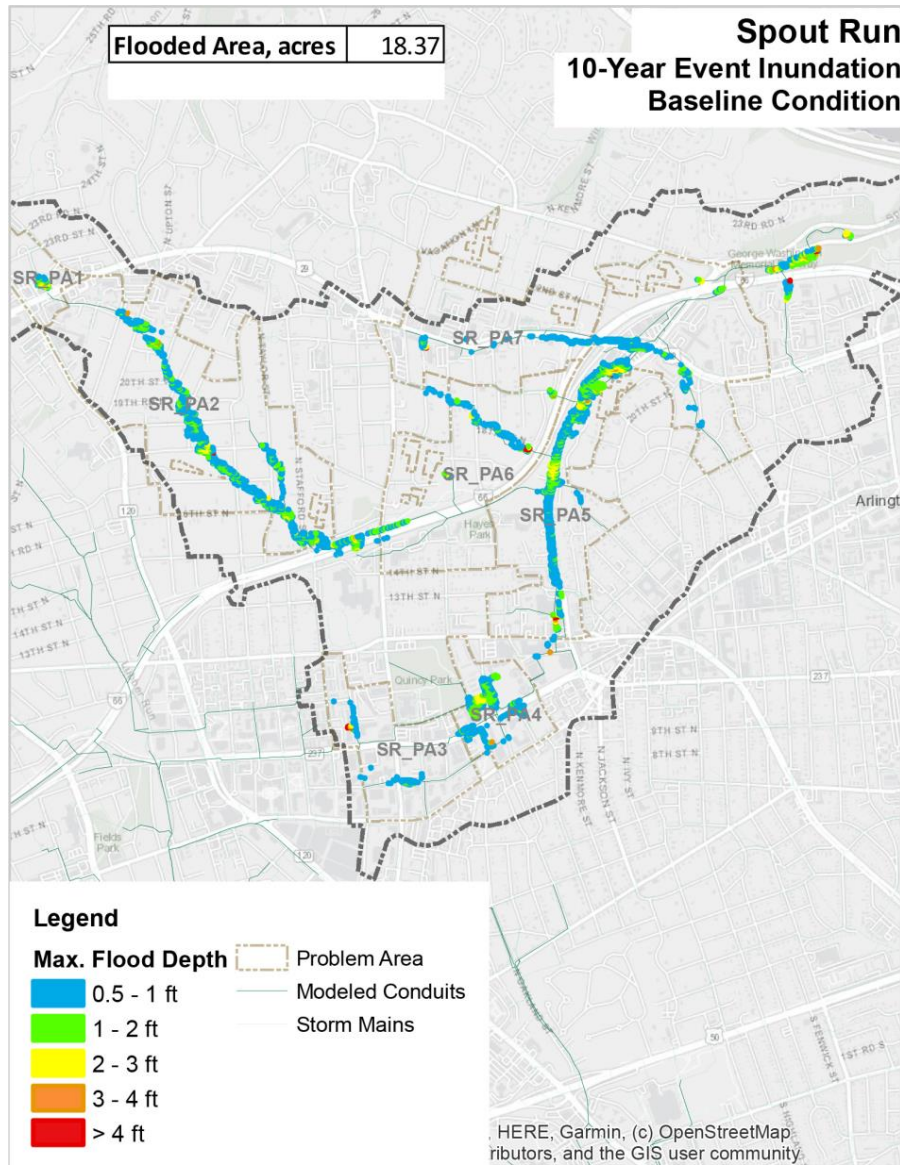


# Spout Run 10-year storm at Baseline and with proposed Conveyance Upgrades



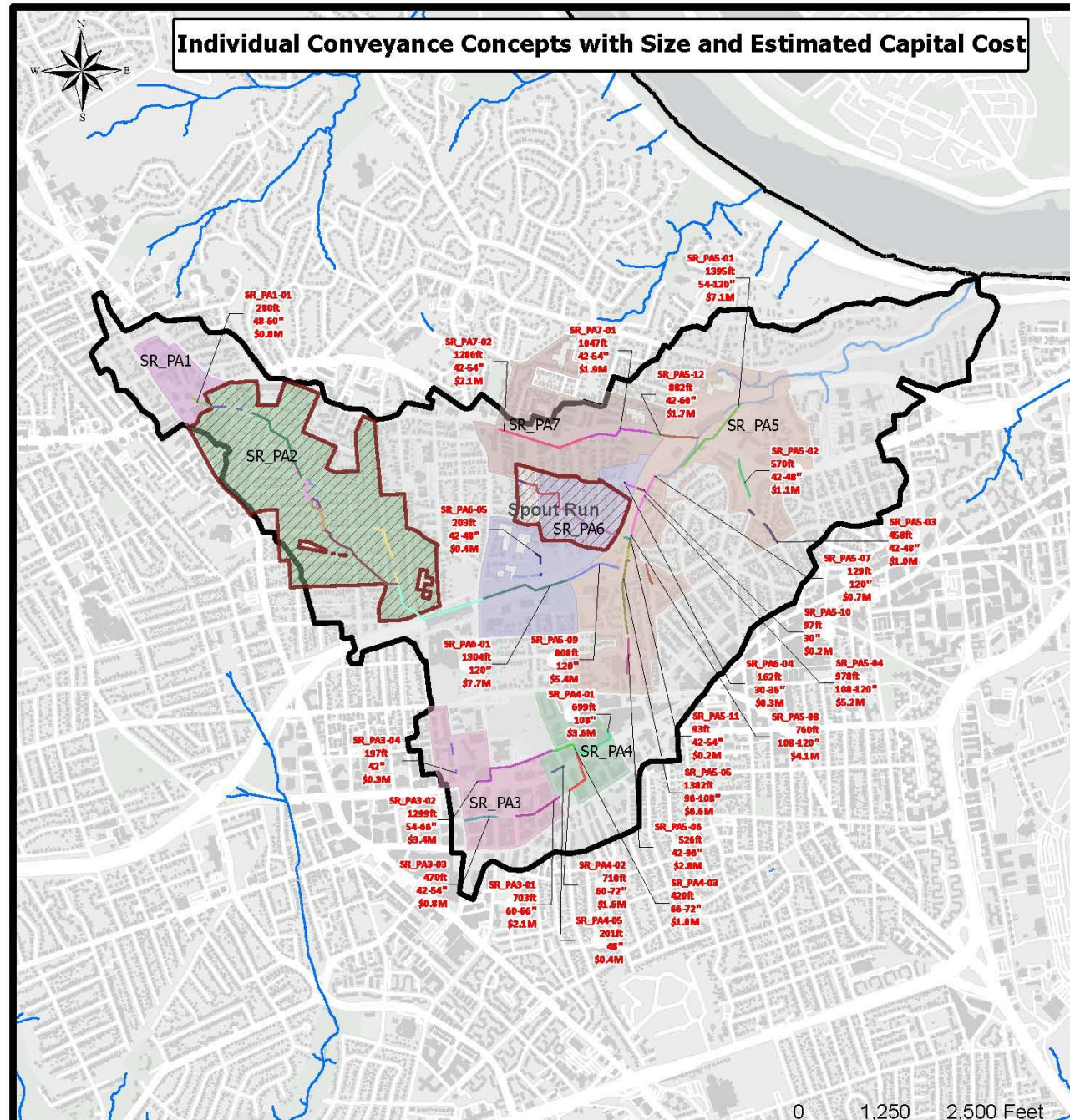
**Percent  
reduction in  
flooded area  
68%**

# Spout Run 10-year storm at Baseline and with proposed **Storage** Upgrades



**Percent reduction in flooded area 41%**

# Spout Run individual conveyance projects with size and estimated cost



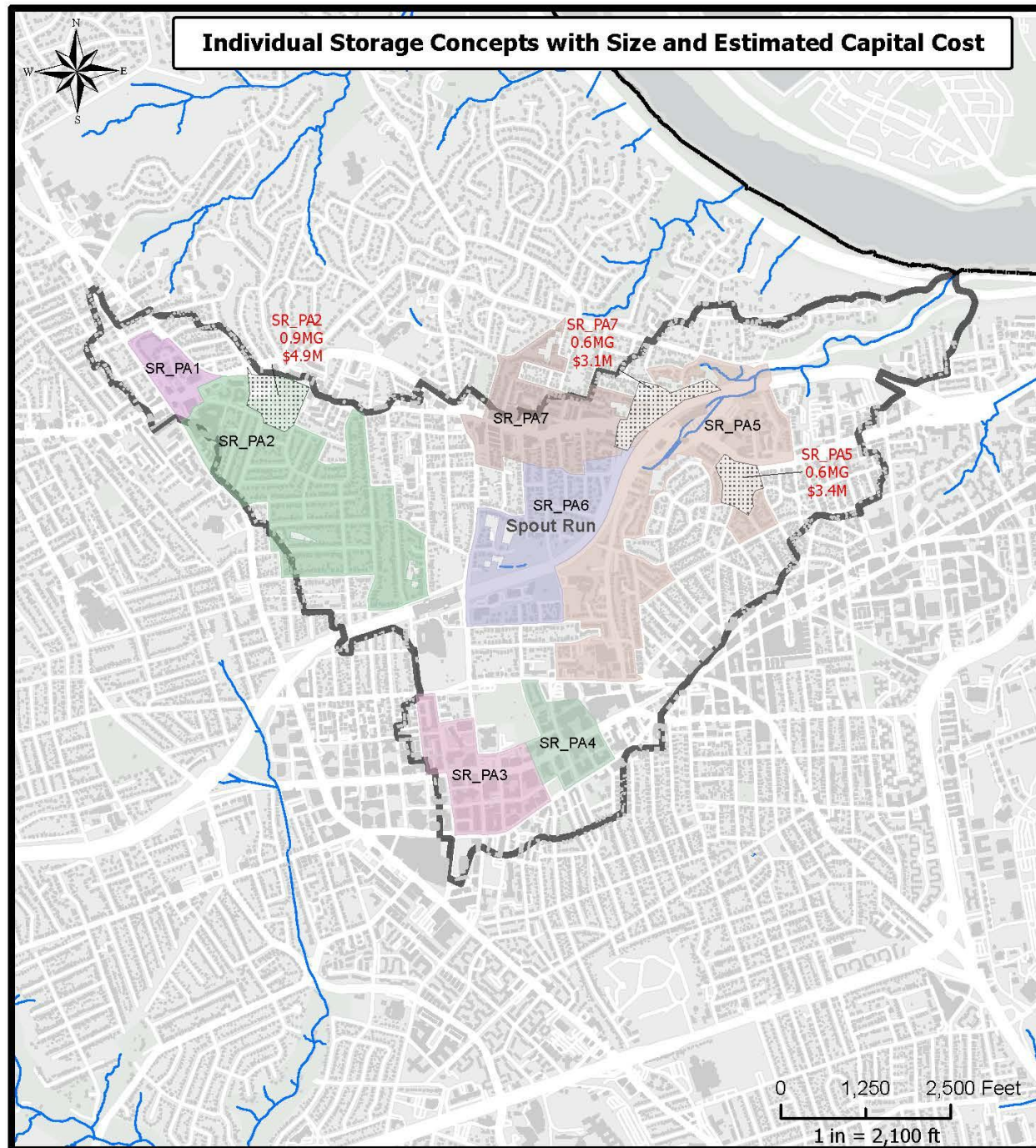
Concept ID	Total Length, feet	Pipe Diameter, inches	Capital Cost, \$millions
SR_PA1-01	280	48-60"	\$0.8
SR_PA2-01	1,587	96-108"	\$7.8
SR_PA2-02	1,394	84-113"	\$4.7
SR_PA2-03	319	48-54"	\$0.6
SR_PA2-04	238	72"	\$0.6
SR_PA2-05	219	54"	\$0.4
SR_PA2-06	516	60-72"	\$1.1
SR_PA2-07	172	54-72"	\$0.4
SR_PA2-08	1,278	54-84"	\$3.0
SR_PA2-09	287	48-72"	\$0.6
SR_PA2-10	696	42-54"	\$1.2
SR_PA3-01	703	60-66"	\$2.1
SR_PA3-02	1,299	54-66"	\$3.4
SR_PA3-03	470	42-54"	\$0.8
SR_PA3-04	197	42"	\$0.3
SR_PA4-01	699	108"	\$3.6
SR_PA4-02	710	60-72"	\$1.6
SR_PA4-03	420	66-72"	\$1.0
SR_PA4-05	201	48"	\$0.4
SR_PA5-01	1,395	54-120"	\$7.1
SR_PA5-02	570	42-48"	\$1.1
SR_PA5-03	458	42-48"	\$1.0
SR_PA5-04	978	108-120"	\$5.2
SR_PA5-05	1,382	96-108"	\$6.6
SR_PA5-06	526	42-96"	\$2.8
SR_PA5-07	129	120"	\$0.7
SR_PA5-08	760	108-120"	\$4.1
SR_PA5-09	808	120"	\$5.4
SR_PA5-10	97	30"	\$0.2
SR_PA5-11	93	42-54"	\$0.2
SR_PA5-12	882	42-60"	\$1.7
SR_PA6-01	1,304	120"	\$7.7
SR_PA6-02	948	42-54"	\$1.9
SR_PA6-03	738	42"	\$1.2
SR_PA6-04	162	30-36"	\$0.3
SR_PA6-05	203	42-48"	\$0.4
SR_PA7-01	1,047	42-54"	\$1.9
SR_PA7-02	1,286	42-54"	\$2.1
SR_PA7-03	136	42"	\$0.2

## LEGEND

- Conveyance Concepts Label: (in the order shown)
- Concept ID
- Pipe Length, feet
- Pipe Diameter, inches
- Capital Cost, \$millions
- Data:
- Problem Areas
- Conveyance Concept Pipes
- Challenging Conveyance Expansion
- Basemap:
- Watershed
- County Boundary
- Buildings
- Hydrology



Spout Run individual storage projects with size and estimated cost



Concept ID	Storage Volume, million gallons	Ownership	Capital Cost, \$ millions
SR_PA2	0.9	Mixed	4.9
SR_PA7	0.6	Mixed	3.1
SR_PA5	0.6	Mixed	3.4

**LEGEND**

Storage Concepts Label: (in the order shown)  
 Concept ID  
 Storage Volume, million gallons  
 Capital Cost, \$millions

Basemap:  
 Watershed  
 County Boundary  
 Buildings  
 Hydrology

Data:  
 Problem Areas  
 General Area for Storage Concept



**Storage Concepts: Spout Run**

# RAMP - Programmatic and Policy Recommendations

Communications and data sharing among agencies

Increasing access to flood risk information for the public

Storm infrastructure asset management

Real time rainfall or stream gauges

Better flood insurance information tracking

Flood proofing technical assistance

Voluntary property acquisition

Adding drainage focus to building permit reviews

Integrate flood risk into land use planning

Update regulations and design standards based on flood risk information

Funding for flood management strategies

# Internal / Public Engagement

## Internal Working Group (Inform/Consult)

- CPHD
- DPR
- DES-Transportation
- DES-Utilities
- DES-Facilities
- DPSCEM
- Arlington Public Schools
- DES-Engineering Bureau
- Water Pollution Control Plant
- Zoning
- DES-GIS
- DMF

## Public Engagement (Inform)

- Civic Federation
- Committee of 100
- Spout Run Civic Associations including Waverly Hills and Cherrydale
- Westover/Torreyson Run Civic Associations
- Bluemont Civic Association
- Columbia Pike Civic Associations
- Northern Virginia Regional Commission

## Commissions (Inform)

C2E2

## Utilities (Inform/Consult)

Dominion Energy Virginia  
Washington Gas

# RAMP Present and Future Uses

**CIP Design and Budgeting**

Compares value of current investments against cost of inaction

**Special Projects Planning**, e.g., Barcroft, PLB

**Resiliency planning** and measurement

Inform **flood resilient design** and construction standards

Use in **plan reviews** (private and public)

Provides **independent confirmation** of previous watershed analyses

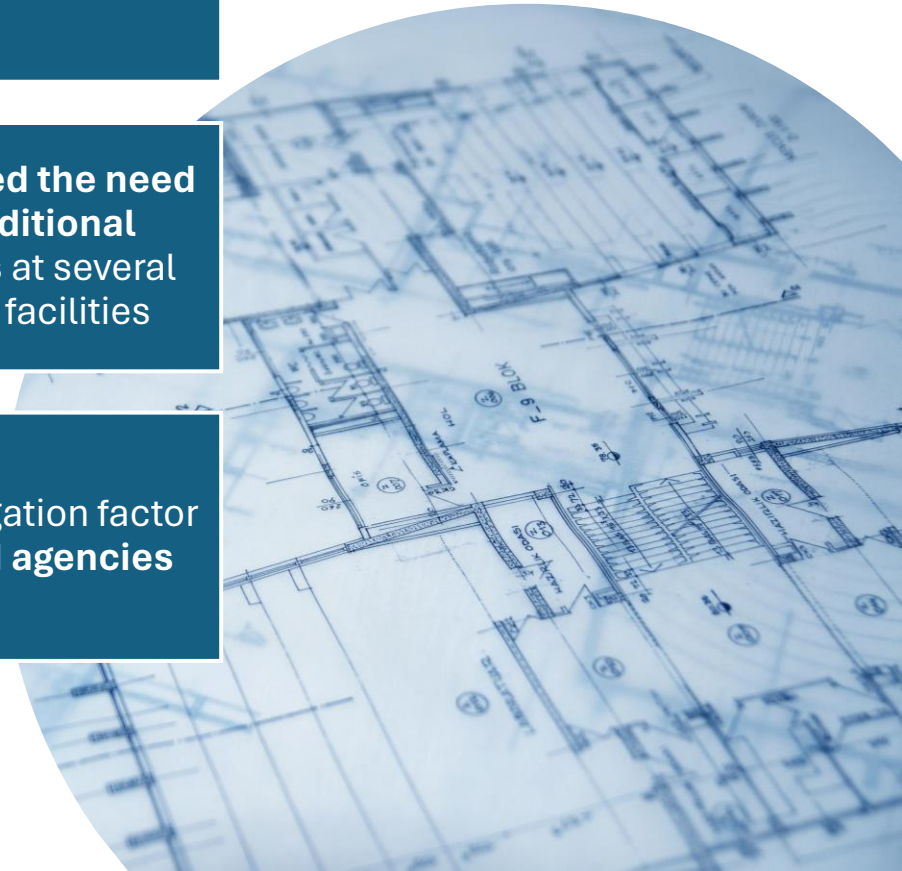
**Eliminated the need for additional analysis** at several critical facilities

Provides guidance on **policies and programmatic measures** for implementation

**Certifications, rankings, and recognitions**, e.g., CDP, LEED® Platinum Cities

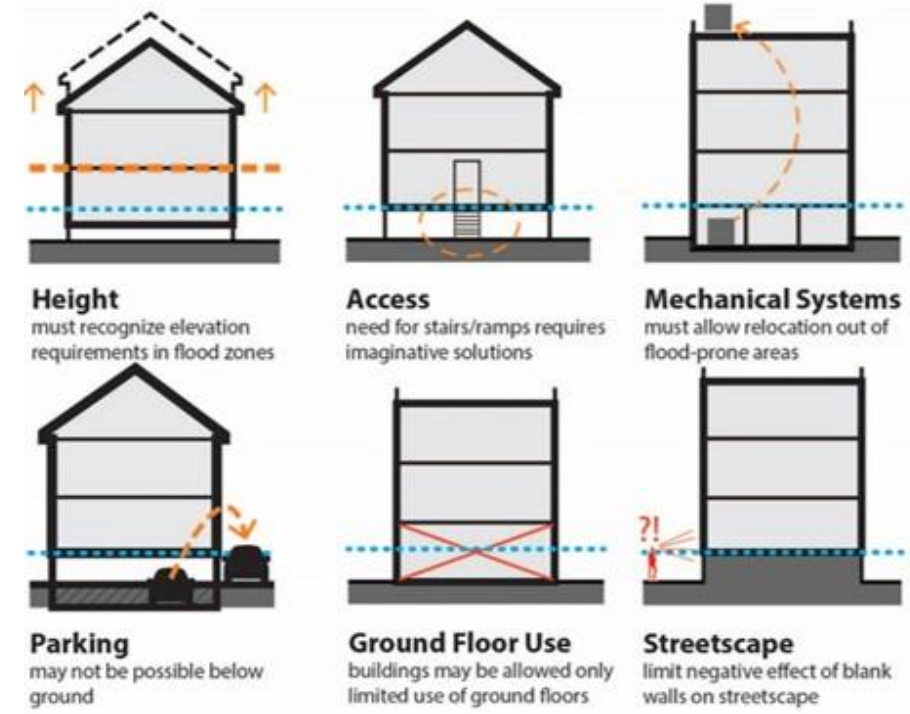
**Grant support**

Risk-mitigation factor for **bond agencies**

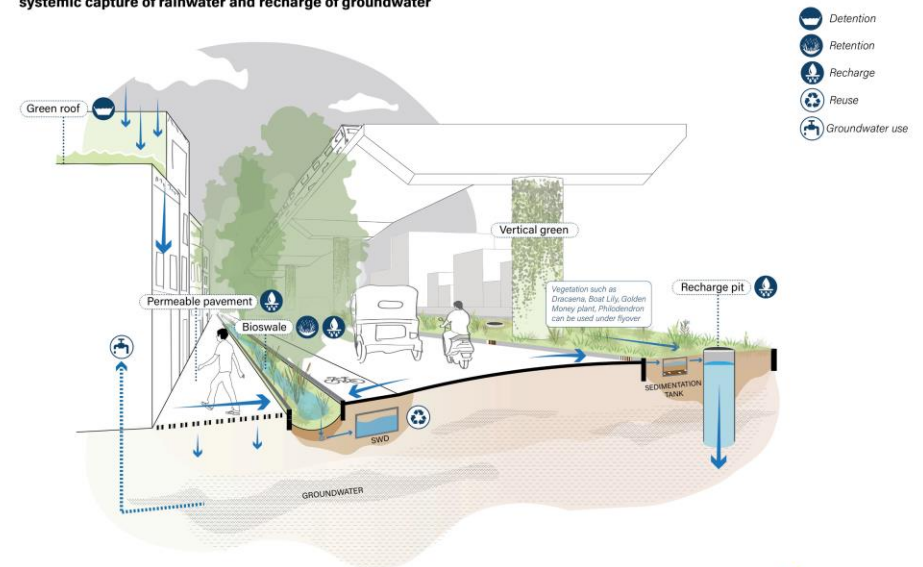


# Coming Design/Construct Guidelines and Blended Infrastructure Survey

- Flood Resilient Design and Construction Guidelines Manual
- Future-Facing Natural Infrastructure Manual – *urban heat mitigation*



Interlinking transit corridors, building roofs, and neighbouring unused urban spaces for systemic capture of rainwater and recharge of groundwater

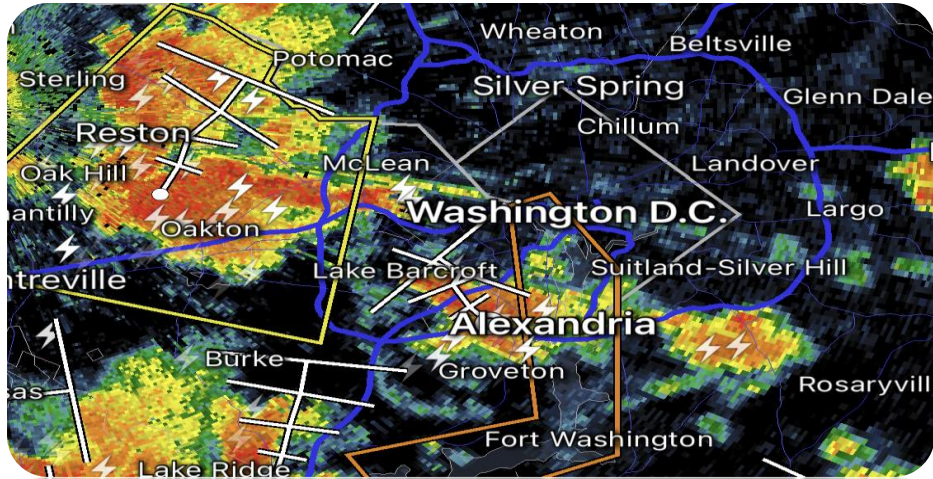


Source: WRI India. Illustration created by Sindhuja Janakiraman



# Resiliency Planning - Active

## RAMP



- **Multiple applications/uses of projects**
- **Cost-Benefit Analysis to Measure Cost-Effectiveness**
- **Equity in Flood Mitigation**
- **Land-use and Building Design for Resiliency**
- **Supports competitive grant applications**
- **Mitigate the government and personal costs**

## Energy Assurance Plan



- **Manage inoperability or interruption of grid**
- **Plan for continuity of key services and operations**
- **Equity-based planning – Resiliency Hubs**
- **Planned coordination across government departments, bureaus and offices**
- **Multi-sector policies, actions and programs**
- **Supports competitive grant applications**

# Resiliency Planning in Progress

## Urban Metabolism and Heat Management



- **Natural Resources & Forestry Plan**
- **RAMP / Stormwater Standards**
- **Re/Development, e.g., Plan Langston Boulevard**
- **Green Building Incentive Program**
- **Transportation / Green Streets**
- **Urban Metabolism/Urban Mechanics Guidelines**
- **Construction Recommendations - Materials**
- **Green Building Incentive Program (upgrade)**
- **Site Plan Review**
- **Enhanced green infrastructure options/uses**

# Questions?

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# Vulnerability Assessments

Vulnerability assessments include social vulnerability, environmental and critical facilities

