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Blue-Green Infrastructure for Climate Resilience

NEWEA Spring Meeting

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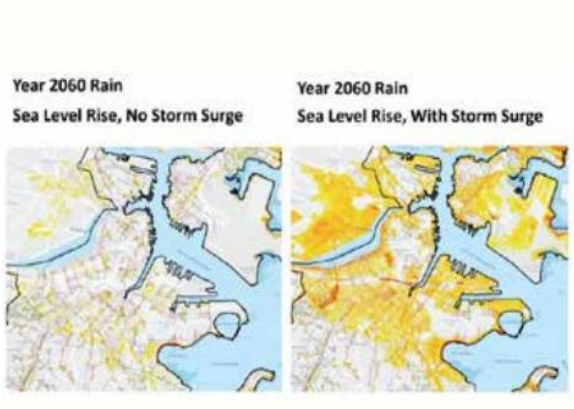
Climate Resilience

Resilience requires integrated solutions that address complex issues like climate change, sea level rise, extreme weather events, environmental improvements, aging infrastructure, community equity and engagement, and funding.



Boston Resiliency Wastewater & Storm Drainage Plan
Boston, MA

East Side Coastal Resiliency
New York, NY

Air Force Reserve Command Resiliency Planning
Various Locations, US

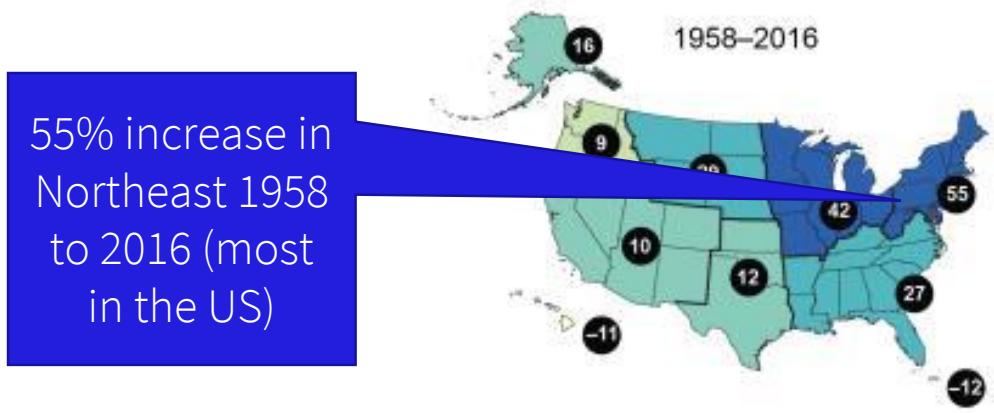
Climate Change Adaptation and Mitigation
City of Alexandria, VA

Climate Change: Past & Future

- Precipitation patterns have changed already (NOAA Atlas 14 is based on data through 2000)
  - Much more rainfall in heavier storms
  - Less rainfall outside those events (drought implications)
- Prediction is for further changes in our region
  - Climate change is an increasingly important consideration in municipal decision making
  - Ensuring that existing and proposed infrastructure can **withstand or adapt** to the precipitation that will occur **throughout its lifespan**
  - Knowledge of current precipitation and future predictions allows for informed decisions about municipal policies, project prioritization, codes and standards, etc.

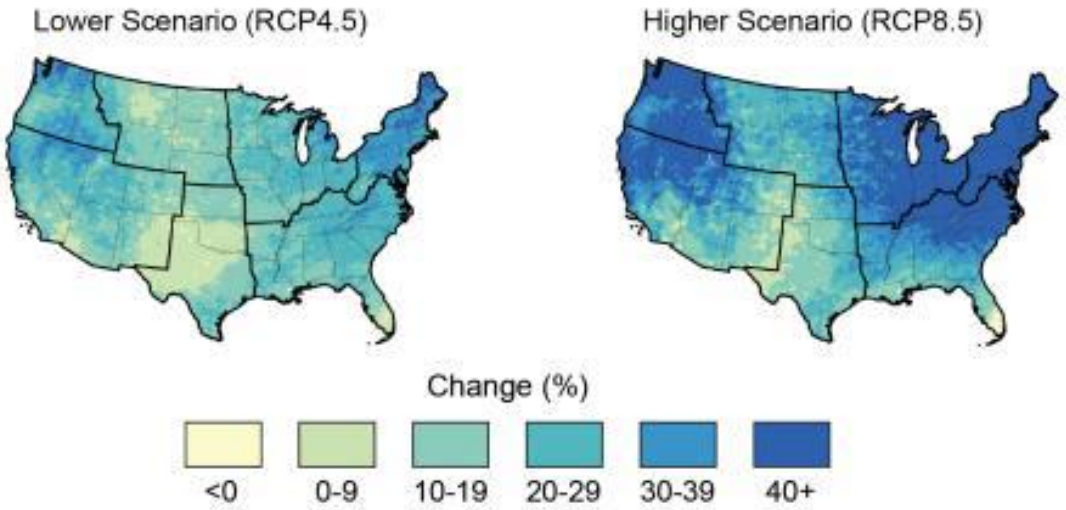
Observed and Projected Change in Heavy Precipitation

Observed Change in Total Annual Precipitation Falling in the Heaviest 1% of Events



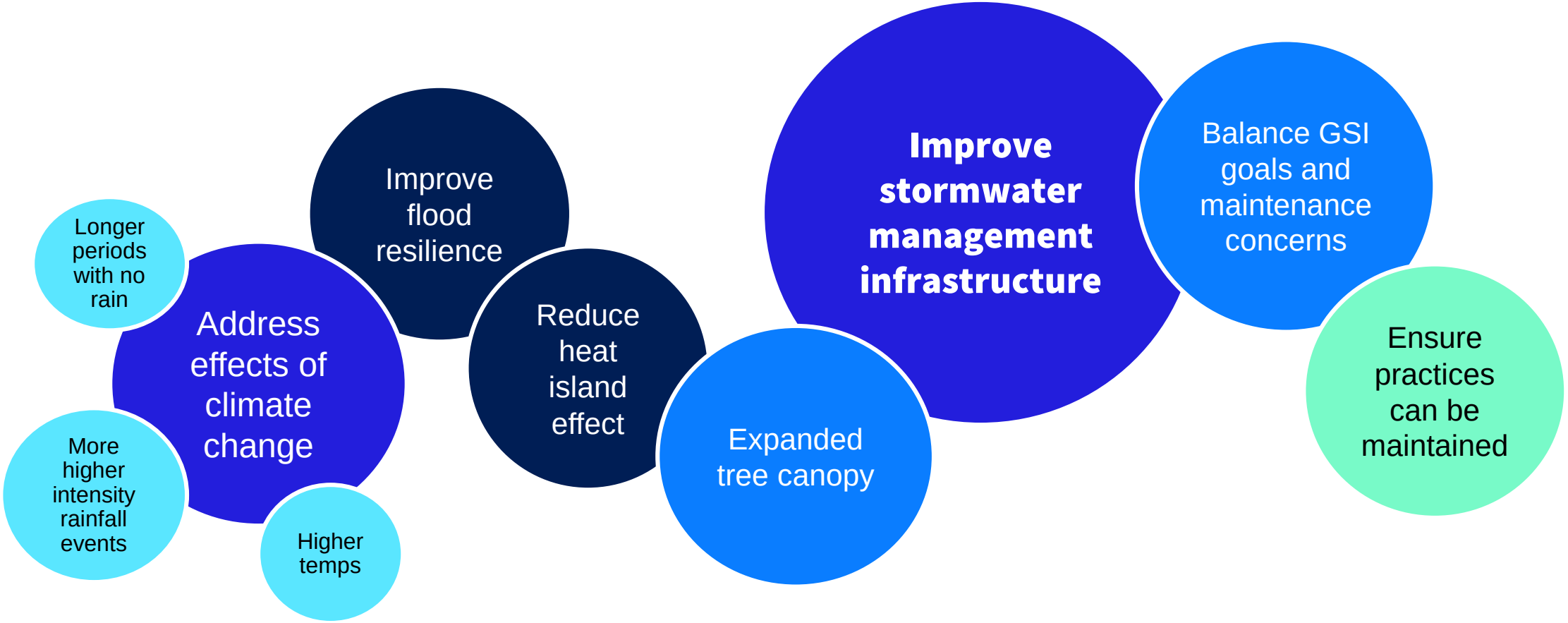
55% increase in Northeast 1958 to 2016 (most in the US)

Projected Change in Total Annual Precipitation Falling in the Heaviest 1% of Events by Late 21st Century



Fourth National Climate Assessment, 2018

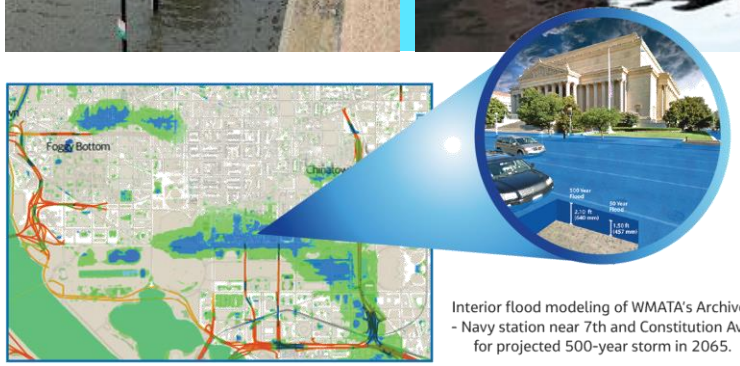
Aligning Stormwater Goals with Climate Resilience



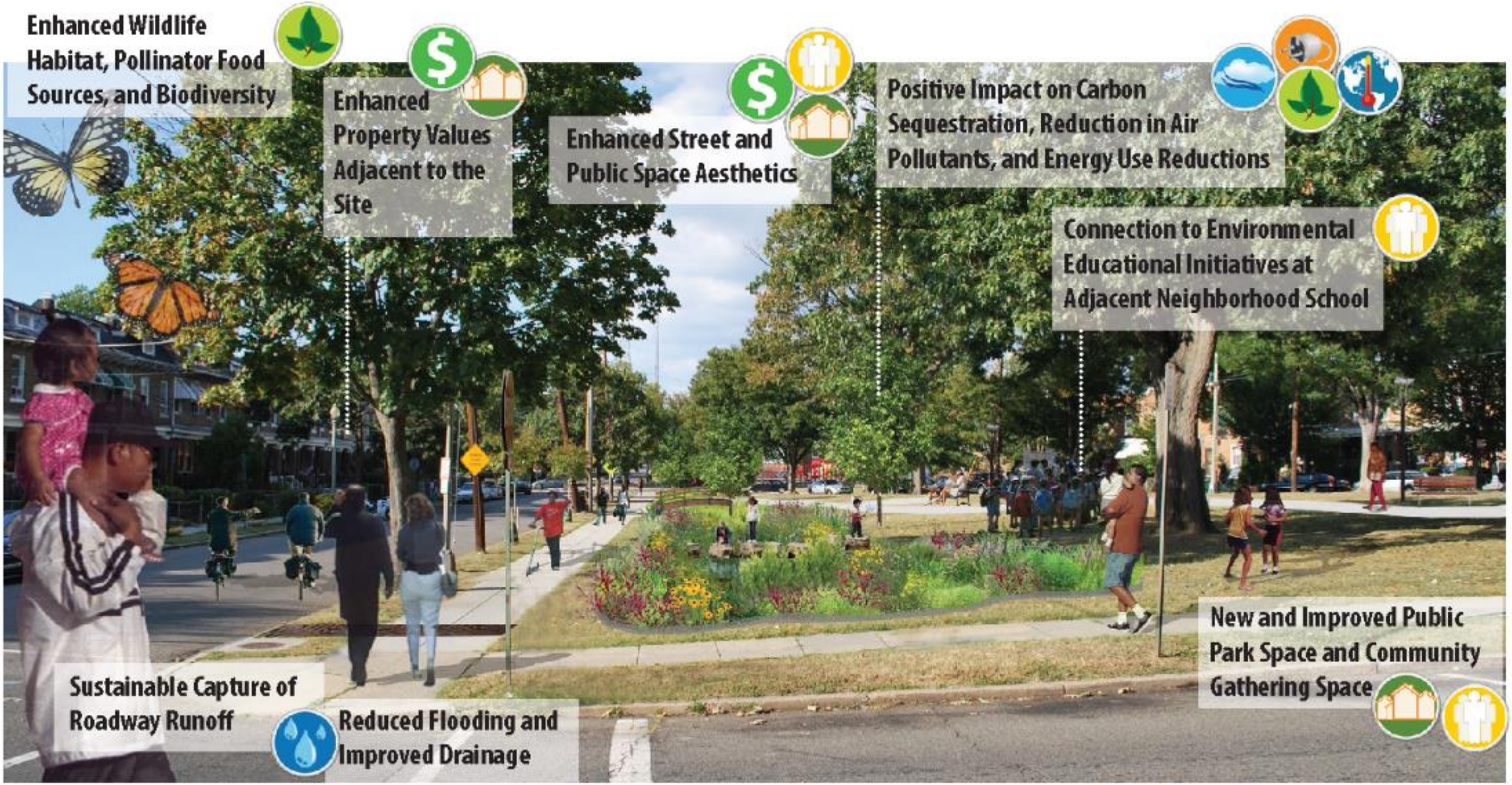
Rethinking Our Current Drainage Infrastructure

A new approach is needed to address new regulations and provide meaningful triple-bottom line (social, environmental, and financial) benefits

- Our current drainage infrastructure has not aged well
- Insufficient capacity
- Does not improve water quality
- Does not reduce volume
- Often just sends the problem downstream



Interior flood modeling of WMATA's Archives - Navy station near 7th and Constitution Ave, for projected 500-year storm in 2065.


Enhanced Wildlife Habitat, Pollinator Food Sources, and Biodiversity
Enhanced Property Values Adjacent to the Site
Enhanced Street and Public Space Aesthetics
Positive Impact on Carbon Sequestration, Reduction in Air Pollutants, and Energy Use Reductions
Connection to Environmental Educational Initiatives at Adjacent Neighborhood School
New and Improved Public Park Space and Community Gathering Space
Sustainable Capture of Roadway Runoff
Reduced Flooding and Improved Drainage

A New and *Evolving* Approach to Stormwater Management

- Many communities face the following challenges:
  - Can we redevelop or retrofit our communities to **reduce flooding, improve water quality, AND create better places**?
  - Can we design stormwater practices that are both sized for **resiliency** AND **cost efficient**?
  - Can we reimagine our public spaces as both useable for **recreation** AND feasible for **flood storage**? Can we embrace the concept of "**living with water**"?

A New and *Evolving* Approach to Stormwater Management

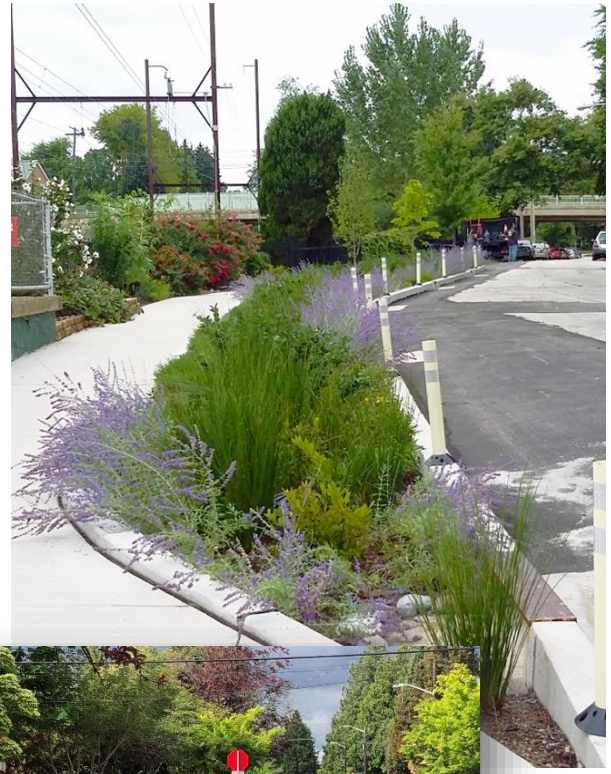
- Can we **retrofit our existing stormwater management facilities** to be more effective for water quality and resiliency?
- Can we more effectively **engage with the community**, manage their expectations, and enhance their quality of life?

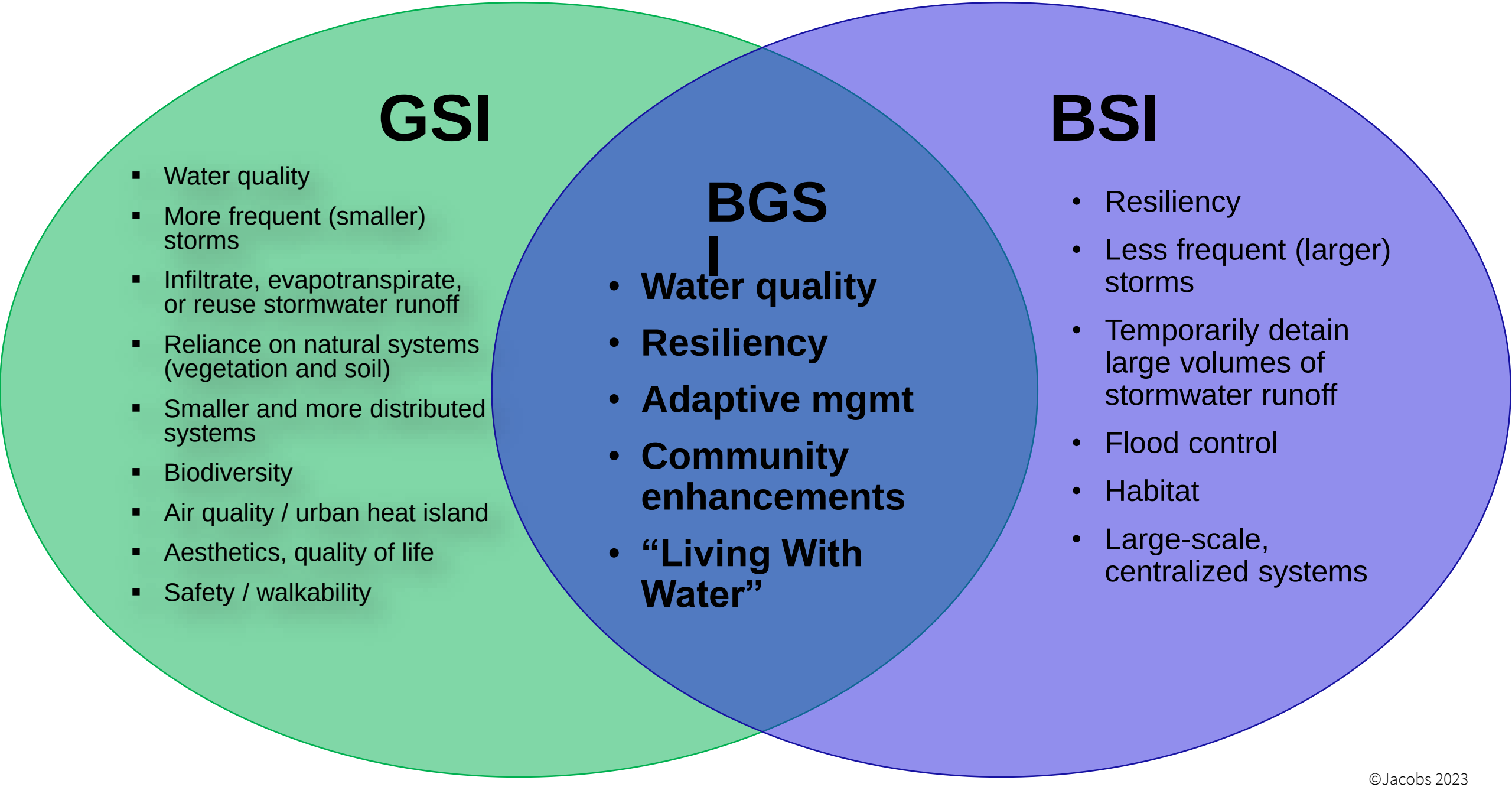
Blue-Green Stormwater Infrastructure (BGSI)… What Does It Mean??

- Multiple definitions exist, but common themes include **resilient** and **attractive,** enhancing **society** and the **environment** through the provision of **multiple co-benefits**, support a **wide range of ecosystem services** (*Roadmap for the BGI Manual*)
- "BGI can be defined as a **strategic network** of **natural** and **manmade** green and blue spaces that **sustain natural processes**. BGI is designed and managed as a **multi-functional** resource, capable of delivering a **wide range of** benefits for society, the environment, and the economy." (*Blue-green infrastructure – perspectives on water quality benefits*)
- AKA, or related to: *Nature-based solutions, nature-based infrastructure, natural flood management, Low Impact Development (LID), cloudburst management measures, "sponge city", sustainable urban drainage system (SUDs), water smart city measures, water sensitive urban design, etc.*

A Working Definition…

- **BGSI** is a strategy that combines the **water quality and community enriching benefits** of “green” stormwater infrastructure (GSI) coupled with the **flood reduction and climate resiliency benefits** of “blue” stormwater infrastructure (BSI)




GSI
Water quality
More frequent (smaller) storms
Infiltrate, evapotranspirate, or reuse stormwater runoff
Reliance on natural systems (vegetation and soil)
Smaller and more distributed systems
Biodiversity
Air quality / urban heat island
Aesthetics, quality of life
Safety / walkability
BGSI
Water quality
Resiliency
Adaptive mgmt
Community enhancements
"Living With Water"
BSI
Resiliency
Less frequent (larger) storms
Temporarily detain large volumes of stormwater runoff
Flood control
Habitat
Large-scale, centralized systems

Improving Resilience to Climate Change – A Combined Strategy Green/Blue/Gray Strategy

- Includes innovative, “floodable” systems such as “floodable parks”, “wet plazas”, and “retention boulevards”
- Stormwater benefits include water quality improvements, groundwater recharge, and detention and flood mitigation
- Community benefits entail urban heat island mitigation, air quality improvement, and habitat creation and improvement
- Other social benefits like…job creation, urban aesthetics, property values, pedestrian safety, and enhanced recreational spaces

Consider the Where and the Who… (Social Equity)

- Planning / prioritizing BGSI projects must consider the where and the who
- Weigh water quality and flood reduction benefits vs. community improvement needs (often aligned, but not always)
- Social benefits of BGSI are many:
  - Job creation
  - Increased pride in the community
  - Increased safety
  - Urban revitalization / redevelopment

Source: Onondaga Earth Corps https://onondagaearthcorps.org/

Re-imagining Public Spaces for Multi-Use

How can we re-imagine our public plazas, parks, and streets to achieve multiple benefits and create “living with water” opportunities?

- Streets typically represent 25 to 35% of the total urban impervious area
- Opportunities often exist within the public right-of-way, even in confined urban areas
- Align well with urban greening efforts and goals; good for business, property values, etc.
- Potential to enhance traffic calming and pedestrian/bicyclist safety
- Can be cost-effectively implemented by integrating with planned utility or other improvements
- Enhance urban landscapes and promote healthier, longer-lived trees

Re-Imagining Public Spaces – Streets

- Notoriously dangerous intersection
- City of Lancaster, PA partnered w/ brewery to install bioretention and permeable pavers (parking and patio)
- Reduce accidents
- Improve pedestrian safety
- Capture runoff
- Best Urban BMP in the Bay Award
- Governor’s Award for Environmental Excellence

700-Gallon Cistern Serves as Public Art and Irrigates Planters

5 MPH reduction in average traffic speed

Re-Imagining Public Spaces – Parks

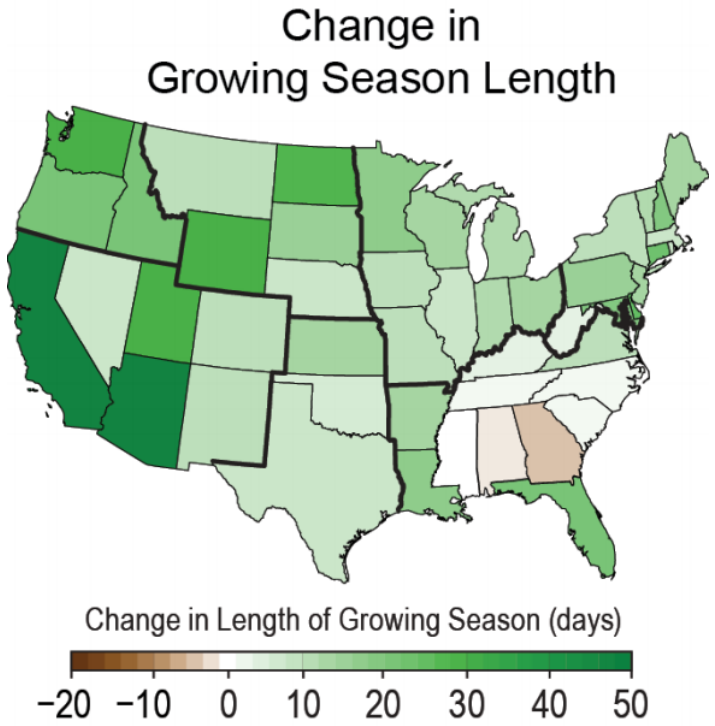
- Sidmouth Amphitheatre, UK
- **Driver:** flooding in beautiful coastal town
  - Insufficient space to deliver flood protection in the town center, due to low elevation, narrow streets, and buildings on shallow foundations
- **Goals:** capture exceedance flows, enhance / minimize negative impacts on parkland, create dual use flood storage facility / public performance space, biodiversity
- **Design Components:** diversion of road runoff, swale w/energy dissipation and check dams, spiral filter drain over drainage blanket and modular storage, and central control chamber that manages infiltration in relation to groundwater levels
- **Community Engagement:** tours to local interest groups, signage, film being developed

See the video at:
Day 2 Session 3 Paul Hargreaves - YouTube

[redacted]

Planning and Designing for Resiliency

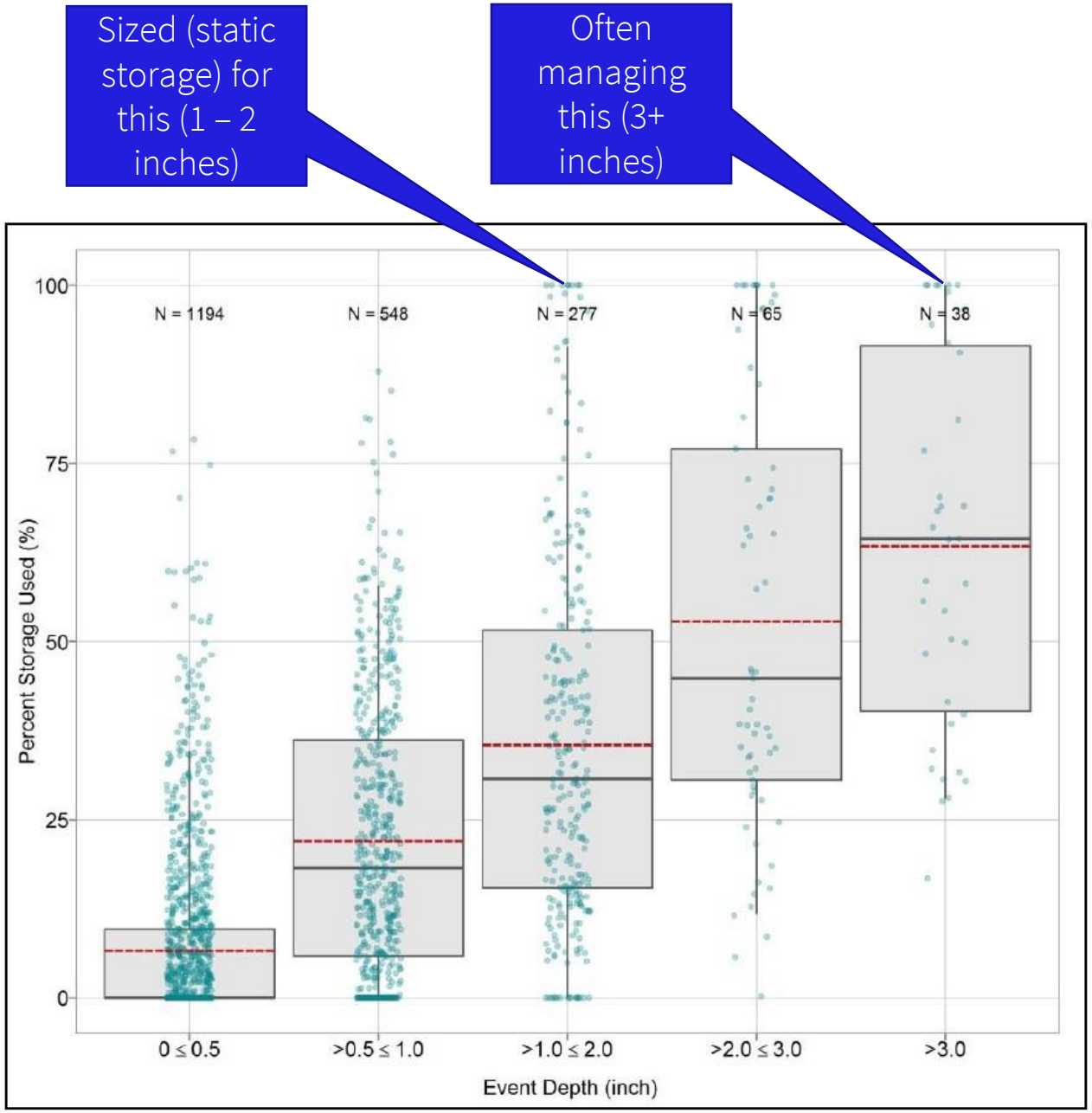
- Consider the design life of the BGSI when determining design criteria
- What external factors should be considered?
  - Flooding
  - Rainfall intensity and duration increases
  - Groundwater elevation changes
  - Extended drought
  - Changing temperature and precipitation patterns
- What BGSI parameters do these factors impact?
  - Location (site selection)
  - Size (footprint & volume)
  - Inlet/outlet configurations
  - Invert
  - Plant selection
  - Maintenance
  - Cost



Fourth National Climate Assessment, 2018

Sizing for Resiliency

- GSI: typically sized for 0.5-1.5 inches of runoff
- BSI: can be sized for flood control (up to 100-year, 24-hour storm)
- Greater resiliency can often be cost effectively achieved by sizing GSI for 1.5-3.0 inches of runoff
  - High voids media
  - Maintain reasonable loading ratios
  - Infiltrate where feasible
  - Consider static vs. dynamic sizing



Green City, Clean Waters 5-year Summary, Philadelphia Water Dept, 2016

Subsurface Floodplain Restoration at Radnor Middle School, Wayne, PA

- Floodplain filled in and stream channel put into pipe
- Historic flooding on school playfield and adjacent streets
- Underground storage / infiltration system w/ modular tanks
- Other GSI: rain gardens, permeable pavement, green roof, infiltration trenches
- LEED – Gold certification

Flood Mitigation – Deer Creek, Brentwood, MO

Address ongoing flooding issues

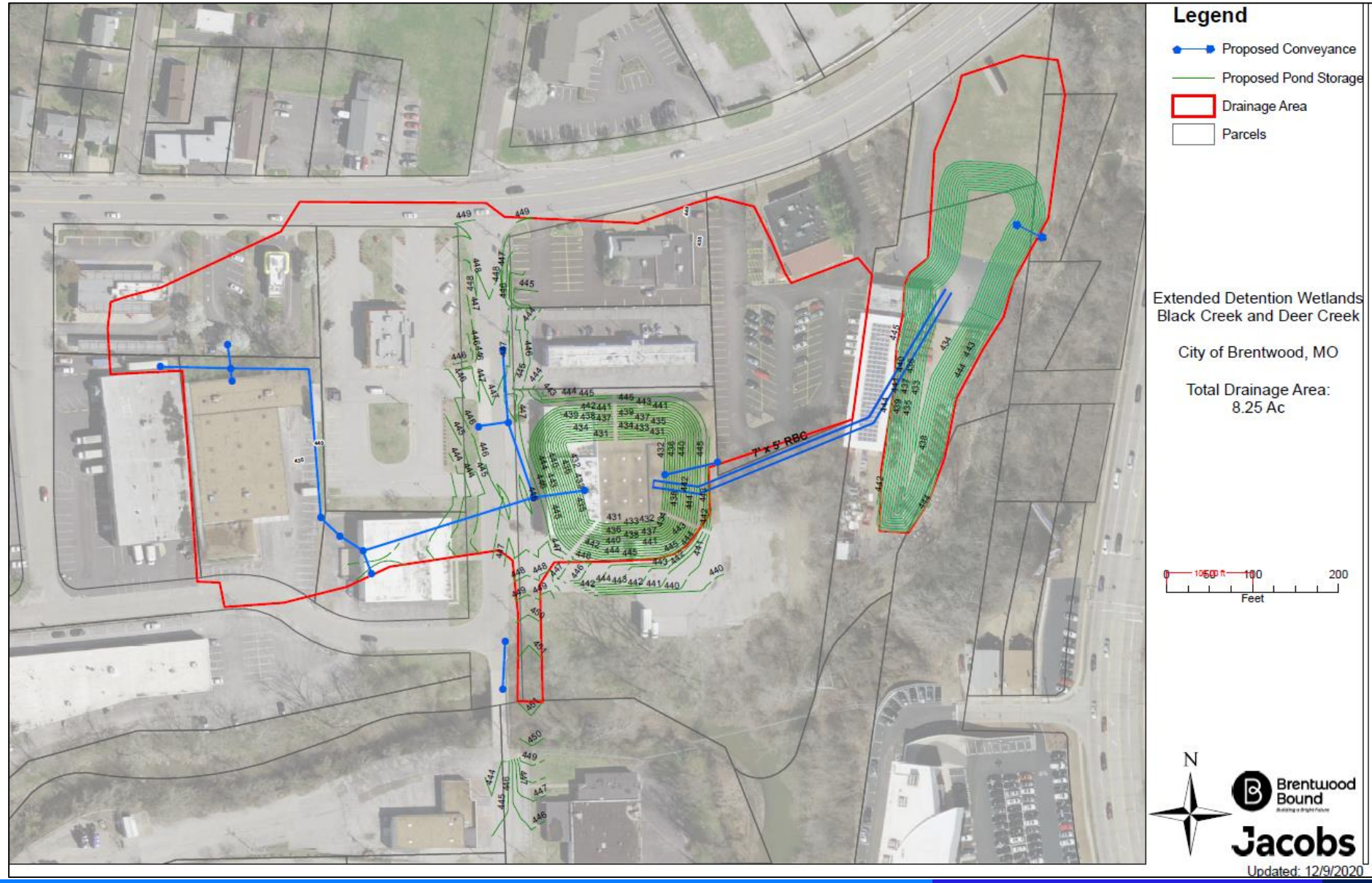
- Opportunity for sustainable urban creek area and redevelopment unique in St. Louis
- Solve 100-year recurring public health & safety problem
- Area has flooded over 30 times since 1957
- Remove Manchester Road from the 100-year floodplain
- Reduce 100-year floodplain from 60 acres to 29 acres (reclaim approximately 31 acres)
- 29 acres remaining in floodplain will adequately handle anticipated stormwater volume

Brentwood Bound – Project Area Current Floodplain

Brentwood Bound – Project Area Future Floodplain

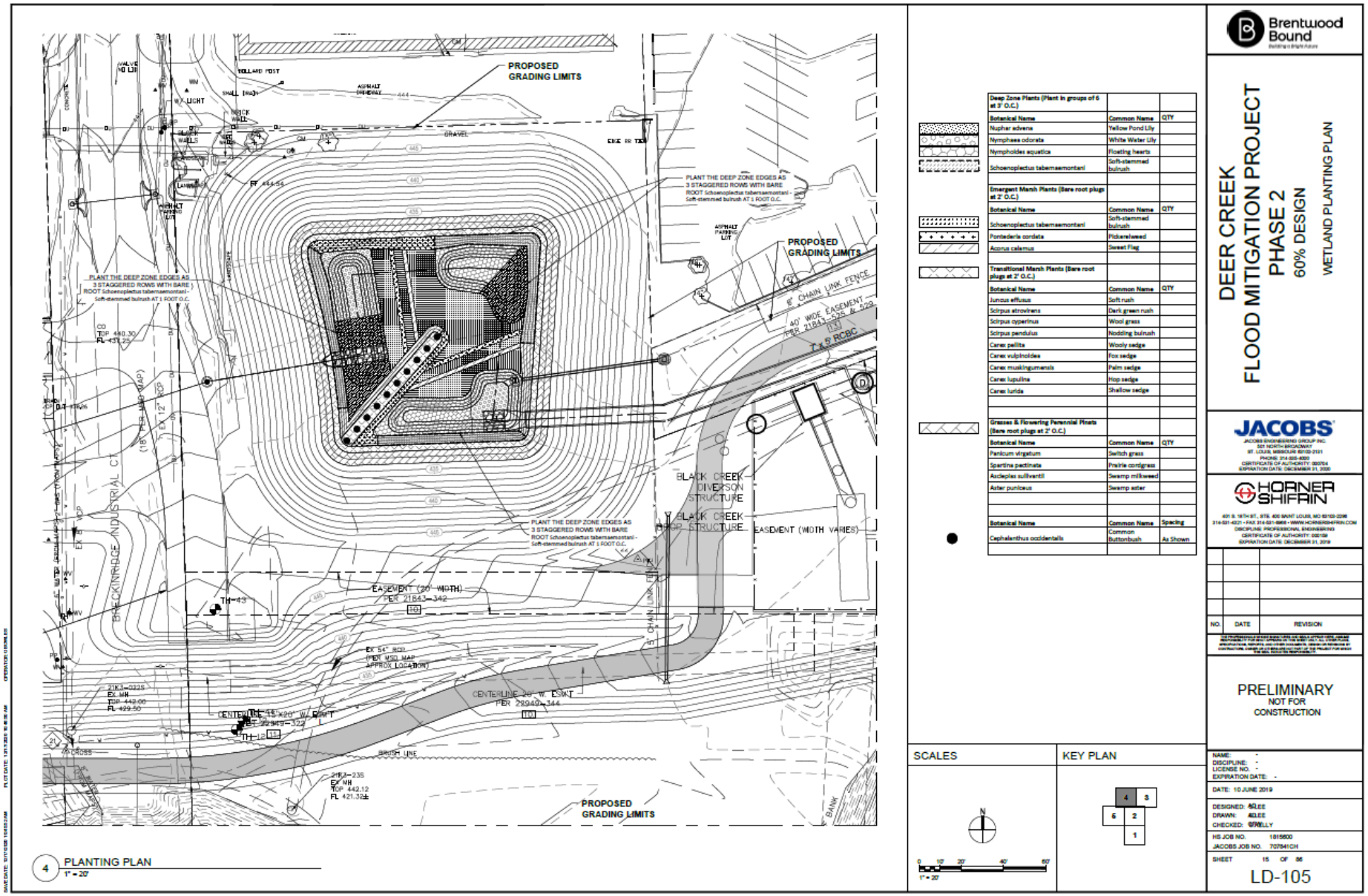
Early Concept of Flood Control Ponds (Blue Only)

- Two pond system
- River backs up into West Pond
- West Pond is connected to East Pond
- Creates extra storage for 50+ year event



Final Design of Flood Control Ponds (BGSI)

- Deer Creek is impaired for E. coli
- Helped City obtain a s.319 grant
- East Pond was converted to dual purpose – Flood Control + Water Quality – as an extended detention wetland
- Pathogens (coliform, E. coli) - Up to 75% reduction with stormwater wetlands



Takeaways

- Blue-Green infrastructure is an evolving term
- It’s a strategy that combines water quality with flood resiliency – while providing community enriching benefits
- Often takes a little more creativity to implement
- Stakeholder buy-in is key to success

Thank you for your time!

Andrea Braga, PE

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