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Innovative Urban Stormwater Management

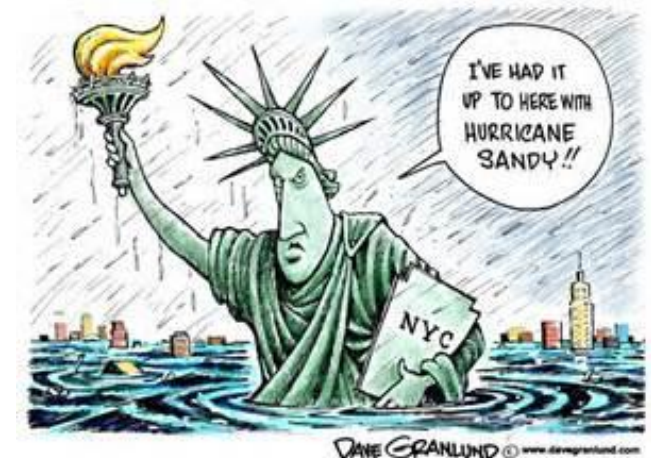
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Stormwater Management Has Evolved



Figure 5-9: BMPs incorporated into a wide sidewalk (modified from San Mateo 2009)


- Management techniques
- Drivers
- Public perception



Where has this led us?

- The public expects more
 - They are well informed and engaged
 - They are viewed as customers
- We (as professionals) are challenged to provide more
 - Holistic solutions (multi beneficial)
 - Integrated planning (inter agency & department)
 - Public & stakeholder engagement
 - Prioritization tools and transparent framework
 - Optimize budget and resources
 - Change management / adaptive management
 - Innovative approaches

Buzz words
or
Key
Elements of
Success?



St. Peters, MO

Implementing Comprehensive Urban Stormwater Management



St. Peters, MO

- The community
 - 28 Miles West of St. Louis
 - Population of 57,000
 - MS4 Community
- The program
 - Spending ~\$3M annually
 - Combination of public and private ownership
 - Easements placed over all retrofits
 - 100% maintained by City
- The Elements of Success
 - Improvements & retrofits based on prioritized master plan (but room for adaptation)
 - Built trust among the public
 - City progressed through a mixture of locations (public & private)
 - Balanced public engagement



Typical Existing Detention Basins



Concrete low flow channels

Existing Outfall



Concrete reinforced banks



Typical Existing Detention Basins (recently constructed)



Existing Outfall

Concrete low flow channels



Post Construction (1st yr)



Post Construction (2nd yr)



Typical Existing Detention Basins



Concrete low flow channels

Existing Outfall



Post Construction



Key Elements of Success – Basin Retrofits

✓ Holistic Solutions

- Clear design objectives
 - Water quality
 - Flood mitigation
 - Aesthetics
- Flexibility in design
 - Highly interactive design process with staff
 - Transparency of challenges

✓ Public Engagement

- Proactively educate & engage residents
- Identify the leaders & interested parties
- Set limits & expectations

- Holistic solutions (multi beneficial)
- Integrated planning (inter agency & department)
- Public & stakeholder engagement
- Prioritization tools and transparent framework
- Optimize budget & resources
- Change management / adaptive management
- Innovative approaches

Channel stabilization & corridor restoration



Existing Condition



Post Construction



Calwood Channel

Understanding the history for:
Engineers & Public



2/1990



3/1996



3/2002



Post Construction (< 1yr)



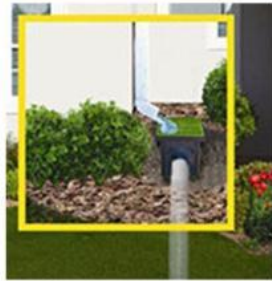
Pre

Construction

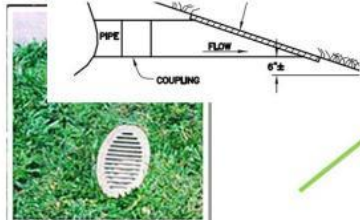


Created Tailored Poster Boards for “trouble” sites & lots

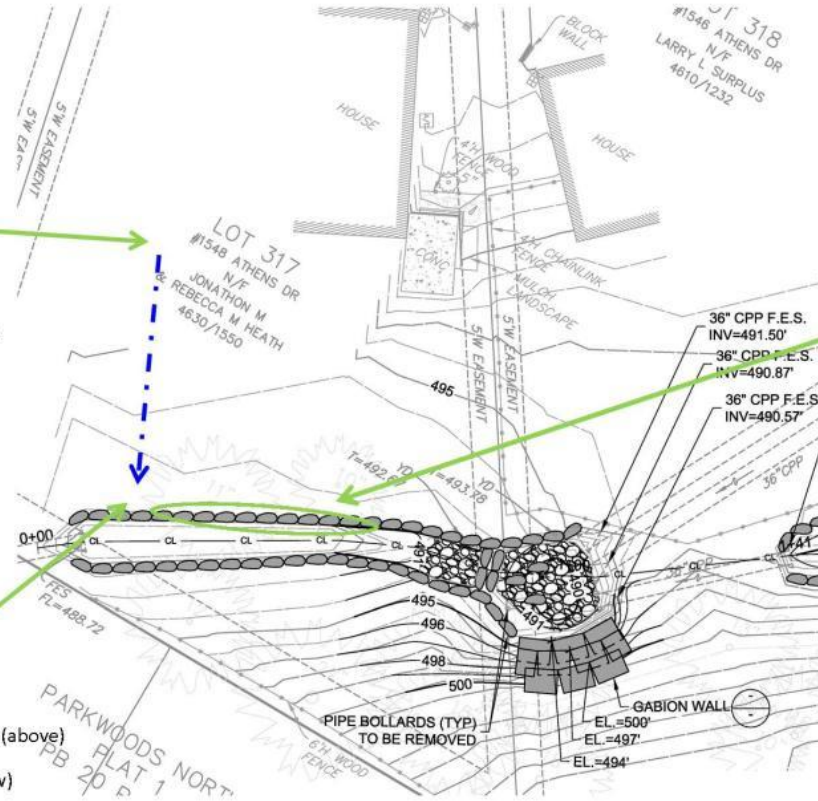
Conceptual Lot Drainage Improvements (Aug, 2013)



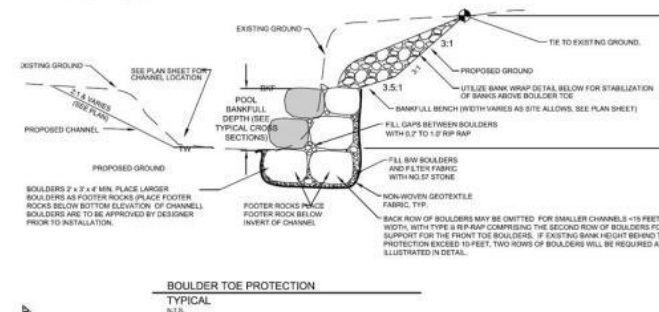
Tie downsouts to drain inlet and drain pipe



Drain pipe outfall can be miter drain at slope (above)
OR
Pop up drain at edge of channel buffer (below)



Channel bank would be stabilized with stone boulder toe protection with native buffer



Key Elements of Success – Stream Channels

✓ Public Engagement

- Listen: Identify concerns (perceived or real)
- Manage expectations
 - What is a “natural system”
 - Tree removal, plantings, & armoring
 - Construction process

✓ Integrated planning (inter-department coordination)

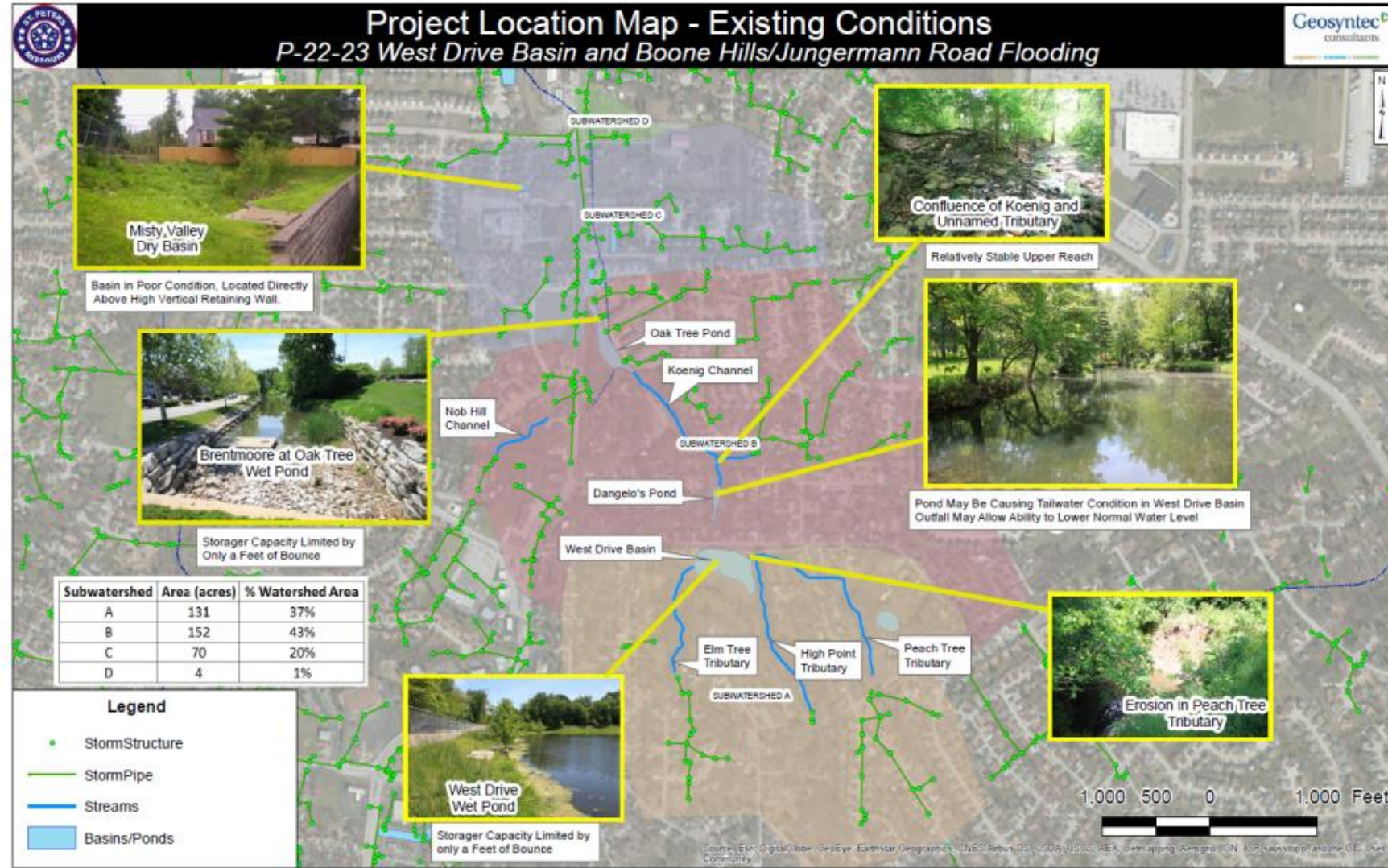
- Engineering, construction, & maintenance teams
- Facilitated by city (not consultant)

- Holistic solutions (multi beneficial)
- Integrated planning (inter agency & department)
- Public & stakeholder engagement
- Prioritization tools and transparent framework
- Optimize budget & resources
- Change management / adaptive management
- Innovative approaches



Stormwater Management – Planning, Design, & Implementation

- 356 Acre urban watershed
- Complete re-envisioning of solutions
 - Leveraged existing assets
 - Floodplain enhancement
 - Tunnel repair
 - Storm sewer improvements
 - Channel restoration
 - Basin modifications



Elements of Success – Planning, Design, & Implementation

- ✓ **Adaptive Management**
 - Openness to new ideas, approaches, & solutions
 - Adaptability of strategic plan
 - Ownership of process by City staff

- ✓ **Innovative approaches**
 - Leverage technology



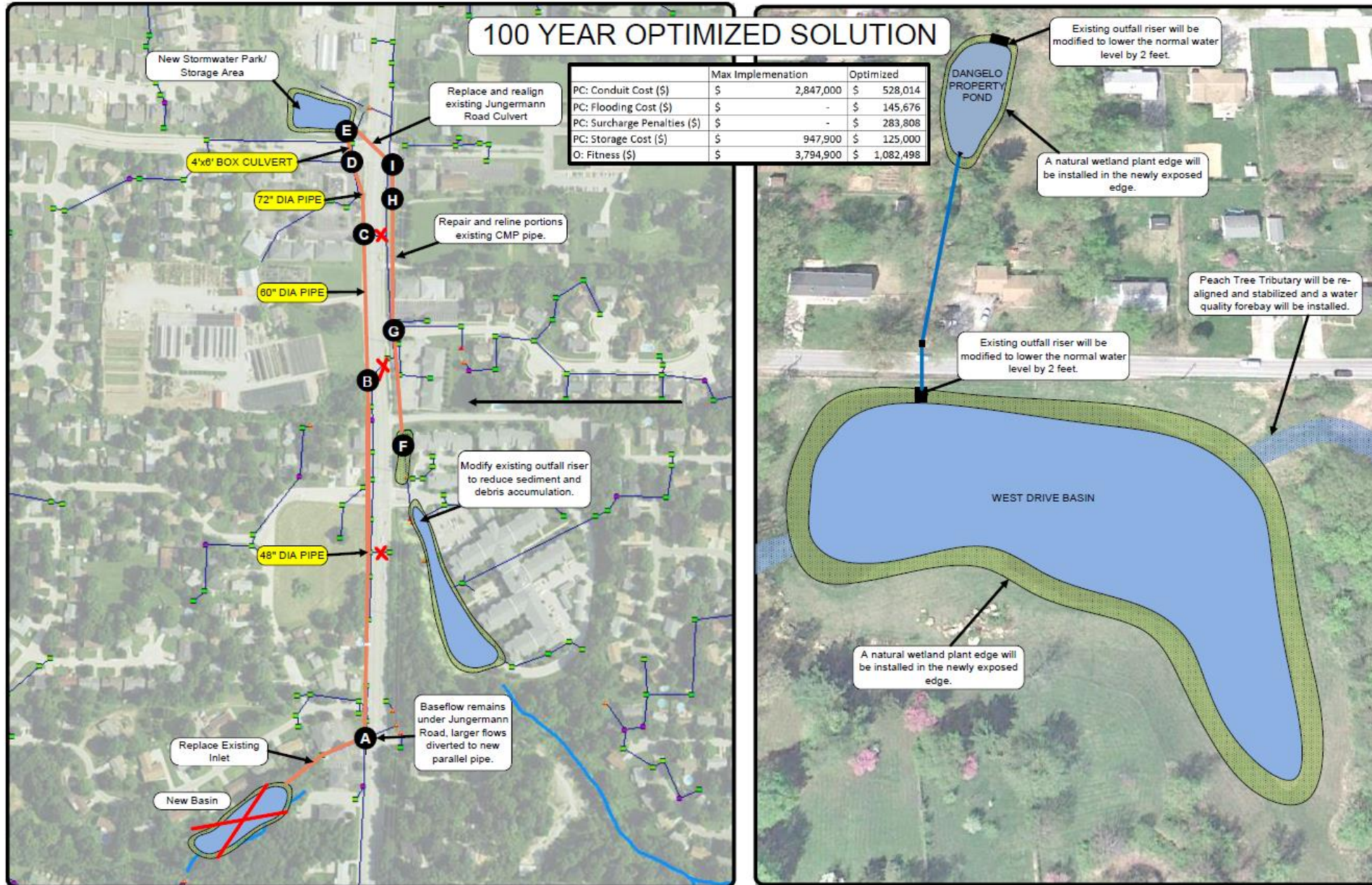
- ✓ **Optimize budget & resources**
 - Alternative analysis (50,000+ alternatives)



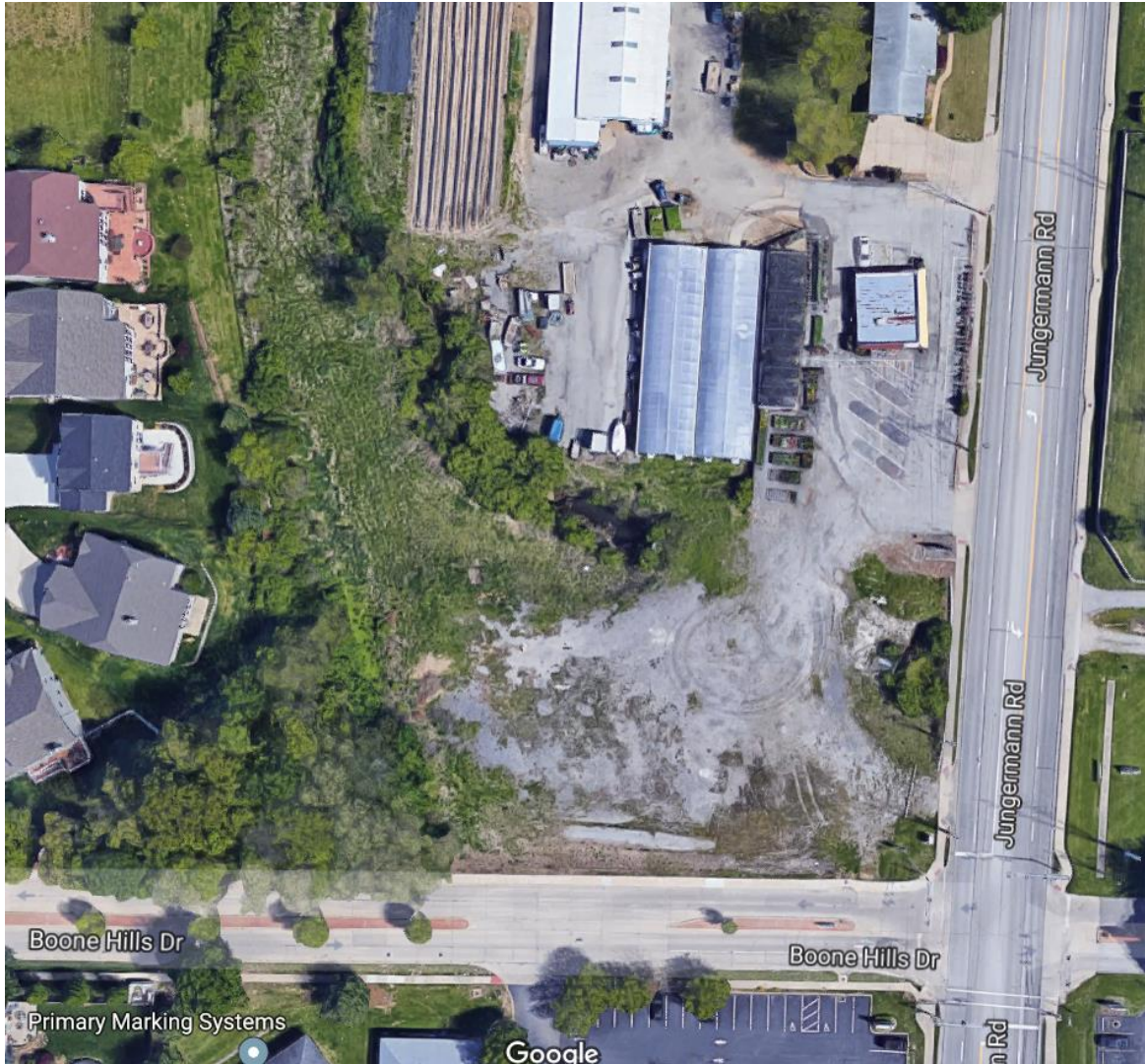
Traditional vs Optimized



Integrated Solutions (public & private)



City purchased land for Stormwater Park



Pre Construction



Post Construction <1yr





New York, NY

Resiliency Audits, Planning,
and Response



Resiliency Audits, Planning, and Response

- **Purpose:**
 - Enhance resiliency through response planning
 - Identify potential flood risk and flood vulnerabilities
 - Leveraged technology for advanced warning system: Real-time estimates of flooding risk
- **Result:**
 - Empowers owners & heightens overall community awareness





Assessing Exterior Vulnerabilities



- Location Specific Resiliency Assessments
 - Engage, inform, & empower owners
- Data Collection via. Web-Based Forms
- Auto Generated Reports
 - Modeling Results & Expected Risk
 - Identified Vulnerabilities
 - Recommendations & Fact Sheets

Floodproofing Fact Sheets

<p>Geosyntec consultants</p> <p>Business Name: Sample Company</p> <p>Business Point of Contact: Mr. X Audit Date: XX/XX/20XX</p> <p>Background and Purpose This business was selected for the Floodproofing System program managed by the Development Block Grant Urban Development (DBG) receiving Flood Resiliency grants. This report provides...</p> <p>Disclaimer and Limitations Information collected during the audit is limited to the information provided by the building owner and is not intended to be a comprehensive assessment of the building's flood risk. The information is provided for informational purposes only.</p> <p>Summary of Findings Three flood risk zones potentially occur: 1) Site, 2) Basement, and 3) Building. The following findings illustrate the flood risk for each zone.</p> <p>1. Inundation Risk: The risk for each flood risk zone is based on the combined precipitation to occur once every 3-year mean high-high water. Annualized risk is based on inundation depth. Refer to the accompanying report for more details.</p>	<p>Geosyntec consultants</p> <p>Zone</p> <p>Site</p> <p>Basement</p> <p>Building</p> <p>2. Vulnerability: Indicate an explanation of specific vulnerabilities considered to help inform the risk assessment.</p> <p>3. Potential Solutions: List any or all potential floodproofing solutions for the identified vulnerabilities. The most effective potential solution is a stackable flood gate with a waterproof sealant to address any major vulnerabilities.</p> <p><i>Refer to the accompanying report for more details.</i></p>	<p>Geosyntec consultants</p> <p>Flood Resiliency Audit Form Sample Company, Audited: XX/XX/20XX Photo(s) of identified Building Zone vulnerabilities</p>  <p>1 (01)-161206-018.JPG</p> <p>Steel Door at Northern Building Exterior</p>  <p>1 (01)-161206-019.JPG</p> <p>Steel Door at Northern Building Exterior (gap between door and floor)</p>
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Accompanying Fact Sheets



Wet Floodproof

Wet Floodproofing entails modifying to enter portions of the building (to equalize pressure on both sides of) for structural damages. Wet flood frequent flooding is known to occur relocation or protection of utilities located in the space allowed to flood.

Sewer

Flooding of through drain of wastewater prevent sewer water sensor the valve.

Perma

Permanent bar the location in side hinged gate designed to au deploy with el lifted, or locked

Tempora

Temporary Barriers plastic, aluminum, provide protection for extended protec installed prior to the these systems are essential to implem

Temporary Barrier Systems

Temporary Barriers Systems provide temporary flood protection from a flood event. They are constructed of a variety of materials, including sand, plastic, aluminum, and steel. Some temporary barriers are designed to provide protection for a single flooding event, while others can be re-used for extended protection time. Temporary barrier systems are required to be installed prior to the start of the flooding event in order to provide protection; these systems are not permanent. Proper warning time and personnel are essential to implement these protection systems prior to flooding.

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SUMP PUMP AND DRAINAGE

System involves allowing water to be detected by the system.

- Pros**
Keeps flood waters from accumulating in below-grade areas. Can be automatic water sensor alert system.
- Cons**
Can be quickly overwhelmed by rising water. Subject to power outages if local off-grid power.
- Deployment Time**
N/A – Sump Pump system will operate installed by a licensed plumber.
- Local New York Suppliers:**
Sump Pump Installation and Materials Plumbing Water Proofing New York located in B Plumbing and Building Supply in Brooklyn Industrial Supply in Brooklyn, NY.

1. Research was conducted to identify NYC contractors that provide floodproofing measures, however, the list provided may not be complete.
2. Research was conducted to identify vendors that supply sump pumps, however, the list provided may not be complete.
3. The NYC Department of Buildings maintains documentation in a General Contractor License Search Engine located at: <http://www1.nyc.gov/site/buildings/business/hiring-a-professional-page>

SEWER BACKFLOW DEVICES

A flap or check valve that prevents backflow when the backflow occurs.

- Pros**
Prevents or limits backflow of wastewater into the building.
- Cons**
Requires sufficient head of wastewater to flow through the device.
- Estimated Deployment Time**
Approximately 15-30 minutes.
- Local New York Suppliers:**
Prevention of Sewer Backflow

1. Research was conducted to identify NYC contractors that provide sewer backflow prevention devices, however, the list provided may not be complete.
2. Research was conducted to identify vendors that supply sewer backflow prevention devices, however, the list provided may not be complete.
3. The NYC Department of Buildings maintains documentation in a General Contractor License Search Engine located at: <http://www1.nyc.gov/site/buildings/business/hiring-a-professional-page>

RETRACTABLE GATES

Flood protection and operations.

- Pros**
Permanent flood protection, not deployed. Car systems (e.g. water device should be used).
- Cons**
Initial construction barrier systems (e.g. concrete).
- Estimated Deployment Time**
Approximately 5-10 minutes.
- Local New York Suppliers:**
Preray Watergate direct from Preray

1. Research was conducted to identify NYC contractors that provide retractable gates, however, the list provided may not be complete.
2. Research was conducted to identify vendors that supply retractable gates, however, the list provided may not be complete.
3. The NYC Department of Buildings maintains documentation in a General Contractor License Search Engine located at: <http://www1.nyc.gov/site/buildings/business/hiring-a-professional-page>

SAND BAG SYSTEMS

Sand filled bags that can be used to create a barrier.

- Pros**
Cheapest temporary measure.
- Cons**
Lengthy and labor-intensive disposal due to the weight of the bags. Requires storage on-site.
- Estimated Deployment Time**
Time varies based on the length of the barrier. Approximately 40 ft long sand barrier.
- Local New York Suppliers:**
Sand Bags to Go – P Brooklyn, NY.
ACECO Industrial Packaging Sandbags located in New York City.
AGSCO Corporation – Sandbags

1. Research was conducted to identify NYC contractors that provide sand bag systems, however, the list provided may not be complete.
2. Research was conducted to identify vendors that supply sand bags, however, the list provided may not be complete.
3. The NYC Department of Buildings maintains documentation in a General Contractor License Search Engine located at: <http://www1.nyc.gov/site/buildings/business/hiring-a-professional-page>

INFLATABLE BARRIERS

Water filled barriers made of durable flexible plastic materials that are filled until they provide a barrier of protection from flooding. When not in use, the deflated barriers can be rolled and stored until required prior to flooding.

- Pros**
Available in versatile sizes (doorsteps to large dams) and can be folded and stored between flooding events.
- Cons**
Require warning time, routine maintenance, and reliable water source to fill.
- Estimated Deployment Time**
Approximately 5-10 minutes required to lay out barrier, but time to fill depends on flow rate of water filling barrier to desired height.
- Local New York Suppliers:**
Quick Dam – available at Granger Industrial Supply, Inc., located in Brooklyn, NY.
Tiger Dams – available direct from Tiger Dams.



Source: FEMA Chapter 8 Barriers



Sources and Additional Information:

- FEMA, "Floodproofing Non-Residential Buildings," FEMA P-936 Edition 1 (July 2013). <https://www.fema.gov/media-library/assets/documents/34270>
- FEMA, "Homeowner's Guide to Retrofitting," Barriers Chapter 8.0, FEMA P-312 Edition 3 (2014). <http://www.fema.gov/media-library/assets/documents/480>
- FEMA, "Selecting Appropriate Mitigation Measures for Floodprone Structures," FEMA 551 (March 2007). http://www.fema.gov/media-library-data/20130726-1606-20460-5083/fema_551.pdf
- De Graaf, Rutger, and Vermeer, Dura, "Technologies for flood-proofing 'hotspot' buildings". Flood Probe Research Project, 2nd Edition (July 2012). http://www.floodprobe.eu/partners/assets/documents/Technologiesforflood-proofinghotspotbuildings_DeltaSync_18032013.pdf
- Thomasnet.com "Qualified Supplier Discovery", <http://www.thomasnet.com/suppliers/> Website Search Engine, (October 2016).
- MFG.com, "Manufacturing Companies Worldwide Directory", <https://discover.mfg.com/?country=92&search=1> Website Search Engine, (October 2016)

FEMA, "Floodproofing Non-Residential Buildings," FEMA P-936 Edition 1 (July 2013). https://www.fema.gov/media-library/assets/documents/34270	NYC.gov	De Graaf, Rutger, and Vermeer, Dura, "Technologies for flood-proofing 'hotspot' buildings". Flood Probe Research Project, 2nd Edition (July 2012). http://www.floodprobe.eu/partners/assets/documents/Technologiesforflood-proofinghotspotbuildings_DeltaSync_18032013.pdf	Castorian
FEMA, "Homeowner's Guide to Retrofitting," Barriers Chapter 8.0, FEMA P-312 Edition 3 (2014). http://www.fema.gov/media-library/assets/documents/480	NYC.gov	De Graaf, Rutger, and Vermeer, Dura, "Technologies for flood-proofing 'hotspot' buildings". Flood Probe Research Project, 2nd Edition (July 2012). http://www.floodprobe.eu/partners/assets/documents/Technologiesforflood-proofinghotspotbuildings_DeltaSync_18032013.pdf	FEMA
FEMA, "Protecting Building Utilities from Flooding," FEMA P-936 Edition 1 (July 2013). https://www.fema.gov/media-library/assets/documents/34270	NYC.gov	De Graaf, Rutger, and Vermeer, Dura, "Technologies for flood-proofing 'hotspot' buildings". Flood Probe Research Project, 2nd Edition (July 2012). http://www.floodprobe.eu/partners/assets/documents/Technologiesforflood-proofinghotspotbuildings_DeltaSync_18032013.pdf	FEMA
FEMA, "Flood Damage-Resistant Materials, a Home Builder's Guide," FEMA P-936 Edition 1 (July 2013). https://www.fema.gov/media-library/assets/documents/34270	NYC.gov	De Graaf, Rutger, and Vermeer, Dura, "Technologies for flood-proofing 'hotspot' buildings". Flood Probe Research Project, 2nd Edition (July 2012). http://www.floodprobe.eu/partners/assets/documents/Technologiesforflood-proofinghotspotbuildings_DeltaSync_18032013.pdf	FEMA
FEMA, "Coastal Building Materials, a Home Builder's Guide," FEMA P-936 Edition 1 (July 2013). https://www.fema.gov/media-library/assets/documents/34270	NYC.gov	De Graaf, Rutger, and Vermeer, Dura, "Technologies for flood-proofing 'hotspot' buildings". Flood Probe Research Project, 2nd Edition (July 2012). http://www.floodprobe.eu/partners/assets/documents/Technologiesforflood-proofinghotspotbuildings_DeltaSync_18032013.pdf	FEMA
Thomasnet.com "Qualified Supplier Discovery", http://www.thomasnet.com/suppliers/ Website Search Engine, (October 2016).	Thomasnet.com	Thomasnet.com "Qualified Supplier Discovery", http://www.thomasnet.com/suppliers/ Website Search Engine, (October 2016).	Thomasnet.com
MFG.com, "Manufacturing Companies Worldwide Directory", https://discover.mfg.com/?country=92&search=1 Website Search Engine, (October 2016)	MFG.com	MFG.com, "Manufacturing Companies Worldwide Directory", https://discover.mfg.com/?country=92&search=1 Website Search Engine, (October 2016)	MFG.com



Flood Resiliency Dashboards - Response



The screenshot displays the Opti dashboard interface. On the left, there is a sidebar with a 'Reset' button and a list of 'Projects (3)' and 'Groups (16)'. The main content area is a grid of project photos, each with a caption below it:

- 54 Commerce St Corp. / Alpha Marine Inc.
- Forecasted Flood Inundation & System Statuses
- Giumenta Corp. DBA Architectural Grille
- HeartSong Speech and Language Pathology
- Hook Enterprises, LLC
- Ice Stone LLC
- Jeffrey F. Zwerling, MD PC
- John Lepore Insurance Agency
- M&R Rockaway
- GOODY'S

On the right side of the dashboard is a map view. A callout box with a blue border and white background points to the map and contains the text: "Link to Site-Specific Resiliency Dashboards". Another callout box, also with a blue border and white background, points to specific locations on the map and contains the text: "Site Locations". The map shows a coastal area with several green circular markers labeled with the numbers 2 and 7. The map interface includes a search bar at the top with the text "The map is filtering results." and a "Remove Filter" button. The bottom of the map view has a copyright notice: "Leaflet | Bing, © 2018 Microsoft Corporation, Earthstar Geographics SIO".



Resiliency Dashboards

Forecasted Site Inundation Depth

"UNKNOWN" status indicates data is unavailable or forecasted precipitation and tide are below modeled thresholds.



Current Flood Advisory System Statuses

"OFFLINE" indicates that one or more datastream has been offline in the past 48 hours which might impact computation of site-specific flood information.



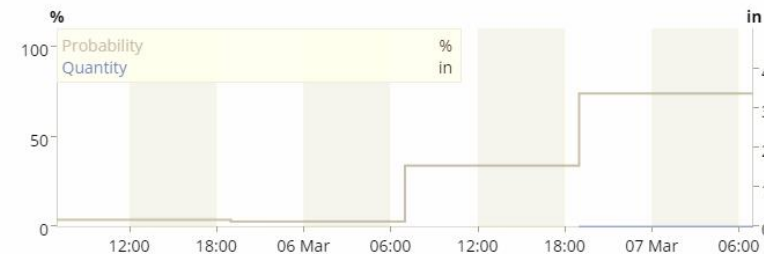
Radar

[Latest Image](#) | 12hr | 24hr



How Much Rain is in the Forecast?

This chart shows the expected probability and quantity of rainfall in the next 48 hours (source: weather.gov).



Elements of Success

✓ Innovative Approaches

- Openness of NYC to leverage technology & new approach

✓ Public & Stakeholder Engagement

- Willingness to engage stakeholders in innovative pilot

✓ Optimize Budget & Resources

- Resiliency through response planning
- Empowerment of residents

- Holistic solutions (multi beneficial)
- Integrated planning (inter agency & department)
- Public & stakeholder engagement
- Prioritization tools and transparent framework
- Optimize budget & resources
- Change management / adaptive management
- Innovative approaches

GREEN INFRASTRUCTURE



Distributed BMPs The case for lot level BMPs

Metropolitan Water Reclamation District of Greater Chicago

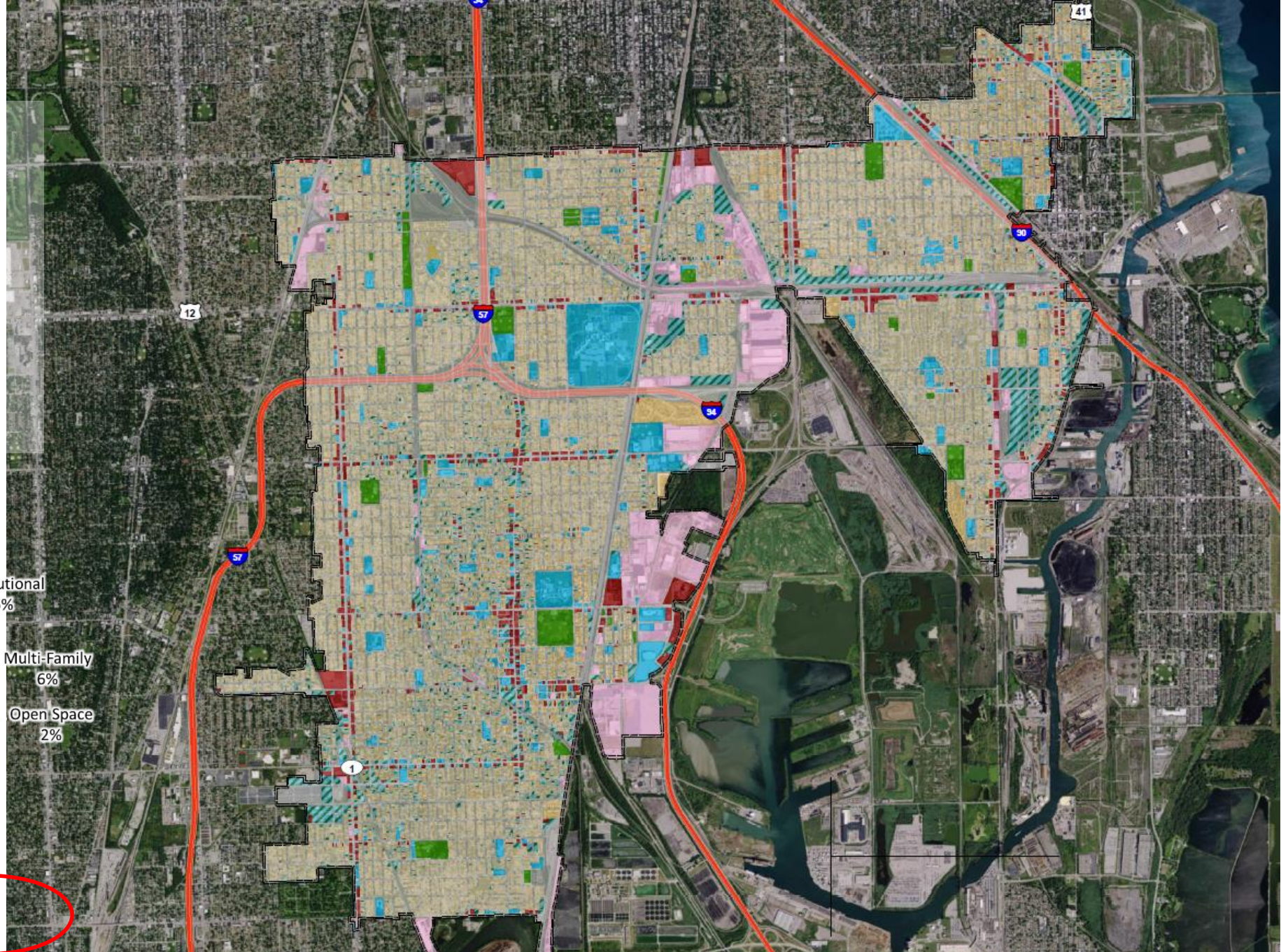
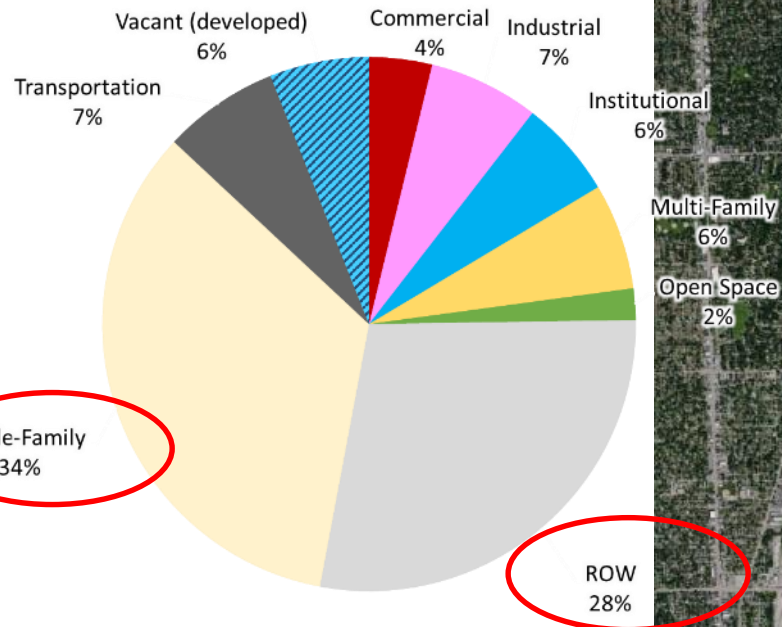
Phase II Pilot Study

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Study Area

- 17 square miles
- 44,053 structures (excludes garages)
- Chronic urban flooding
 - Basement backups
 - Surface flooding



Looking for Solutions

- Balance **system engineering & outcome engineering:**

- System – target level of performance of network (the system)
- Outcome – focuses on desired outcome (protect homes)



- Flooding solutions balance:

- Conveyance
 - Volume
 - Structural flood protection
- ← system
← outcome



- Ensure the question being asked is framed properly

The Big Question: Will BMPs Work?

These are a few follow on questions that should be answered before jumping to the question of how to implement lot level BMPs.

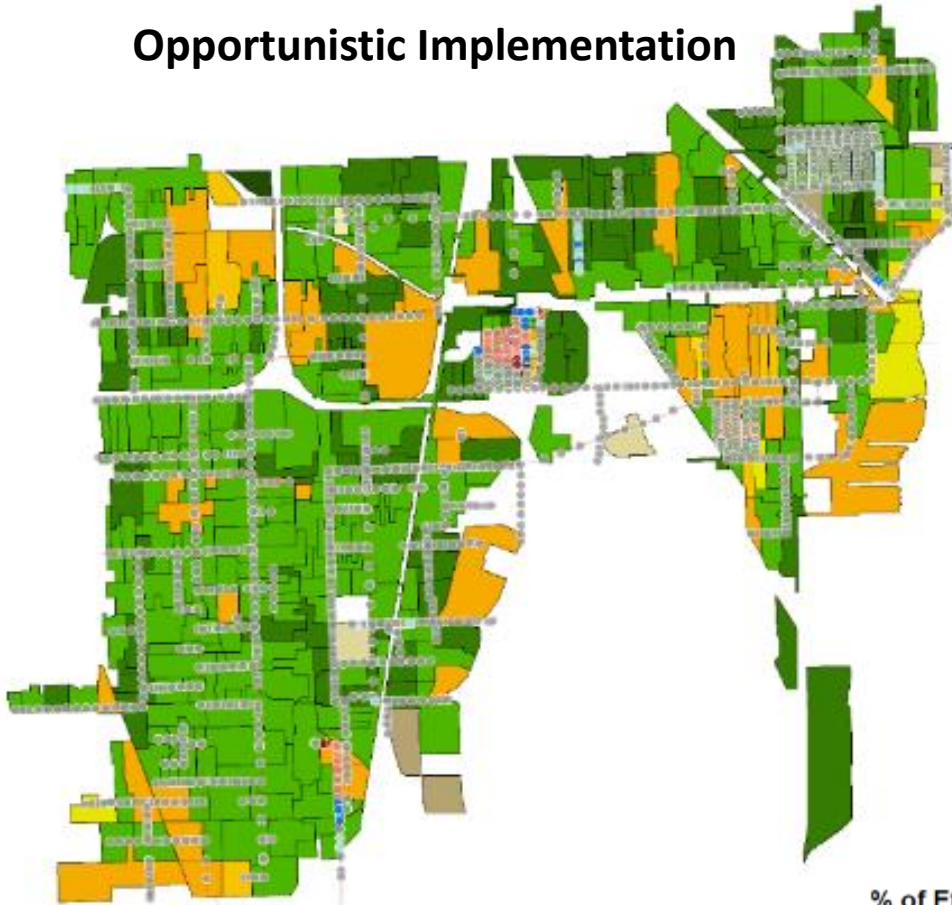
- What level of performance can be expected from BMPs?
- How to quantify performance? How well does it work?
- Does it matter where GI or distributed BMPs are placed?
- Is there a critical mass or threshold of implementation that is needed?
- How can the best location and type of BMP be determined?
- How to compare Green vs Gray vs other solutions?



Integration of GI with Regional Gray – 100 yr

Maximum GI

Opportunistic Implementation

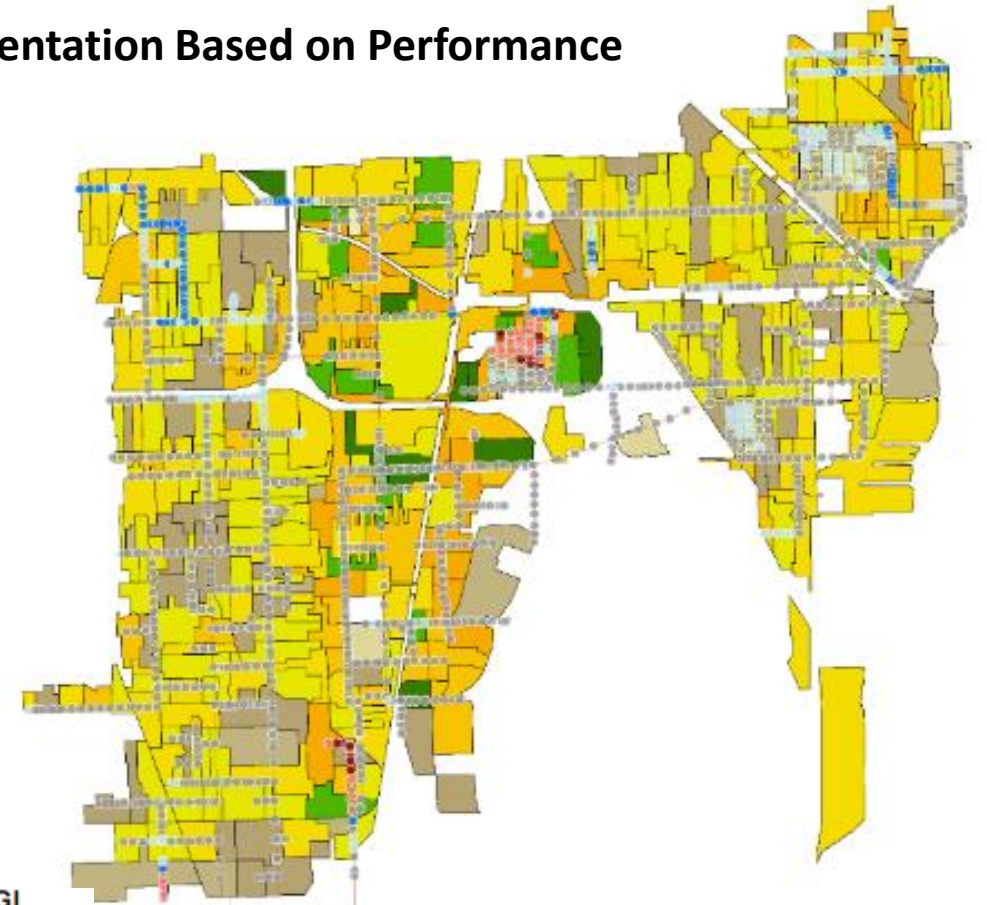


Structures removed:

42,300

Optimized GI

Implementation Based on Performance



Structures removed:

43,300

% of Effective Area treated by GI



Elements Leading to Success

✓ Innovative Approaches

- Openness of MWRDGC to leverage technology

✓ Prioritization Tools & Transparent Framework

- Ownership & engagement of MWRDGC staff

✓ Optimize Budget & Resources

- Robust alternative analysis

✓ Integrated Planning

- MWRDGC & City collaboration

- Holistic solutions (multi beneficial)
- Integrated planning (inter agency & department)
- Public & stakeholder engagement
- Prioritization tools and transparent framework
- Optimize budget & resources
- Change management / adaptive management
- Innovative approaches

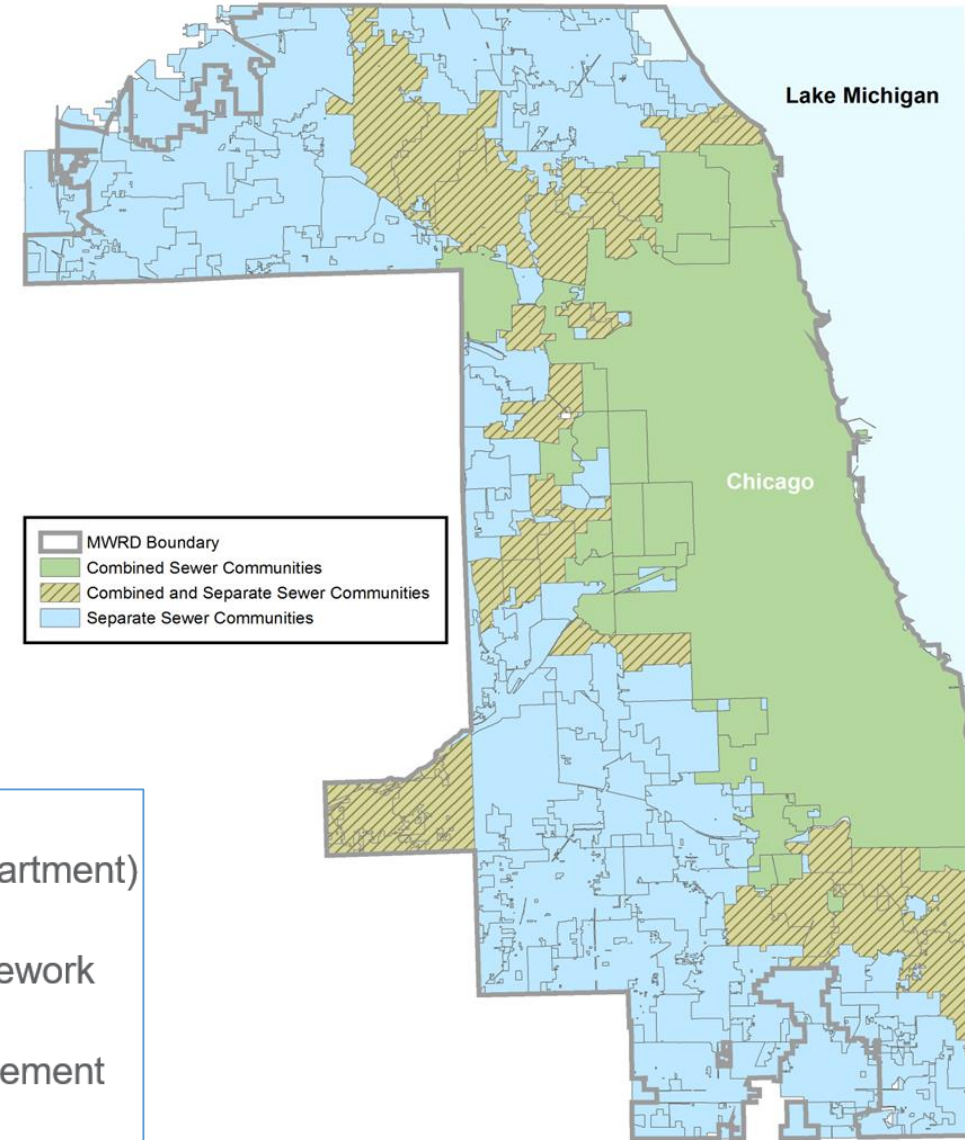




Future Stormwater Master Plans (SMP)

- Richard Fisher (MWRDGC) Presented Overview at Prior MPC Meeting
- Moving Forward:
 - Evaluate master planning needs throughout county
 - Develop adaptive approach, centered on managing local stormwater issues with multiple-disciplined teams
 - Leverage and build upon work of others
 - Develop a repeatable process
 - Create actionable plans

- Holistic solutions (multi beneficial)
- Integrated planning (inter agency & department)
- Public & stakeholder engagement
- Prioritization tools and transparent framework
- Optimize budget & resources
- Change management / adaptive management
- Innovative approaches



Questions?

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