Hydrogeological soil research for green stormwater infrastructure planning and design:
new methods for adapting urban coastal communities
aka "Calumet Soils Design"

Presenting today
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Kristine Ryan, NRCS
Numerous others who we thank immensely!

Illinois-Indiana Sea Grant Program (NOAA) 2018-2020, #NA18OAR170082

Calumet soils design: update

research premise *coordinated* Green Infrastructure is a better investment than *opportunistic* Green Infrastructure.

research steps

- ✓ soils research
- ✓ design/engineering
- ✓ optimized GI network in pilot communities
- ✓ process guide

where are we now? GI designs presented to pilot communities, working with communities on pilot projects and process guide.

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Calumet soils design: research premise

soil properties are the foundation of GI design performance at a coordinated scale.

Coordinated GI Implementation

20% - 40% GI

Same Performance Level

Opportunistic GI Implementation

80% GI

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Calumet soils design: steps and status

Soils research	Design Engineering	Proof of concept Pilots	Process guide
1) Update publically-available data 2) Site-specific soils properties in pilot communities ***Status: Complete, some work ongoing***	Model soils performance under differing rainfall volumes and GI types ***Status: Complete***	Optimal green infrastructure network ***Status: Complete, some work ongoing***	Sharable process toolkit to incorporate soils into GI planning ***Status: In progress***
← Outreach →			

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Calumet Soils Design: early findings and next steps

- Early research findings
  - for more permeable (coarser) soils, depth of installation does not matter
  - as the loading ratio (impervious drainage area to infiltration area) decreases, retrofitting not as effective
  - loading ratio is key determinant to GI Success (performance reliability)
  - placement is important, critical not to site GI at the end of a drainage surface or network
- Next steps
  - working with communities on pilot projects
  - developing sharable process toolkit to incorporate soils data into GI planning
  - peer reviewed publications

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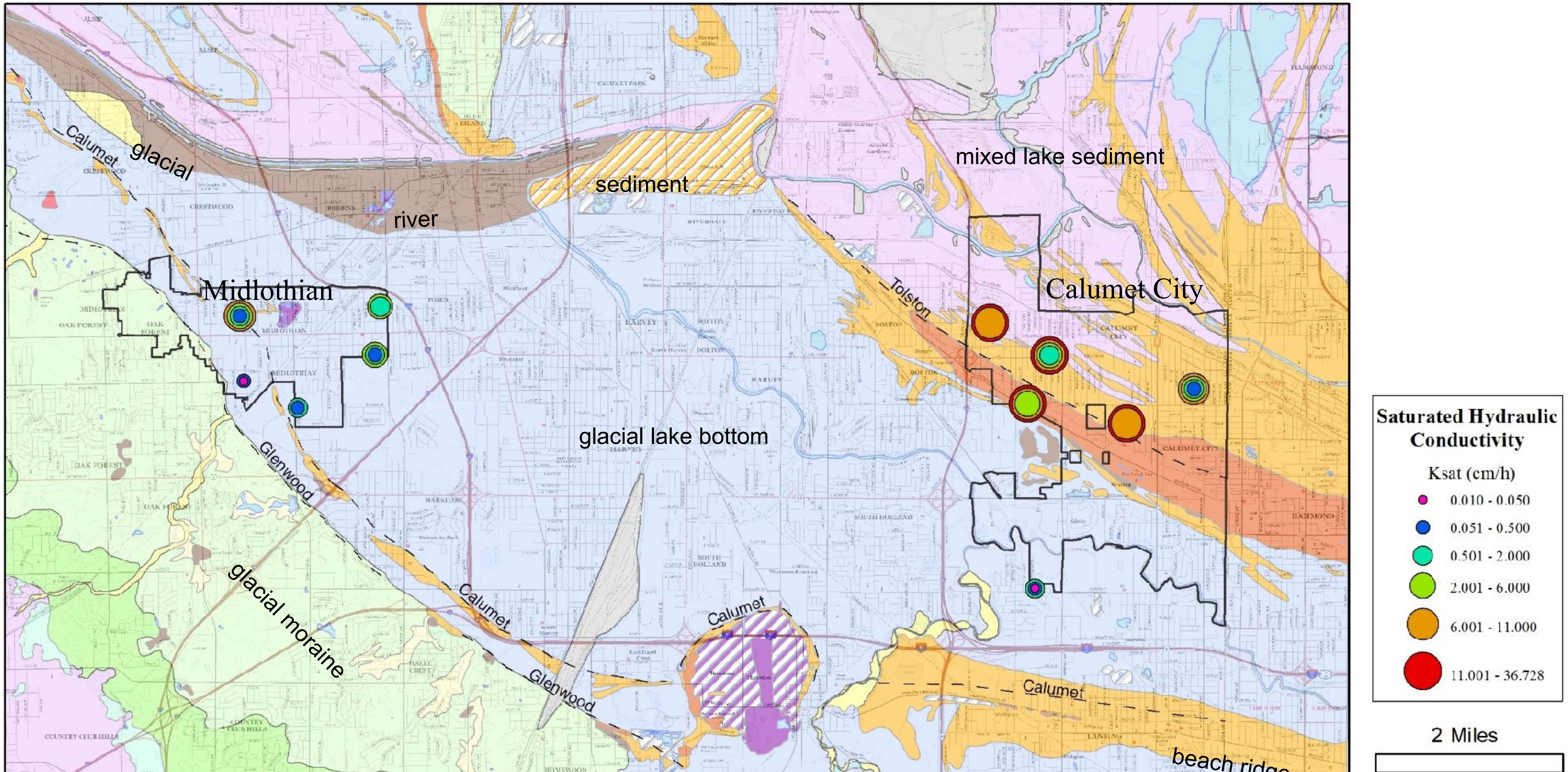
Soil Characteristics for Green Infrastructure Planning



Geology from J.H. Bretz (1948)

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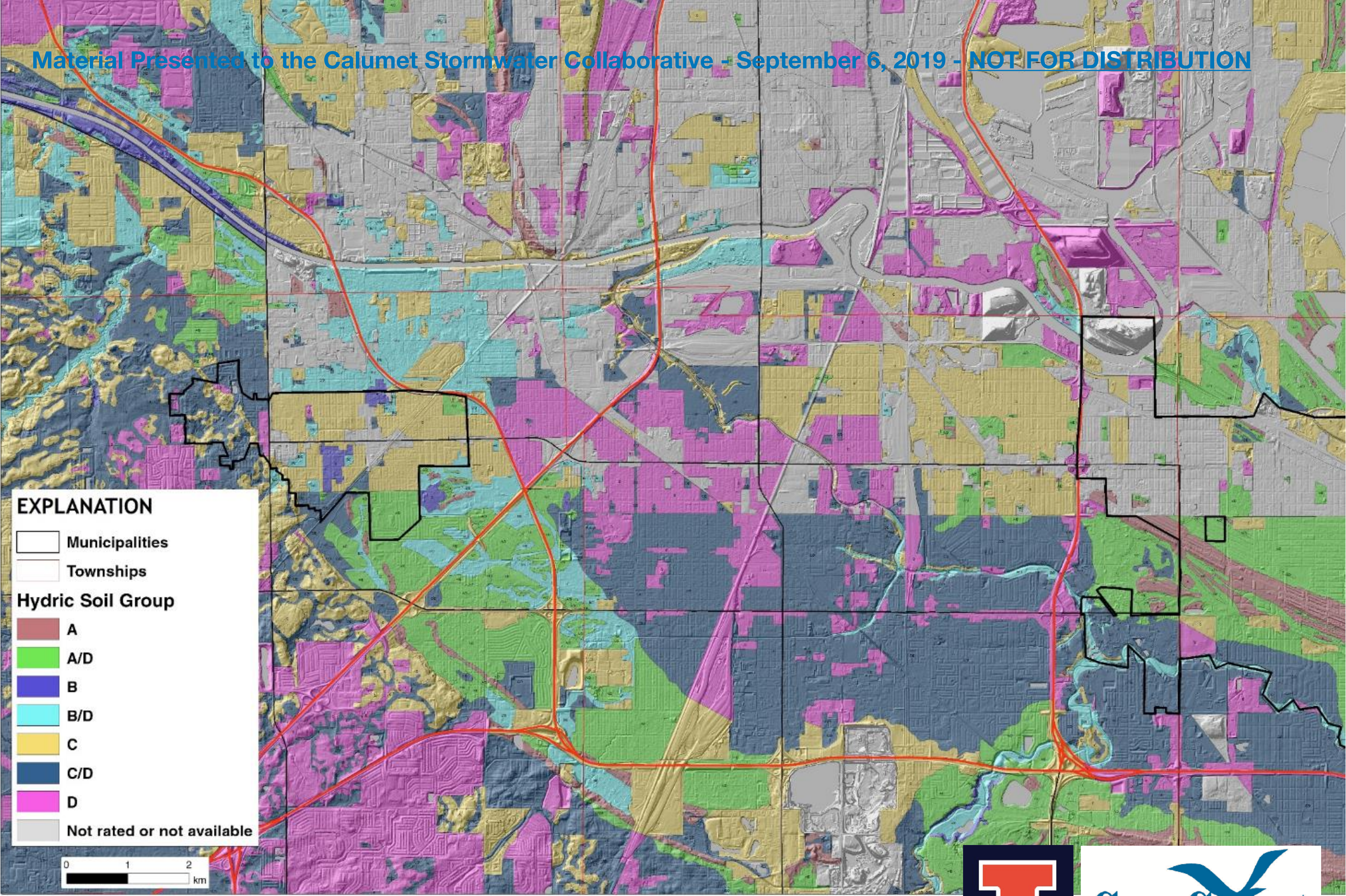

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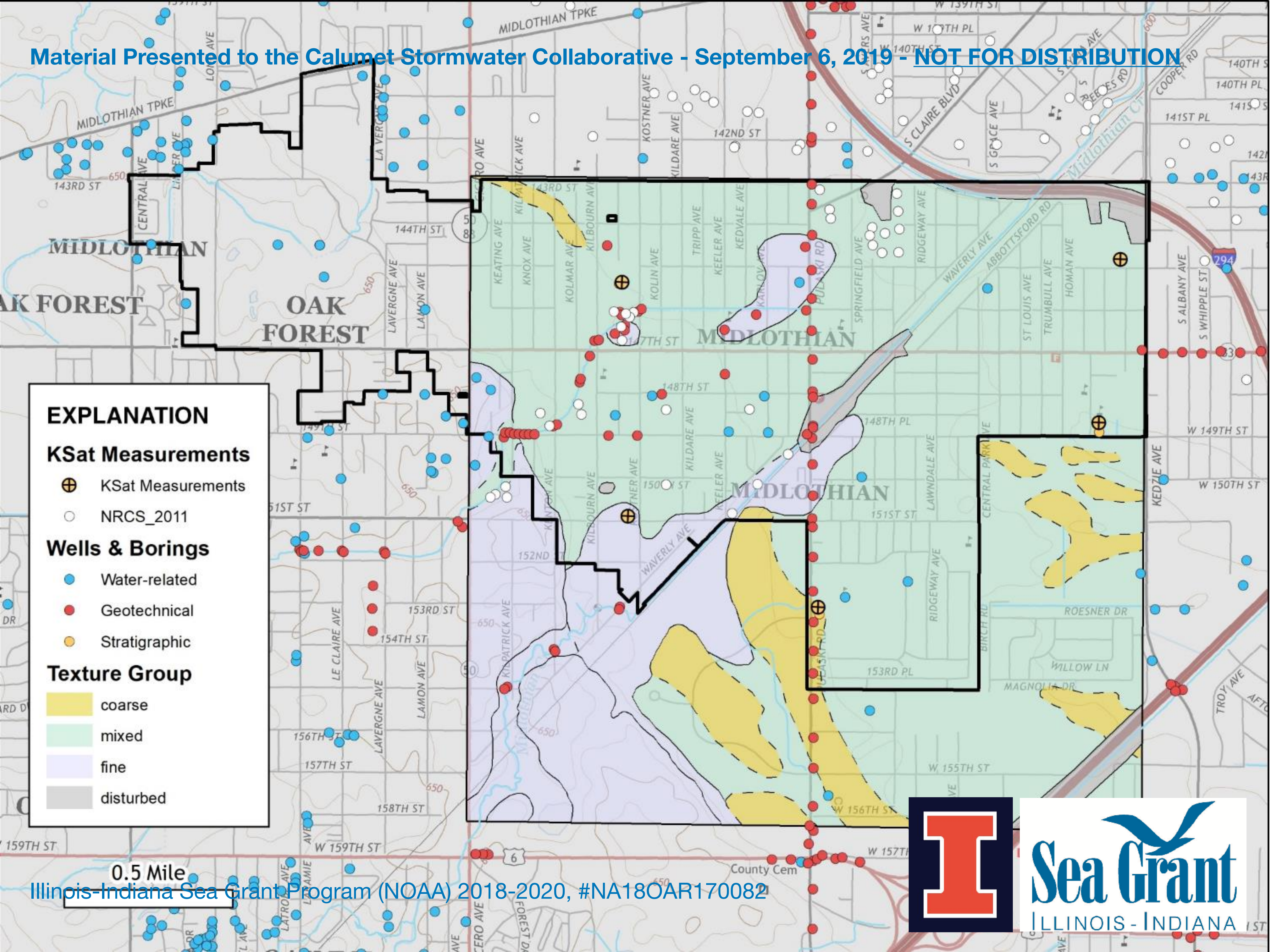

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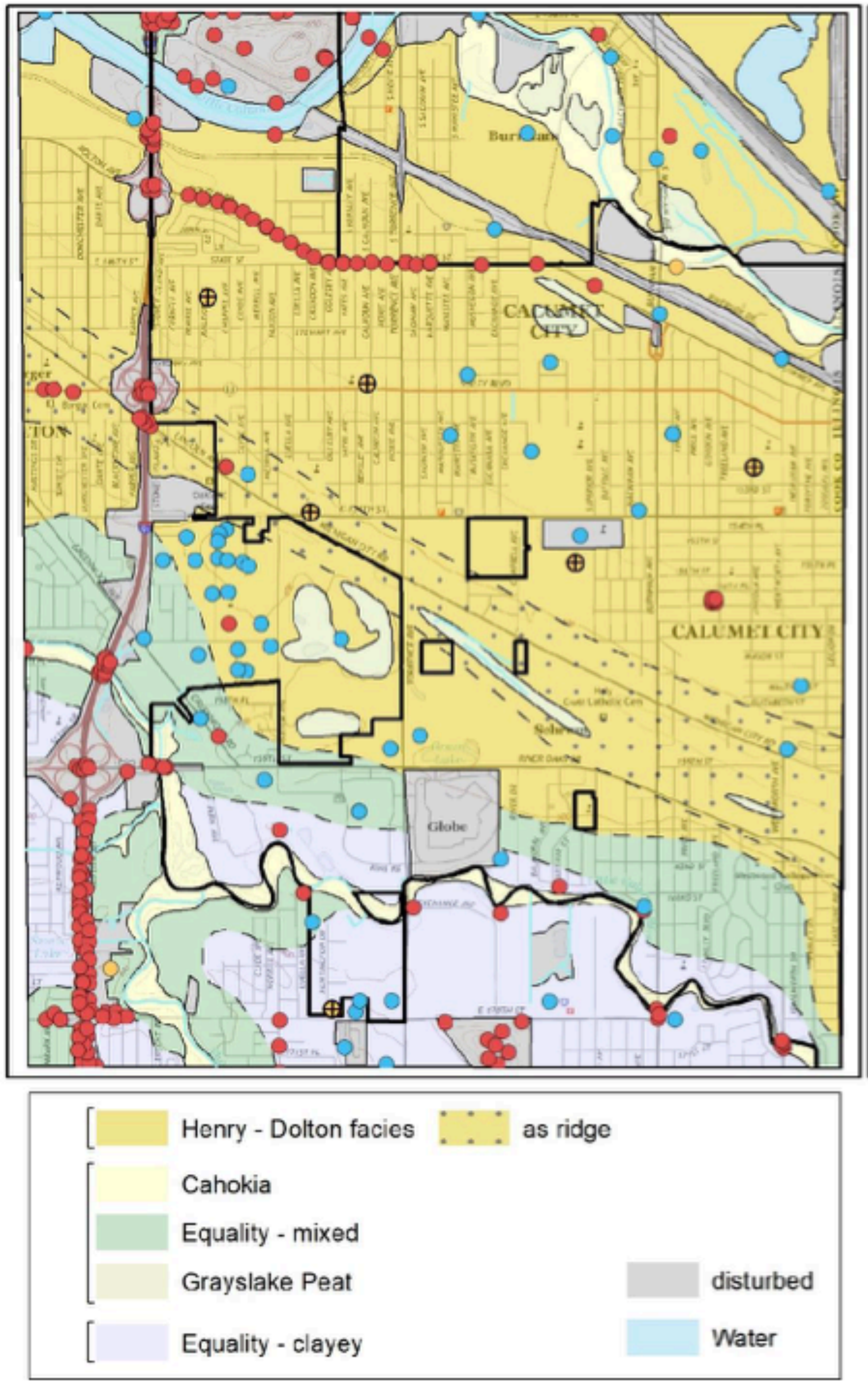
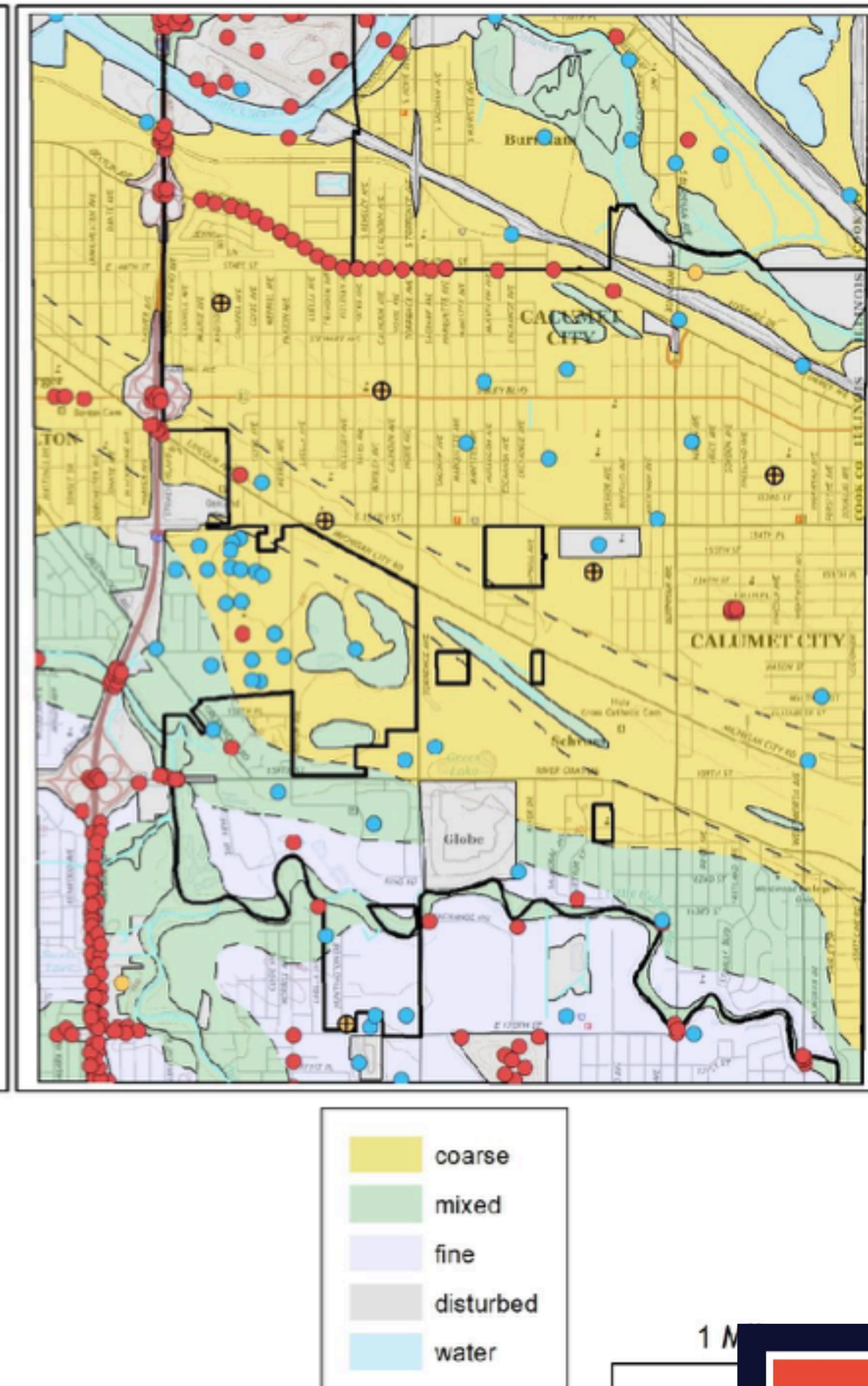
Surficial Geology



Texture Group



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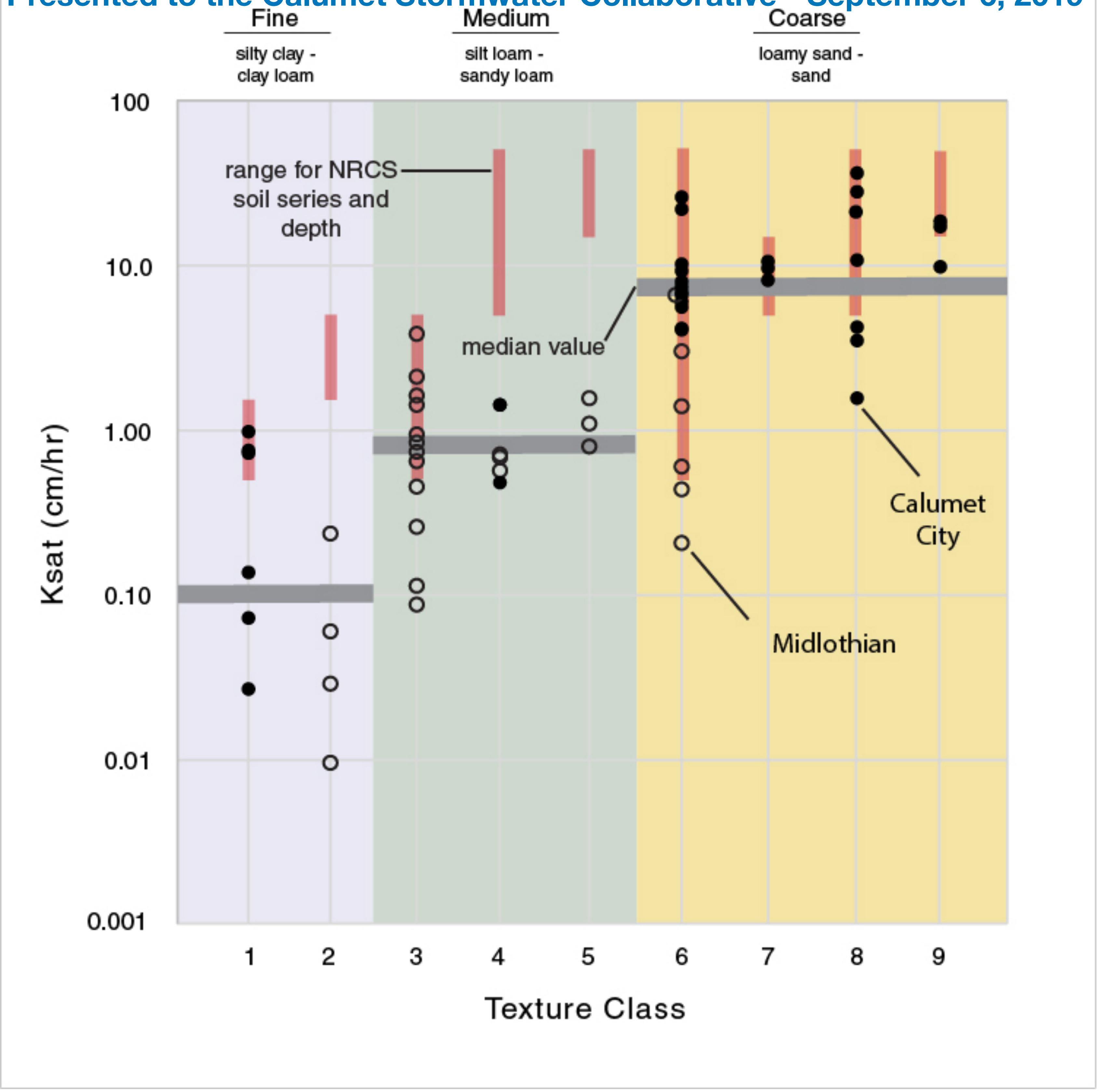

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Lithologic Cross Section

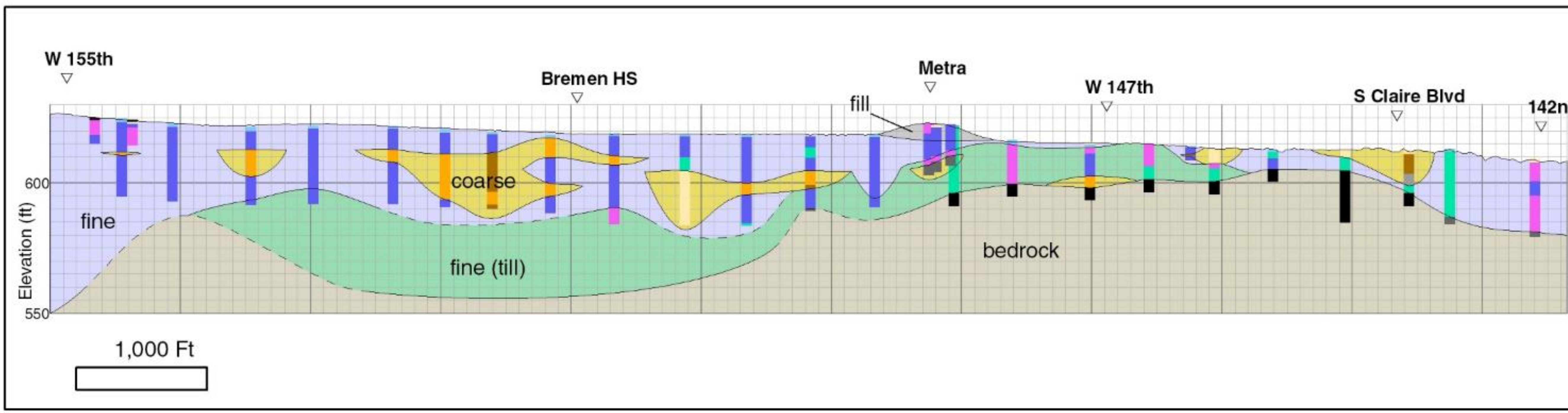
EXPLANATION

Unit Contacts

- Confident
- Inferred

Texture Unit

- fill
- fine
- coarse
- diamict
- bedrock



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Material Presented to the Calumet Stormwater Collaborative - September 6, 2019 - NOT FOR DISTRIBUTION

Green Stormwater Infrastructure Design, based on underlying soils

key principles:
- intercept water directly (or, as close as possible)
- create underlyng layers of material (organic and/or open-graded) to further capture water
- reduce energy and erosion (make capture very direct)
- convey water downward through soils, through gravity and/or soil properties
- use planting to uptake (everywhere possibe)

GI Surfaces
(e.g. parking lots)

- designed to handle water directly through the surface
- optional to receive from adjacent surfaces
- lower loading ratio

GI Features
(e.g. bioswales)

- designed to receive water from adjacent surfaces
- higher loading ratio

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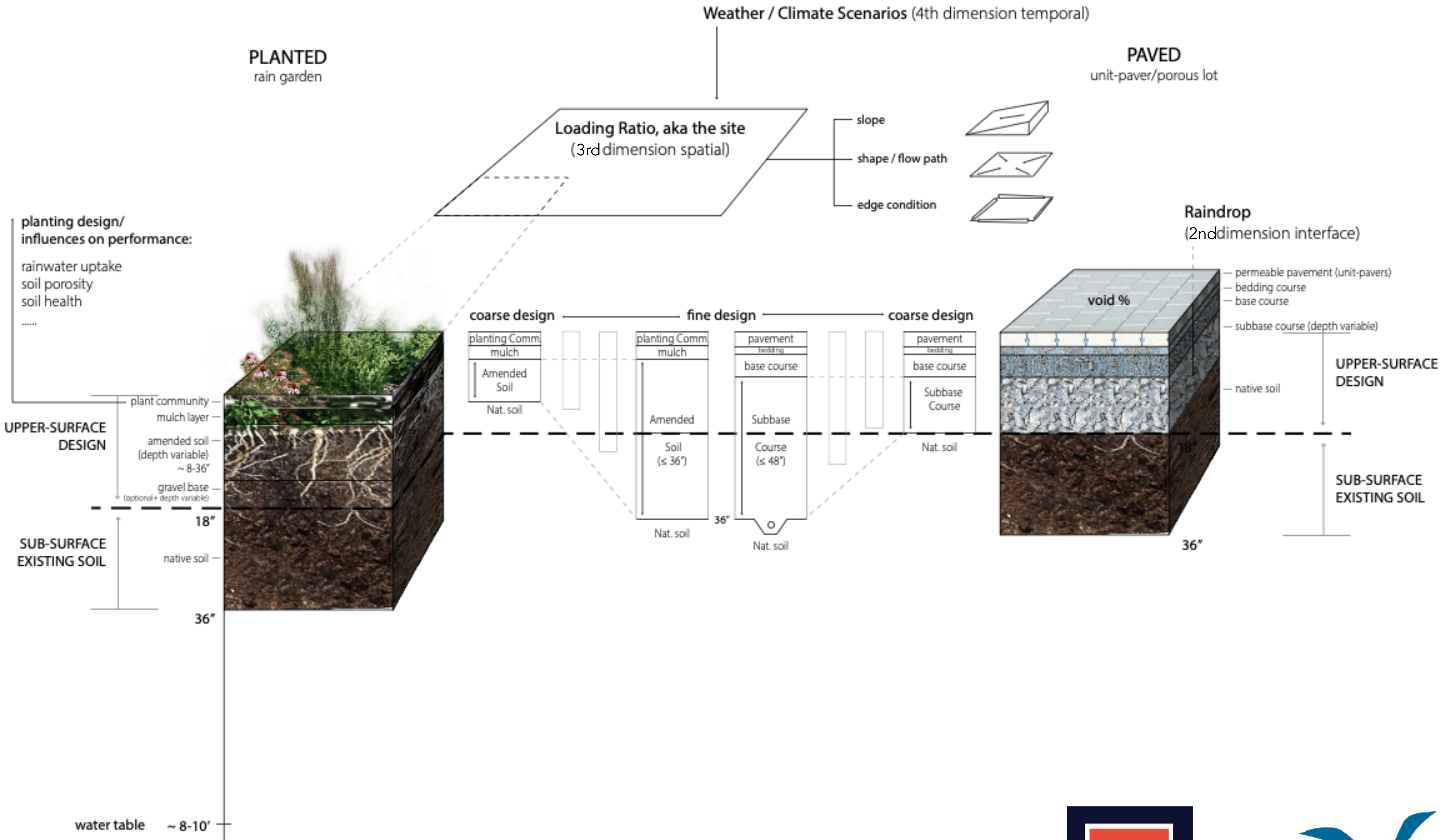

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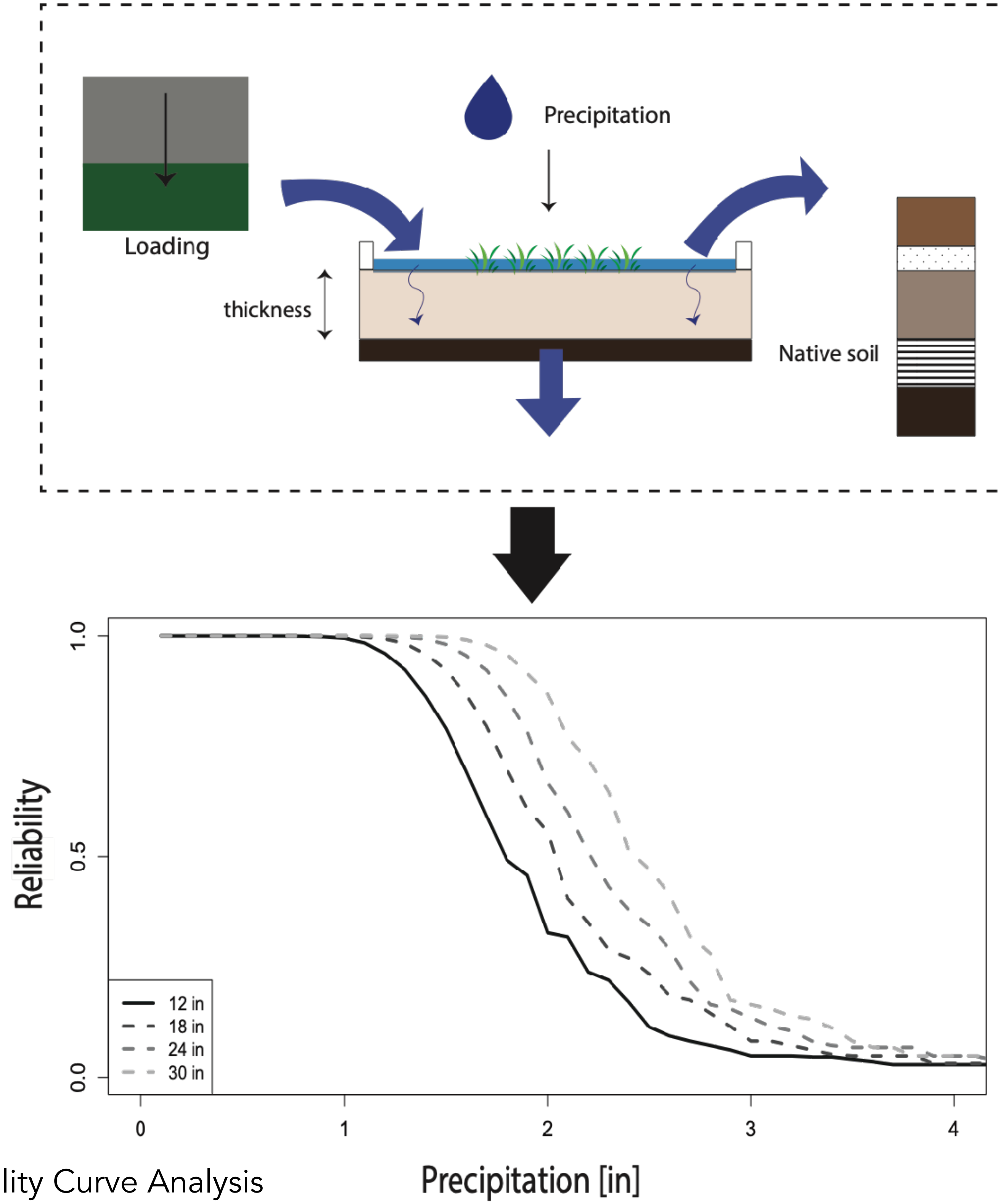

Variability and Fragility Curve Analysis

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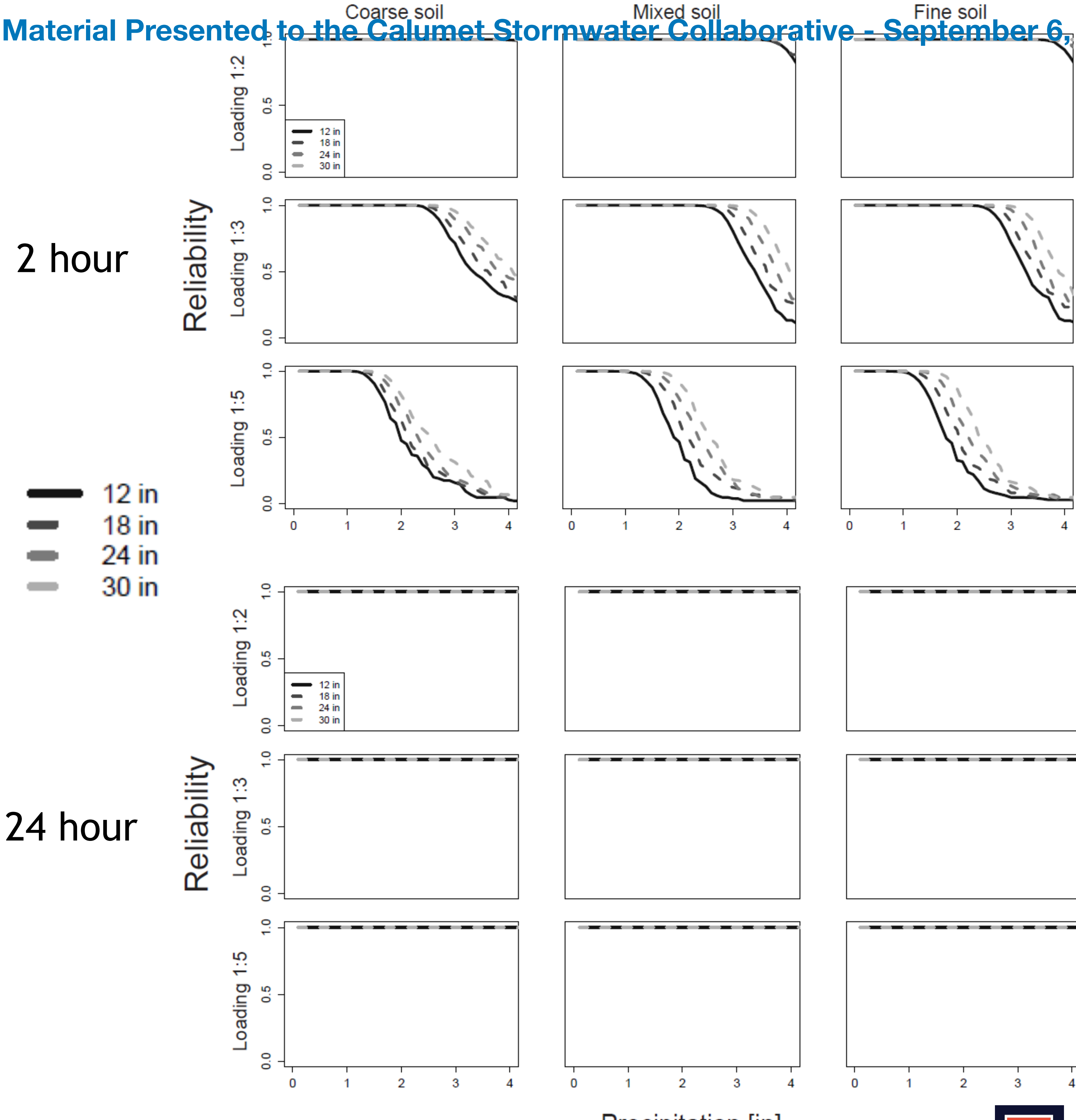
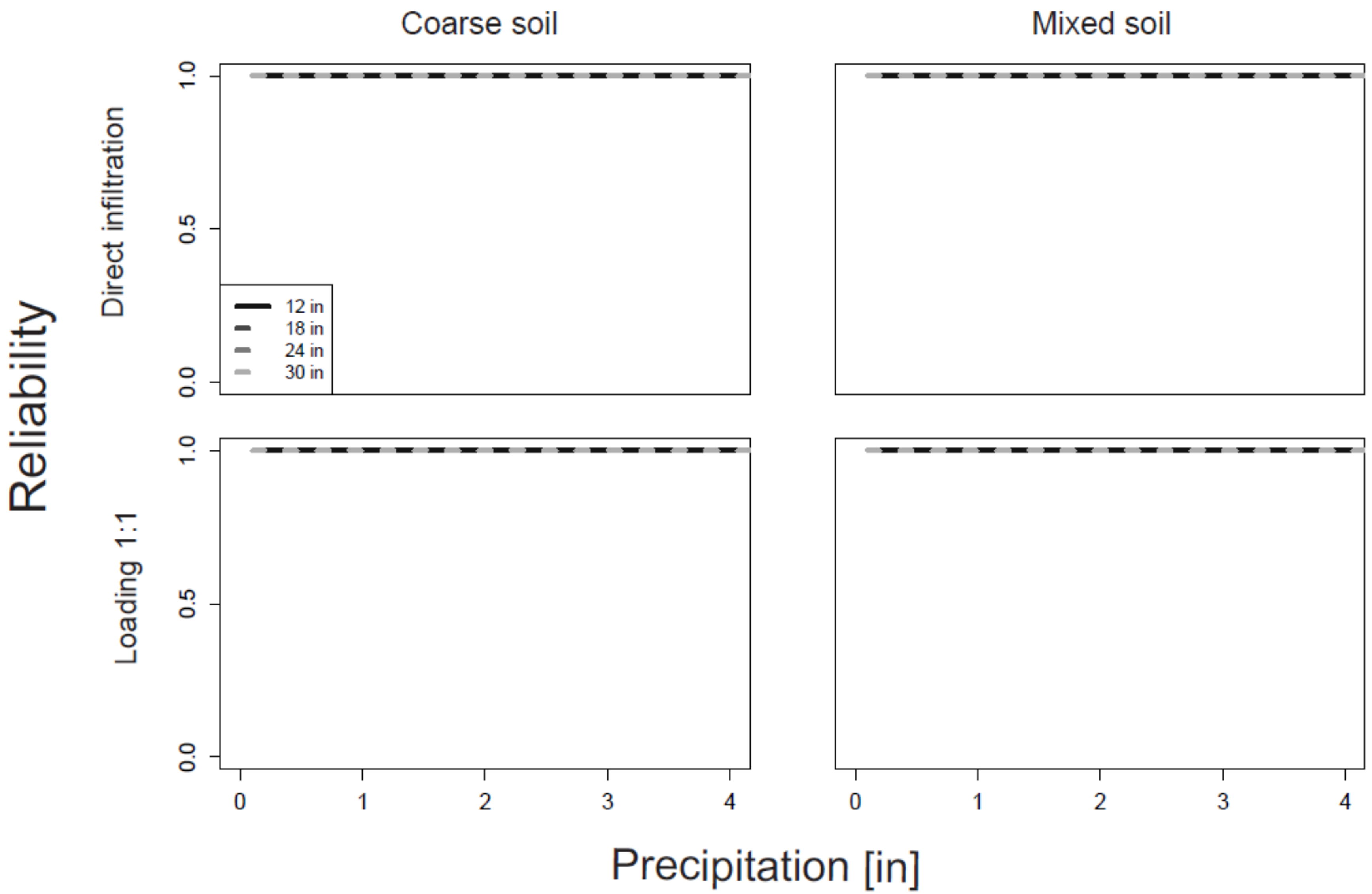
Planted



- Rain garden **performance variability** can be quantified.
- Rain gardens can effectively reduce runoff **even with fine native soils.**
- Rain gardens can effectively reduce runoff (~80% runoff reduction) **even with clayey native soils.**
- **Media thickness** is most important for mixed and fine native soils.
- **Loading ratio** is the most important design consideration for improved reliability

Paved



- To prevent clogging, a loading of **no greater than 1:2** is recommended.
- Because of the low loading, **permeable pavement is highly effective** over a wider range of storms.
- **Coarse and mixed soils** do not require an underdrain.

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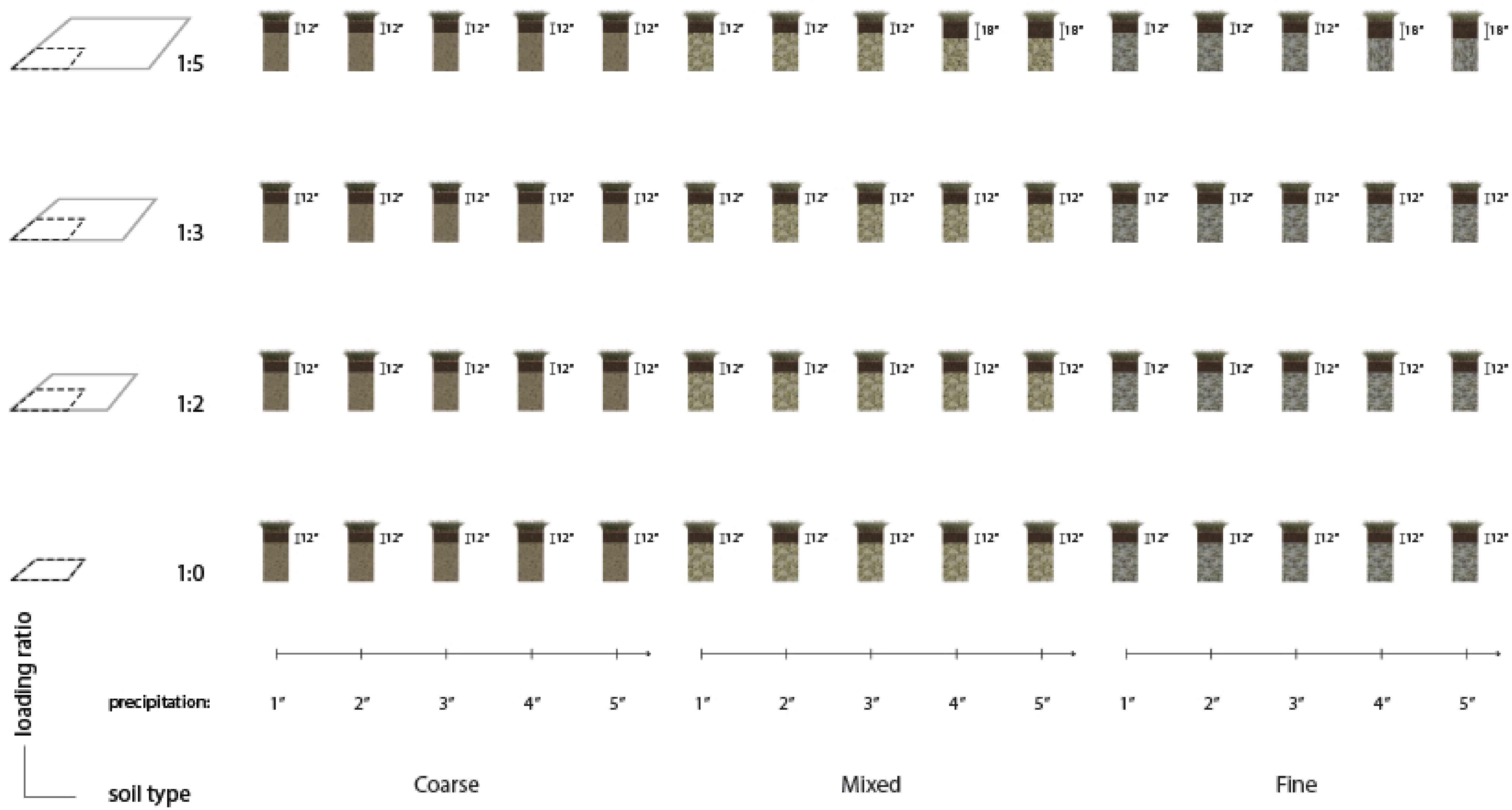
Design Prototypes - sections for planted surface (80% peak reduction standard / 24-hour duration)



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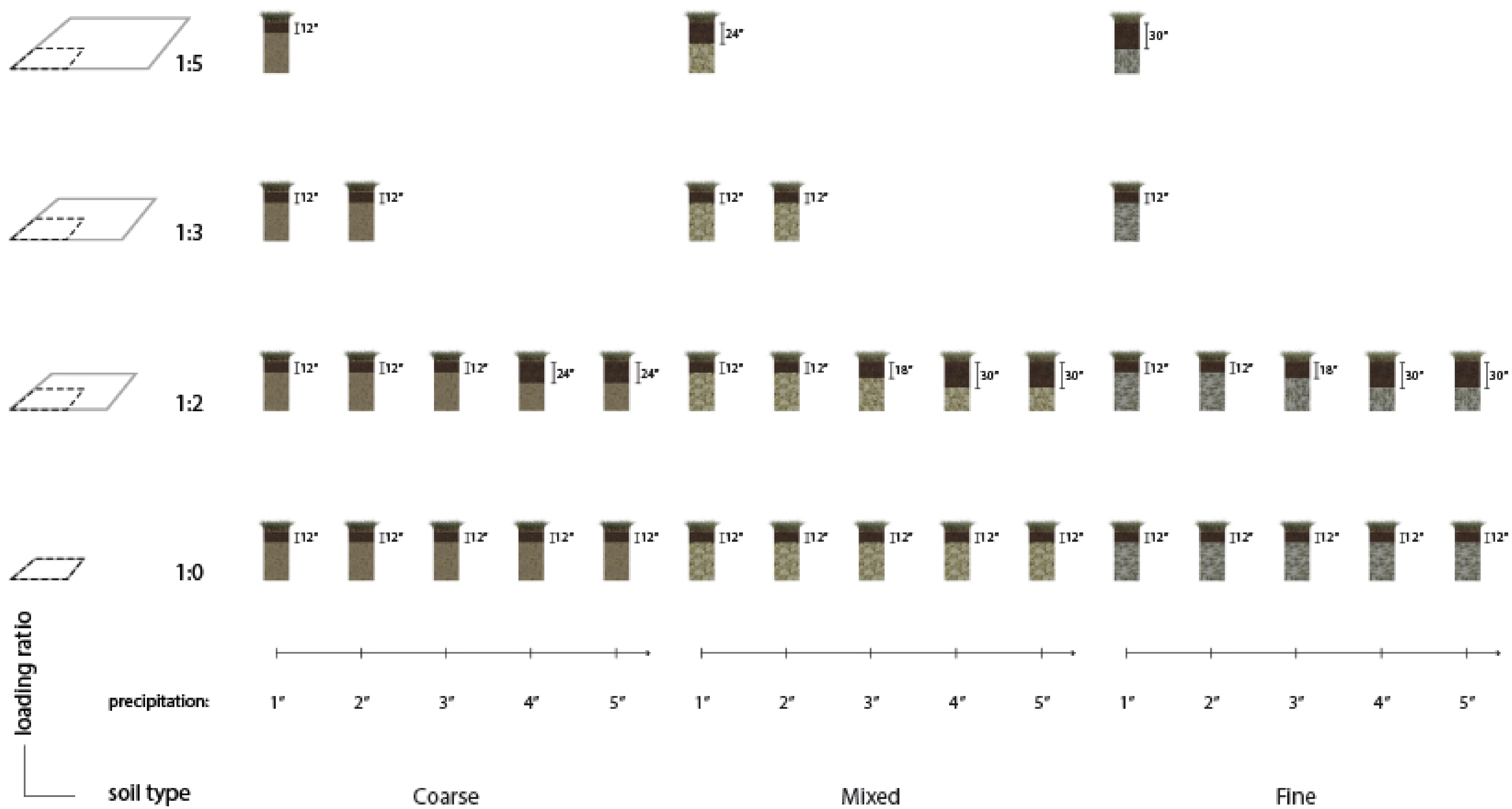
Design Prototypes - sections for planted surface (80% peak reduction standard / 2-hour duration)



- **Loading ratio (ratio of green infrastructure surface area to directly connected impervious surface area) is an important design consideration for increasing reliability of green infrastructure runoff reduction.**

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Village of Midlothian, IL: Green infrastructure design framework

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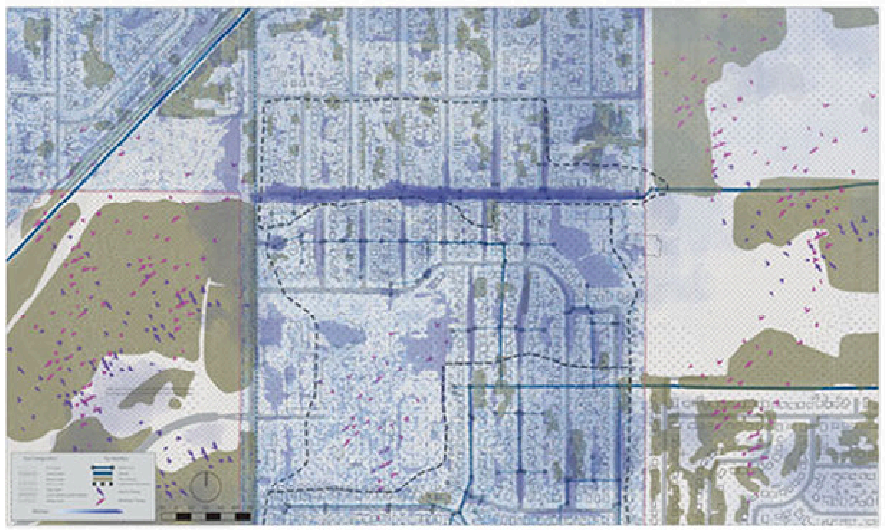
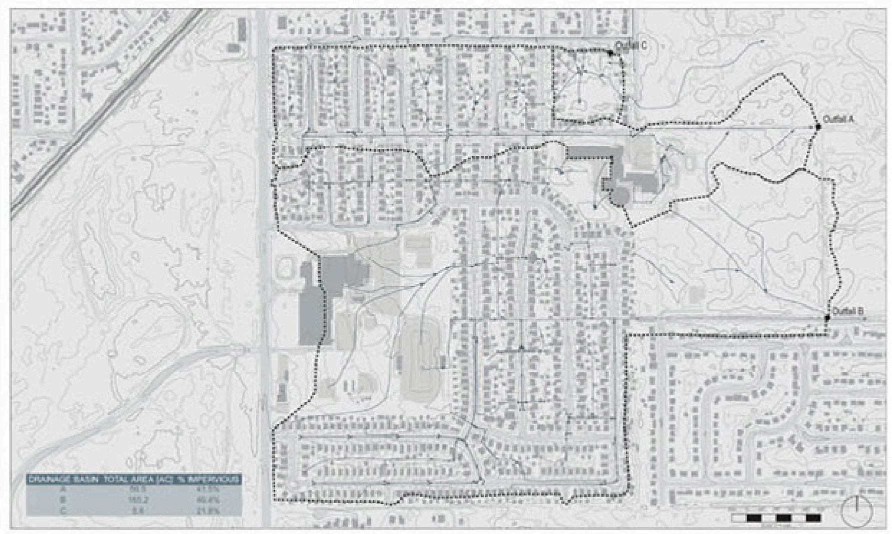
Village of Midlothian, IL: site observation and analysis

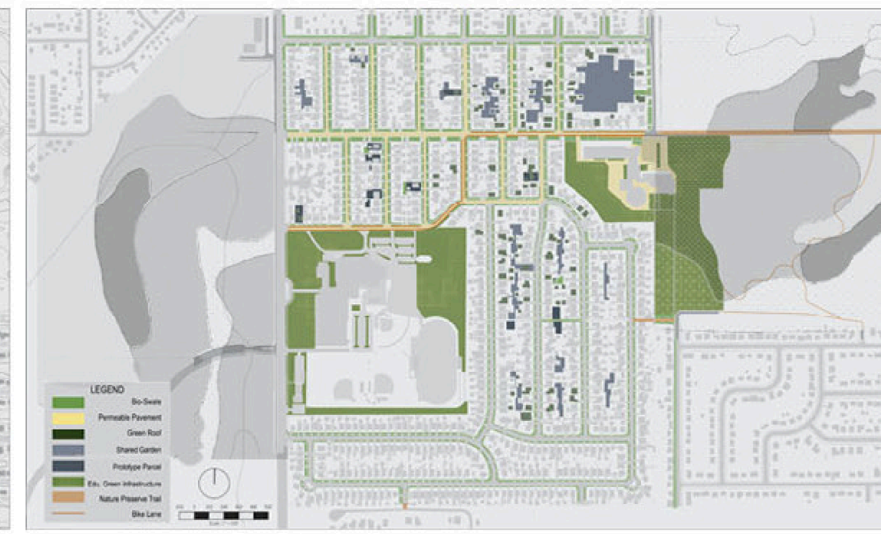
The wetness pattern highlights the 151 street as a key area of flooding.



The catchment supports the study area as a unit for green infrastructure



The native soil pattern is seemingly cut-off by the urban fabric. Our intervention rebuilds that connection.



The ice in lawn surface depression pond.

The messy boundary between a nature preserve and the school yard.

The fenced nature preserve area.

The backup sweer stream.

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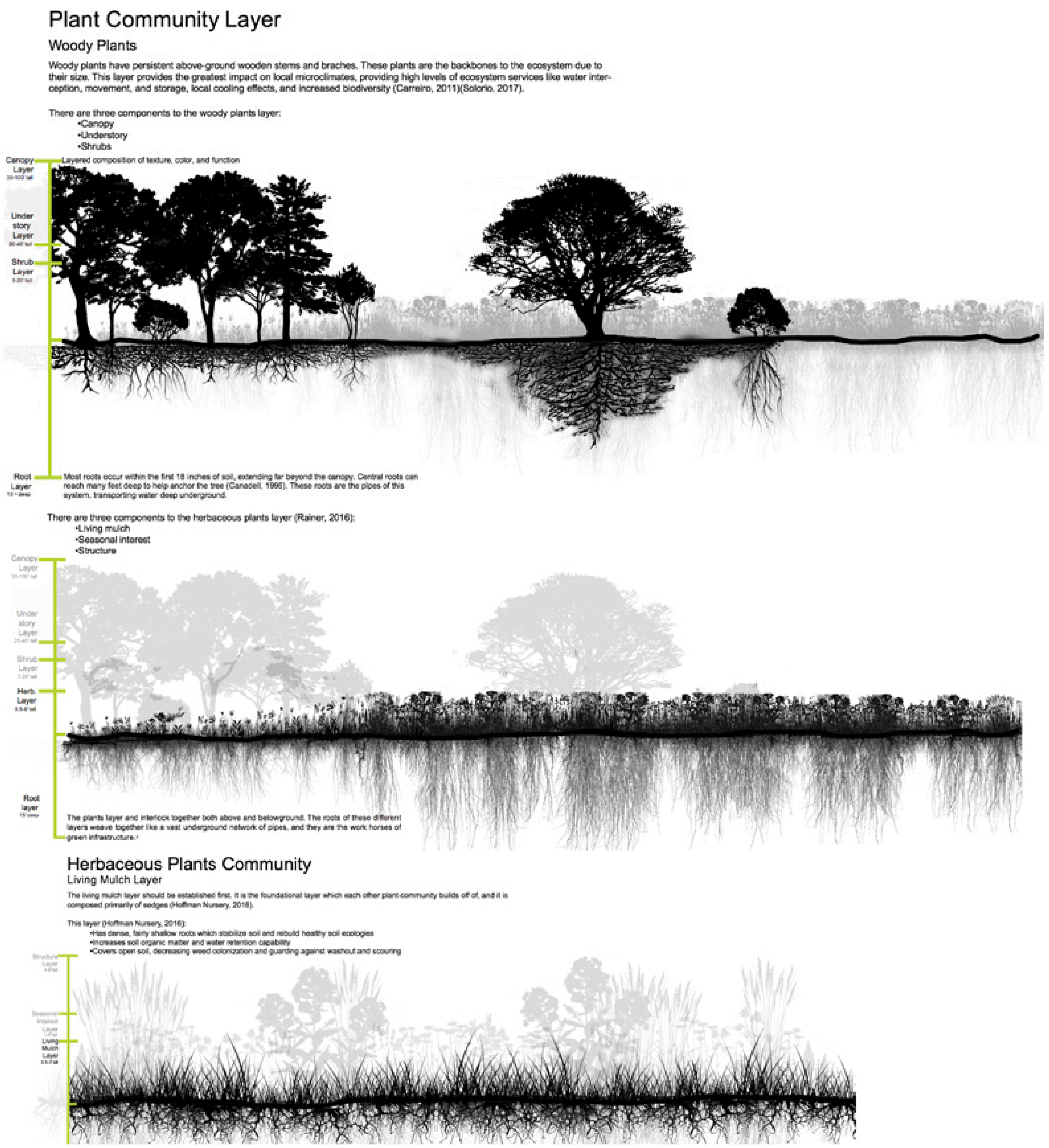
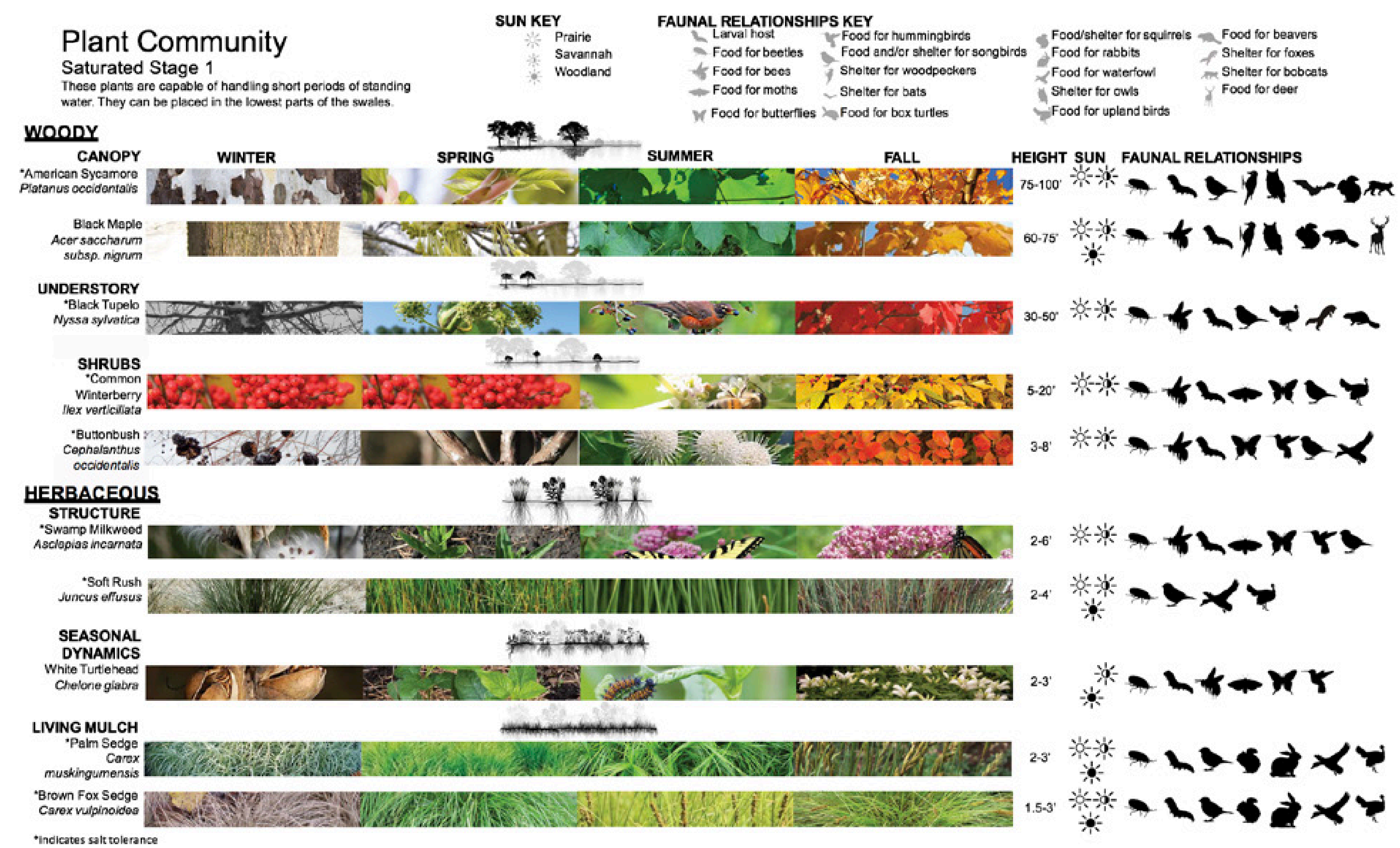
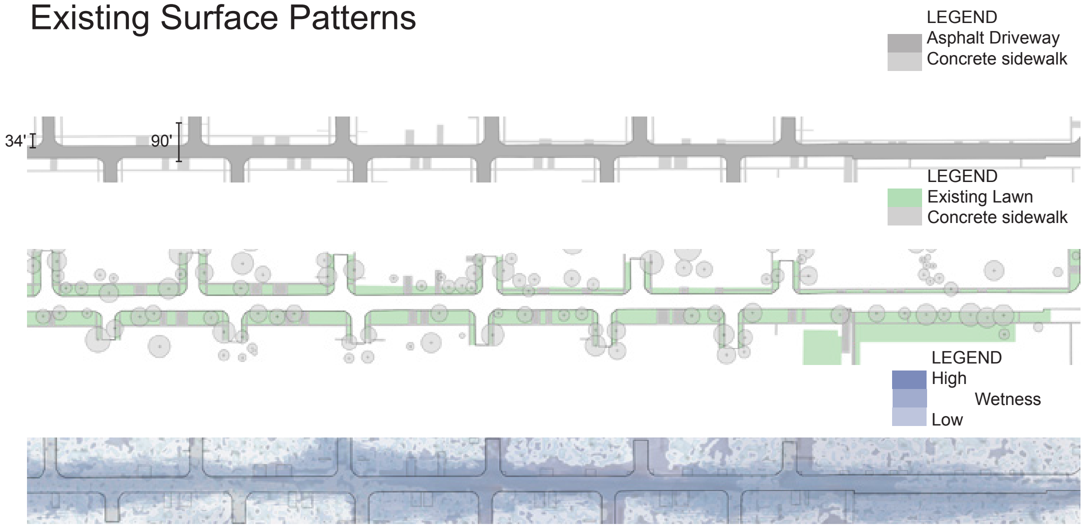
Calumet Corridor: plants research



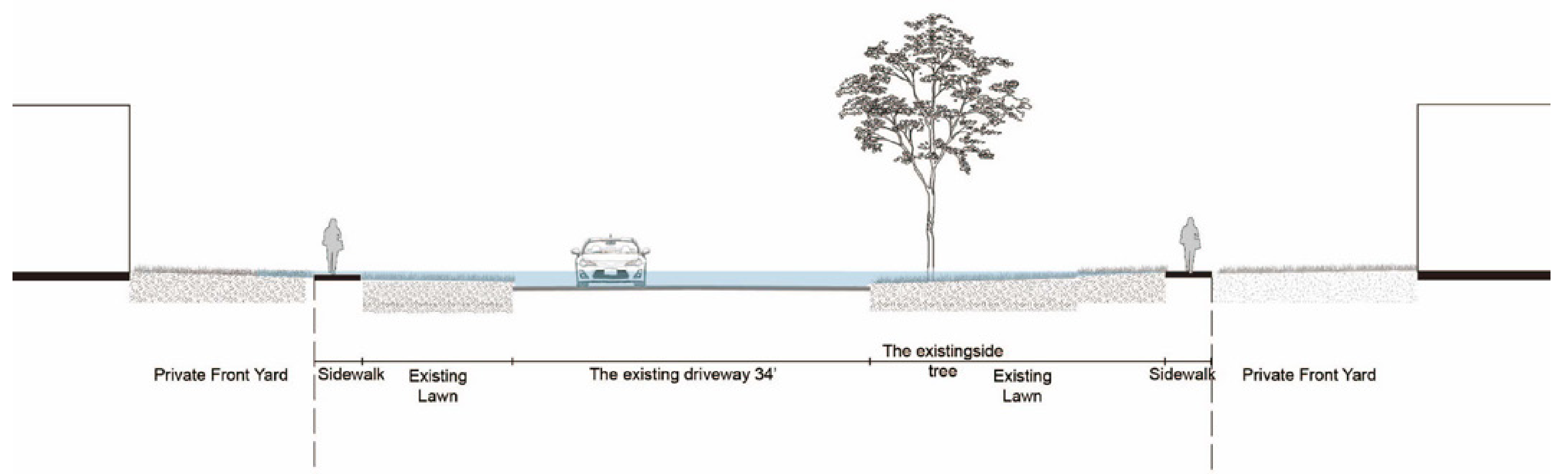


Village of Midlothian, IL: designing the ground for healthy rainwater

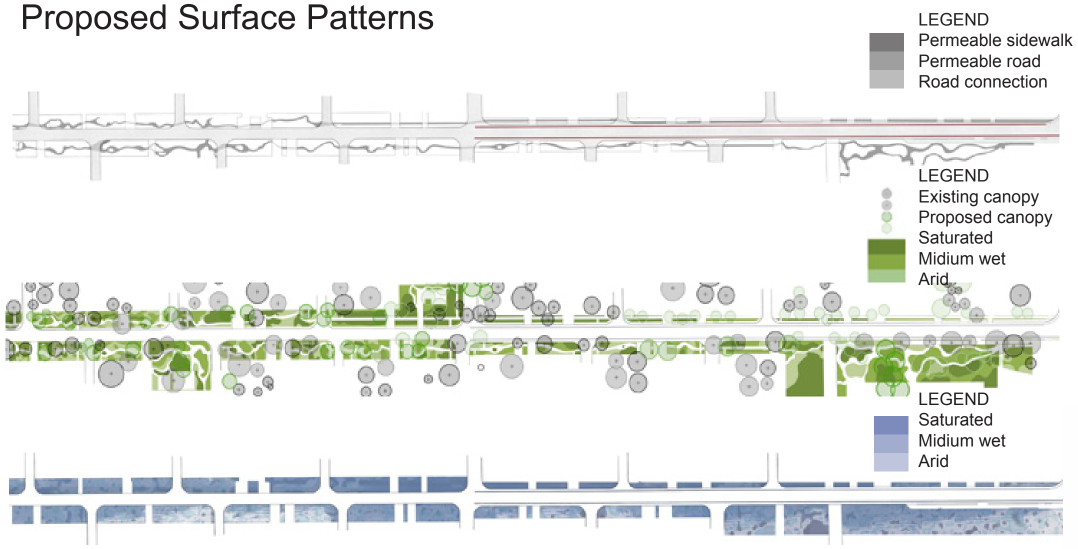
Existing Surface Patterns



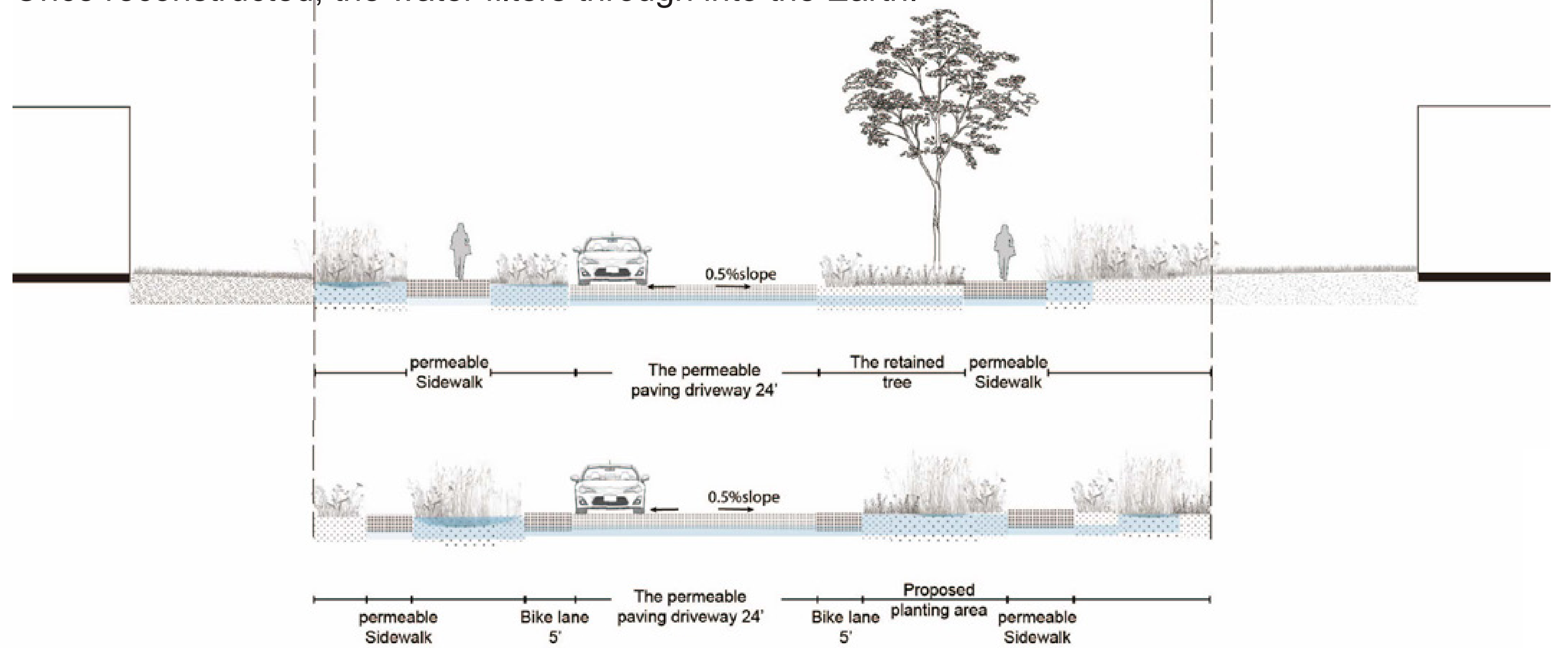
Rain water currently sits above the ground.



Proposed Surface Patterns



Once reconstructed, the water filters through into the Earth.



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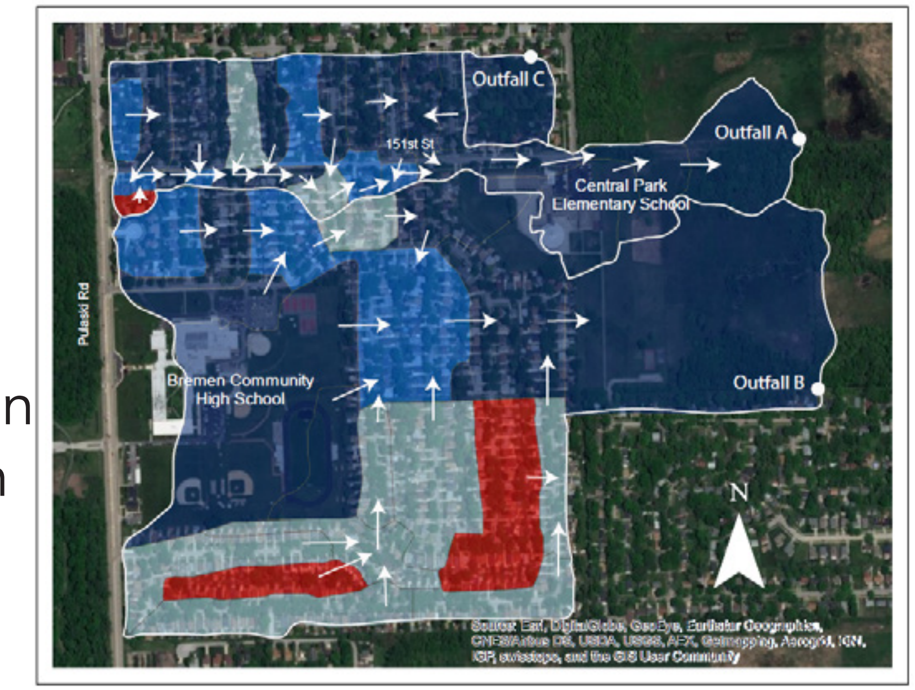
Village of Midlothian, IL : results for Jolly Homes

Maximum storm with 100% reliable reduction

- Minimal reduction
- 2.0 inch
- 3.5 inch
- 5.0 inch

5.0 inches
80% Reduction
24-hour storm



Maximum storm with 100% reliable reduction

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- 2.0 inch
- 3.5 inch
- 5.0 inch

1.9 inches
80% Reduction
2-hour storm

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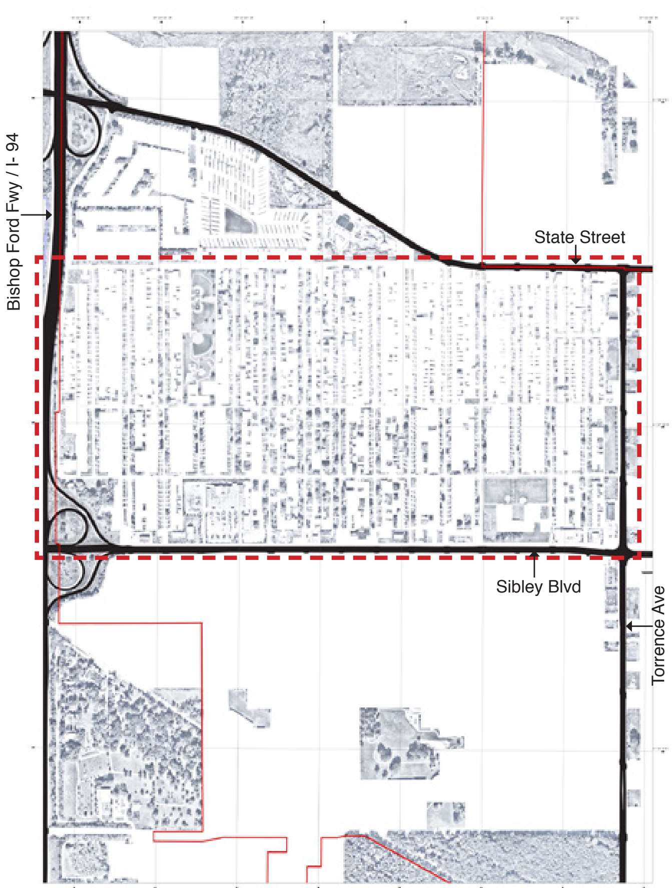
Calumet City, IL: Green infrastructure design framework

Illinois-Indiana Sea Grant Program (NOAA) 2018-2020, #NA18OAR170082

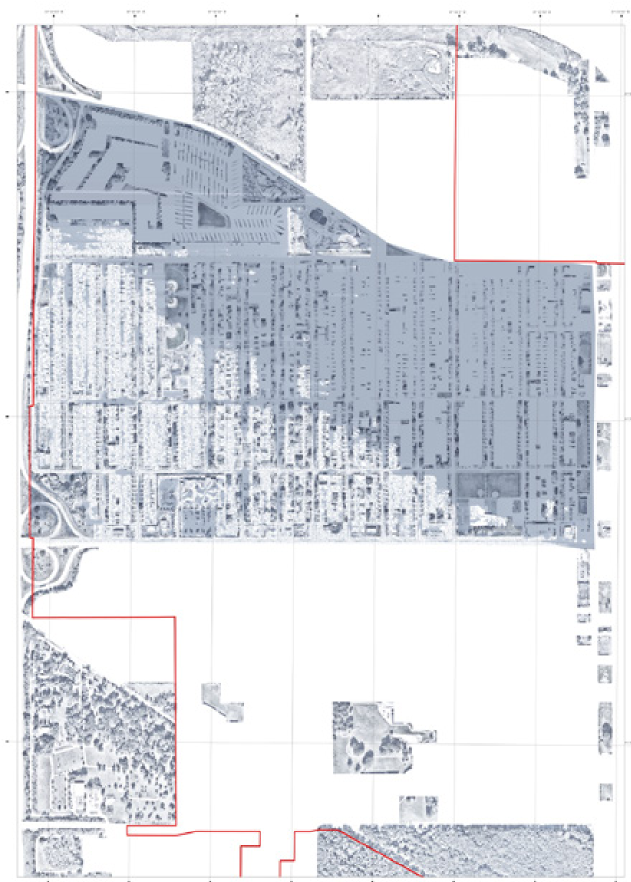
Calumet City, IL: site observation and analysis

Site Location



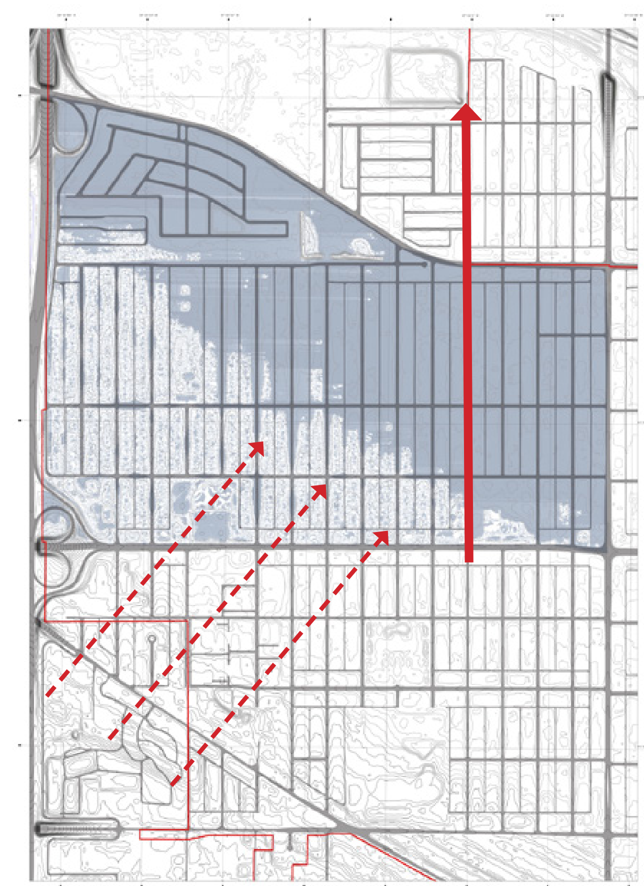
Calumet City Neighborhood Project Area (~250 acres)

Flooding Pattern



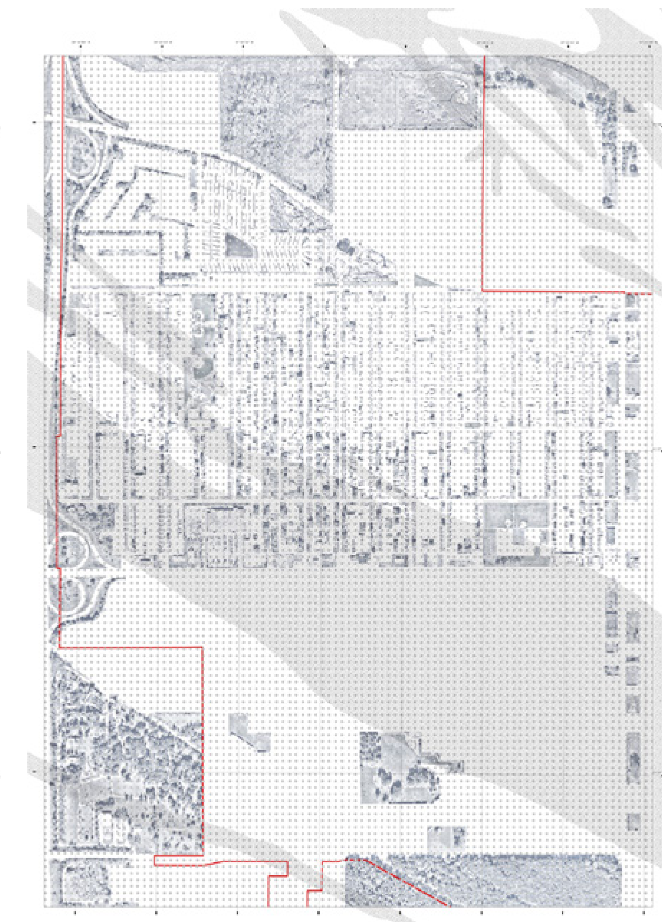
Flooding Pattern
Source: CMAP Chicago Metropolitan Area for Planning

Two Primary Causes of Flooding



Bottleneck in the gray infrastructure system
General Topographic Trend from Beach Ridge

Soil Data



Qb, Beach Deposit
Source: U.S. Geological Survey, J Harlen Bretz, 1930's

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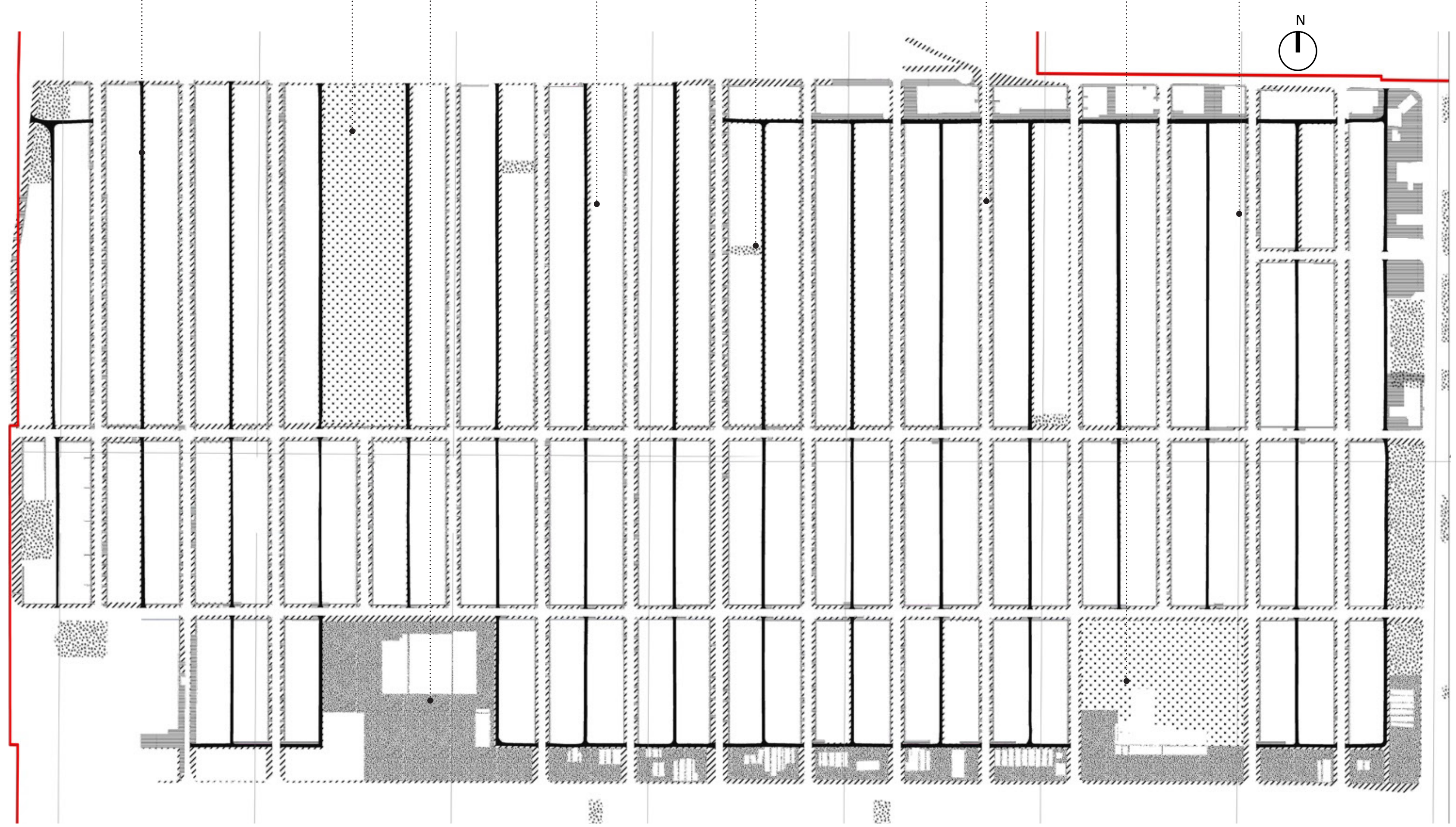
Calumet City, IL: inventory of surfaces for redesign

Surface Type Surface condition	Alley Impermeable surface and varying topography	Community Park Compacted ground, low quality vegetation	Parking Lot Large Areas of impervious pavement	Frontyard Compacted ground, low quality vegetation	Backyard Missing or overgrown vegetation	Wet Street Areas most prone to flooding because of its low topography	Elementary Schoolyard Compacted ground, low quality vegetation	Sidewalk Impermeable and featureless surface



Neighborhood Area 410.97 acres
Impermeable Surface **149.14 acres, 36.3%**

- Alley 10.4 acres, 2.5%
- Sidewalk 58.89 acres, 14.3%
- Street 61.6 acres, 15%
- Vacant Land 7.7 acres, 1.9%
- Parking 18.25 acres, 4.4%

Opportunity Surface **273.83 acres, 51.6%**

- Alley 10.4 acres, 2.5%
- Vacant Land 7.7 acres, 1.9%
- Parking 18.25 acres, 4.4%
- Park 18 acres, 4.4%
- Sidewalk 58.89 acres, 14.3%

Impervious Asphalt Ground

Can we transform neighborhood streets for better rainwater collection and infiltration?

Neighborhood and its Residents

Can we create spaces in the neighborhood that provide rainwater management and socially beneficial spaces?

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Calumet City, IL: linking GI to the regional soil ecology

Soil Fieldwork in the Calumet

Dune-Swale

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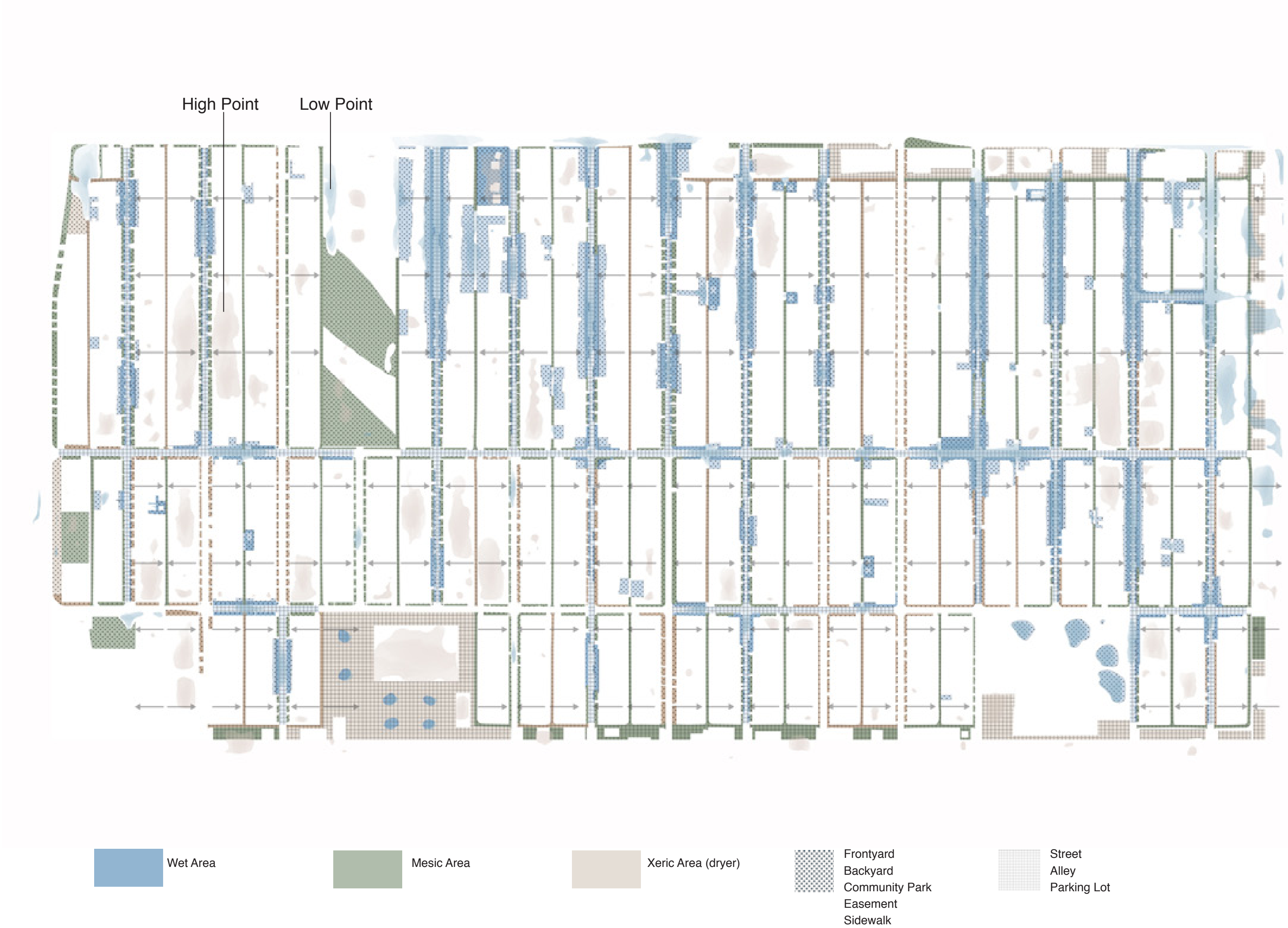
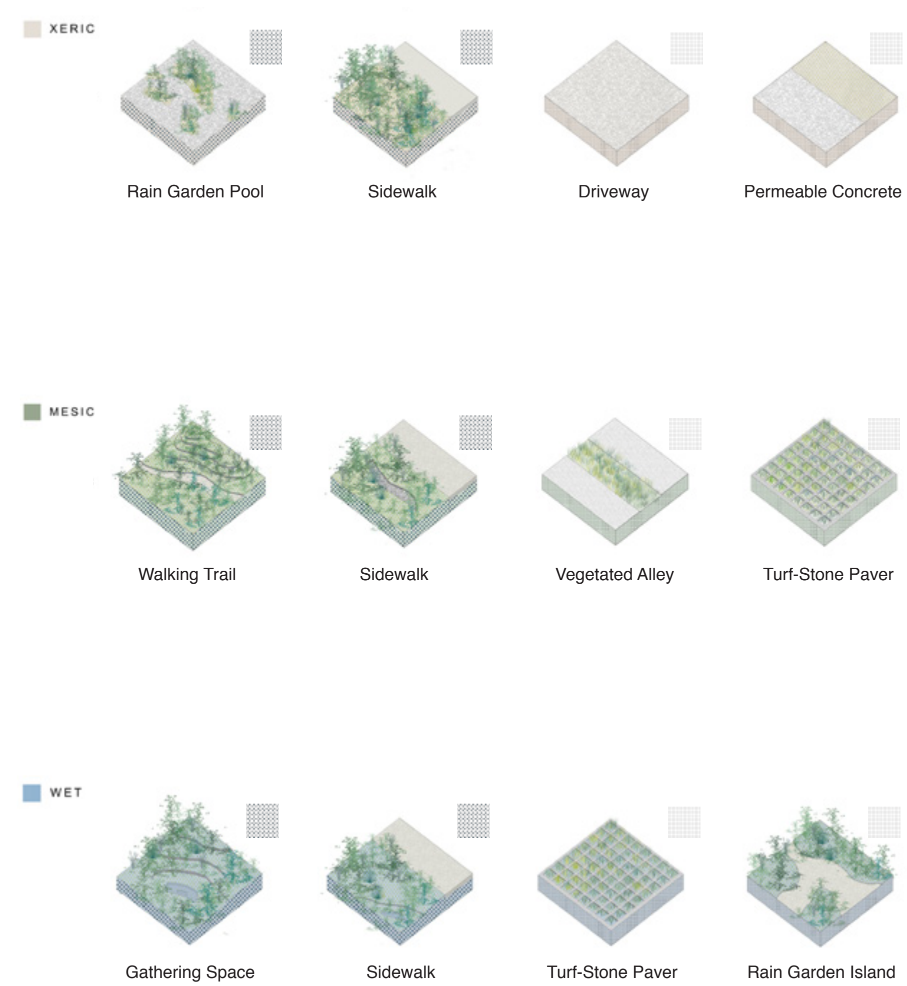
Calumet City, IL: collection of strategies





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Calumet City, IL: wet street example

Wet Street a precedent for other "new swale streets"

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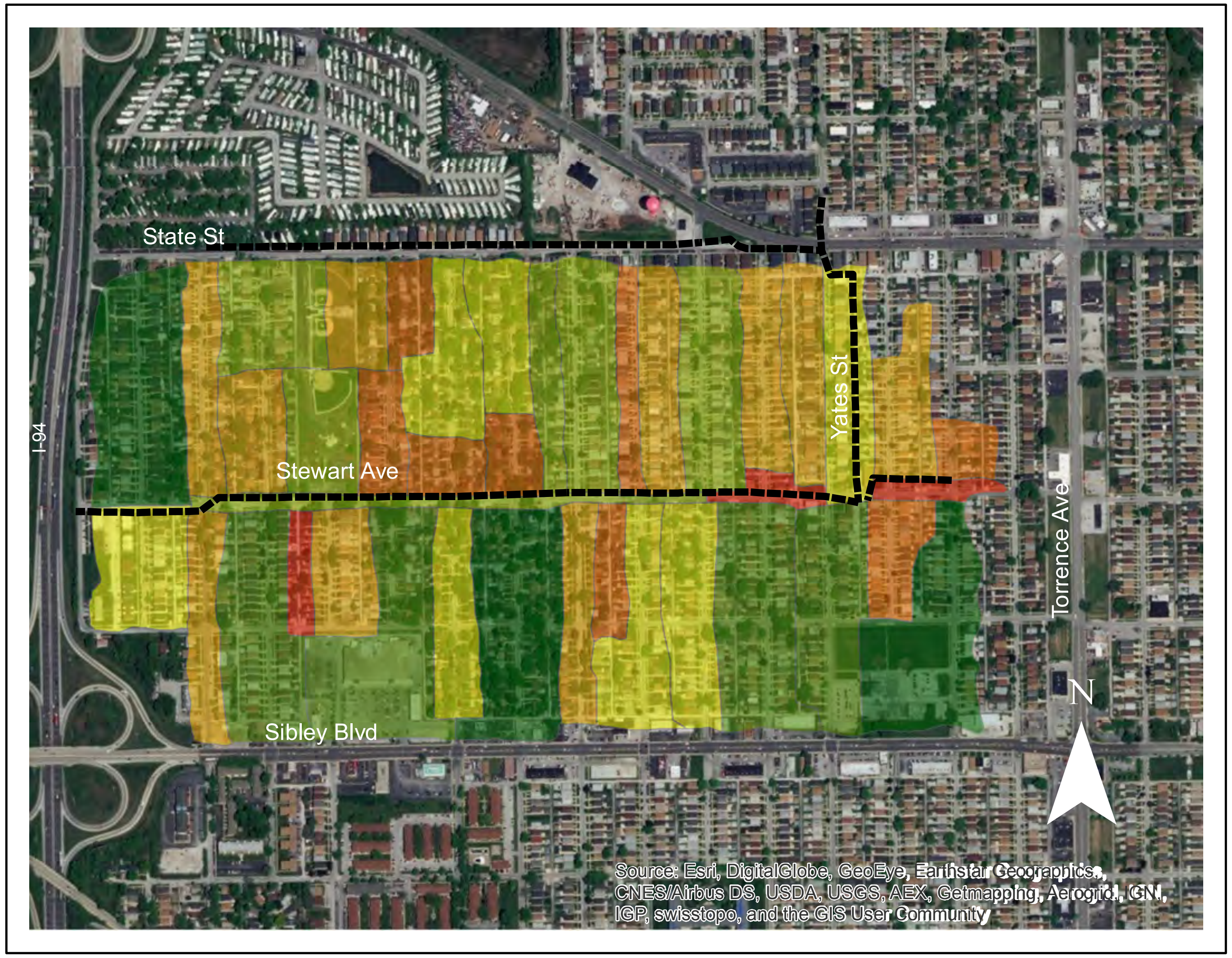
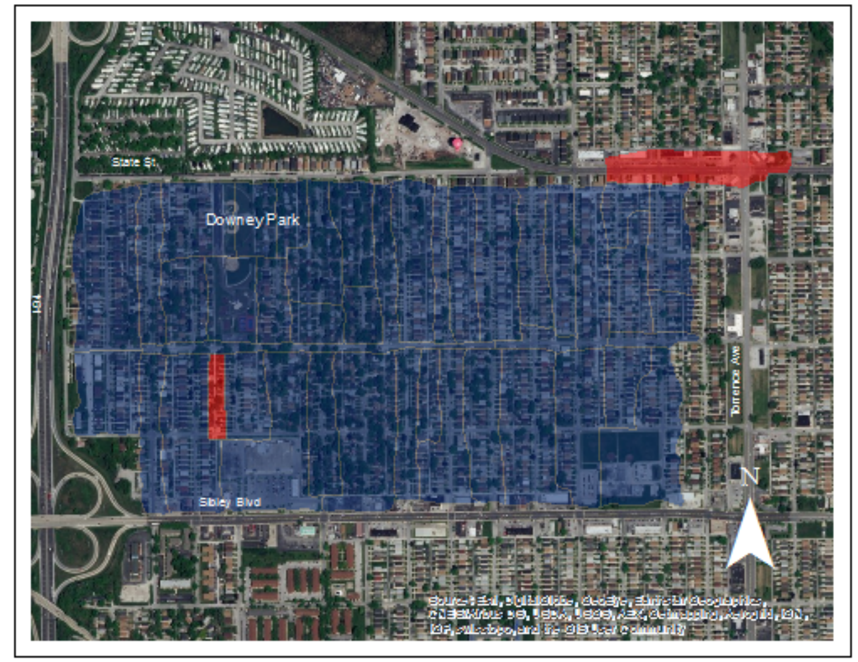
Calumet City, IL : stormwater volume reduction results





Maximum storm with 100% reliable reduction

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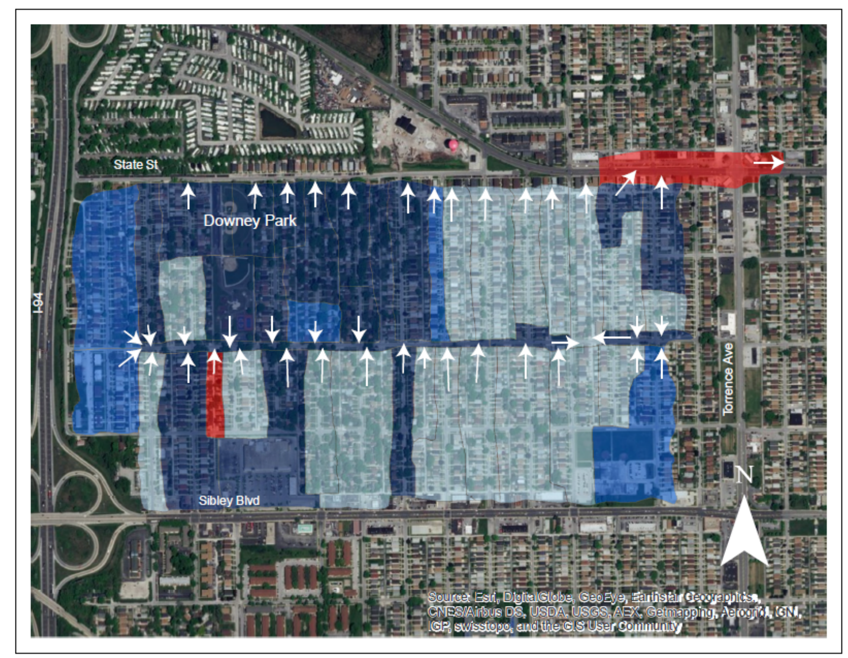
- 2.0 inch
- 3.5 inch
- 5.0 inch

5.0 inches
80% Reduction
24-hour storm



Maximum storm with 100% reliable reduction

- Minimal reduction
- 2.0 inch
- 3.5 inch
- 5.0 inch

2.0 inches
80% Reduction
2-hour storm

Gallons of water removed with GI for 2-inch, 2-hour storm

Water prevented from entering sewer system

- 0- 50,000
- 50,000 - 100,000
- 100,000-150,000
- 150,000-200,000
- 200,000-250,000
- 250,000-300,000
- 300,000-400,000

0 0.05 0.1 0.2 0.3 0.4 Miles

The dashed line represents the existing combined/ seperated storm sewer system, as infered from the Calumet City sewer atlas.

The total amount of water removed using GI from each of the sewers in the network is as follows:

Stewart: 3,350,000 gallons
State: 1,720,000 gallons
Yates: 1,430,000 gallons

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Map created by Reshmina William, PhD
June 18th 2019

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Current Phase

Calumet soils design: steps and status

Soils research	Design Engineering	Proof of concept Pilots	Process guide
1) Update publically-available data 2) Site-specific soils properties in pilot communities *Status: Complete, some work ongoing*	Model soils performance under differing rainfall volumes and GI types *Status: Complete*	Optimal green infrastructure network *Status: Complete, some work ongoing*	Sharable process toolkit to incorporate soils into GI planning ***Status: In progress***

← Outreach →

Sea Grant Program (NOAA) 2018-2019 # NA18OAR4170082 Hydrogeological soil research for green stormwater infrastructure planning and
ıods for adapting coastal communities

Q: we developed a process, but how should this be organized?

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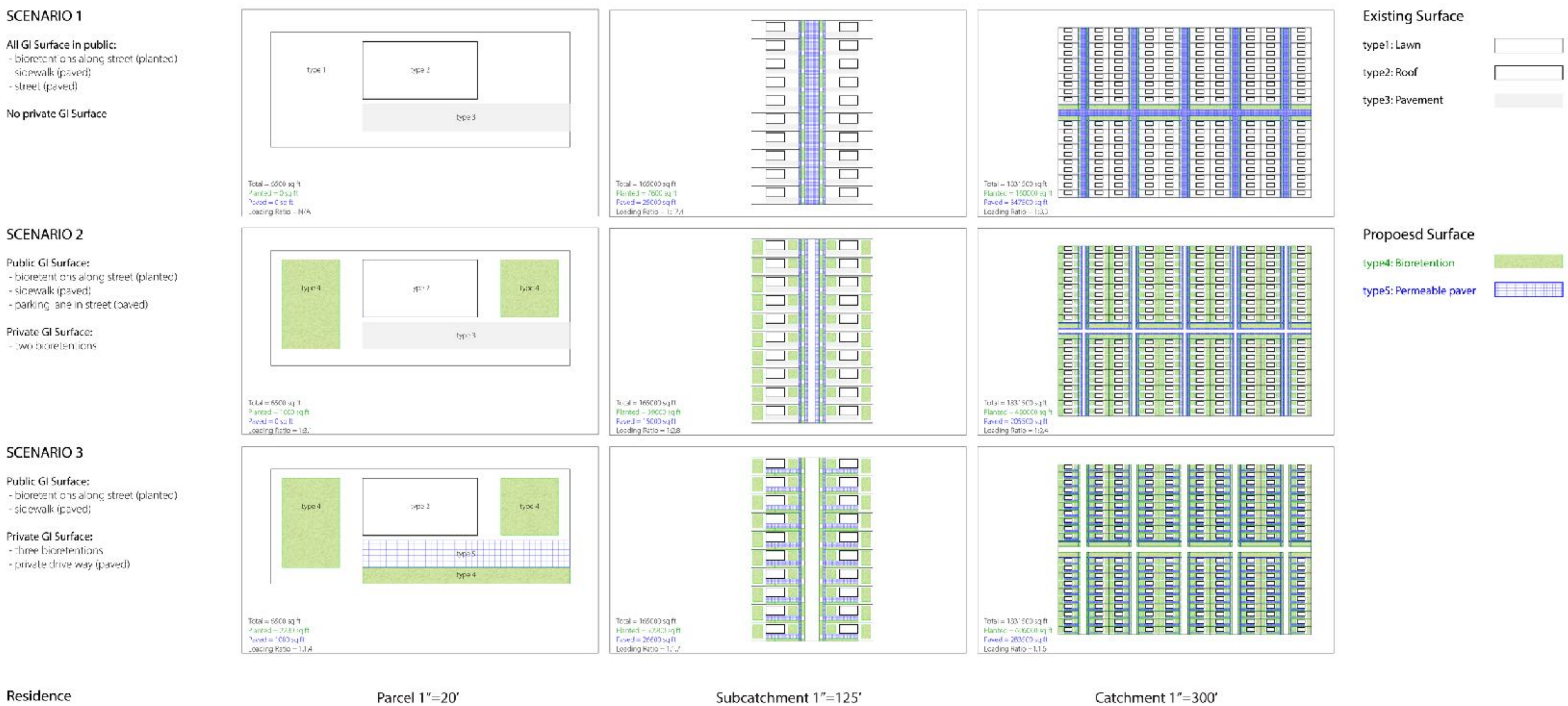
2019-2020

Decision Toolkit

STAGE	1 WILLINGNESS/SUPPORT	2 SITE ANALYSIS/SITE RESEARCH PROCESS	3 APPLY PROTOTYPE/MODEL	4 EVALUATION & VALUES ASSESSMENT	5 ADJUST/MODIFY	6 DECISION
	ESTABLISH COMMITMENT AND PROCESS: - capital planning - regional/municipal plan - leadership and staff - regional institutional support	**ESTABLISH GOALS + PRIORITIES** - Performative - Economic - Qualitative - social, aesthetic	**UNDERSTAND THE PROTOTYPES** - identify relevant charts/graphs/curves *(see diagrams)* - Review the variables (cakes + images) - Review performance data - compare against targets (Goals in #2)	**MEETING TARGETS**: (objective/subjective targets; measurable targets, + public process for evaluation essential in this stage)	**(RE)SET PRIORITIES, BASED ON OUTCOMES** (above) and the condition and realities/potentials of: - Support ($ and people - see #1) - Education and buy-in (engagement on the ground and in the public works staff) - Funding opportunities - Long-term care	**THE PLAN:** What we will build + where we will build it When we will build it - phasing? Develop a plan for funding Hiring consultants Constituency/buy-in process Other
		INVENTORY AND EVALUATE EXISTING CONDITIONS (histories of the site, disconnections - where) Identify Potential (re)new(ed) Relationships/Identify Areas and Issues of Priority + Opportunity	**APPLY THE LOGIC OF THE UNIT** *(see diagrams)* - At parcel scale (both public and private sites) - At sub-catchment scale (private (+public) ———> public) - At catchment scale (public ———> public)	**QUANTITATIVE VALUES (modeling)** - Run-Off reduction - Reduction in flooding (water in the wrong place to water in the right place) - Water quality improvement - Gray/green infrastructure design? - Cost evaluation - construction cost, and maintenance over time	**BIG OPPORTUNITY/HOPE** - Can see/vision the site through time - Make a long-term decision and investment - History of the site, determines its future - The design tells a story and creates a new setting for people	
		DATA/INPUTS Gather information (quantitative + qualitative) - Land-use - Surface (ground) conditions (land cover) - Flooding areas - Soil type - People, community organization and character - Gray infrastructure, network and condition Identify - Opportunities for social improvement, ecological connectivity, economic growth	**DEVELOP/EVALUATE SPATIAL DISTRIBUTION** - by loading ratios - by soils - by topography, flow path - by culture and care (maintenance)	**OTHER VALUES/BENEFITS** - Economic benefits - to the public, to private home/land/business owners - Ecological benefits - human health, biodiversity, other - Social benefits - human health, connectivity to each other and to nature, aesthetic		
		CORRELATION MAPPING - Mapping overlays (by various units of analysis) - Conduct interviews (reports of conditions and patterns) - Conduct site visits (ground truth observations)	**RECORD AND ACCOUNT FOR OPTIONS/ LIMITATIONS** (site specific) - soil texture - public land versus private land participation - stormwater ordinance and goals - severity and patterns of flooding - cost and budget - education of public/community; buy-in			
		VISUALIZATION/COMMUNICATION - Create maps and diagrams, photos and images - Look at relationships - Talk through patterns and opportunities - Build consensus about sites of interest				

Q: we have modeled data, but how should this be shared?

Parcel - Subcatchment - Catchment Diagram



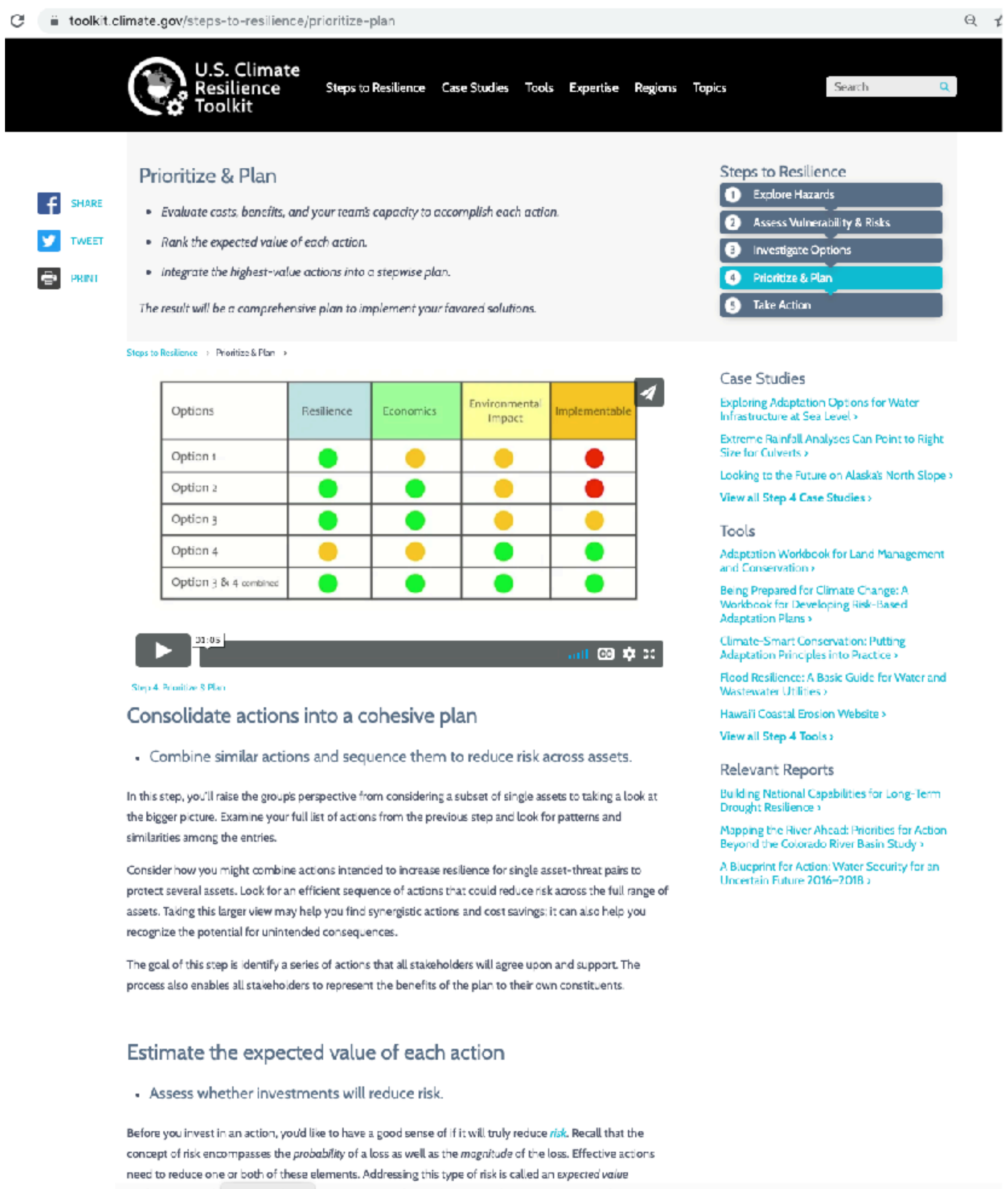
All values in this table are based on calculations assuming a 30 inch deep rain garden layout, and a mixed soil profile for a 2 hour duration storm.

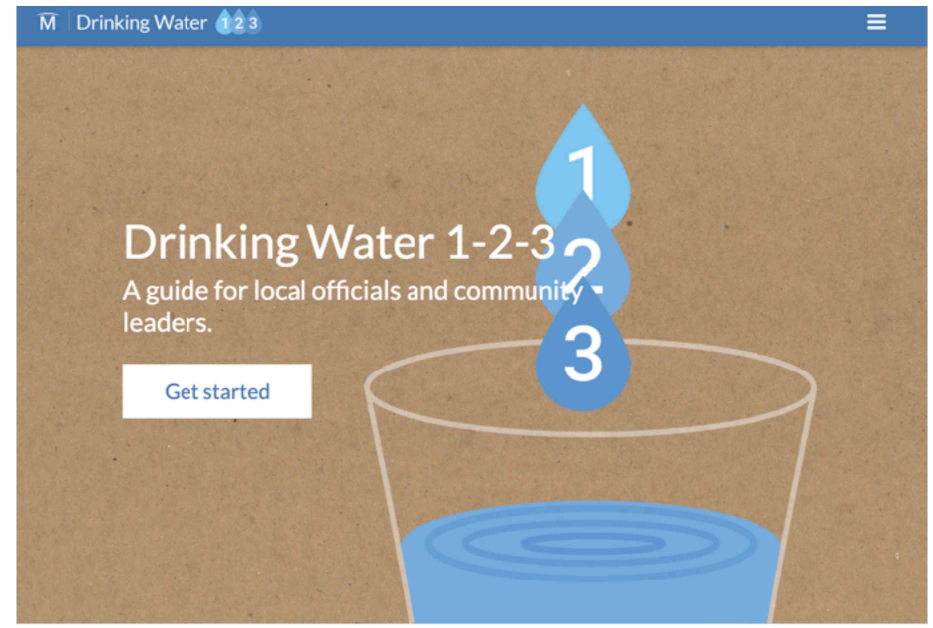
	Parcel	Subcatchment	Catchment
1	N/A	N/A[1]	N/A[2]
2	3.5 inch	3.6 inch	3.7 inch
3	5 inch	5 inch	5 inch

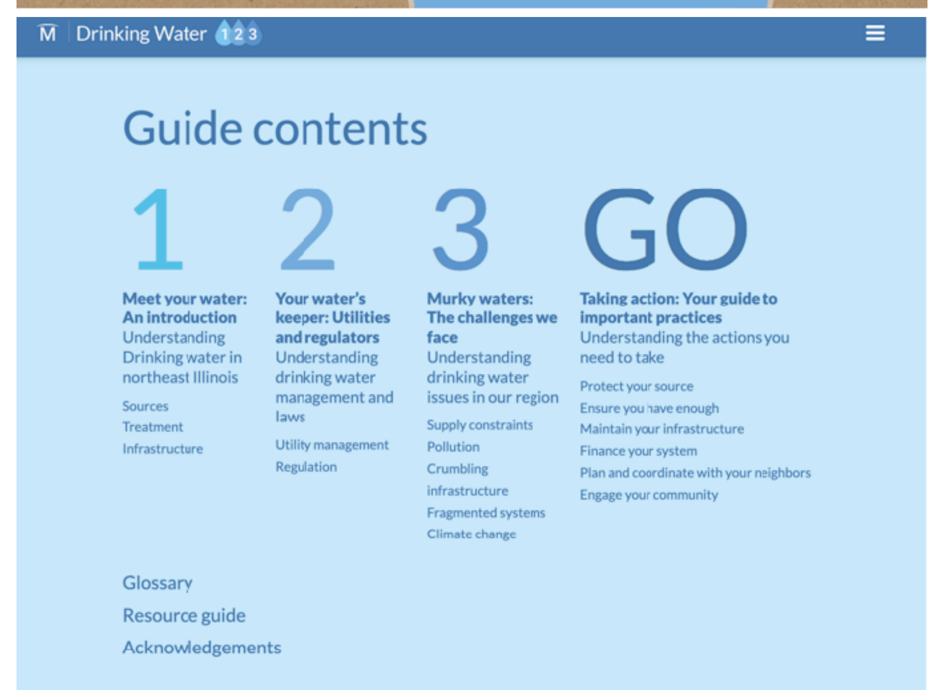
[1]Routing excessive amounts of water to permeable pavement installations, especially across permeable (lawn) surfaces is not encouraged, since the excessive loading ratio means that the system will clog much more quickly than desired. We recommend that these paved areas be maintained as direct infiltration of stormwater rather than upstream runoff.

[2]At this loading ratio, a planted intervention would be able to deal with a 1.5 inch storm. See note [1] regarding paved interventions.

Examples of interactive toolkits







Questions we have for you:

What information from this research is most useful for you at this point?

In what form is it most useful to receive this information?

What municipalities have interest in continuing soil studies (Kristine/NRCS)?

(Please fill out the handout - thank you for your feedback!)

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