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Stormwater Management Essentials for Small Systems and Communities

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Presented by: Danish Kumar, University of Maryland Environmental Finance Center

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University of Maryland Environmental Finance Center

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- Educational resources & trainings, plus technical assistance around U.S.: efcnetwork.org
- For technical assistance email or call Danish Kumar dkumar18@umd.edu (301) 405-9945

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Agenda

- *Introduction to Stormwater Runoff and Urban Hydrology*
- *Climate Impacts on Stormwater*
- *Nutrients, Sediments & Stormwater Impacts*
- *Green Infrastructure Practices to Protect Infrastructure and Watersheds*
- *MS4 Permits*
- *Free EPA Online Tools on Green Infrastructure*
  - *Green Infrastructure Wizard (GIWiz)*
  - *National Stormwater Calculator (SWC)*
  - *Green Values® Stormwater Management Calculator*
  - *Green Asset Resource Database*

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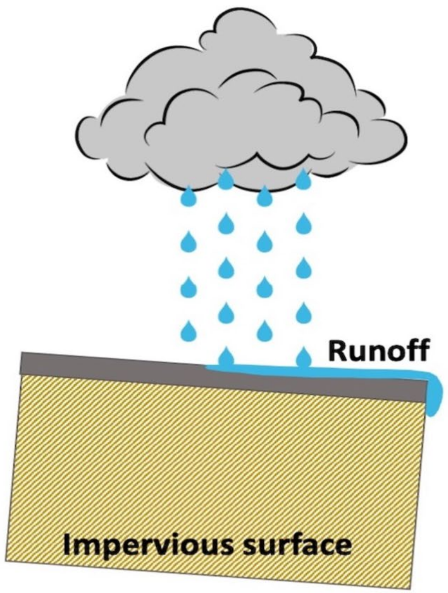
Poll*

- Who do you represent
  - Regulatory Agency
  - Wastewater system/Drinking water system
  - Municipal government
  - Academia
  - Consultant

Rainfall Runoff

Intro to Stormwater Runoff & Hydrology

Precipitation → Runoff → Conveyance → Receiving waters

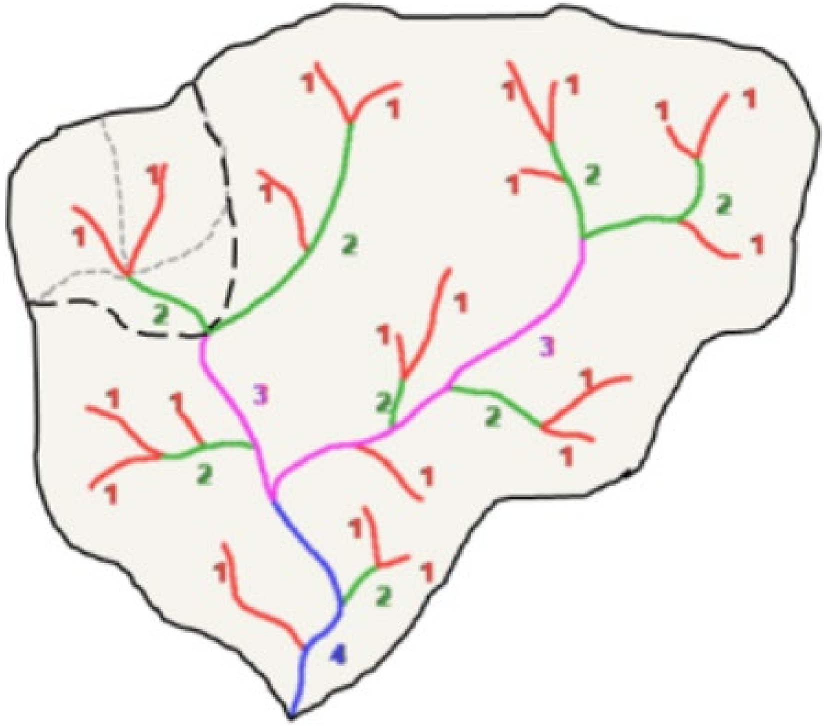


Infiltration

Watersheds

- **Watersheds** are areas of land that channel water to a specific river, lake, or ocean.

- **stream network** is comprised of multiple water bodies



Healthy Watershed Services

- Flood insurance
- Filter for clean drinking water
- Treatment of stormwater runoff
- Corridors for safe recreation and utilities
- Improved aquatic and terrestrial habitats for wildlife

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runoff coefficient

The **runoff coefficient** is the proportion of rainfall converted to runoff for different types of landcover and soil groups. It has a linear relationship with the watershed's impervious cover

$$RV = 0.05 + 0.009(I)$$

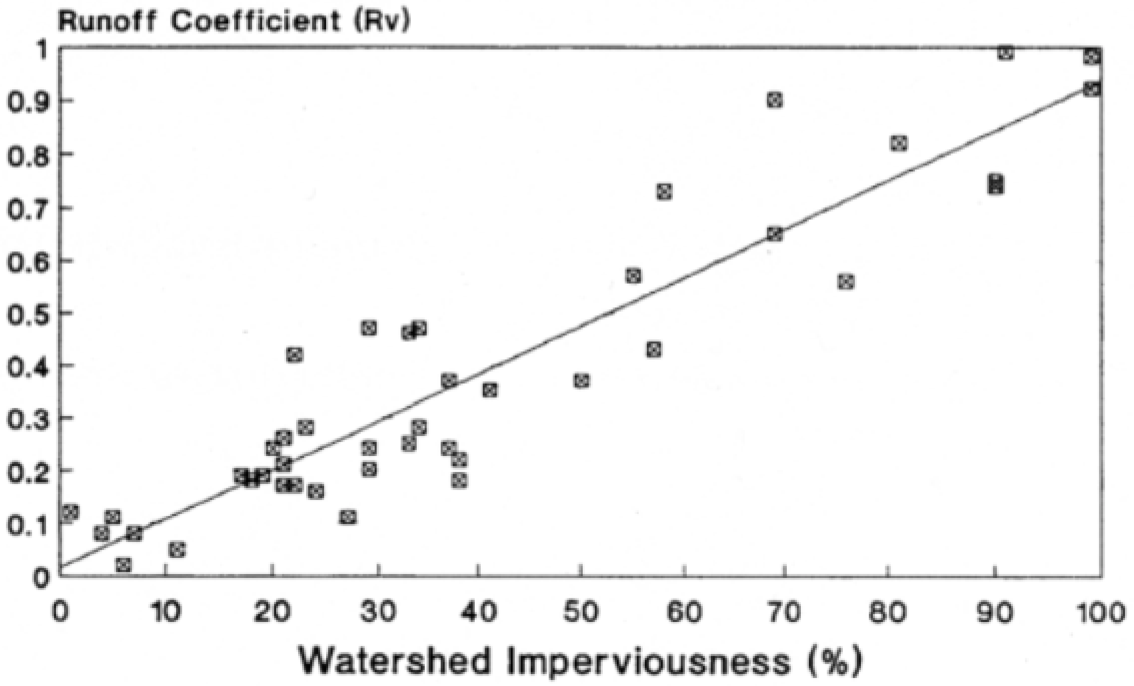

Figure 1: Relationship between Watershed Imperviousness and the Runoff Coefficient (Rv)
Source: Scheuler and Holland 2000a.

Where (I) is the watershed imperviousness percentage. This linear relationship means more pavement equals more runoff.

Runoff volumes and land use

Land Use	% Impervious Cover
Commercial and Business District	85–100
Industrial	70–80
High Density Residential	45–60
Medium Density Residential	35–45
Low Density Residential	20–40
Open Areas	0–10

Sources: MADEP, 1997; Kauffman and Brant, 2000; Arnold and Gibbons, 1996; Soil Conservation Service, 1975.

Calculating Runoff volume for 1 inch of rainfall for 10-acre area

Rv = 0.05 + 0.009 (%I)

$$Volume = P \times A \times R_v$$

- **Before Development (5% Impervious Cover)**

Rv = **0.05, or 5%** of rainfall in the catchment is converted to runoff

$Volume =$ (1/12”) (10 acres) (0.05) = 0.0416 acre-feet of runoff (≈ 13,577 gallons)

- **After Development (32% Impervious Cover))**

Rv = **0.32, or 32%** of rainfall in the catchment is converted to runoff

$Volume =$ (1/12”) (10 acres) (0.32) = 0.267 acre-feet of runoff (≈ 86,900 gallons)

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Runoff volumes and land use

Potential Maximum Retention (S):

$$S = \frac{1000}{CN} - 10$$

Runoff Depth (Q):

$$Q = \frac{(P - 0.2S)^2}{P + 0.8S}$$

Runoff curve numbers for urban areas

Cover description: Cover type and hydrologic condition	Average percent impervious area	Curve numbers for hydrologic soil group: A	B	C	D
Fully developed urban areas (vegetation established)					
Open space (lawns, parks, golf courses, cemeteries, etc.)[3/]:					
Poor condition (grass cover < 50%)		68	79	86	89
Fair condition (grass cover 50% to 75%)		49	69	79	84
Good condition (grass cover > 75%)		39	61	74	80
Impervious areas:					
Paved parking lots, roofs, driveways, etc. (excluding right-of-way)		98	98	98	98
Streets and roads:					
Paved; curbs and storm sewers (excluding right-of-way)		98	98	98	98
Paved; open ditches (including right-of-way)		83	89	92	93
Gravel (including right-of-way)		76	85	89	91
Dirt (including right-of-way)		72	82	87	89
Western desert urban areas:					
Natural desert landscaping (pervious areas only) [4/]		63	77	85	88
Artificial desert landscaping (impervious weed barrier, desert shrub with 1- to 2-inch sand or gravel mulch and basin borders)		96	96	96	96
Urban districts:					
Commercial and business	85	89	92	94	95
Industrial	72	81	88	91	93
Residential districts by average lot size:					
1/8 acre or less (town houses)	65	77	85	90	92
1/4 acre	38	61	75	83	87
1/3 acre	30	57	72	81	86
1/2 acre	25	54	70	80	85
1 acre	20	51	68	79	84
2 acres	12	46	65	77	82
Developing urban areas					
Newly graded areas (pervious areas only, no vegetation) [5/]		77	86	91	94

Land Cover Type	Curve Number (CN)	Retention (S)	Runoff Depth (Q)	Total Gallons
Open Green Space	61 (Soil Type B)	6.39"	0.08"	~21,700
Residential (1/4 acre)	75	3.33"	0.38"	~103,300
Paved Parking Lot	98	0.20"	1.77"	~480,500

- P= Precipitation (2 inches)
- Area= 10 Acres

USDA Natural Resources Conservation Service (NRCS) Curve Number (CN)

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Key Concepts

- **Detention:** This involves temporary storage used to attenuate peak discharges for short periods, typically ranging from 10 minutes to an hour. The primary goal is to prevent downstream bankfull flooding and reduce stream erosion by releasing water at a controlled rate.
- **Retention**: This refers to practices that keep stormwater on-site permanently, preventing it from becoming runoff. This is achieved through infiltration into the soil, evapotranspiration by plants, or harvesting (e.g., rain barrels or cisterns)

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Key Concepts

- **Peak flow:** (or peak discharge) refers to the highest rate of streamflow recorded during a specific storm event

  equation to estimate peak flow: $Q=CiA$

- **Flow Attenuation**: This is the process of using temporary storage to minimize or "flatten" these runoff peaks.

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Design Storms

A design storm is a simulated rainfall event based on historical data used for engineering and regulatory purposes.

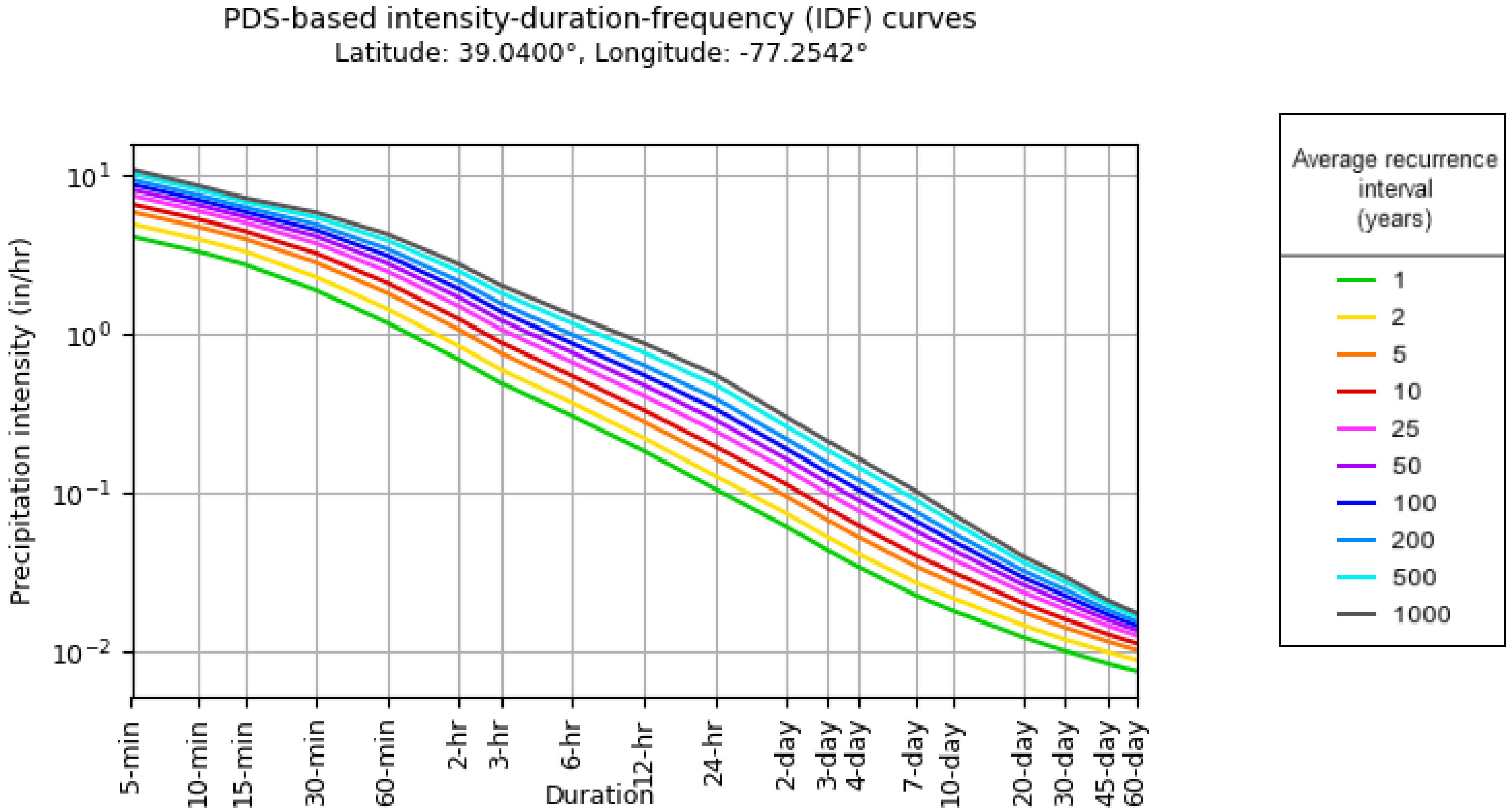
A design storm is defined by its duration (commonly 24 hours), its depth (the amount of rain in inches), and its return interval (frequency).

- A 100-year storm has a 1% chance of occurring in any given year.
- A 2-year storm has a 50% chance of occurring in any given year.

- A community might use the 1-year storm for water quality treatment but must design infrastructure to handle the 100-year storm to prevent extreme flooding.

IDF Curves

- Used to design stormwater infrastructure
- Relate rainfall intensity or depth · duration & return period
- Based on historica precipitation data



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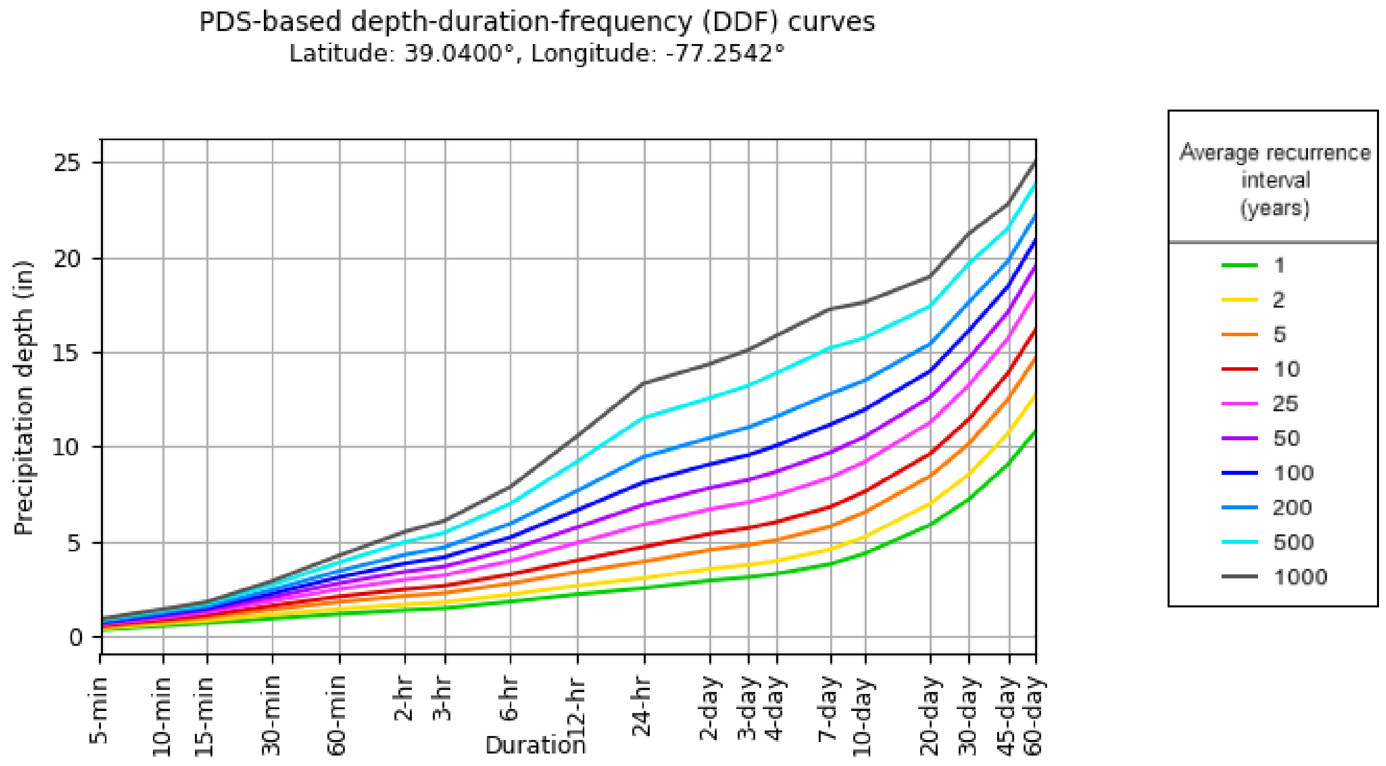
DDF Curves

- DDF Curves focus on total rainfall depth
- Useful for designing storage systems such as detention basins, retention ponds, and green infrastructure



How much precipitation would be expected for a storm event that is 10 days in duration and has a 1% chance of being observed?

Climate Change & Stormwater Impacts

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Poll*

- How would you describe the change in rainfall patterns affecting your infrastructure over the last 10 years?
  - More frequent intense "flash" storms
  - Higher total seasonal volumes
  - No significant change noticed
  - Decreased rainfall / Drought periods

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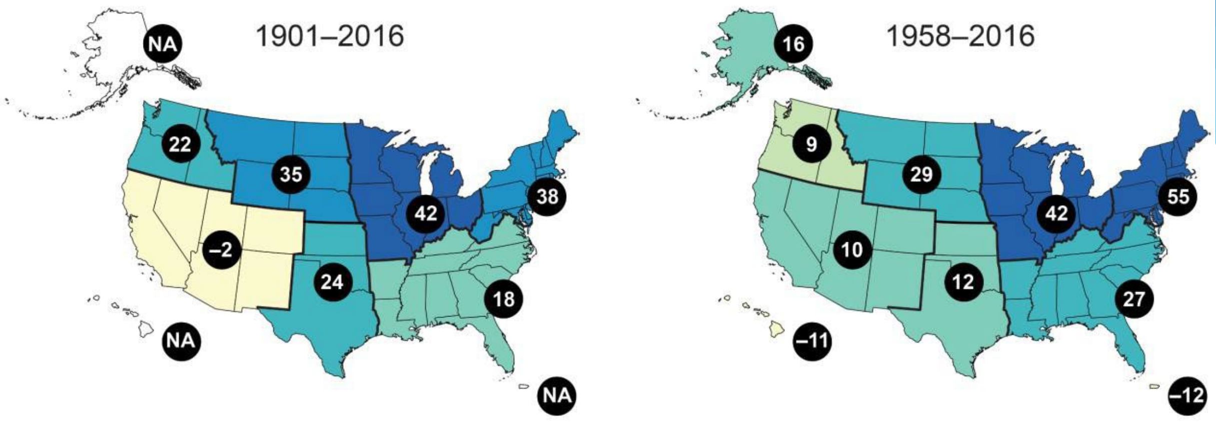
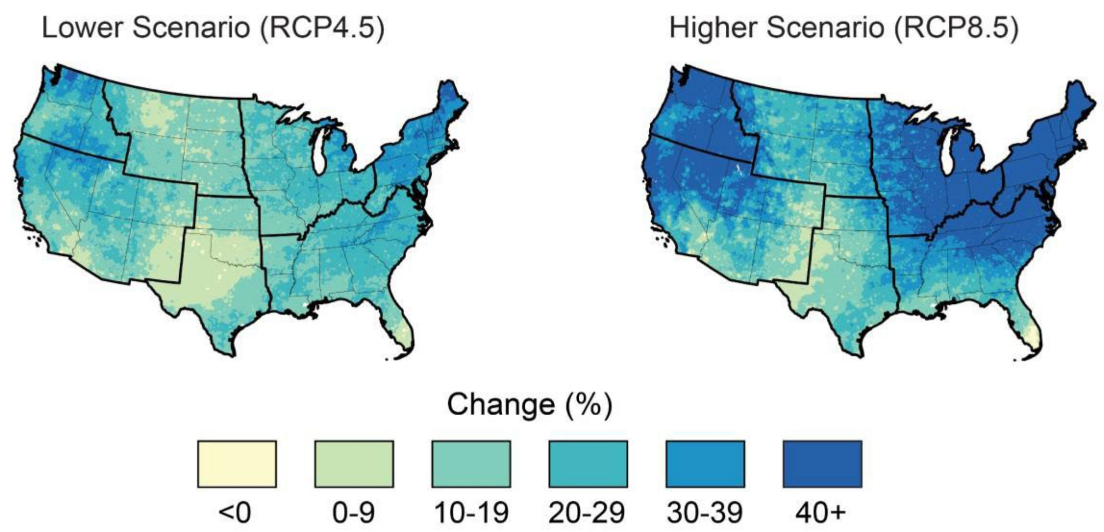
Extreme Rainfall

- Precipitation patterns have changed over past century
- Heavy rain events have become heavier
- More of annual rainfall in fewer events

Observed change in total annual precipitation falling in the heaviest 1% of events*

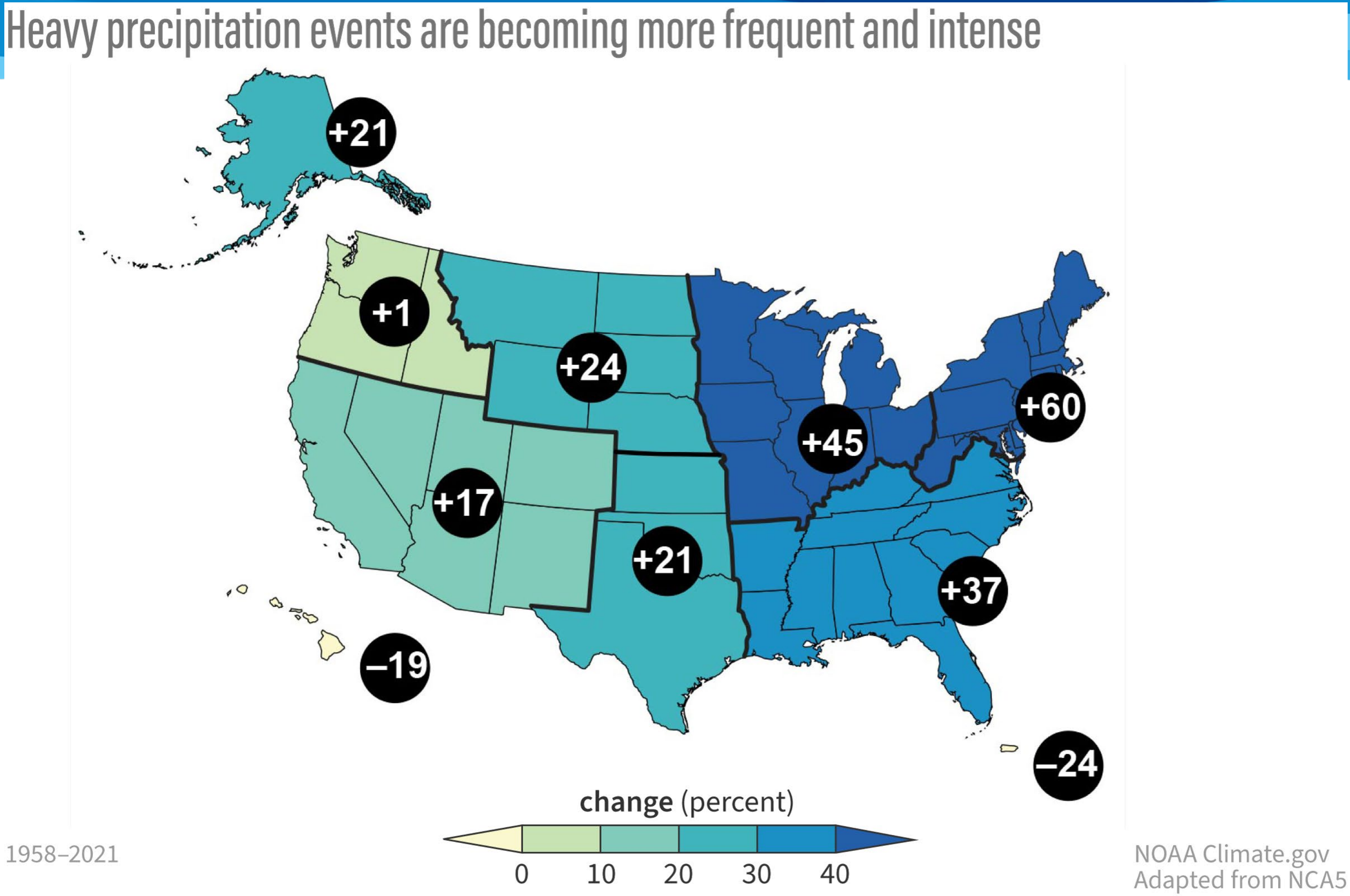


Projected change in total annual precipitation falling in the heaviest 1% of events by late 21st century*



*Source: National Climate Assessment (2018)

Extreme Rainfall



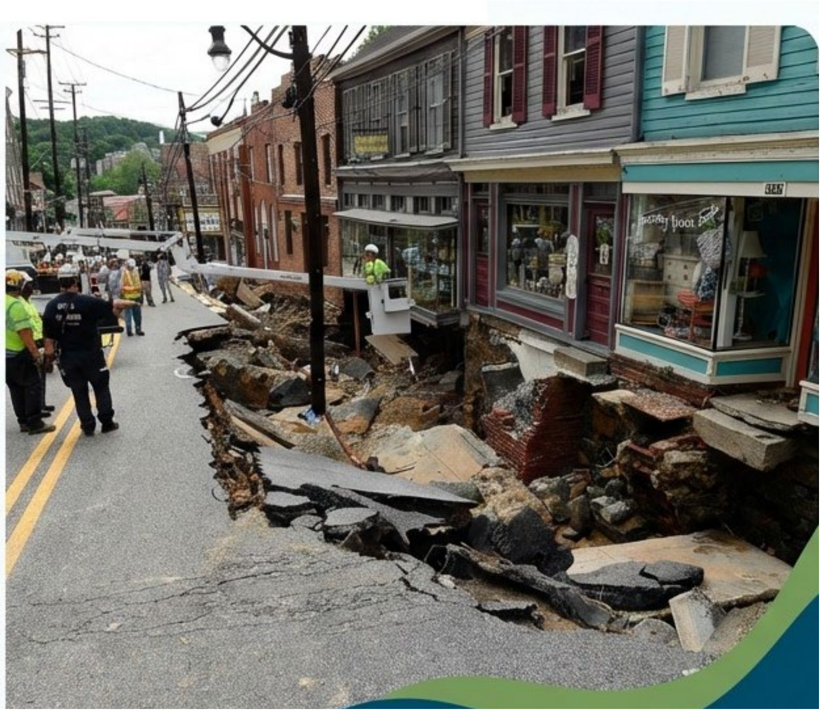
Extreme Rainfall Implications

Combined Sewer Overflows (CSOs)

- In older systems, stormwater and wastewater share the same pipe. Heavy rain causes the system to exceed capacity, discharging untreated sewage directly into waterbodies.

Physical Impacts

- **Erosion:** High-velocity flows scour stream banks.
- **Infrastructure Damage**: Collapse of roads and utility lines.
- **Economic Cost:** Property damage and disruption to local economies.



Source: NPR (https://apps.npr.org/ellicott-city/)

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Why Stormwater Matters

Stormwater directly affects influent quality, flows, and plant stability

High-flow events can cause bypasses, overflows, and permit violations

Stormwater carries nutrients, sediments, oils, metals, and bacteria

Understanding stormwater helps operators protect plant performance and the receiving watershed

Nutrients, Sediments & Stormwater Impacts

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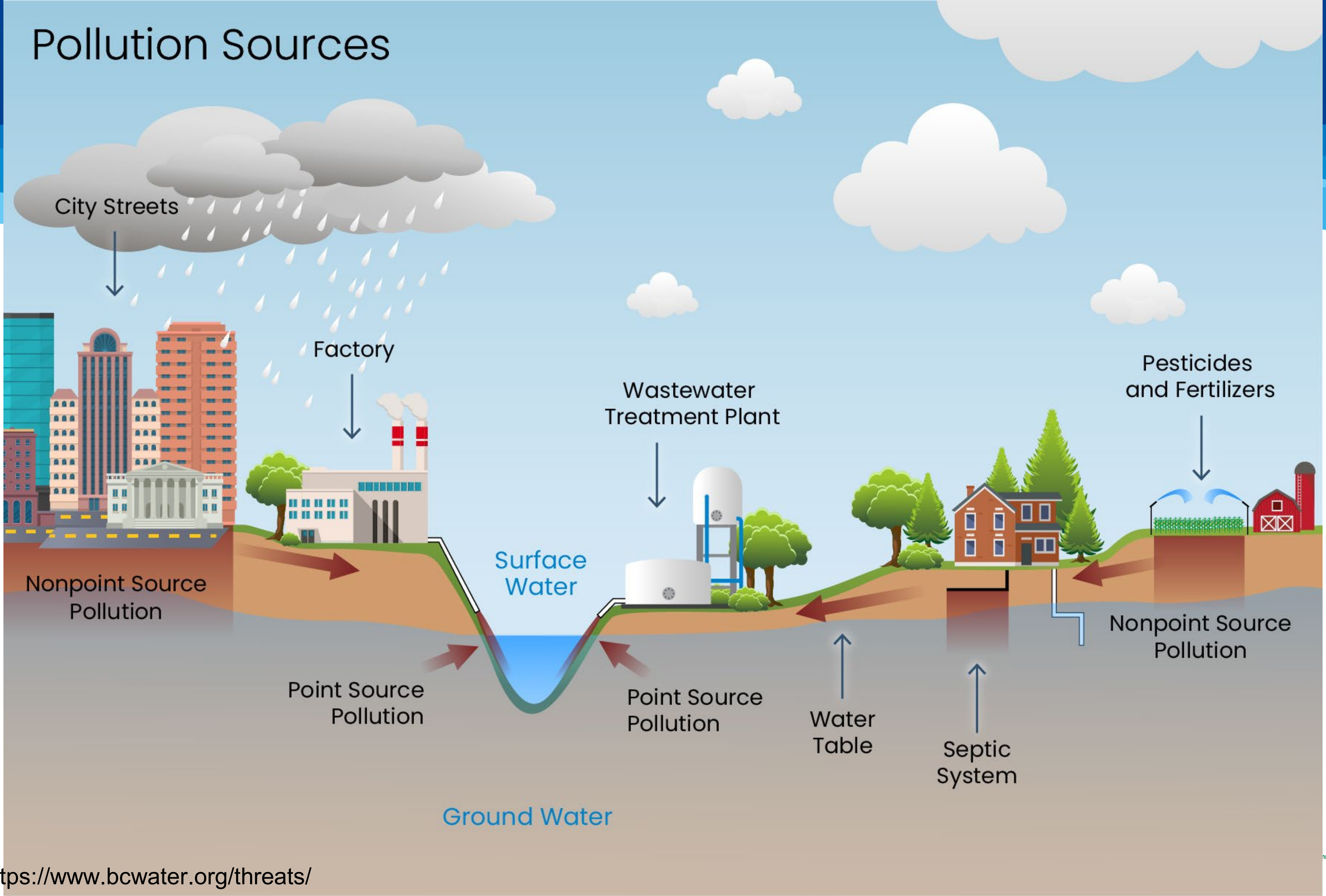


Source: https://www.bcwater.org/threats/

Pollution Sources

Nutrients

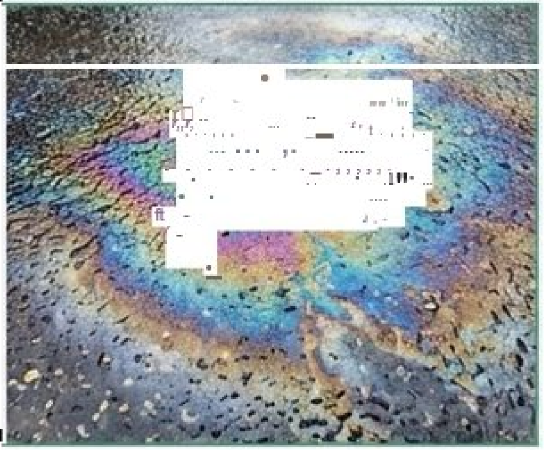
Nitrogen & Phosphorus from organic matter and fertilizers.

Sediments

Street dirt, erosion particles, and suspended solids.

Chemicals

Toxins from vehicles, industrial spills, and illicit discharges.



Pathogens

Bacteria and viruses from pet waste and sewage cross-contamination.

Pollution Sources-Road Salting

Salting Impacts on waters

Toxic Chloride Levels

- Salt is harmful to fish, amphibians, and invertebrates, rapidly reducing aquatic biodiversity.

Persistent Contamination

- Chloride does not break down; it accumulates indefinitely in soil, groundwater, and freshwater ecosystems.

Heavy Metal Mobilization

- Increased salinity triggers chemical reactions that release heavy metals from sediment into the water column.

Innovative approaches to reduce salt usage

Pre-treatment

- Applying brine *before* storms prevents ice bonding and reduces overall salt usage.

Equipment Calibration

- Calibrating trucks ensures precise application and prevents oversalting.

Smart Alternatives

- Using alternative materials (e.g., magnesium chloride) or abrasives like sand.

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Pollutant Impacts

Accumulation

- During dry periods, pollutants accumulate on roads and roofs. Atmospheric deposition adds airborne particles.

Precipitation

- Rain acts as a solvent, mobilizing solids and dissolving chemicals.

The First Flush

- The initial wave of the storm sweeps the highest concentration of pollutants into the conveyance system.

Importance of Perviousness

Natural Cover (Meadow)

- Curve Number (CN): 58
- Runoff Coefficient: 0.06
- Annual Nitrogen Load: 2.0 lbs/ac/yr
- Peak Discharge (100-yr storm): 3.1 cfs

Impervious Cover (Parking Lot)

- Curve Number (CN): 98
- Runoff Coefficient: 0.95
- Annual Nitrogen Load: 15.4 lbs/ac/yr
- Peak Discharge (100-yr storm): 12.6 cfs

Poll*

- What is the most persistent Water Quality concern you face at your plant or in your watershed?
  - Road salt and high chloride levels
  - Nutrient loading (Phosphorus/Nitrogen)
  - Sediment and trash accumulation
  - Heavy metals and oils from "First Flush" events

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Stormwater Practices to Protect Watersheds

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Existing Infrastructure

Gray Infrastructure

- Built with a single goal to move water away as fast as possible.

Consequences:

- Prevents natural ground filtration.
- Concentrates pollutant loads.
- Delivers high-velocity flows that scour stream banks.

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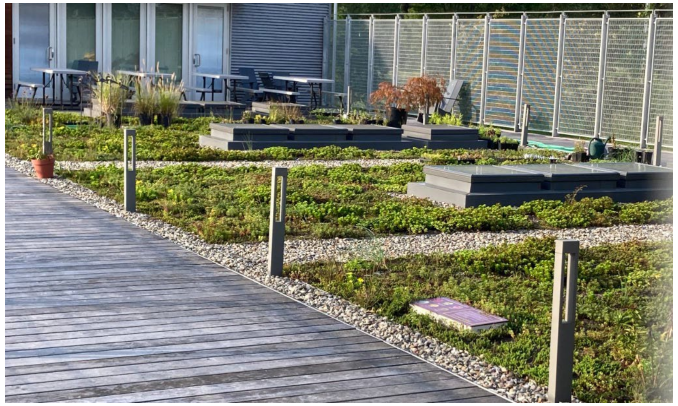
Stormwater Practices to Protect Watersheds

- Structural practices:
  - Detention/retention basins
  - Swales and bioswales
  - Rain gardens
  - Permeable pavement
  - Constructed wetlands
- Non-structural practices:
  - Street sweeping
  - Erosion control



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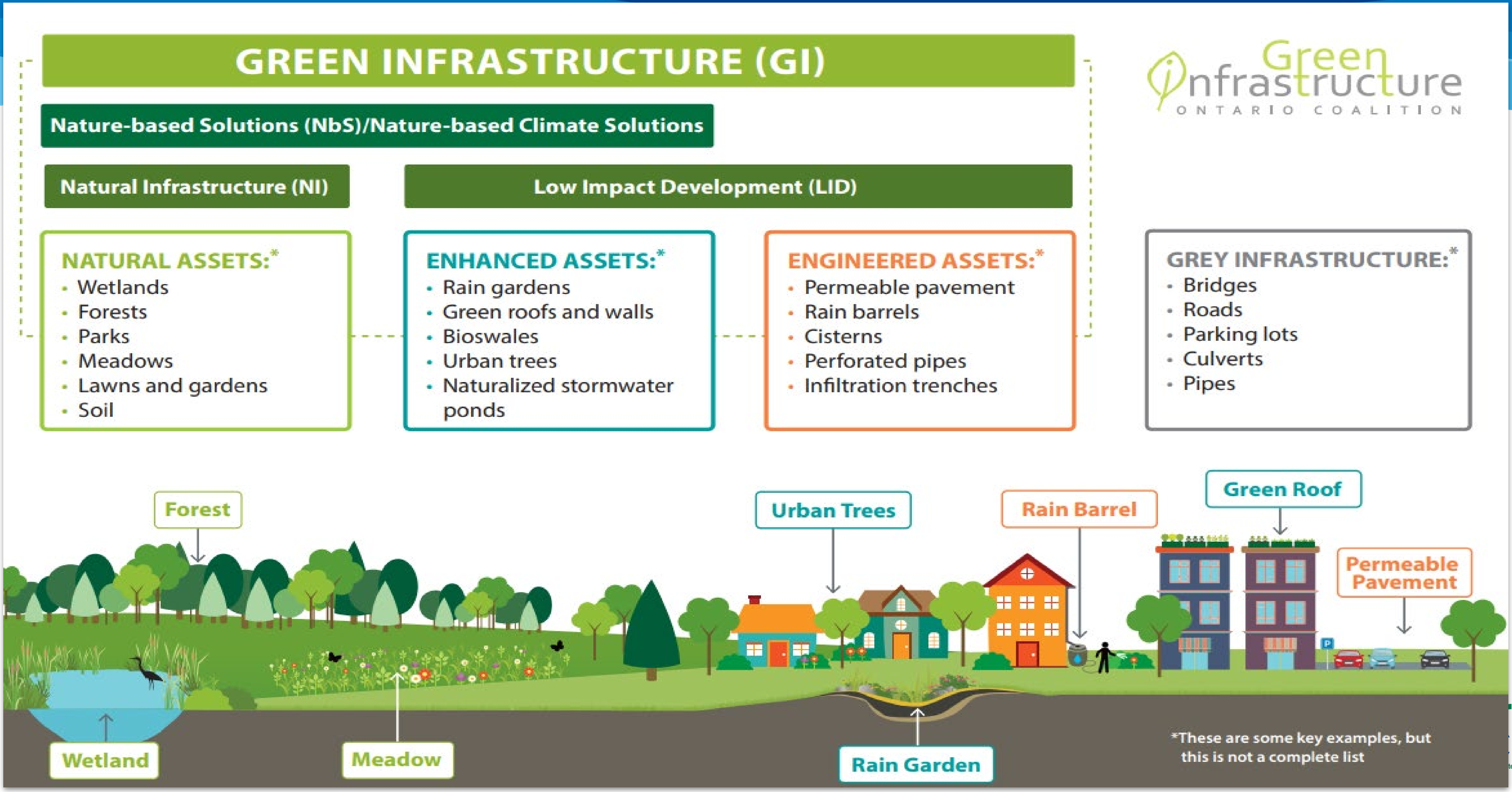
Green Infrastructure



Poll*

- How familiar is your team with designing or maintaining Green Infrastructure (Bioretention, Permeable Pavement, etc.)?
  - We are just starting to learn
  - We have some projects in place
  - We have a robust, established program

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Green Infrastructure

Rain Gardens

Excavated depressions with engineered soil and salt-tolerant plants. They collect runoff, allow sediment to settle, and filter pollutants.

Permeable Pavements

Porous asphalt or pavers allow water to pass through to a stone reservoir. Reduces winter icing and restores groundwater recharge.

Vegetative Swales

Open channels with vegetation that convey and runoff, serving as a greener alternative to concrete curbs and gutters.

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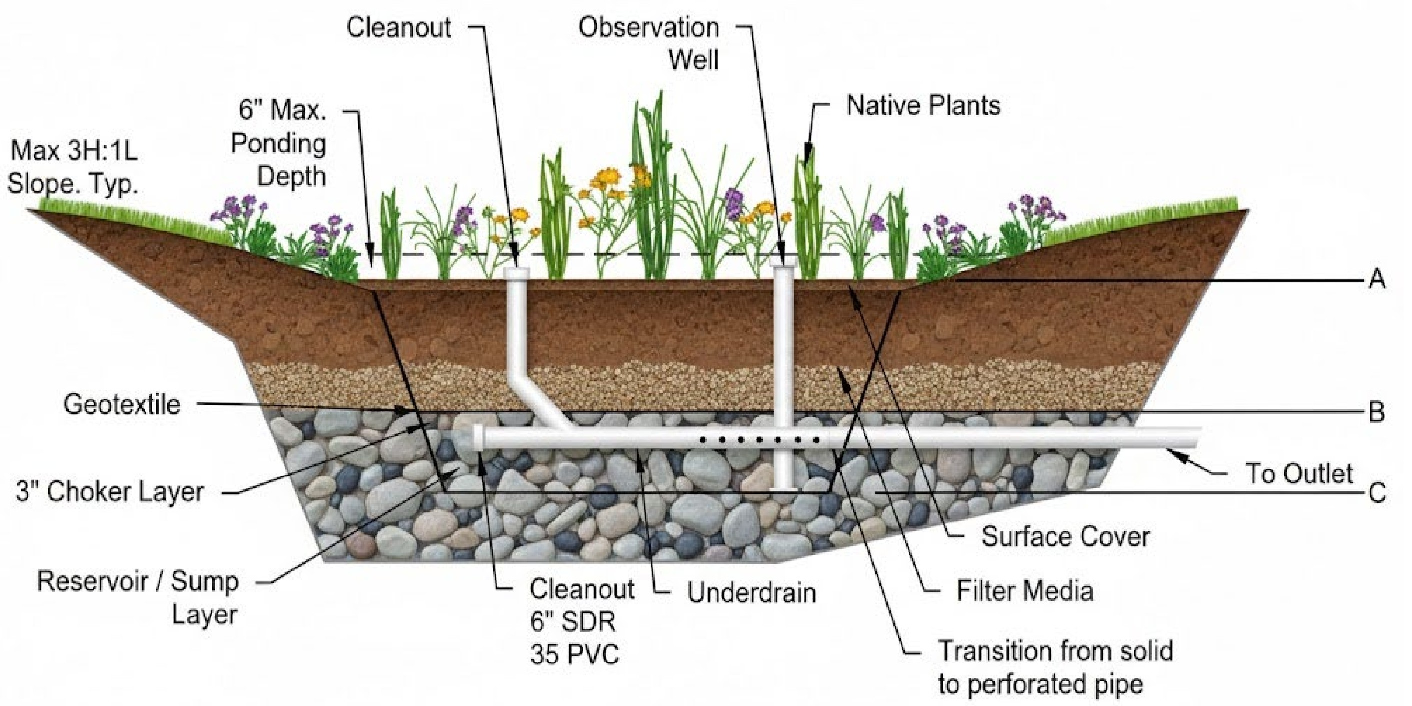
Green Infrastructure (GI) as a Buffer

- GI slows, spreads and soaks stormwater—helping to reduce:
  - Inflow & infiltration
  - Peak wet-weather flows
  - Shock loads to biological processes
- GI examples relevant to small systems and communities
  - Riparian buffers
  - Wetland restoration
  - Vegetated filter strips
  - Tree canopy expansion
- GI can help extend the life of your treatment infrastructure

How bioretention works



Source:
https://filetransfer.nashville.gov/Portals/0/SiteContent/WaterServices/Stormwater/docs/SWMM/2021/vol5/GIP01_Bioretention_2021.pdf

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Co-Benefits of Green Infrastructure

Benefit	Reduces Stormwater Runoff											Improves Community Livability						
	Reduces Water Treatment Needs	Improves Water Quality	Reduces Grey Infrastructure Needs	Reduces Flooding	Increases Available Water Supply	Increases Groundwater Recharge	Reduces Salt Use	Reduces Energy Use	Improves Air Quality	Reduces Atmospheric CO_2	Reduces Urban Heat Island	Improves Aesthetics	Increases Recreational Opportunity	Reduces Noise Pollution	Improves Community Cohesion	Urban Agriculture	Improves Habitat	Cultivates Public Education Opportunities
Practice																		
Green Roofs	Yes	Yes	Yes	Yes	No	No	No	Yes	Yes	Yes	Yes	Yes	Maybe	Yes	Maybe	Maybe	Yes	Yes
Tree Planting	Yes	Yes	Yes	Yes	No	Maybe	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Maybe	Yes	Yes
Bioretention & Infiltration	Yes	Yes	Yes	Yes	Maybe	Maybe	No	No	Yes	Yes	Yes	Yes	Yes	Maybe	Maybe	No	Yes	Yes
Permeable Pavement	Yes	Yes	Yes	Yes	No	Maybe	Yes	Maybe	Yes	Yes	Yes	No	No	Yes	No	No	No	Yes
Water Harvesting	Yes	Yes	Yes	Yes	Yes	Maybe	No	Maybe	Maybe	Maybe	No	No	No	No	No	No	No	Yes

● Yes ◒ Maybe ○ No

Source: https://www.cleanwisconsin.org/wp-content/uploads/2023/03/Green-Infrastructure-Toolkit-for-WI-Municipalities-3.7.23.pdf

Green Infrastructure Retention Potential

Green Infrastructure Practice	Average Annual Runoff Reduction	Area of Practice Implementation	Annual Stormwater Runoff Reduction
Rain garden	17 gallons/sq ft	100 sq ft (approximately 10 rain gardens)	1,700 gallons
Bioswale	17 gallons/sq ft	One 1,000 sq ft bioswale collecting runoff from 2,000 sq ft parking lot	51,000 gallons
Green roof	16 gallons/sq ft	4,000 sq ft (approximately 5 homes)	64,000 gallons
Permeable pavement	14 gallons/sq ft	7,500 sq ft (approximately one block)	105,000 gallons
Medium street tree	1,130 gallons/tree	10 trees at maturation (approximately one block)	11,300 gallons
		Total	**233,000 gallons**

Source: https://www.cleanwisconsin.org/wp-content/uploads/2023/03/Green-Infrastructure-Toolkit-for-WI-Municipalities-3.7.23.pdf

Poll*

- Which Green Infrastructure practice do you believe has the highest potential for success in your specific community?
  - Bioretention & Rain Gardens
  - Permeable Pavement
  - Tree Planting and Canopy expansion
  - Water Harvesting (Rain barrels/cisterns)
  - Wetlands

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MS4 Permits

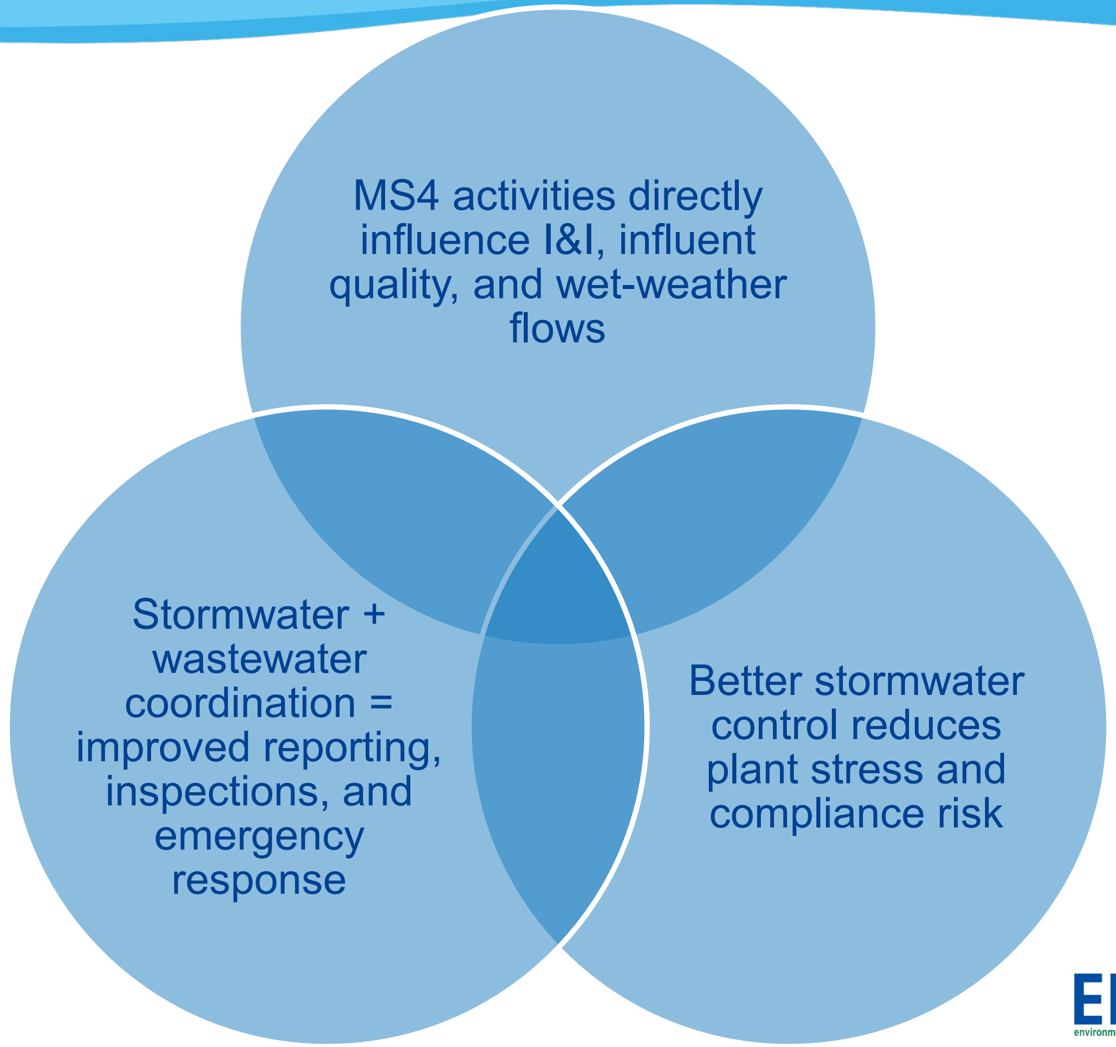
Municipal Separate Storm Sewer System (MS4 Permits)

- An MS4 Permit (Municipal Separate Storm Sewer System) is a regulatory requirement under the Clean Water Act designed to reduce the discharge of pollutants from storm sewer systems into local water bodies.
- These permits are essential for managing the impacts of urban runoff on watersheds.
- MS4 programs are the primary line of defense against the degradation caused by extreme rainfall and urbanization

Municipal Separate Storm Sewer System (MS4 Permits)

Minimum Control Measures (MCMs)

- Public education & outreach
- Public involvement
- Illicit discharge detection & elimination (IDDE)
- Construction site runoff control
- Post-construction stormwater management
- Good housekeeping for municipal operations



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MS4 Compliance

- Recognize and report potential illicit discharges
- Support municipal housekeeping practices (chemical storage, yard management, vehicle washing)
- Assist with outfalls, manholes, drainage structures inspections
- Document wet-weather events that affect plant performance
- Coordinate with stormwater staff on I&I investigations and cross-connection issues

Engaging the Public

Why public engagement matters:

- Reduces contamination from improper disposal
- Builds support for funding and staffing
- Helps prevent illicit discharges

Effective strategies:

- Community cleanups
- Utility open houses
- Social media updates
- Partnering with schools and local groups

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Stormwater Education & Outreach

- Key messages for residents:
  - “Only rain down the drain”
  - Proper disposal of oils, chemicals, and wipes
  - Yard care practices that reduce nutrients
  - Pet waste management
- Tools for operators:
  - Short videos
  - Flyers, bill inserts, and door hangers
  - Demonstrations at community events
  - Partnerships with conservation districts

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Tools & Resources for Green Infrastructure & Better Stormwater Management

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Poll*

- In which area do you need the most support or training to improve stormwater management?
    - Mapping
    - Funding & Financing
    - Design & Maintenance
    - Planning
    - Grant Writing

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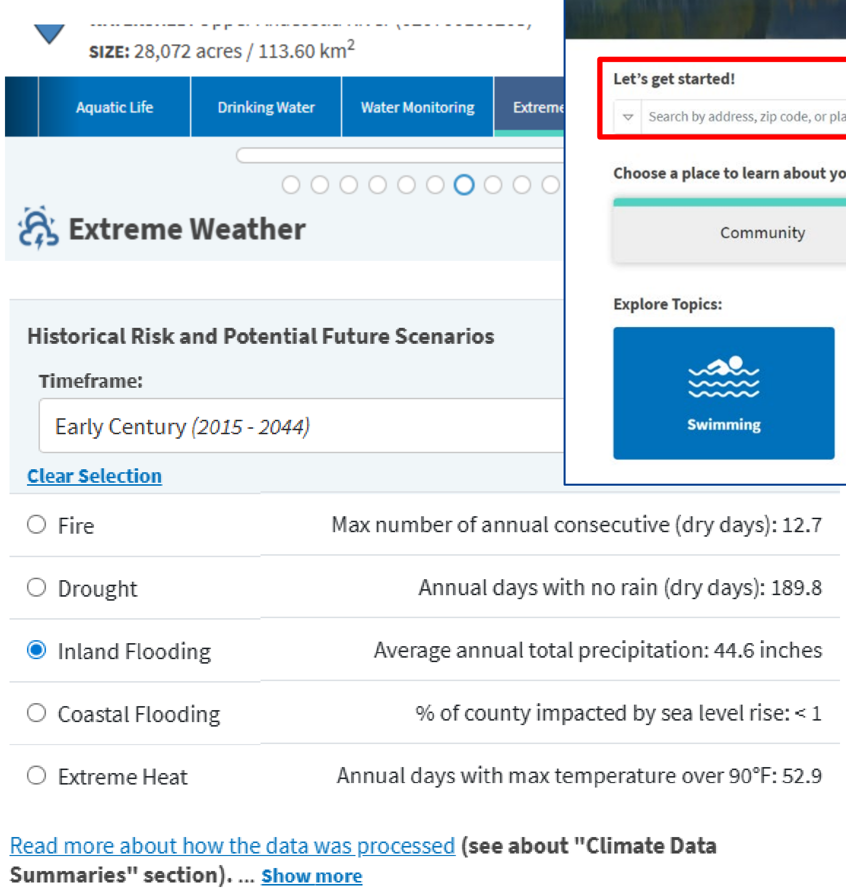
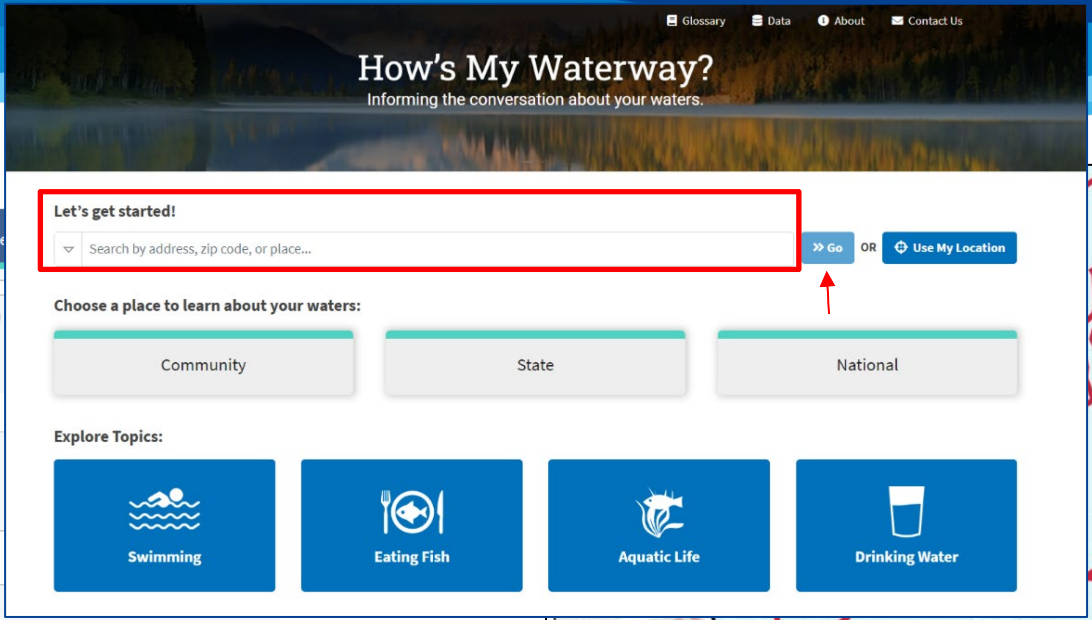
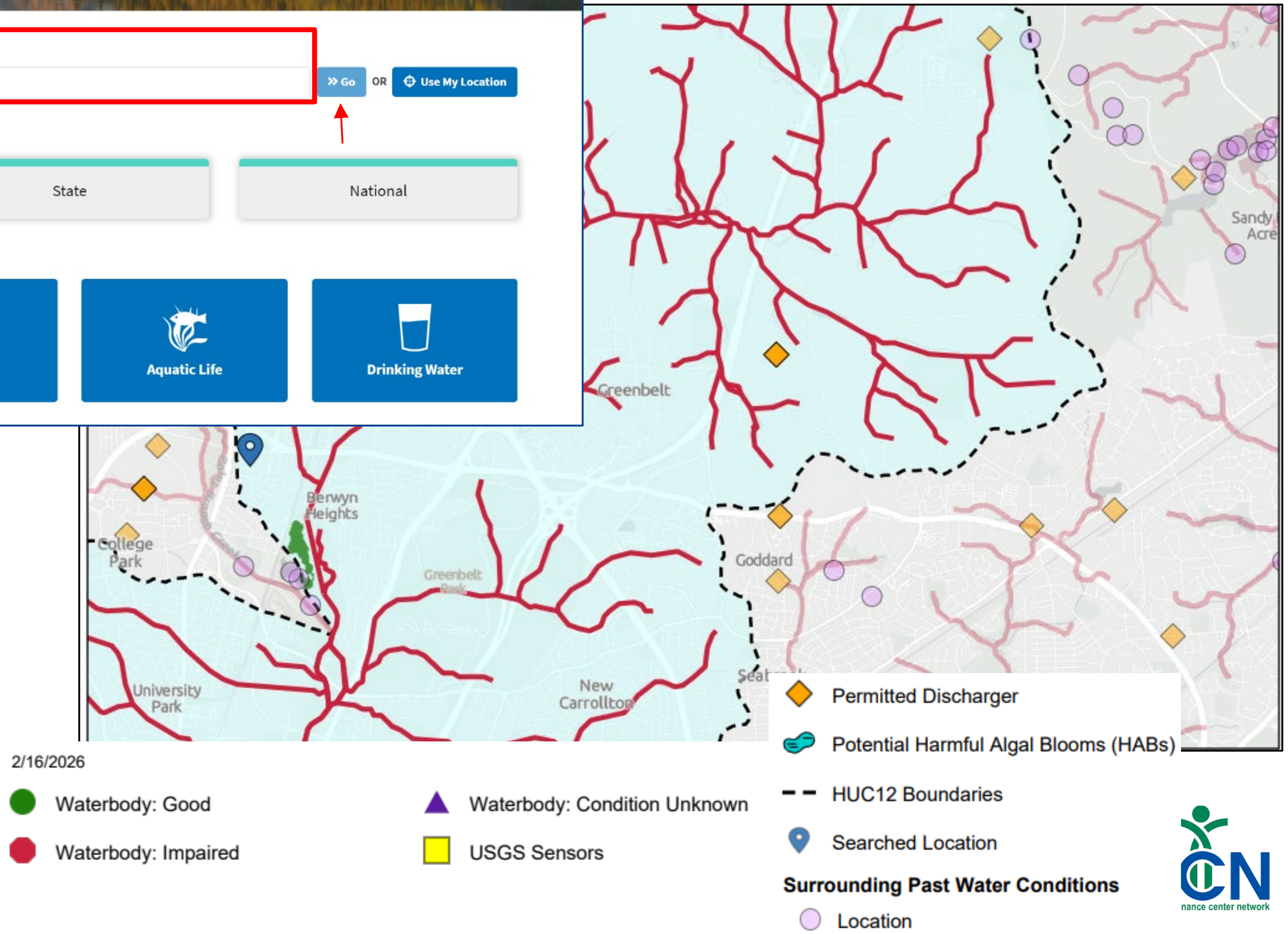
How’s my Waterway



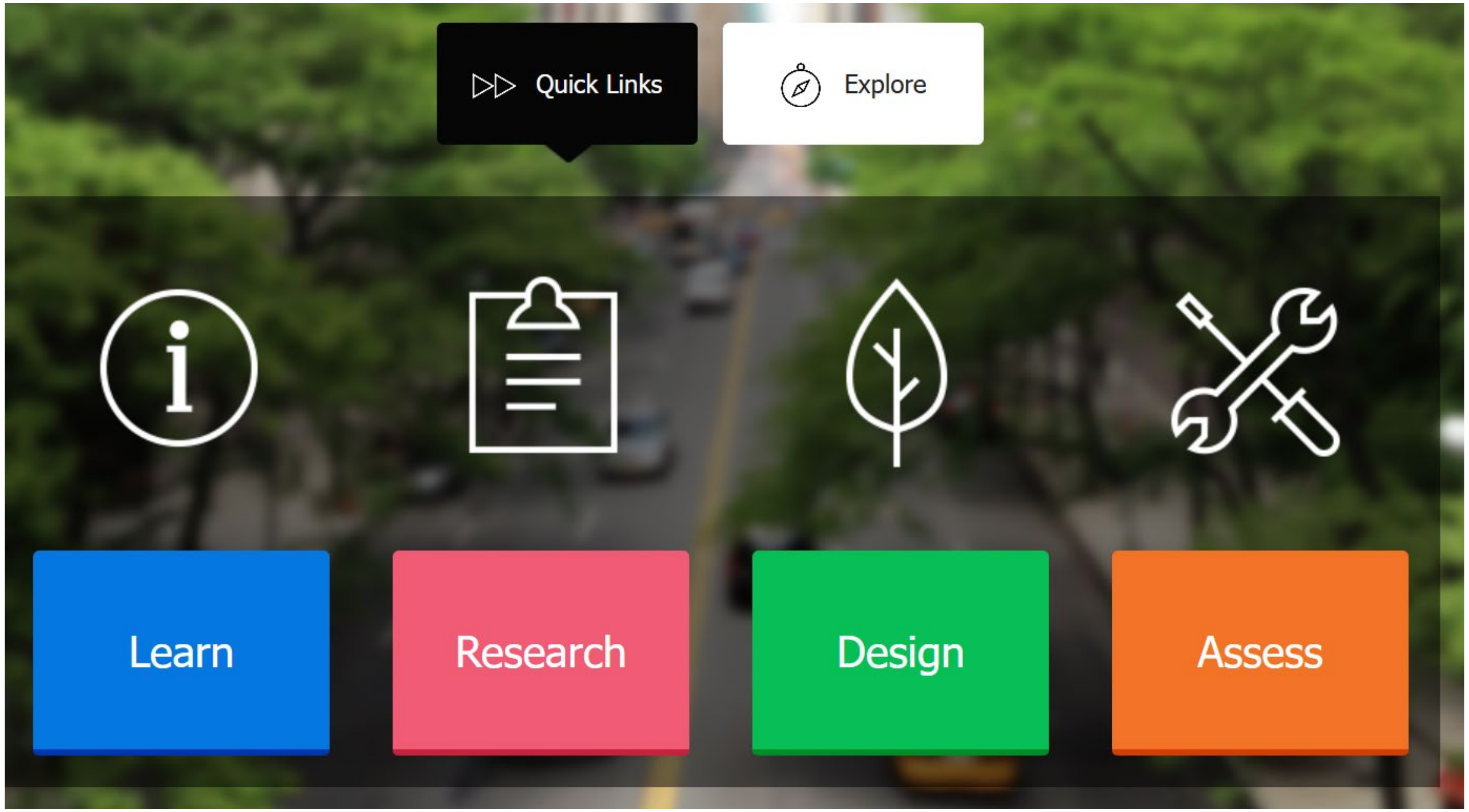




https://mywaterway.epa.gov/

Green Infrastructure Wizard (GIWiz)

- GIWiz offers EPA-sourced Green Infrastructure tools and resources designed to support and promote sustainable water management and community planning decisions.

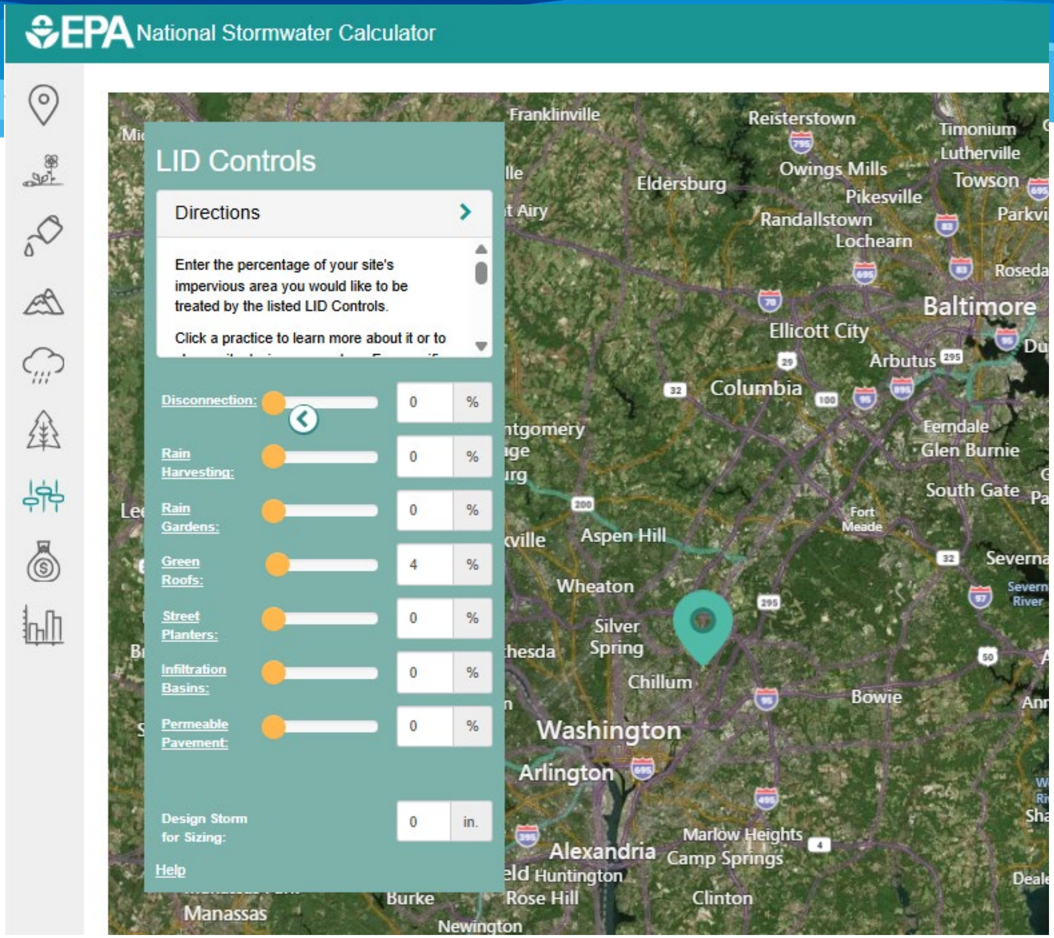


Source: https://cfpub.epa.gov/wizards/giwiz/

National Stormwater Calculator (SWC)

- Informs users on how well they can meet a desired stormwater retention target with and without the use of green infrastructure. It can also be used by landscapers and homeowners.

10 Basic Steps to Analyze a site:



https://swcweb.epa.gov/stormwatercalculator/

Location → Soil Type → Soil Drainage → Topography → Precipitation/Evaporation → Climate Change → Land Cover → LID Controls → Project Cost → Results/Runoff

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National Stormwater Calculator (SWC)

LID Controls

Directions

Enter the percentage of your site's impervious area you would like to be treated by the listed LID Controls.

Click a practice to learn more about it or to

Disconnection:	0	%
Rain Harvesting:	20	%
Rain Gardens:	0	%
Green Roofs:	0	%
Street Planters:	20	%
Infiltration Basins:	5	%
Permeable Pavement:	0	%
Design Storm for Sizing:	2	in.

Help

Summary Results

Current Scenario

Annual Rainfall: 40.61 in.

Runoff Infiltration Evaporation

Baseline Scenario

Annual Rainfall: 40.63 in.

Runoff Infiltration Evaporation

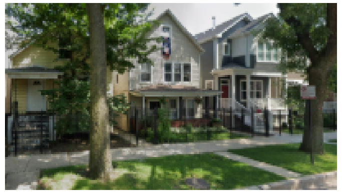
Statistic	Current Scenario	Baseline Scenario
Average Annual Rainfall (inches)	40.61	40.63
Average Annual Runoff (inches)	15.23	22.33
Days per Year with Rainfall	69.81	69.41
Days per Year with Runoff	37.88	49.82
Percent of Wet Days Retained	45.74	28.22
Smallest Rainfall w/ Runoff (inches)	0.11	0.11
Largest Rainfall w/o Runoff (inches)	0.42	0.29
Max Rainfall Retained (inches)	1.76	1.51

Green Values® Stormwater Management Calculator

Site Information | **Green Improvements**

Start from a template or design a custom scenario.

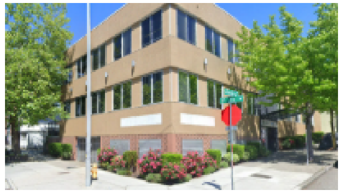
Urban Home



Small lot 6,075 ft^2 (135' x 45')

- a small house
- garage
- sidewalk
- yard

Apartment



Medium lot 8,400 ft^2 (140' x 60')

- a building
- sidewalk
- patio
- very small yard

Suburban

Large lot 24,000ft^2 (200' x 120')

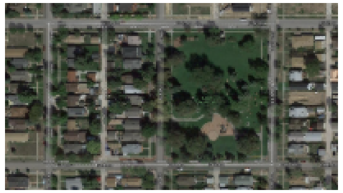
- a large house
- garage
- driveway
- sidewalk
- yard

Commercial

Large lot 50,000 ft^2 (250' x 200')

- a building
- parking lot
- driveway
- small amount of landscaping

Urban Park Area



6.8 Acres Area With a Park

- 3 Acre park
- Streets and sidewalks
- Residential buildings, lawns and landscaping

Community Garden

Small lot 6,075 ft^2 (135' x 45')

- 5 100' x 4' Raised Beds
- Paved Sidewalks
- Staging Area
- Lawn Walkways

0.0%

0 Volume Captured 100

Total Cost: $**0**

Site Overview | Volume | Runoff | Costs | Benefits

Total Land Use

Choose a template or design a custom scenario.

Land Use	Original Area	Area including BMP(s)
Total Impervious Area	0 ft^2	0 ft^2
Total Landscape Area	0 ft^2	0 ft^2
Total BMP Area		0 ft^2
Total Lot Area	0 ft^2	0 ft^2
Other Volume Control		0 gallons

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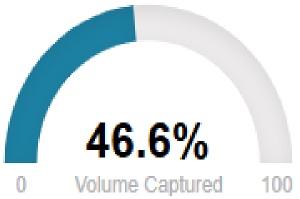

Total Cost: **$20,304**

Results: The green infrastructure applied in this scenario increases the area's potential volume capture capacity by **922.4** ft^3 or **46.6**% of the desired goal.

Site Overview | Volume | Runoff | Costs | Benefits

Total Land Use

Land Use	Original Area	Area including BMP(s)
Total Impervious Area	47,450 ft^2	47,350 ft^2
Flat Roof	10,000 ft^2	10,000 ft^2
Parking Surface	32,450 ft^2	32,350 ft^2
Parking Lot Swales		100 ft^2
Driveway	5,000 ft^2	5,000 ft^2
Total Landscape Area	2,550 ft^2	2,050 ft^2
Shrub and Bushes	2,550 ft^2	2,050 ft^2
Rain Garden		500 ft^2
Total BMP Area		600 ft^2
Total Lot Area	50,000 ft^2	50,000 ft^2
Other Volume Control		330 gallons
Rain Barrel		330 gallons

Site Overview | Volume | Runoff | Costs | Benefits

Volume Control

Required Volume Capture Potential from 0.5" over 47450 ft^2 of impervious area is: 1,977 ft^3 or 14,789 Gallons.

BMP	ft^3	Gallons
Rain Barrel	44.1	330
Rain Garden	422.3	3159.3
Trees	416	3111.9
Parking Lot Swales	40	299.2
Total of all BMPs	922.4	6,900.4
Percentage of Volume Capacity Capture Goal	46.6	%

Runoff and Hydrology

Runoff	Without BMPs	With BMPs	Difference
Average Annual Rainfall: 32.64" Rain			
Runoff	16.017"	12.312"	23%
Runoff Volume	66738.1 ft^3 499235.4 gal.	51300.9 ft^3 383757.5 gal.	15437.1 ft^3 115477.8 gal.
Average Storm Rainfall: 2.33" Rain			
Runoff	1.957"	1.785"	9%
Runoff Volume	8155.9 ft^3 61010 gal.	7436.1 ft^3 55625.6 gal.	719.8 ft^3 5384.4 gal.

Hydrology	Without BMPs	With BMPs	Difference
Average Initial Abstractions Rainfall: " Rain			
Initial Abstractions	0.07"	0.11"	0.04%
Initial Abstractions Volume	291.25 ft^3 2178.72 gal.	452.9 ft^3 3387.95 gal.	161.65 ft^3 1209.23 gal.
Average Cumulative Abstractions			
Cumulative Abstractions	0.35"	0.54"	0.19%
Cumulative Abstractions Volume	1456.26 ft^3 10893.59 gal.	2264.51 ft^3 16939.73 gal.	808.25 ft^3 6046.13 gal.
Curve Number	96.6	94.8	

Site Overview | Volume | Runoff | Costs | Benefits

Benefits

Financial Benefit	Annual Benefits	Life Cycle Benefits (NPV)
Owner Total	$360	$7325.82
Reduced Energy Use from Trees	$360	$7325.82
Community Total	$2794.26	$56861.68
Reduced Air Pollutants from Trees	$1.81	$36.83
Carbon Dioxide Sequestration from Trees	$1.2	$24.42
Compensatory Value of Trees	$2750	$55961.09
Groundwater Replenishment	$30.63	$623.37
Reduced Treatment benefits	$10.61	$215.97
Total	$3154.26	$64187.5

Increased Real Estate Value ?

Value From	Existence	Area
Rain Gardens, Swales, Planters, Etc.	5.7%	0.2%
Trees	5%	0.8%
Total	11%	1%

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Green Asset Resource Database

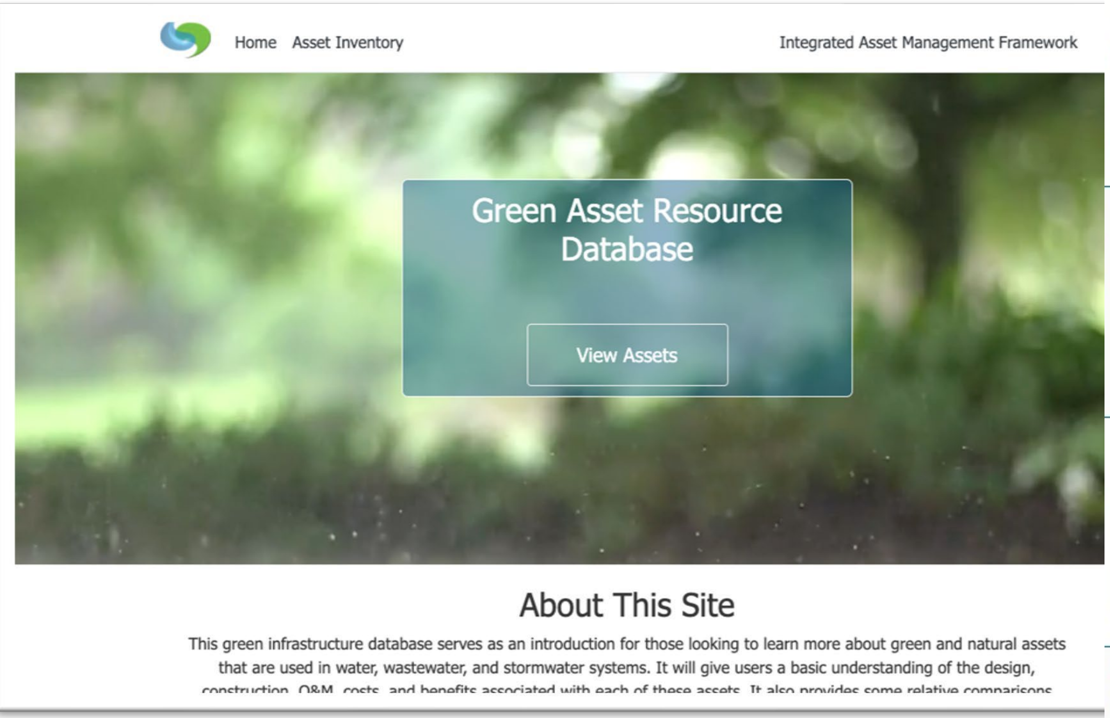

Image	Asset Name	Asset Type	Construction Rank	O&M Difficulty	Details
	Rain Gardens	Enhanced	1	2	View
	Bioretention Areas	Enhanced	2	2	View
	Drainage Ditch or Channel	Enhanced	2	2	View
	Infiltration Planter	Enhanced	2	2	View

https://swefcapps.unm.edu/gardb

Green Infrastructure Toolkit for Municipalities

Stormwater Management Program Requirements from MS4 Permit	Ways to Use Green Infrastructure to Help Meet Requirement
Public education and outreach- Programs must encourage the public and business to adopt behaviors and procedures to reduce stormwater pollution.	**Install a demonstration project** to educate the community on the importance of green infrastructure and stormwater management.
Public involvement and participation- Programs must encourage participation from individuals to prevent stormwater pollution.	**Implement projects that encourage community participation** like rain garden installations or street tree planting days.
Illicit discharge detection and elimination- Programs must identify, prevent, and eliminate illicit (non-rainwater) pollutants and discharges to storm sewer systems.	**Install a stormwater infiltration basin** paired with a bioswale to prevent polluted water from getting into waterways.
Construction site pollutant control- Municipalities must develop a soil erosion control ordinance and enforce it on construction sites	**Add green infrastructure requirements** (e.g., vegetation buffers) to slow runoff and trap sediments before entering the waterways.

Green Infrastructure Practice	Average Stormwater Holding Capacity[17]	Average Annual Retention[17]	Average Annual Runoff Reduction
Rain barrel	Up to 55 gallons	100%	Depends on collection area
Rain garden	5.37 gallons/sq ft	80%	17 gallons/sq ft
Bioswale	7.48 gallons/sq ft	80%	17 gallons/sq ft
Infiltration basin	Depends on size of basin (can be thousands of gallons)	100%	Depends on collection area
Green roof	2.2 gallons/sq ft	75%	16 gallons/sq ft
Permeable pavement	7.09 gallons/sq ft	65%	14 gallons/sq ft
Constructed wetland	14.36 gallons/sq ft	72%	15 gallons/sq ft
Medium street tree	50 gallons/tree	25%	1,130 gallons/tree

Source: https://www.cleanwisconsin.org/wp-content/uploads/2023/03/Green-Infrastructure-Toolkit-for-WI-Municipalities-3.7.23.pdf

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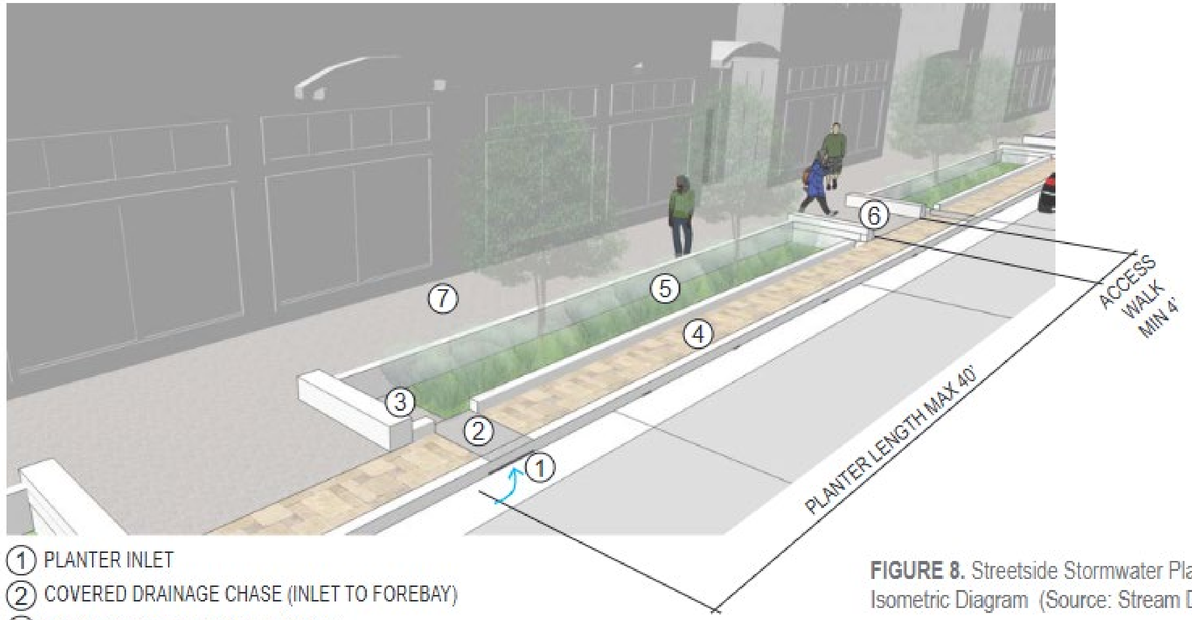
Green Infrastructure Guidelines

TABLE 2: Material Specification for Bioretention/Rain Garden Facilities

Material		Specification		
Bioretention Growing Media (soil + organics)	Bioretention soil	Particle size distribution (by weight): 80-90% sand (0.05 - 2.0 mm diameter) 3-14% silt (0.002-0.5 mm diameter) 3-14% clay (<0.002 diameter) 3 to 5% shredded mulch (see notes) Chemical attribute and nutrient analysis: pH 6.8 - 7.5 organic matter < 1.5% nitrogen <15 ppm phosphorus < 15 ppm salinity < 6 mmhos/cm		
Landscape mulch (where applicable)		Shredded mulch		
Underdrain aggregate	CDOT filter material (Class B or C as specified)		Class B	Class C
		37.5 mm (1.5")	100	
		19.0 mm (0.75")		100
		4.75 mm (No.4)	20-60	60-100
		1.18 um (No. 16)	10-30	
		300 um (No. 50)	0-10	10-30
		150 um (No. 100)		0-10
		75 um (No. 200)	0-3	0-3
Underdrain Pipe		Pipe diameter and type	Maximum slot width (inches)	Minimum open area (per foot)
		4-inch slotted PVC	0.032	1.90 in.²
		6-inch slotted PVC	0.032	1.98 in.²



1 PLANTER INLET
2 COVERED DRAINAGE CHASE (INLET TO FOREBAY)
3 FOREBAY (SEDIMENT COLLECTION)
4 STEP-OUT ZONE
5 PLANTING AREA (IRRIGATED)
6 ACCESS WALK
7 PEDESTRIAN SIDEWALK

FIGURE 8. Streetside Stormwater Planter Isometric Diagram (Source: Stream Design.2015.)

https://www.denvergov.org/files/assets/public/v/1/doti/documents/standards/pwes-013.0-ultra_urban_green_infrastructure_guide.pdf

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Thank you!

Any Questions?

For Technical Assistance reach out at dkumar18@umd.edu

This program is made possible under a cooperative agreement with US EPA.